2 IDENTIFYING THE ISSUES

This chapter documents the identification of issues relevant to sediment and hydrodynamic processes in the Lower Myall River. The issues were identified through:

- Review of existing literature; and
- Community Consultation.

2.1 Existing Literature

A number of documents prepared in recent years describe coastal and estuarine processes in Port Stephens and the Lower Myall River. This section provides a summary of the relevant aspects of these documents, as they relate to understanding the hydrodynamics and sediment characteristics, within and around the study area.

2.1.1 Paleo Geomorphology

The period extending from around 2.6 million years to around 10,000 years before the present is known as the Pleistocene epoch. This epoch is characterised by glacial periods (lasting around 80,000 – 100,000 yrs. with a lowered sea level, typically around 120 m below present sea level) and interglacial periods (typically lasting around 20,000 years with higher sea level, typically at or near present sea level +/- 20 m). The period extending from around 10,000 years ago to the present is known as the Holocene epoch, and is characterised by an interglacial period with an approximate "still-stand" sea level for the past 6,000 years.

Processes acting during the late Pleistocene (from around 140,000 years ago) to the present have shaped many of the identifiable features of New South Wales present day coastline. During the last interglacial period (sea level peak at around 120,000 years ago) mean sea level was approximately 5 m above that of today. The dune system that formed under these times is now known as the Pleistocene inner sand barrier, and is located landward of the present coastline. Stabilisation of the present sea level, following subsequent glacial and interglacial times has formed a second or 'outer' Holocene barrier sand dune system along the present day coastline. The Lower Myall River presently drains the Myall Lakes system through the topographic depression between the inner and outer barriers.

In the area north of Port Stephens, the outer barrier presently comprises both stable and mobile sections with dunes up to 30 m in height (MHL 1993). The inner barrier is located further inland comprising dunes and beach ridges which are less pronounced and sometimes not readily discernible. The Port Stephens estuary sits primarily within in the inner barrier system which extends some 5 - 10kms inland, creating sandy lowland areas adjacent to the estuary foreshore for much of its perimeter (MHL 1999).

Based on the dating of shell fragments from a remnant tidal delta in Bombah Broadwater, Thom *et al*. (1992) surmise that the Myall Lakes previously discharged directly to the ocean in the vicinity of Mungo Brush where the outer barrier is very narrow. It was estimated that approximately 2000 years ago, this entrance closed permanently, and all catchment inflows to the lakes were subsequently diverted southwards along the low lying inter-barrier depression, creating the Lower Myall River.

The Lower Myall River has become wider and deeper over the past 2000 years, and the net direction of marine-origin bed sediment transport is now upstream, towards Bombah Broadwater. This is evidenced by inspection of aerial photography showing the development of a flood tide delta where the Myall River enters the Bombah Broadwater, and the shape of bed forms in the Lower Myall River, which are typically oriented in an upstream direction.

2.1.2 Recent Geomorphology

Port Stephens can be split into two different geomorphologic sections, which are located to the east and west of Soldiers Point (a bedrock ridge). The deepest part of the Estuary (depths > 30 m) are located offshore of Soldiers Point. Port Stephens presently acts as a depositional environment for both marine and fluvial sediments (east and west of Soldiers Point), as discussed below.

The depositional areas of Port Stephens, as presented by Thom *et al.* (1992) are shown as Figure 2-1.

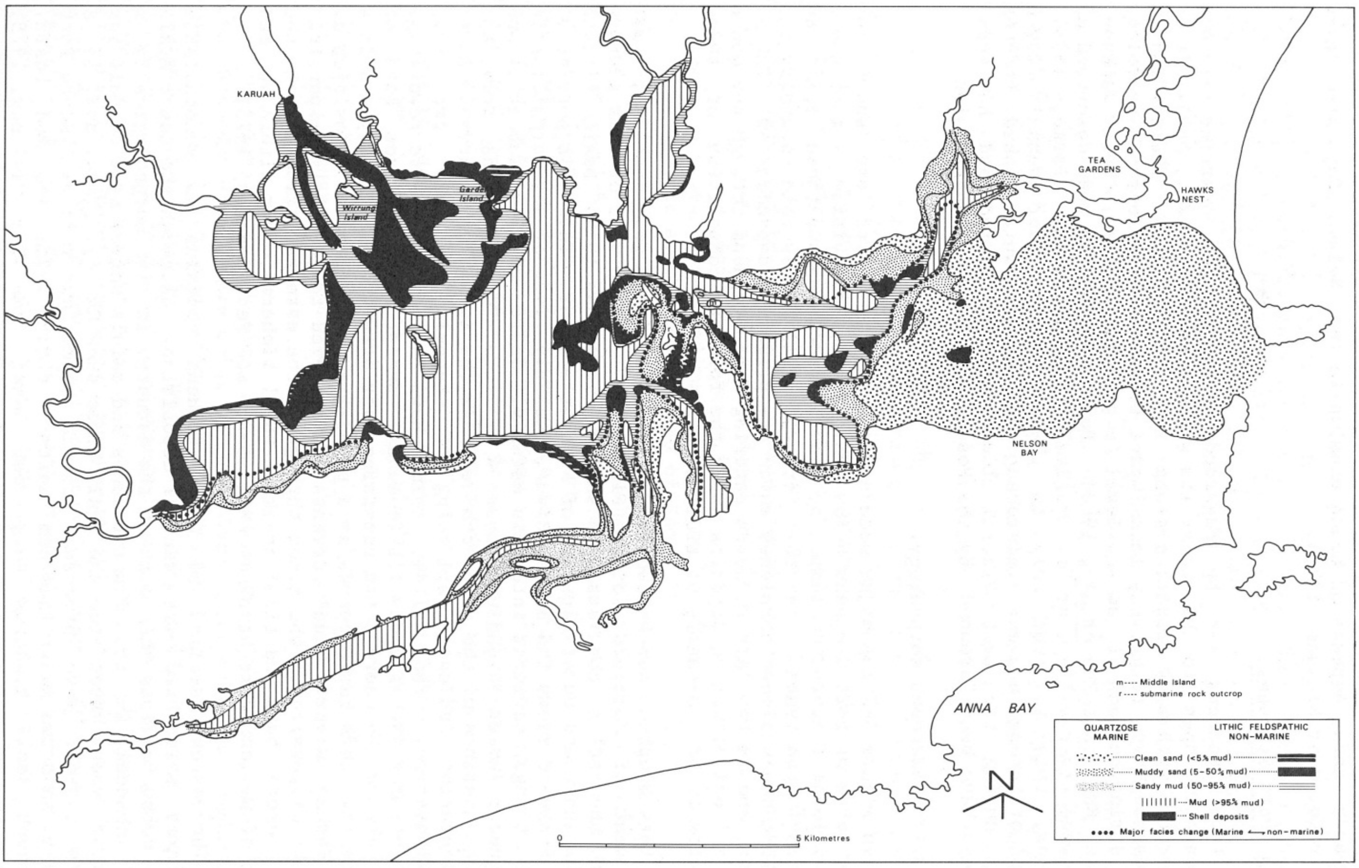


Figure 2-1 Depositional Areas Within Port Stephens (from Thom *et al.*, 1992)

To the east of Soldiers Point is an active marine flood tide delta, adjacent to the Lower Myall River entrance. The flood tide delta is very shallow, typically no more than 4-8 m below mean sea level (refer Figure 2-2), and waves break at low tide on sand shoals that extend most of the way across the mouth of the estuary (MHL 1999).

To the west of Soldiers Point is a shallow mud settling basin with water depths typically <10m (refer Figure 2-2). The Karuah River is the only significant supply of fluvial sediment to the whole estuarine system.

The Lower Myall River meanders through non cohesive (sandy) alluvium deposits, estuarine sand and mud (MHL 1993). It is understood that the vegetation in this area established before the meanders of the River, and that the vegetation now controls development of the River's plan form. The sandy bed of the River also contains some silt and organic material.

The bed of the present study area is located within the marine delta of Port Stephens, and the downstream reaches of the Lower Myall River, which comprise a mixture of marine sediments carried into the mouth by the combined action of waves and tides, and sands derived from the interbarrier depression. The area is constantly changing under the influence of complex interactions between tides, ocean swell, wind waves and flows from the Myall River.

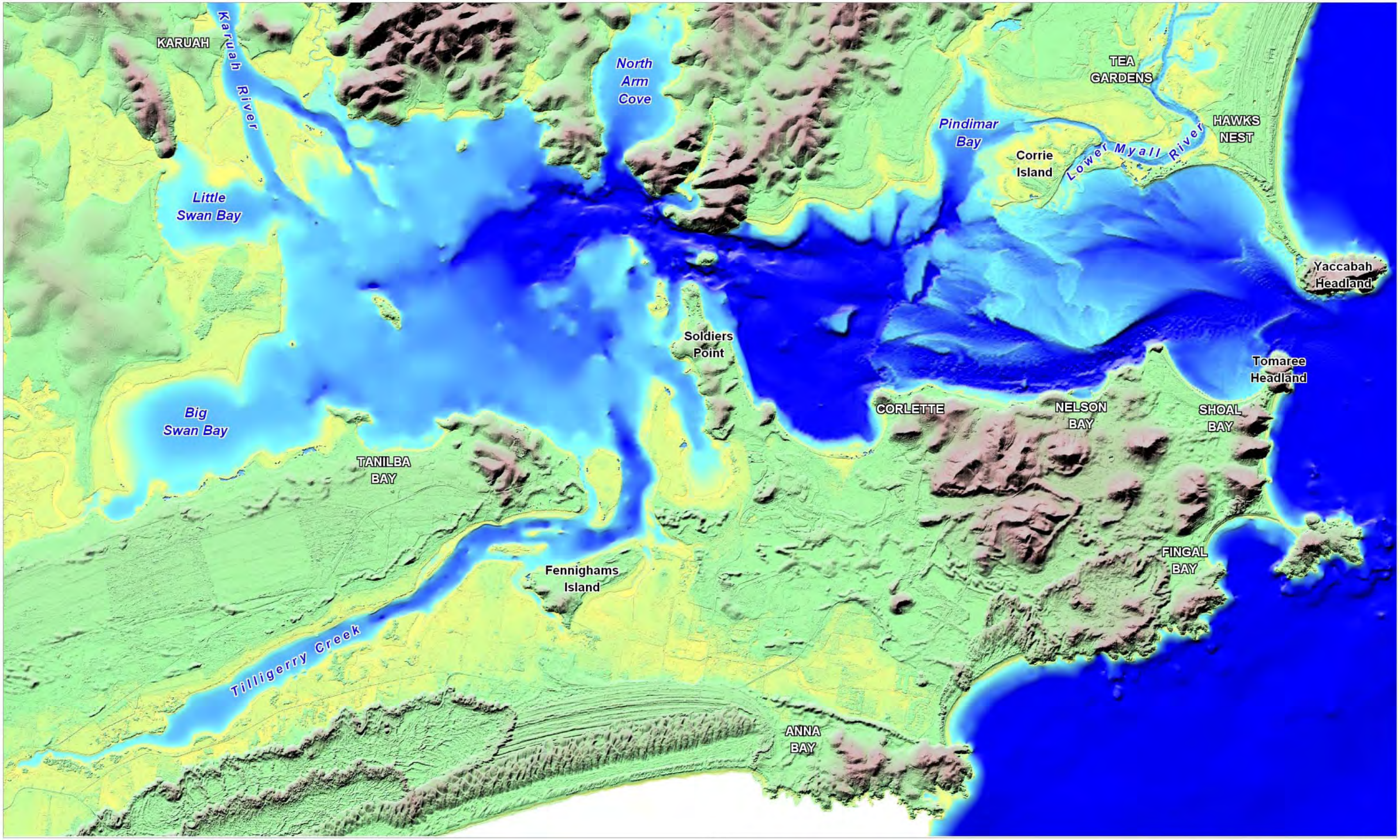
A steep dropover at the edge of the delta into deeper water extends roughly north-south from Corlette Head to the western side of Corrie Island. West of the drop over, water depths increase up to 20 metres (MHL, 1999) (refer Figure 2-2).

Changes in the immediate study area have been significant since European settlement of Australia. Thom *et al*. (1992) examined historical maps of Port Stephens from 1795 through to 1941, reducing the mapped features to a common scale and presenting them in a sequence of graphics, reproduced here as Figure 2-3. A more comprehensive set of adjusted charts is available from Watson (2008), although Figure 2-3 reproduces the key aspects.

The most notable feature is the variation to Myall Point over time. It appears likely that this feature provided protection from ocean swell, and enhanced the growth of Corrie Island. During a field inspection on 17th August, 2010, the exposure and active erosion of indurated sands known as "Coffee Rock" on the eastern edge of Corrie Island was noted. This indicates that Corrie Island at least partly comprises sediments laid down as part of the inner barrier during the Pleistocene epoch.

Myall Point was ultimately destroyed by a storm in 1927. As described in Thom *et al*. (1992):

> *"a spit was initiated from a sand shoal about 170 years ago, conforming in plan with the diffracted swell wave patterns which enters Port Stephens and crosses the shallow sand surface of the flood tide delta. The spit (Myall Point) reached its maximum length in about 1910. It was "trimmed" by erosion until 1927 when it was catastrophically removed in a storm. Since then, there has been considerable reworking of sand landwards to form a beach across a formerly sheltered mangrove island (itself initiated in the early 19th century) Lateral extension of both Corrie Island to the southwest and Winda Woppa to the west has occurred in recent years"*



LEGEND

Elevation (m AHD)

🟦	-10
🟦	-1
🟨	0
🟩	2
🟫	50

Title:

Present Day Bathymetry of Port Stephens and the Lower Myall River

N

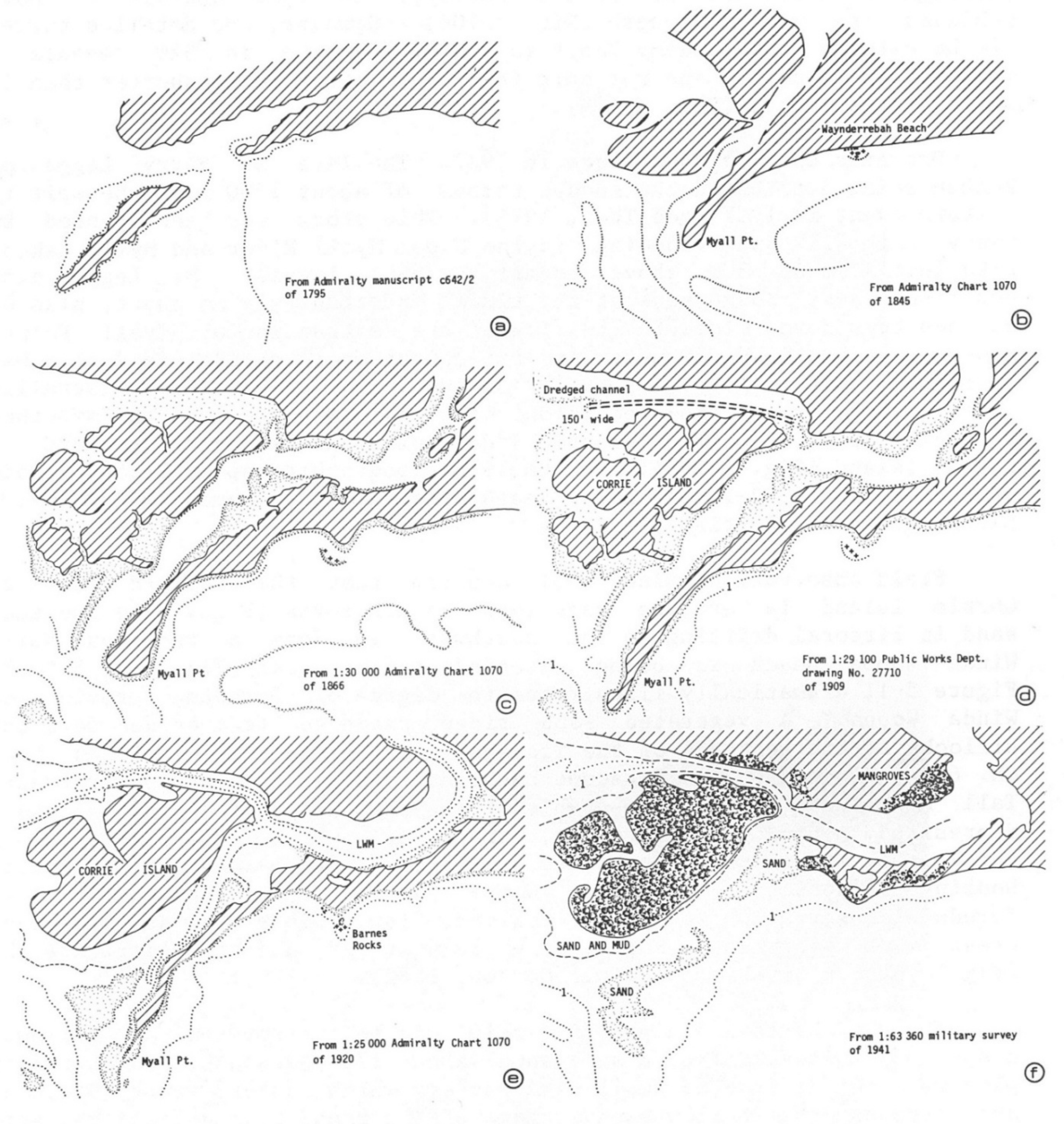
0 1.25 2.5km
Approx. Scale

Figure:
2-2

Rev:
A

BMT WBM
www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_006_100930 Bathymetry.WOR



From Admiralty manuscript c642/2 of 1795

From Admiralty Chart 1070 of 1845

From 1:30 000 Admiralty Chart 1070 of 1866

From 1:29 100 Public Works Dept. drawing No. 27710 of 1909

From 1:25 000 Admiralty Chart 1070 of 1920

From 1:63 360 military survey of 1941

Figure 2-3 Historical Development of the Study Area (from Thom et al, 1992)

Whether or not the spit growth only initiated 170 years ago could be argued, due to the poor quality of underlying maps used to develop Figure 2-3. The presence of Coffee Rock along the actively eroding shoreline (Figure 2-4) indicates that Corrie Island has been present, at least partly, since Pleistocene times.

The beach of Winda Woppa, to the west of Barnes Rock, has been extending westwards as noted above for some time. The ongoing growth of Winda Woppa is causing a contraction of the tidal channel between Winda Woppa and Corrie Island, and this is contributing to the ongoing erosion of Corrie Island by pinching tidal flows hard against the edge of the Island.

Figure 2-4 Coffee Rock Eroding from Eastern Edge of Corrie Island (17/08/2010)
(courtesy Martin Fitzhenry, DECCW)

The beach at Winda Woppa is known to be receding (Thom *et al*., 1992). Evidence from field inspection indicates recent breakthrough of the low sand barrier forming the beach in this area. Vila Concejo et al (2007) link evolution of the beaches on the northern shoreline of eastern Port Stephens to flood-tide delta morphodynamics. They suggest a net westward directed sediment transport based on field measurements and observations. Earlier work by the Public Works Department of New South Wales, however, computed a net eastward direction for the sediment transport along Jimmy's beach (near threatened properties along The Boulevard), dominated by waves created by westerly winds. Vila-Concejo *et al*. conclude that that sediment transport patterns inside Port Stephens estuary are not clear and a morphodynamic model should be established to examine the processes driving these patterns.

Jimmys Beach is located to the east of Barnes Rock and is not part of the immediate study area. Sediment transport patterns around Barnes Rock, however, are of relevance to the present study and there is present conjecture in the literature relating to the processes acting at Jimmy's Beach (Watson *et al*., 2000; Vila-Concejo *et al*., 2007). Recession at Jimmy's Beach has been a notable management issue for at least the past 30 years, and has been managed primarily by on-going beach nourishment. Residential development behind Jimmy's Beach began in the 1960's (Watson, 2000), and has driven much of the concern for recession. The issues at Jimmy's Beach are discussed within this report, as necessary to inform understanding of the present study area.

Of significance is the present day Northern Channel ("Dredged Channel" noted on the 1909 survey). Comparison of tidal volumes between the Northern Channel and the Eastern Channel indicate that an increasing proportion of the tides is exchanging through the Northern Channel with time.

Vila-Concejo et al (2009) note that the shoreline within and adjacent to the study area contains alternating areas of erosion and accretion, terminating at the westward extending Winda Woppa spit. Using rectified aerial imagery, Vila-Concejo *et al*. (2008) estimated that Winda Woppa spit had undergone around 800 m of westward extension and between 50 – 100 m of recession since 1951.

2.1.3 Catchment Hydrology

The Port Stephens catchment contains steep areas that drain into two major river networks, the Karuah and Myall Rivers. These two rivers have a combined total catchment area of 2900km^2 (MHL 1999). The Myall Lakes have a total waterway area of approximately 100 to 150 km^2 (MHL 1999) and a catchment area of some 1660 km^2. The steep hills of the hinterland provide a source of groundwater that contributes inflow to the Lakes (MHL 1999).

Normally the mean water levels within Myall Lakes are higher than in the Ocean, due to the constrained nature of the Lower Myall River, which retards the flow of water from the Lakes to the ocean. During periods of high evaporation (summer) and low precipitation in the Myall Lakes catchment, the mean water level in the Lakes may fall below mean sea level (MHL, 1993). Lake water levels do not respond significantly to semi-diurnal ocean tides. The main tributary of the Myall Lakes is the Upper Myall River which flows into the Bombah Broadwater. Boolambayte Lake has a minor tributary (Boolambayte Creek) and Myall Lake has a small catchment receiving most of its inflow from Boolambayte Lake.

Water levels in the study area (i.e. Lower Myall River and Port Stephens) are overwhelmingly dominated by ocean tides. Flow from the Lakes into the study area may be significant following substantial rainfall, which elevates water levels in the Lakes. Sanderson (2008) shows that water levels in the Lakes rise quickly in response to rainfall, but fall slowly as water is released through the Lower Myall River. He concludes that the constricted connection between the Broadwater and ocean causes runoff events (primarily from Upper Myall River into Bombah Broadwater) to raise water levels throughout Myall Lakes, causing backflow from the Bombah Broadwater "up-lake" into Boolambayte and Myall Lakes. Flow between the lake basins occurs when there is an imbalance between water levels, which can occur due to differential catchment runoff, wind stress and ocean water levels variations of lower frequency than the tides.

Within the catchment south of Port Stephens, there is minimal runoff, with most excess rainfall on the flat terrain percolating through the sandy soils, eventually entering the unconfined aquifers of the Tomago and Stockton sand beds. The main tributary entering the southern side of the Port is Tilligerry Creek, although flow in this creek is predominantly tidal.

2.1.4 Hydrodynamics

2.1.4.1 Tides

The estuary is located along a micro-tidal, wave dominated coastline and contains a wide entrance to the ocean. Measurements of tidal velocities and circulation patterns across the Port Stephens tidal delta (Austin *et al.*, 2009) demonstrate that flood tides dominate on the shallower wider regions of the flood tide delta, whereas ebb tides dominate in the narrow, deeper channels.

Tidal discharges through the Northern Channel (*Site 3, Corrie Channel)* and the Eastern Channel (*Site 4, Eastern Channel)* were measured using Acoustic Doppler Current Profiling (ADCP) on 24th September, 2009 (MHL, 2010).The total flood tide volumes measured were 2.8 x 10^6 m^3 in the Northern Channel and 2.51 x 10^6 m^3 in the Eastern Channel, while ebb tide volumes were 2.55 x 10^6 m^3 in the Northern Channel and 2.27 x 10^6 m^3 in the Eastern Channel. This monitoring indicates that tidal exchange is presently approximately evenly split between the two channels with a slight dominance towards discharge through the Northern Channel.

During a similar tidal gauging exercise in 1975, total flood tide volumes (0.96 x 10^6 m^3 in the Northern Channel, 4.60 x 10^6 m^3 in the Eastern Channel) and ebb tide volumes (1.65 x 10^6 m^3, 4.61 x 10^6 m^3 respectively) were measured. 35 years ago, discharge through the Northern Channel was notably less than in the Eastern Channel. The change in dominance of the Northern Channel is of some concern to the community, and potentially impacts on flushing and mixing in the Lower Myall River.

2.1.4.2 Salinity, Mixing and Flushing

Mixing within the Port Stephens estuary is driven by tidal, wind and fresh water runoff events. Mixing within smaller bays and tributaries of the Port are dependent on the exchange and mixing with the main waterbody of Port Stephens, and will typically have longer flushing times. Stratification can develop in the Lower Myall River following large rainfall events (PWD 1978), however, temperatures measured during a dry weather period on 17th December 1997 showed no vertical stratification in the water column, although there was significant variation along the river (MHL 1999).

The Lower Myall River constrains mixing between the Port Stephens estuary and Bombah Broadwater, evidenced by the large reduction in tidal range between the two locations (1.8m reducing to 0.1m: MHL, 1999). Flushing times vary significantly along the Lower Myall River, from approximately 1 day at the river mouth, to days to weeks within the lower reaches, and several months in the upper reaches, particularly during drier periods (MHL 1999). The Myall Lakes experience very little tidal flushing and the majority of saltwater entering the Lakes is trapped in the Broadwater, and then slowly dispersed through the rest of the lakes system (PWD 1978). Salt is flushed out of the system following catchment rain which elevates water levels in the Lakes (Sanderson, 2008). Using salinity data, MHL (1999) estimates the time to exchange the whole volume of Myall Lakes with water from Port Stephens as approximately 750 to 800 days.

The salinity in Port Stephens is similar to the ocean, at approximately 35 ppt. The salinity of the Lower Myall River is affected by floods and droughts with dramatic changes occurring after either a period of wet weather (promoting brackish/fresh waters) or drought periods (promoting saline waters) (PWD 1978). Further upstream, a flood entering the Broadwater from the Upper Myall River may produce an initial increase in salinity in Myall Lake, as water is pushed further upstream. Groundwater is also expected to provide a small but consistent baseflow of freshwater (<150mg/L of Total Dissolved Solids) to the Myall Lakes and Lower Myall River system.

2.1.4.3 Waves

Generally, ocean swell waves do not penetrate further than Soldiers Point or into the Myall River entrance and their effects are confined to the lower port (MHL 1999). Waves are important in driving sediment transport and morphology of the River mouth, which affect hydrodynamics in the Lower Myall River significantly.

2.1.5 Sediment Dynamics

The movement of sand in the study area is effected by waves, tides, wind and river discharges which can cause notable changes over relatively short periods, such as during a storm.

These processes mobilise sand from the bed and transport it from one area to another, resulting in areas of erosion and accretion.

At the entrance to the Lower Myall River, swell waves dominate the sediment transport process and drive a longshore transport from east to west along Winda Woppa Spit (Jiang et al 2009). This presently results in the erosion of sand from the shoreline west of Barnes Rock and deposition of that particular sand at the end of Winda Woppa spit and in the Eastern Channel. As presented in Section 3.7 and Appendix D, on-going erosion of Jimmy's Beach does not have a significant contribution to sediment accumulation within the Eastern Channel of the Lower Myall River.

The shape of the mouth of the Lower Myall River is also affected by the tides and their interaction with waves. River discharges and wind waves also affect sand movement in the study area, but their relative importance is small.

Further inside the Lower Myall River, the predominant wave energy is created by boats, and the banks of the River are very susceptible to erosion (MHL 1999). The transport of sediments, sourced from bank erosion, along the Myall River to the Lower Myall River entrance is expected to be small (MHL 1999).

Over longer periods, broad scale changes can affect the context within which waves and tides transport sand. For example, sea level rise since the end of the last glacial period is responsible for the ongoing movement of the flood tide delta into Port Stephens. Similarly, the sea level rise expected over the next century will also alter sand movement.

Sustained dredging or the construction of groynes or breakwaters will also alter the way that sand is transported within the study area, if adopted as a management strategy for the site.

Waves, tidal hydrodynamics and sediment transport are of primary significance to this study, and further technical information is provided in Section 3.

2.1.6 Estuarine Vegetation

The wetlands and vegetation surrounding the fringes of Port Stephens, Myall Lakes and the Lower Myall River comprise mangroves, open scrub, saltmarsh, rushland and swamp forest. The mangrove stands are the largest in NSW whilst the saltmarsh constitutes 18% of that remaining in the state (MHL 1999).

Groundwater flowing through the wetlands surrounding Myall Lakes can pick up tannins and humic acids, which result in tea brown coloured waters and an additional organic nutrient load to the estuary. The groundwater therefore influences water quality in the Lakes.

Figure 2-5 shows approximate extents of mangrove, saltmarsh and seagrass distribution as mapped by the Department of Primary Industries (2006). The locations of these vegetation features will change over the course of a few years, which is highlighted by the differences with the background aerial image in Figure 2-5, which dates from April, 2010.

Areas along the Lower Myall River form part of the Myall Lakes National Park. The National Parks and Wildlife Service also manage the Corrie Island Nature Reserve. A number of gazetted SEPP-14 wetlands are also located adjacent to the study area.

The Port Stephens – Great Lakes Marine Park includes a sanctuary zone offshore of the southern and western shorelines of Corrie Island. A smaller sanctuary zone is also located offshore and to the east of Barnes Rock. A habitat protection zone is located immediately north of the Singing Bridge.

2.1.7 Assessment of Estuarine Health

Parallel to the present study, the New South Wales Department of Environment, Climate Change and Water (DECCW) has undertaken "Estuarine Health" study of the Lower Myall River. The draft study report (Scanes *et al*., 2010) focuses on actual ecological condition, with assessment based on field experiments of indicators ranging from low level measures such as habitat availability and water chemistry, up to high level measures such as fish ulcers and mangrove parasitism.

A similar set of field experiments were conducted at other sites in Port Stephens (Pindimar Bay, Salamander) and a comparable site in Wallis Lake. Overall, that study finds that *"the ecological health in the river is excellent and equivalent to other comparable estuarine locations that have not experienced changed entrance conditions"* and that *"there is no evidence that changes to the river mouth channels are negatively impacting on the estuarine ecology".*

Scanes *et al*. (2010) note that the slow release of freshwater from the Myall Lakes system after rainfall has a significant impact on the Lower Myall River estuary, including salinity and tidal characteristics. However, tides still dominate the local currents up to and in the vicinity of Tea Gardens.

The report does note, that westward extension of the Winda Woppa shoal has constricted the channel and affected the tidal flow in the Eastern Channel over the last 4 years. This loss in tidal flow appears to have been offset by an increase in tidal exchange through the Northern Channel.

Title:

Estuarine Vegetation and Planning Boundaries

Figure: 2-5

Rev: A

N

0 0.5 1km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_002_100928 Estuarine Veg.WOR

2.1.8 Existing Numerical Models

A number of numerical models have been developed to help describe and understand hydrodynamics and sediment transport in and around the study area. These models are noted below.

2.1.8.1 Myall Lakes and Lower Myall River Numerical Model (2008)

Sanderson (2008) reports on two dimensional numerical modelling of the Myall Lakes, linked to a one dimensional model of the Lower Myall River. The study focused on mixing in the Myall Lakes water bodies, while the Lower Myall River was only included to provide tidal input into the lakes system. As a consequence, this model provides limited value to the present study.

2.1.8.2 Lower Myall River Numerical Model (1980)

PWD (1980) undertook one dimensional, unsteady flow, numerical modelling of the Lower Myall River. The model allowed the input of upstream flows and downstream (tidal) water levels (MHL 1993). The bathymetry was derived from cross section data obtained during a hydrographic survey in 1977, covering the river channel and tidal flats. The cross sections were spaced at 500 m. Sediment transport modelling, using the Ackers and White formulae, was also undertaken based on the results of the 1D modelling.

This model is limited in its coverage of estuarine processes, such as the wave driven sediment transport process, and as such, is also limited in its value to the present study.

2.1.8.3 University of Sydney, School of Geosciences Model

The University of Sydney, School of Geosciences have established a numerical model covering the entrance of Port Stephens and Lower Myall River using the Mike-21 software (University of Sydney, 2010). Details of the model extent and capabilities were published in Jiang *et al* (2009) which indicates the model faithfully reproduces Port Stephens and the coastal zone. In place of the main tributaries (Lower Myall River and Lakes, Tilligerry Creek and Karuah River) rectangular areas of tidal storage were included. The model solves the Reynolds Averaged Navier Stokes equations on a flexible mesh and propagates waves into the system using a spectral wave model. The methods are similar to those implemented in the present study.

The model appears to be well validated to current measurements offshore of Jimmy’s Beach. However, the detail present in the Lower Myall River does not meet the requirements for the present study.

2.1.8.4 Model Described in Watson (2000)

Watson (2000) describes the use of “computer based numerical modelling, wave refraction analyses, wind induced current studies, wind wave correlations, sand transport rates and shoreline recession analyses” indicating a net transport rate of 5,000 m^3/yr eastwards towards the Yacaaba Headland.

Although relatively recent, this model still does not include many of the advanced algorithms that characterise present day numerical models that have resulted from research efforts over the past decade. Therefore, this model is unlikely to be a suitable tool for application in the present study.

Despite the lack of suitability of the model, a series of surveys were undertaken by the New South Wales Government as described in Watson (2000). Some of the raw data from these surveys were provided for use by this study, although it appears that a full set of data covering all surveys from the 1990's is still not readily available.

2.2 Community Perspectives

A community and stakeholder meeting was held at the Tea Gardens office of Great Lakes Council on 6th October 2010. Outlined below are the main issues that were identified by attendees of that meeting. Information presented in this section represents the views and opinions of the meeting attendees, and is not necessarily scientifically validated, nor is it necessarily the express views of the study team responsible for preparing the present study.

2.2.1 Perception of Existing Problems

A number of specific but inter-related problems were identified within the Lower Myall River region. The relevant issues are described below, and locations are shown on Figure 2-6.

2.2.1.1 Poor Water Quality in the Lower Myall River

Community members believe that water quality in the Lower Myall River is declining, possibly because the River now exchanges more readily with Pindimar Bay than through the eastern channel.. Since 2008 the community believe that salinity in Pindimar Bay has been less than 18ppt. This is considerably fresher than seawater (35ppt) and indicates a possible reduction in full tidal exchange with the ocean.

Tidal data indicates a time lag in tidal flows between the eastern and western side of Corrie Island (MHL 1993). As the flood tide is flowing into the Eastern Channel, the ebb tide is still flowing westward out of the Northern Channel, which results in “short circuiting” of the tidal flows. The community have also witnessed this process.

A tidal data collection campaign in September 2009 (DECCW 2010) found that tidal exchange between the estuary and the Lower Myall River is now evenly split between the Northern and Eastern Channels with a slight dominance towards discharge through the Northern Channel. This intimates that a greater flow from the Lower Myall River is discharging into Pindimar Bay, potentially making it fresher.

Higher levels of freshwater discharge from the Myall Lakes in recent years also delivers higher levels of tannins to the Lower Myall River, thus reducing water clarity. The community tend to directly relate water clarity to water quality. When combined with a possible reduction in flushing by ‘clean’ ocean water through the Eastern Channel, the higher levels of tannin staining in the water lead to perceptions of reduced water quality in the Lower Myall River.

Poor water quality in the Lower Myall River may result from factors including exchange of waters with the lesser flushed Pindimar Bay, blockage of the Eastern Channel and point sources of pollutants / nutrients entering the river.

2.2.1.2 Sand Nourishment at Jimmys Beach

Jimmys Beach has been nourished with sand a number of times over the past few decades. This is an ongoing and costly exercise. Some community members believe that this introduces large volumes of sand into the local coastal compartment, that then become redistributed across Winda Woppa, resulting in the progressive infilling of the Eastern Channel.

The community also consider that material used for on-going nourishment could be obtained by dredging the Lower Myall River and the Eastern Channel, rather than other locations.

2.2.1.3 Loss of the Myall Spit

The destruction of Myall Spit in the late 1920's, caused redistribution of a large volume of sand in the area to the east of Corrie Island and at the mouth of the Lower Myall. Loss of the Spit removed the barrier protecting Corrie Island from ocean swell waves.

Re-building Myall Spit would restore protection to the eastern shoreline of Corrie Island and by addressing the westward transport of sediment, reduce infilling of the Eastern Channel. As discussed above, the community has linked this infilling to reduced flushing and poor water quality in the Lower Myall River

2.2.1.4 Sand Accumulation along the River

Sand accumulation is occurring at a number of locations within the Lower Myall River, and around the southern edge of Corrie Island. As a consequence seagrass and oyster leases are now being smothered. Sand accumulation has also occurred at locations along the Lower Myall River (Figure 2-6) including:

- The waters where the Northern Channel enters Pindimar Bay;
- Mainland shoreline opposite the northern end of Corrie Island where spat collection sticks are now covered in sand;
- Northern shoreline prior to the splitting of the Lower Myall River around Corrie Island;
- Shoals opposite the town site of Winda Woppa; and
- Upstream and downstream of the Singing Bridge.

2.2.1.5 Connection of Corrie Island to the Mainland

Effort may be required to ensure Corrie Island remains separated from the mainland. Corrie Island is an internationally recognised Ramsar listed wetland (included in the Myall Lakes group of Ramsar wetlands, Ramsar site no.944) and is an important roosting and nesting ground for migratory birds, including the Little Tern.

The accumulation of sands in the Eastern Channel has produced a sand barrier that almost joins Corrie Island to the mainland, which may allow predators, including dingoes to access the Island. Community concern, over the connection of the Island to the mainland, has been documented in the media (Figure 2-7).

Title:

Community Identified Problems

Figure:

2-6

Rev:

A

N

0 375 750m

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_011_101018 Community Concerns.WOR

Jewel lies neglected

Island desperate for conservation

MATTHEW KELLY

CORRIE Island should be the jewel in the crown of the Myall River, a nesting sanctuary for endangered birdlife including the little tern and the mangrove kingfisher.

Instead, siltation of the river's eastern entrance has allowed predators such as dingoes to roam freely around the Ramsar-listed nature reserve.

Tea Gardens residents are calling on the state government to urgently increase protection for the island's sensitive ecology.

It follows recent installation of fencing to protect the nesting area of the endangered little tern from feral pests and human activity in Swansea Channel and Botany Bay.

To back their concerns, Tea Gardens residents have taken numerous photos of foxes and dingoes crossing onto Corrie Island via the silted waterway at low tide.

A long-running community campaign to have the eastern channel dredged has to date been unsuccessful.

Myall River Action Group spokesman Gordon Grainger said the National Parks and Wildlife Service had shown no interest in protecting the island.

"While we applaud their efforts in protecting the little tern in Sydney and Lake Macquarie, we wonder why there isn't similar concern for Corrie Island," he said.

National Parks and Wildlife Service spokesman Lawrence Orel said there had been no reports of little terns nesting on the island.

"The temporary fencing, along with advisory signs on about a quarter of Sand Island in the Swansea Channel, is designed to provide protection and help create awareness by users of active nesting attempts by the little terns for the first time since 1966," he said.

THREATENED: The little tern (above) is in danger on Corrie Island from predators such as marauding dingoes, left.

WARNING: Tourists are asked to stay clear at Marks Point, Swansea.

Figure 2-7 Newspaper Article on Corrie Island (Newcastle Herald, 25th September 2010)

2.2.2 Initial Community Suggestions for Potential Solutions

In addition to identifying the issues of concern, attendees at the 6th October, 2010 meeting also provided ideas regarding management of those issues. The suggestions are described in the following sections. Specific management actions are addressed in more detail in Section 5.

2.2.2.1 Poor Water Quality in the Lower Myall River

Investigations are required to confirm the presence of poor water quality within the Lower Myall River, and to identify the source of the problem, and the environmental processes contributing to the problem. The issue of poor water quality could be addressed by increasing tidal exchange between the Lower Myall River and the Ocean.

One strategy aimed at increasing tidal exchange is to restrict further sand accumulation in the Eastern Channel. Additionally an option to block the Northern Channel would further promote tidal exchange through the Eastern Channel, potentially making that channel more self-sustaining.

2.2.2.2 Sand Nourishment at Jimmys Beach

The direction of sand transport along Jimmys Beach requires clarification to manage sand nourishment works and ensure adequate beach widths are maintained. Management options that limit the introduction of additional volumes of sand to the system and promote stability of the beach should be investigated.

Once the dominant direction of longshore sand transport has been defined, additional options to stabilise the sands may be investigated and could include offshore structures to reduce the wave energy reaching Jimmys Beach, or groynes along the beach to restrict longshore sand transport.

Sand nourishment for Jimmys Beach was initially sourced from the Eastern Channel, beginning in 1984 (Watson 2000). That sand was quickly eroded by a series of storm events.

Community members believe sand should be sourced from within the immediate coastal compartment to reduce the addition of more sand into an already "sand flooded" environment. Potential sources include the Eastern Channel/Paddy Marrs Spit, sand spits at the southern end of Corrie Island locations for the sourcing of sand, aside from the Eastern Channel/Paddy Marrs Spit, may include sand spits at the southern end of Corrie Island, or shoals as identified in sand accumulation areas within the river.

2.2.2.3 *Loss of the Myall Spit*

Investigations are required to identify the positive and negative impacts of re-building the Myall Spit, with specific focus on the redistribution of wave energies, tidal flows and sediment transport. In addition, a variety of materials could be utilised for re-building including sand, rocks or concrete. If the spit were to be constructed from sand then revegetating the spit may provide further protection.

Training walls along either side of the Eastern Channel may also provide permanent separation of the island from the mainland although this option should be coupled with detailed investigations into the impacts of such structures. Another option may include closing the Northern Channel; which would ensure that all tidal exchange occurred through the Eastern Channel into the Lower Myall River.

2.2.2.4 *Sand Accumulation along the River*

Identification of sand sources and transport processes associated with the accumulation of sand at various locations within the Lower Myall River and shorelines is required.

Shoals in the Lower Myall River show little spatial movement, but erode and accrete periodically resulting in a redistribution of sediment. The recent development of new shoals and sand accumulation along shorelines may indicate an additional source of sediment and/or change to the hydrodynamics and sediment transport within the region.

2.2.2.5 *Connection of Corrie Island to the Mainland*

Management solutions are required to ensure that Corrie Island remains separated from the mainland.

A range of management solutions may include dredging the Eastern Channel, re-building Myall Spit to restrict sand transport into the Eastern Channel, and seawalls or training walls to provide barriers to sand transport. The impact of any such structures would need to be investigated.

2.3 Summary of Issues and Likely Causes

The perceived problems in the Lower Myall River have been linked by the community to the interrelationships of hydrodynamics and sediment transport. A change to hydrodynamics can affect sediment transport and vice versa (Figure 2-8).

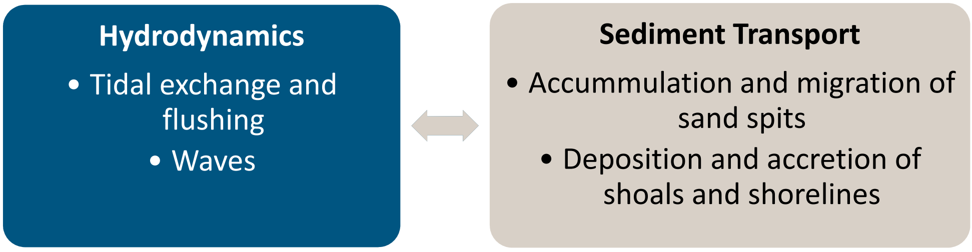


Figure 2-8 Interaction of Processes Leading to Perceived Problems

There are numerous examples of these interactions and the feedback they can cause:

- Dredging of the northern channel has altered the distribution of tides around Corrie Island;
- The redistribution of tides around Corrie Island has resulted in a reduced capacity for the eastern channel to 'self-scour' and remain open; and
- The reduced tendency for the eastern channel to remain open further encourages more tidal flow through the Northern Channel.
- Ongoing movement of the flood tide delta into Port Stephens results in the redistribution of wave energy along the foreshore;
- Variation in wave energy along the foreshore results in variation of longshore transport rates for exposed beaches (such as Winda Woppa);
- Longshore transport along Winda Woppa is causing extension of the Winda Woppa Spit, which has progressively filled the eastern channel over the past 10 years; and
- Filling of the eastern channel further increases the tendency of tidal flows towards the Northern Channel.

These interactions make predicting behaviour of the system a complex task. The required analyses are typically, which is typically addressed through the application of numerical (computer) models considering all of the required processes (Wind, Waves, Tides, Sand Movement, Erosion and Deposition).

The key concern to the community is one of reduced clarity and perceived poorer water quality in the Lower Myall River. The community believes that this is caused by less effective tidal flushing, as an increasing proportion of the tide is carried through the northern channel, which exchanges with Pindimar Bay, and not the Outer Basin of Port Stephens. Changes to the tides are also considered responsible to changing shoal dynamics within the Lower Myall River.

The less effective flushing relates to progressive closure of the Eastern Channel in recent years. That closure is related to sand movement along Winda Woppa spit and on the Port Stephens Marine tide delta, which is presently pushing against the eastern edge of Corrie Island.

These processes are examined further in Chapters 3 and 4, which validate the processes using existing data and computer modelling respectively.

3 AVAILABLE DATA AND ANALYSIS

A variety of available data provide insight into hydrodynamics and sediment transport processes within the Lower Myall River. These data sets and associated analyses are documented below.

3.1 Bathymetric Data

3.1.1 Existing Information

Numerous hydrographic surveys are available for regions within Port Stephens and the Myall River, dating back to 1866. The most recent hydrographic surveys for the study area are:

- **September 2009** - Myall River Entrance Hydrographic Survey, collected and supplied by DECCW, covers the Lower Myall River, Corrie Creek (Northern Channel) and Paddy Marrs inlet (Eastern Channel);
- **2007** - Port Stephens Hydrographic Survey (Draft) collected and supplied by DECCW covers the central and eastern basin regions of Port Stephens;
- **2006** - Australian Bathymetry and Topography Grid - 250 m Digital Elevation Model supplied by Geoscience Australia. The data set comprises relatively coarse regular grid data;
- **2001 / 2002** - Myall Lake & Myall River Hydrographic Survey collected and supplied by DECCW, covers the Myall Lakes, Myall River, and the north eastern section of Port Stephens;
- **2001** - Australian Hydrographic Service bathymetric chart AUS00209 of Port Stephens. The Chart covers the whole region of the Port Stephens estuary; and
- **1990** – Cross Sections of the Upper Myall River, extending from the Broadwater to Bulahdelah.

In addition to the above mentioned data sets, there are also a number of historical surveys (referring to those that have been superseded by data sets mentioned previously) that are also available for the study area, including the following:

- **1998** – Pre and Post Dredge Hydrographic Surveys of Jimmy's Beach at dredging Locations 1 and 2;
- **1994** – Hydrographic Survey of Shoal Bay, extending from Tomaree Head to Yacaaba and Nelson Heads;
- **1984 and 1986** – Cross section profiles from Jimmy's Beach to approximately 150m offshore. The 1984 data set includes 6 different dates for the hydrographic data and 4 different dates for the land based surveys, and the 1986 data set includes profiles for 1985 and 1986;
- **1983, 1982, 1981, 1980, 1978, 1976, 1974, 1969 and 1955** – Hydrographic survey of Jimmy's Beach, extending approximately 200m offshore;

- **1983** – Hydrographic survey of Barnes Rock, just offshore from Jimmy's Beach;
- **1982** – Beach profiles to the west of Barnes Rock;
- **1982** – Beach profiles across Yacaaba Spit, comparing data obtained from profiles measured in 1969, 1978 and 1982;
- **1978, 1977 and 1976** – Hydrographic survey of the Myall River entrance extending from the Northern Channel and around the southern edge of Corrie Island;
- **1977 and 1963** - Hydrographic survey along the Lower Myall River from Tea Gardens to the Broadwater; and
- **1969** - Hydrographic survey of Port Stephens and the nearby coastal ocean, extending from Cabbage Tree Island / Boondelbah Island in the east, and Fame Cove and Soldiers Point to the west;
- **1866** – Hydrographic survey of Port Stephens extending from Cabbage Tree Island and Boondelbah Island in the east, to the western edge of Corrie Island.

3.1.2 Historical Features and Trends

Historical hydrographic surveys (Appendix A) provide evidence of sediment transport patterns within the study region. Previous analysis of historical hydrographic surveys, by Watson (2008) and MHL (1993), can be summarised into the following features and trends.

The evolution of Corrie Island has involved the gradual deposition of sediments (sands) at a location downstream from the mouth of the Myall River, which has then slowly stabilised and become vegetated (Table 3-1). The shape of the island has experienced some changes, most likely from the waves and tidal flows. Photographic evidence of Coffee Rock along the edge of Corrie Island (Figure 2-4) collected by this study indicates that Corrie Island has existed in some form since well before European Settlement.

The evolution of the Myall Point / Spit (refer Table 3-2) has been described as a gradual accretion of sediments at the end of Winda Woppa, which has slowly become vegetated. The spit began to reduce in length from around 1910 onwards (Thom *et al*., 1992). The spit was then destroyed during the 1927 storms.

The depth of the channels surrounding Corrie Island have been subject to natural and artificial changes (Table 3-3), which have resulted in changes to tidal and current velocities, discharges and associated sediment transport.

Table 3-1 Evolution of Corrie Island

Year	Description
1792	Shallow shoals appear on charts. However, the presence of Coffee Rock along the presently eroding eastern foreshore of Corrie Island indicates that at least part of Corrie Island has been present since the Pleistocene.
1795	Shoals form a sand island
1828	The island becomes covered in mangroves and becomes known as ‘Mud Island’
1845	The island becomes covered with low scrub and referred to as a ‘Sand Island’
1969	Erosion on the eastern side of Corrie Island and the shoreline has retreated and rotated anti clockwise to a more north-south direction; Accretion has occurred at the south eastern end (progradation of 200 – 300m) as a result from littoral drift.

Table 3-2 Evolution of Myall Point / Spit

Year	Description
1826	Myall Point first appears on maps
1828	Shoal extends from the southern tip of the island, through the Middle Ground and join Jimmys Beach, completely blocking the south eastern inlet to the Lower Myall River
1845	Myall Point broadens and becomes vegetated
1866	Myall Point appears as a low sand point covered with small scrub
1909	Myall Point becomes elongated by 450m (most likely from littoral drift, as evident by the direction of growth northeast – southwest) and narrows, suggesting sand movement from the seaward face of the Point to the tip
1920	Narrowing of Myall Point continues, with a 350m erosion retreat of the tip above high water mark
1927	Myall Point destroyed by an extreme storm and flood event and reduced to shoal area known as ‘Paddy Marrs Bar;
1972 / 1977	Myall Spit accumulating with sand

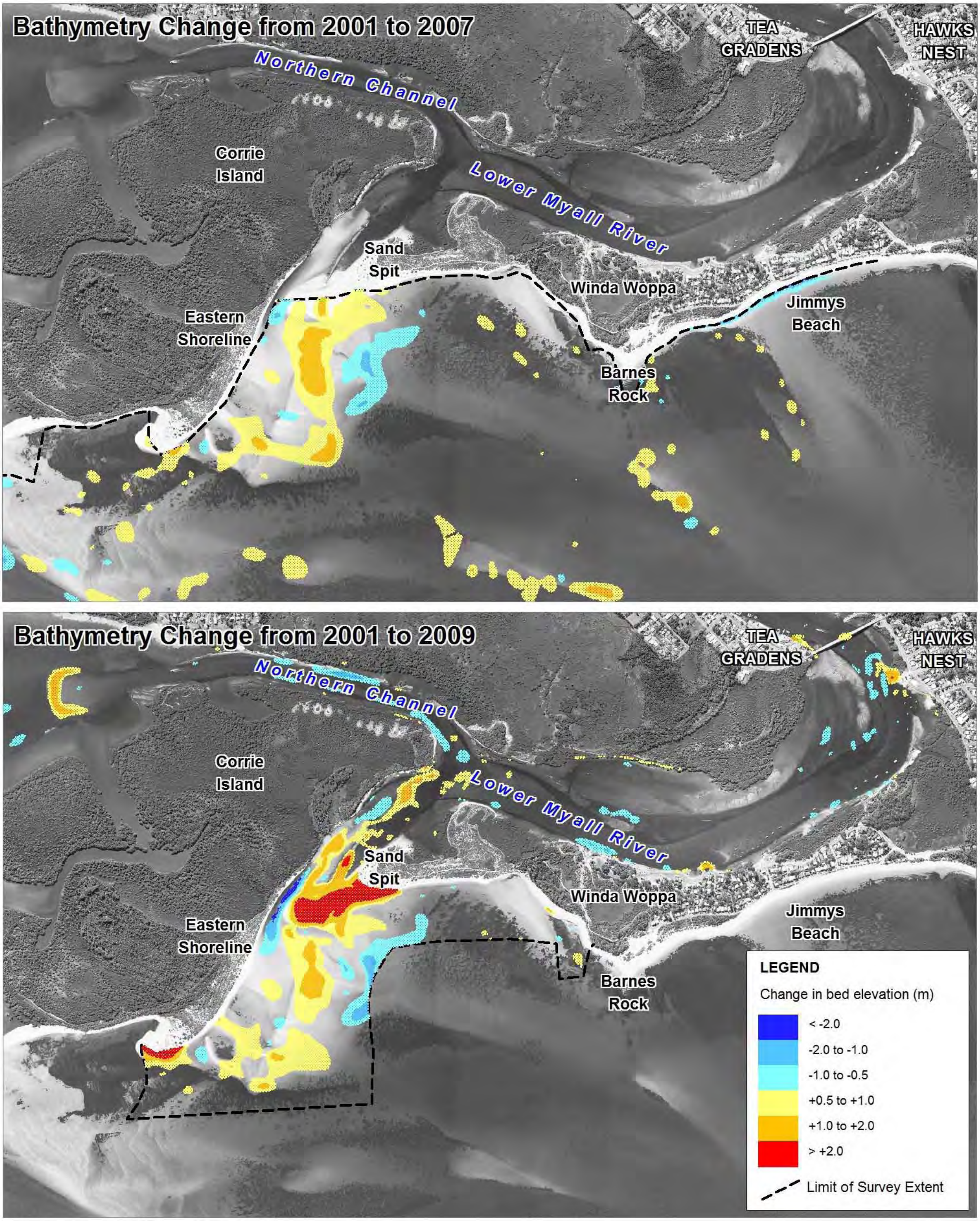
Table 3-3 Channel Dynamics surrounding Corrie Island

Year	Description
1792	The Lower Myall River entrance is shown as an unspecified inlet.
1795	A well-defined channel is now located to the north of the island.
1828	A huge shoal completely blocks the southern channel to the Lower Myall River.
1845	A well-defined southern channel is now present with a minimum depth of 2m and the northern channel is blocked.
1866	The southern channel, now known as Paddy Marrs Inlet appears as a well-defined channel with a depth generally greater than 1m and the north channel is blocked.
1909	A 50m wide navigation channel is dredged on the northern side of Corrie Island. This is accompanied by shoaling of the southern Channel.
1909-1920	The north channel deepens to 6m (likely from dredging), except between Myall Point and Middle Ground, where shoaling occurs (to less than 2m) and the river entrance channel shallows.
1920	Large sand bar forms in Paddy Marrs Inlet.
1963	The northern channel, also known as Corrie Creek, decreases in depth by about 0.5m.
1969	Sand bar still present in Paddy Marrs Inlet, with erosion and realignment of the north channel to a more east-west orientation.
1972-1977	Paddy Marrs Inlet is pushed in a south-west alignment by the rebuilding of Myall Spit.

3.1.3 Recent Features and Trends

Bed level changes surrounding Corrie Island and the Lower Myall River have been identified for the years 2001 to 2007, and 2001 to 2009 (Figure 3-1).

The most significant change has been the accretion of the sand spit from Winda Woppa and the accretion of the sand spit at the southern end of Corrie Island, with bed levels changes of >+2.0m. At the western end of the Northern Channel there is also an area of accretion where ebb tide velocities decrease upon entering Pindimar Bay.



Title:

Changes in the Study Region Bathymetry from 2001 to 2009

Figure: **3-1**

Rev: **A**

N

0 0.5 1km

Approx. Scale

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_009_101011 Bathy Comparison.WOR

The most significant erosion has occurred along the eastern shoreline of Corrie Island, with bed level changes of >-2.0m. A similar region of erosion is located on the other side of the Winda Woppa sand spit, in both of the figures, and may contribute some sand to extension of the sand spit.

Smaller erosion areas are located in the Northern Channel and along the Lower Myall River and may be due to movement of shoals or artefacts of dredging. The data does not indicate widespread instability of the Lower Myall River Channel. The issues of sedimentation and erosion raised by the community therefore appear to be localised, but may be affected by changes to the depth and shape of the eastern channel.

Although the survey extent does not cover the entire area where sediment transport is likely to occur, there is a clear indication of greater accretion than erosion within this area of the estuary. This is likely to be related to sand arriving from areas that are not well represented by the survey. These are likely:

- Erosion from the foreshore of Winda Woppa; and
- Progressive migration of the flood tide delta from offshore towards the eastern edge of Corrie Island.

3.2 Tidal Data

A series of data collection campaigns have been undertaken within the Lower Myall River region, and these are summarised below.

3.2.1 Tidal Data Collection Campaigns

- Myall River Tidal Data Collection, 22nd October 1975 (PWD 1982)

Field data was collected from a number of transects in and around the confluence of the Myall River as it enters Port Stephens. Data collected included tidal water levels, tidal gradients, float tracking of currents, tidal velocities and tidal flows. The data record is incomplete due to inclement weather and equipment failure.

- Lower Myall River, Process Study Datum Establishment, September 1979 (PWD 1981)

Field data was collected on the 16th November 1977, with some additional sampling on surrounding dates. Data collected included: water levels (7 locations), water velocities (4 lines), salinity and temperature (infrequent measurements) and bed samples for suspended sediments at a number of locations.

- Port Stephens Tidal Data Collection, September 1993 (PWD 1998)

Two field data collection exercises were undertaken on the 29 and 30th September 1993, each over a full tidal cycle. Data collected included: water levels (7 sites), tidal discharge (6 sites), tidal velocities (12 sites), water quality (10 sites).

- Myall River Data Collection, September 2008 to September 2009 (DECCW & MHL 2010)

Two separate data collection exercises were undertaken between September 2008 and 2009. The first occurred during September 2008 - February 2009, when water levels and salinity were monitored at 3 sites within the estuary. Additional water quality profiles were measured during the high water slack on 5th September and the low water slack on 25th October 2008. Measurements included: density, conductivity, temperature, salinity, DO, pH, chlorophyll-a, photosynthetically active radiation (PAR), turbidity and water depth.

The second data collection period involved intensive field sampling from the 21st to 24th September 2009. The locations of various collection sites are shown on Figure 3-2, measuring tidal velocities, flow discharges and tidal prisms at 3 sites (Northern Channel, Eastern Channel and Monkey Jacket Creek) in the estuary over a full spring tide cycle. Hydrographic survey of the Lower Myall River was undertaken in conjunction with the tidal gauging. A temporary meteorological station was also established in the front yard of a house on, Winda Woppa, during the second data collection period. Salinity data was measured at Pindimar Bay (site 2), Corrie Island Confluence (site 5), Monkey Jacket Upstream (site 8), Brasswater (site 10) and Bombah Point (site 12).

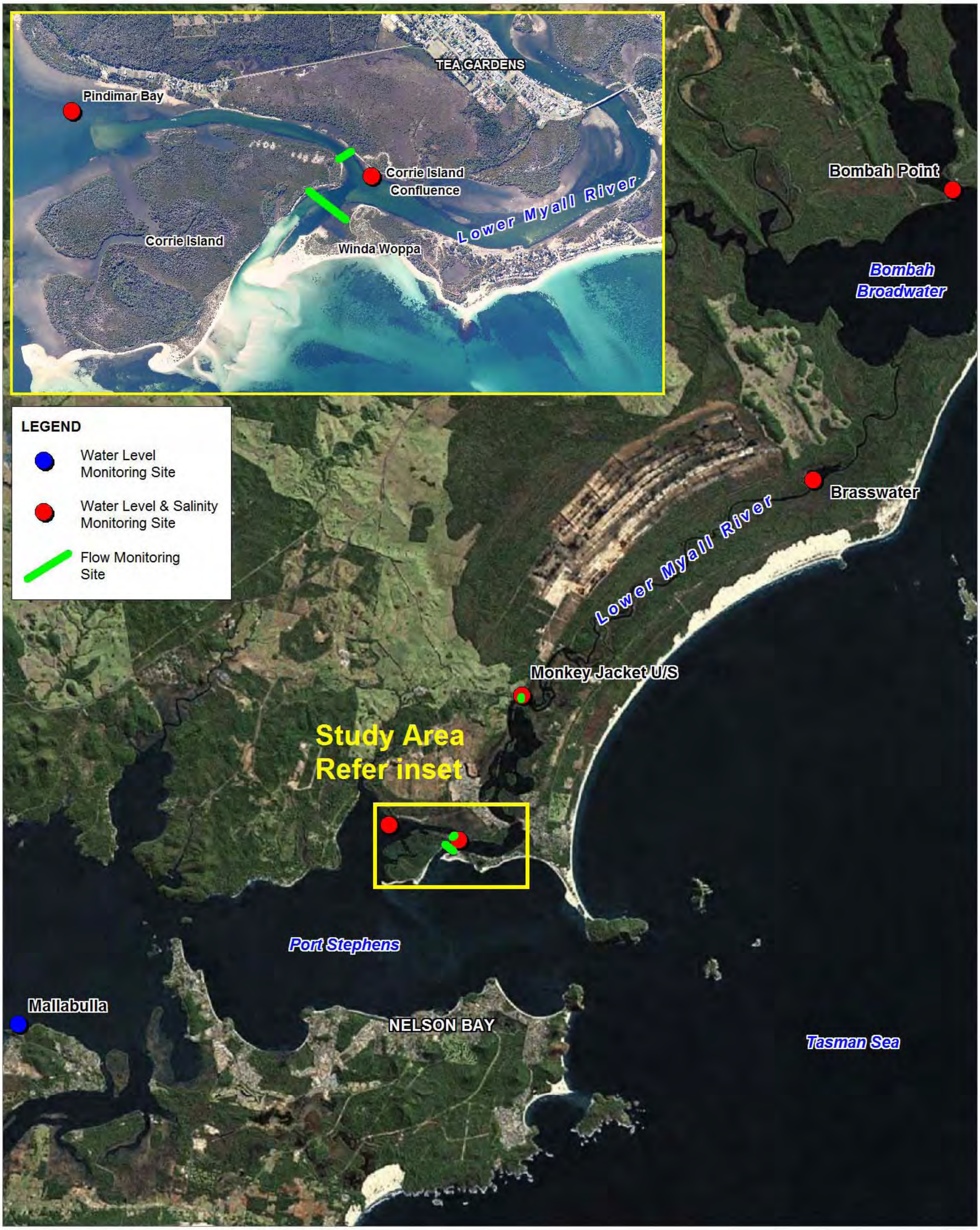
The September 2009 data represents the most complete and useful data set for validation of the numerical models established for this study.

3.2.2 Tidal Characteristics

Tides along the NSW Coast, including Port Stephens, are micro tidal (i.e. < 2 m in range) and semi-diurnal (i.e. ~ two tides occur every day). Specific tidal ranges and planes for Port Stephens are outlined in Table 3-4. The tidal range exhibits minimal attenuation across the Port Stephen's estuary flood tide delta, due to the estuary's wide entrance (1.24 km, Vila-Concejo *et al*., 2007). The tidal range within Port Stephens is amplified along the estuary, with field measurements collected on the 29th September 1993 demonstrating the flood ranges of 1.13 m recorded at Tomaree, 1.19 m at Soldiers Point 1.25 m at Tilligerry Creek 1.28 m at Mallabulla and 1.31 m at Karuah (PWD 1998). Water levels in the Upper Myall River are driven by water levels in the Lakes with negligible tidal range (MHL 1993).

Water levels for the model calibration period are shown in Figure 3-3 and demonstrate the amplitude in water levels from Tomaree (at the ocean entrance to the estuary) and Mallabulla (western basin of the estuary) as well as the large reduction in tidal influence within the Myall Lakes (Bombah Point).

Elevated water levels can promote greater tidal ranges for short periods of time, and occur along the coast in response to storms. The combined elevated water levels at Fort Denison in Sydney (reasonably consistent with the entrance to Port Stephens) for various ARIs are given in Table 3-5 (DECCW, 2009). The values do not include wave set-up, however, for most ocean conditions, water depths at the entrance to Port Stephens are such that wave breaking is not occurring and, therefore, wave set-up at the mouth of the Port is not a significant factor (MHL 1999).



Title:

Water Level, Flow and Salinity Measurement Sites

Figure: **3-2**

Rev: **A**

N

0 2.5 5km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\Figure 3-2 Water Level, flow and salinity measurement sites.WOR

Table 3-4 Tidal Planes and Tidal Ranges for Port Stephens (source: MHL, 2009)

Tidal Planes	Water Level (m AHD)
HHWSS	0.979
MHWS	0.603
MHW	0.476
MHWN	0.349
MSL	-0.034
MLWN	-0.418
MLW	-0.544
MLWS	-0.671
ISLW	-0.939
Tidal Ranges	
Mean Neap Range (MHWN-MLWN)	0.766m
Mean Range (MHW-MLW)	1.020m
Mean Spring Range (MHWS-MLWS)	1.274m
Range (HHWSS-ISLW)	1.918m

**Where: Highest High Water Solstice Spring (HHWSS); Mean High Water Spring (MHWS); Mean High Water (MHW); Mean High Water Neap (MHWN); Mean Sea Level (MSL); Mean Low Water Neap (MLWN); Mean Low Water (MLW); Mean Low Water Spring (MLWS); and Indian Spring Low Water (ISLW).*

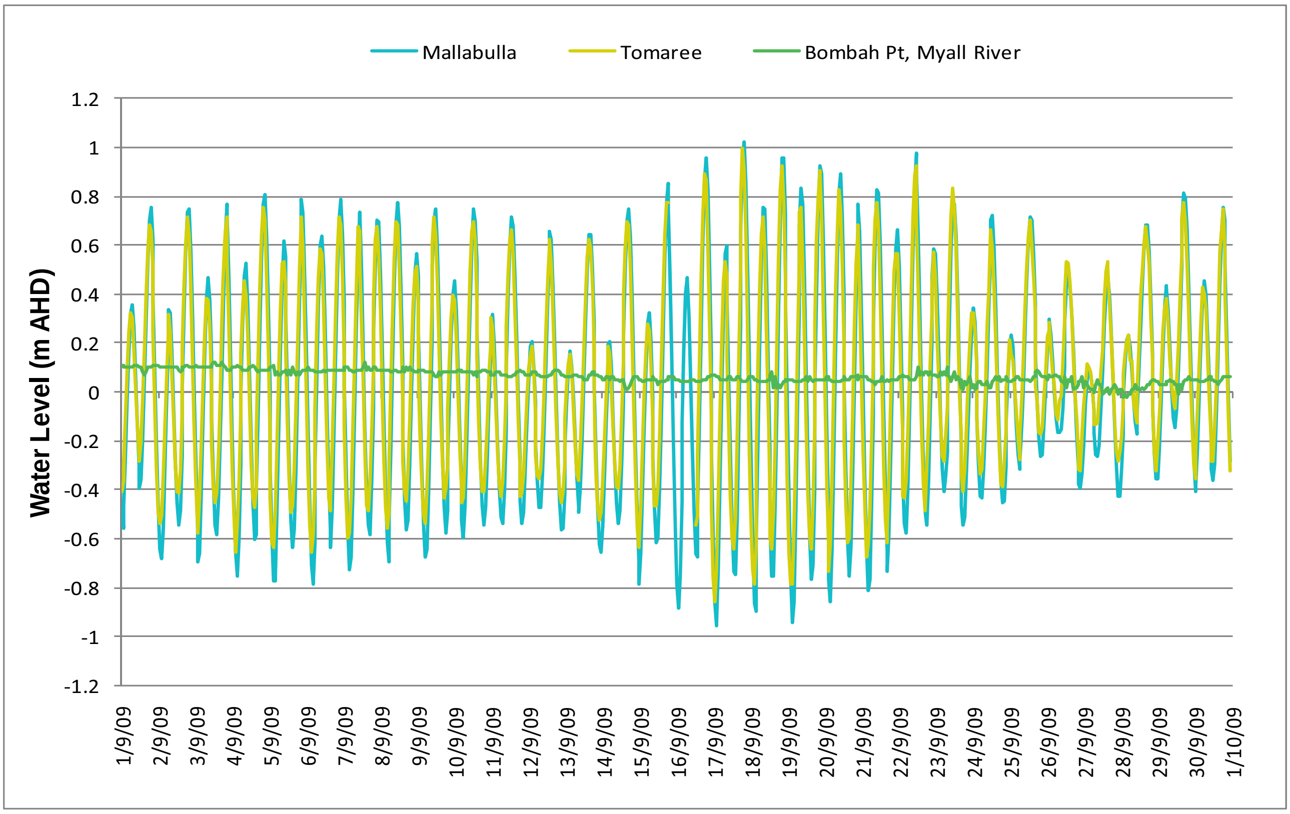


Figure 3-3 Water levels within Port Stephens and the Myall Lakes, September 2009 (MHL)

Table 3-5 Elevated Water Levels, Fort Denison, Sydney (WBM 2010)

Average Recurrence Interval (years)	Extreme Water Level (Storm Surge + HHWSS) Sydney (DECCW, 2009) (m AHD)
10	1.35
20	1.38
50	1.42
100	1.44

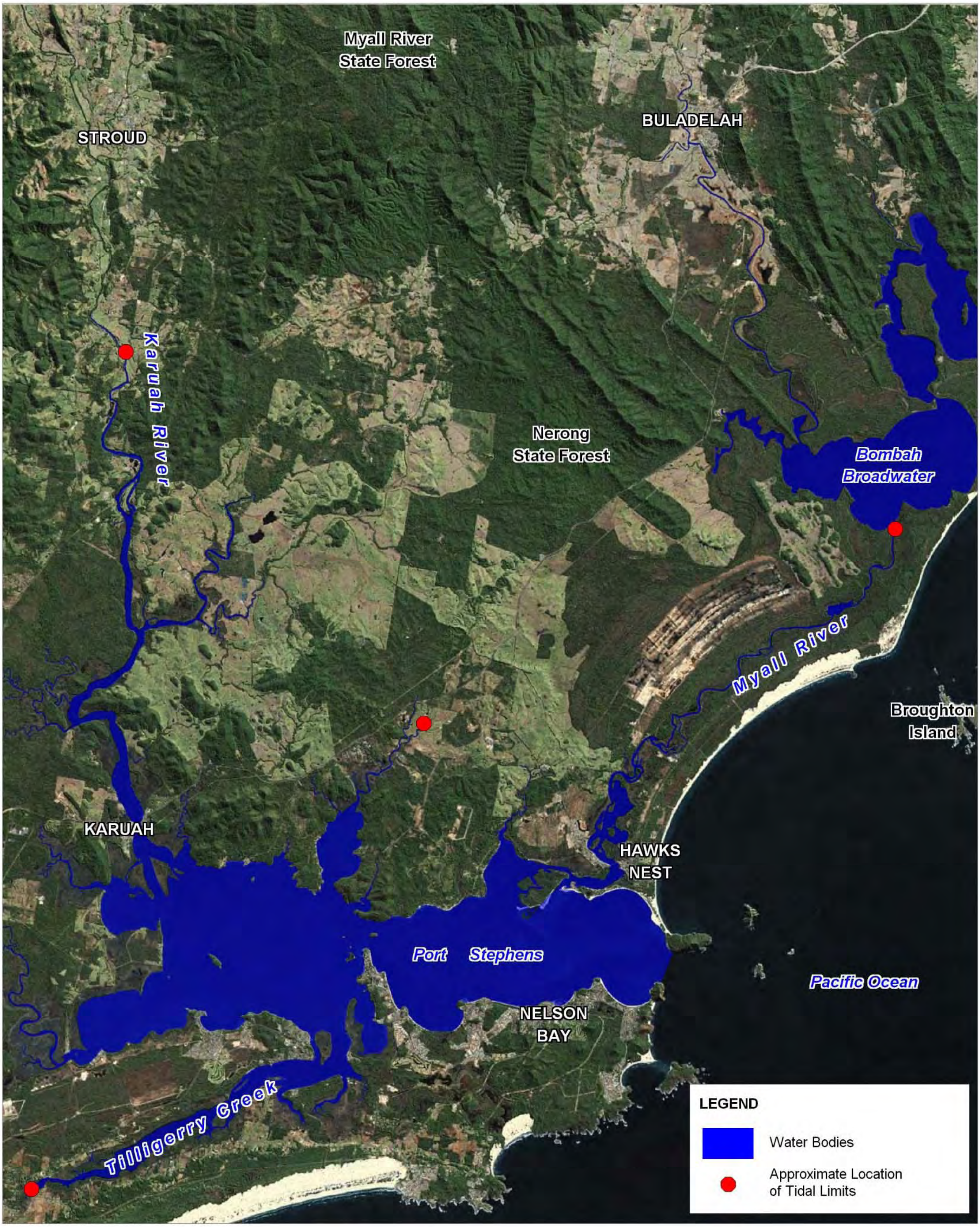
Tidal lags in peak water levels were evident at a number of locations within the Estuary. One significant time lag exists between the eastern and western side of Corrie Island (MHL 1993). During the flood tide, a change in direction of flow in the Northern Channel was observed 2hrs 30mins after that in the Eastern Channel. During the ebb tide the time lag was less, at 1hr 45mins. This resulted in an ebb tide in the Northern Channel that was much longer than the flood tide. (e.g. 7 hrs. 30 mins vs. 4 hrs. 45 mins). At the start of the flood tide, water from the Eastern Channel flowed directly into the Northern Channel instead of the Myall River (MHL 1993).

Tidal limits within the Port Stephens / Myall River are identified as follows (PWD 1988, DECCW & MHL 2010) and shown in Figure 3-4:

- 24 km upstream from Karuah, along the Karuah River (52 km from the ocean),
- in the Broadwater, 32 km along the Lower Myall River from Port Stephens (37 km from the ocean);
- 17 km from Port Stephens along Tilligerry Creek near Salt Ash, (33 km from ocean);
- 4 km upstream from Port Stephens in North Arm Cove; and
- 0.75 km upstream at a tidal barrage along the Crawford River, from the Myall River.

Maximum tidal velocities recorded by the NSW Public Works Department at the entrance to Port Stephens, exceeded 1m/s (PWD 1998). Austin *et al*. (2009) found the central channel entering Port Stephens was dominated by the flood tide (both for duration and velocities), while ebb-tide dominated channels existed adjacent to the north and south headlands at the estuary entrance.

Typical maximum tidal velocities surrounding Corrie Island were just over half that measured at the entrance and are shown in Table 3-6 (MHL 2010). The Northern Channel recorded greater tidal velocities and discharge than the Eastern Channel, and across all three sites the ebb tidal velocities were shown to be greater than the flood tide velocities, in this region of the estuary. These values, however, are for one particular tide and not necessarily representative of all tides that occur here.



Title:

Tidal Limits for Port Stephens

Figure:
3-4

Rev:
A

N

0 5 10km
Approx. Scale

BMT WBM
www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_003_100929 Tidal Limits.WOR

Table 3-6 Typical Maximum Tidal Velocities

Location	Typical Maximum Flood Tide velocities	Typical Maximum Ebb Tide velocities
Northern Channel	0.66m/s	0.70m/s
Eastern Channel	0.40m/s	0.52m/s
u/s Lower Myall River	0.52m/s	0.56m/s

Tidal prism measurements by PWD (1998) over a spring tide indicated a significant reduction in the tidal prism between the estuary entrance and the western basin (from 168 x 10^6 m^3 and 165 x 10^6 m^3 for the ebb and flood tides respectively at the entrance to 5.5 x 10^6 m^3 and 4.9 x 10^6 m^3 for the ebb and flood tides respectively in the western basin).

Tidal prisms surrounding Corrie Island were measured in 2009, and are shown in Table 3-7 (MHL 2010). The largest discharge occurs through the Northern Channel. There is a significant reduction in discharge, with distance along the Lower Myall River. Fluctuations in the discharge were observed, when measurements were plotted (as seen in MHL 2010) and are thought to result from a coastal anomaly travelling north, up the NSW coast, independent of the tide (MHL 2010).

Table 3-7 Tidal Prisms (MHL, 2010)

Location	Flood Discharge (m^3 x 10^6)	Ebb Discharge (m^3 x 10^6)
Northern Channel	2.80	2.55
Eastern Channel	2.51	2.27
u/s Lower Myall River	0.67	0.57

3.3 Wave Data

Available data on waves within the Lower Myall River have been separated into three components: swell waves, wind waves and boat wake.

3.3.1 Swell Waves

Offshore wave data is collected in NSW using WaveRider buoys moored in approximately 85 m water depth, and approximately 10 km offshore. One WaveRider buoy located at Crowdy Head (140 km north of Port Stephens) does not measure wave direction; with the next closest being the Sydney buoy which is located approximately 200 km south of Port Stephens. MHL (1997) compared wave data from the Sydney buoy with measurements at Jimmys Beach in Port Stephens, and found the Sydney data to be sufficiently similar to represent the offshore wave climate at Port Stephens. As a consequence the information contained within this report has been obtained from the Sydney WaveRider buoy.

Significant wave height (H_s) is an average of the highest one-third of wave heights recorded during a set period of time. For Sydney, the average H_s is 1.63 m and maximum recorded H_s is 8.43 m (refer to Appendix B). Average and maximum wave heights are greater during the autumn to early winter months (March to July). During this period, three of the wave generation sources for the NSW coastline overlap in their seasonal occurrence, namely mid-latitude cyclones, east coast low cyclones and tropical cyclones. Average and maximum wave heights are typically lowest during the spring to early summer months.

Storm wave height and duration curves for Sydney are given in Appendix B. From these curves, values describing the 1-hour and 6-hour duration storm wave heights for the 1, 20, 50 and 100 year average recurrence interval (ARI) storms have been derived. These are presented in Table 3-8.

Table 3-8 Average Recurrence Interval Storm Wave Heights (derived from MHL, 2009)

Return Period (years)	1-hour H_s (m)	6-hour H_s (m)
1	5.8	5.3
20	8.2	7.4
50	8.9	8.1
100	9.4	8.6

The mid-NSW coast most commonly receives ocean waves from the south east and east directions, although north-east swells are also common in summer and spring. The larger swells occur most commonly from the south to south-east sector (MHL 1999).

The data provided in Appendix B illustrates that, at Sydney, 65% of all waves arrive from the south east, south-south-east (SSE) and south (S) sectors combined, with 30% of all waves from the SSE alone. Mid-latitude cyclones generate this predominant south east swell, and these storms may occur throughout the year. Typically, mid-latitude cyclones occur closer to the southern Australian continent during winter and further south during summer, thus wave heights from these systems are typically greater during winter.

South easterly waves dominate the wave record during all months. However there is a noticeable shift in wave direction towards the north (with waves becoming more easterly in direction) during the summer months (WBM 2010). This is due in part to the tropical cyclone wave generation mechanism that occurs over the summer to autumn months, generating north-easterly waves on the NSW coast. In addition, north easterly sea breezes are also dominant during the summer (warmer) months, in response to the land heating faster than the ocean. This can generate smaller north to easterly wind waves along the coast in summer.

For coastal assessments, a storm is typically defined as H_s > 3 m in NSW (You and Lord, 2008), however, the waves that have produced the greatest damage and erosion around the Port Stephens estuary are typically H_s >6m (MHL 1999). The highest waves in the NSW record occurred during east coast low cyclones, which generate south-easterly to north-easterly waves, depending on the location of the storm relative to the coast (Short, 2007). The highest waves on record arrived from the SSE direction. East coast low cyclones may occur any time of the year, but are more common from May to July. Other storm waves may occur infrequently from the north-east (NE) and south-west (SW) sectors.

The height and directions along the coast may be described by joint occurrence statistics (refer Table 3-9).

Wave period statistics for the dominant or peak, spectral wave period (T_p) at any given time is given in Table B-3 (Appendix B). Swell waves typically have periods ranging from 8 to 12 seconds, and wind waves (seas) typically have periods between 2 to 5 seconds. The average and maximum T_p values in the record are 9.8 s and 20 s respectively.

Wave period seasonality is also evident and consistent with the observations for wave height and wave direction. The spring and summer months are characterised by shorter wave periods, and this is consistent with the prevalence of wind waves generated by afternoon sea breezes during summer. Wave period is typically longer over the late autumn to winter months (March to August), and this is consistent with the occurrence of larger storm waves.

Wave data were obtained for September 2009 from Manly Hydraulics Laboratory, as recorded by the Crowdy Head and Sydney WaveRiders. The obtained data comprises time series' of significant wave heights (Hsig), peak spectral time periods (Tp) and wave directions (for the Sydney site only). There were some data gaps identified in the two data sets and these are shown by breaks in the lines within the figures

Table 3-9 Percentage Joint Occurrence of Wave Height and Direction, Sydney (March 1992 to December 2008, 16.84 years)

		Significant Wave Height (H_s, m)									
Dir'n	**(Deg, TN)**	**0 - 0.99**	**1 - 1.99**	**2 - 2.99**	**3 - 3.99**	**4 - 4.99**	**5 - 5.99**	**6 - 6.99**	**7 - 7.99**	**8 - 8.99**	**TOTAL (%)**
N	**348.75 - 11.24**	0	0	0	0	0	0	0	0	0	0
NNE	**11.25 - 33.74**	0.03	0.06	0	0	0	0	0	0	0	0.09
NE	**33.75 - 56.24**	0.45	2.3	0.31	0.01	0	0	0	0	0	3.07
ENE	**56.25 - 78.74**	1.26	6.53	1.02	0.11	0.02	0	0	0	0	8.95
E	**78.75 - 101.24**	1.74	7.54	1.37	0.26	0.06	0.01	0	0	0	10.99
ESE	**101.25 - 123.74**	1.89	6.3	1.49	0.28	0.06	0.01	0	0	0	10.04
SE	**123.75 - 146.24**	3.3	9.77	2.48	0.52	0.14	0.05	0.02	0	0	16.28
SSE	**146.25 - 168.74**	5.28	17.93	5.24	1.23	0.34	0.1	0.02	0.01	0	30.16

Dir'n	(Deg, TN)	Significant Wave Height (H_S, m)									
		0 - 0.99	1 - 1.99	2 - 2.99	3 - 3.99	4 - 4.99	5 - 5.99	6 - 6.99	7 - 7.99	8 - 8.99	TOTAL (%)
S	**168.75 - 191.24**	1.81	10.01	5.26	1.53	0.39	0.1	0.02	0	0	19.12
SSW	**191.25 - 213.74**	0.11	0.57	0.2	0.05	0.01	0	0	0	0	0.94
SW	**213.75 - 236.24**	0.03	0.04	0	0	0	0	0	0	0	0.07
WSW	**236.25 - 258.74**	0.01	0.03	0	0	0	0	0	0	0	0.04
W	***258.75 - 281.24***	*0.05*	*0.02*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.08*
WNW	***281.25 - 303.74***	*0.05*	*0.03*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.08*
NW	***303.75 - 326.24***	*0.05*	*0.01*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.06*
NNW	***326.25 - 348.74***	*0.02*	*0.01*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0.03*
Total	**%**	16.08	61.16	17.39	4.00	1.03	0.28	0.06	0.01	0	100.00

Significant wave heights (Hsig) across the two sites were typically between 1-2 metres (Figure 3-5). Common peaks were observed around the 10-11th, 25th and the 30th September, and suggest large storms passing across the coastline. Uncommon peaks also occurred at the two locations, often with a time lag, and suggest smaller storms passing up or down the coast. Immediately prior to the field sampling time period (24th September) the offshore wave data contains significant wave heights building to 2.75m, peaking around the 25th Sept and again on the 30th September. The peaks correspond to two separate periods of strong southerly winds.

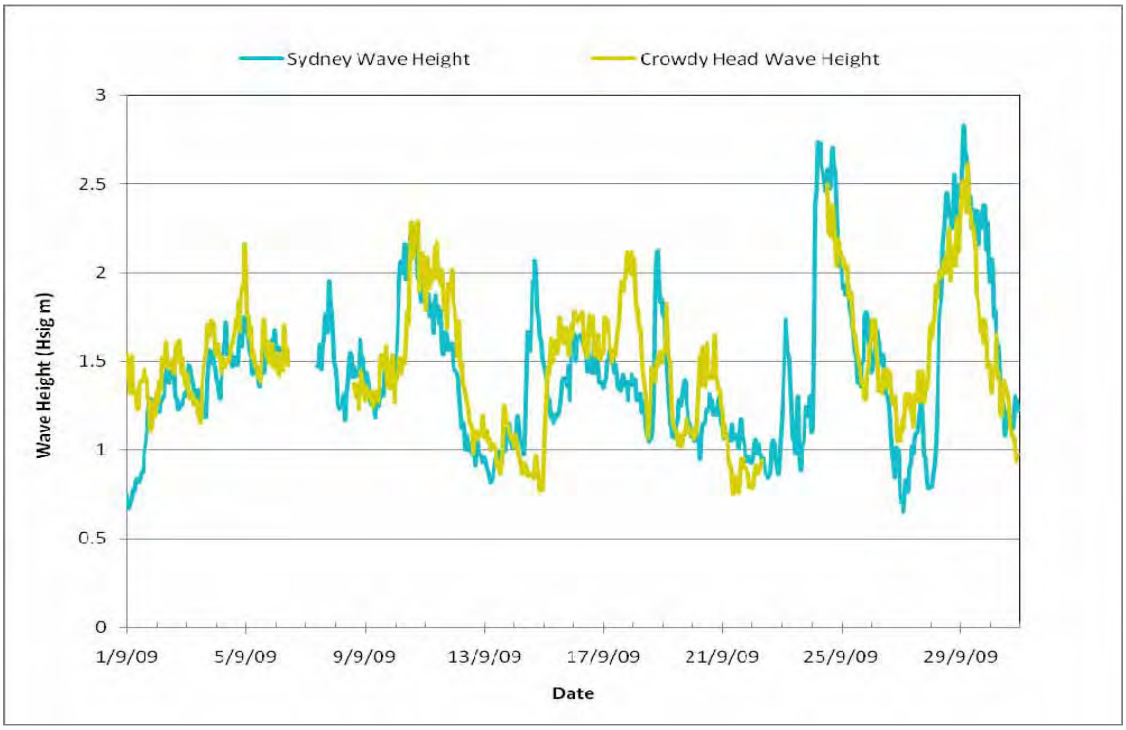


Figure 3-5 Wave heights for Sydney and Crowdy Head for September 2009

Wave directions offshore from Sydney showed large southerly waves (180 degrees direction) (Figure 3-6) which slowly decreased in magnitude and shifted in direction to easterly, then northerly and then back from the south again. This pattern appeared to be repeated on an approximate weekly basis. Five peaks in Hsig > 2m were also observed and corresponded with typically southerly waves, with one exception around the 19th September where the waves observed are from the north. On the 24th September (model calibration period) the waves originate from the south and slowly shift towards the south east.

Peak spectral periods for the majority of offshore waves were approximately 10 seconds (Figure 3-7). During the 24th September peak spectral wave periods decreased to approximately 4-6 seconds, indicating the addition of wind driven waves, but this only occurred for a short time period.

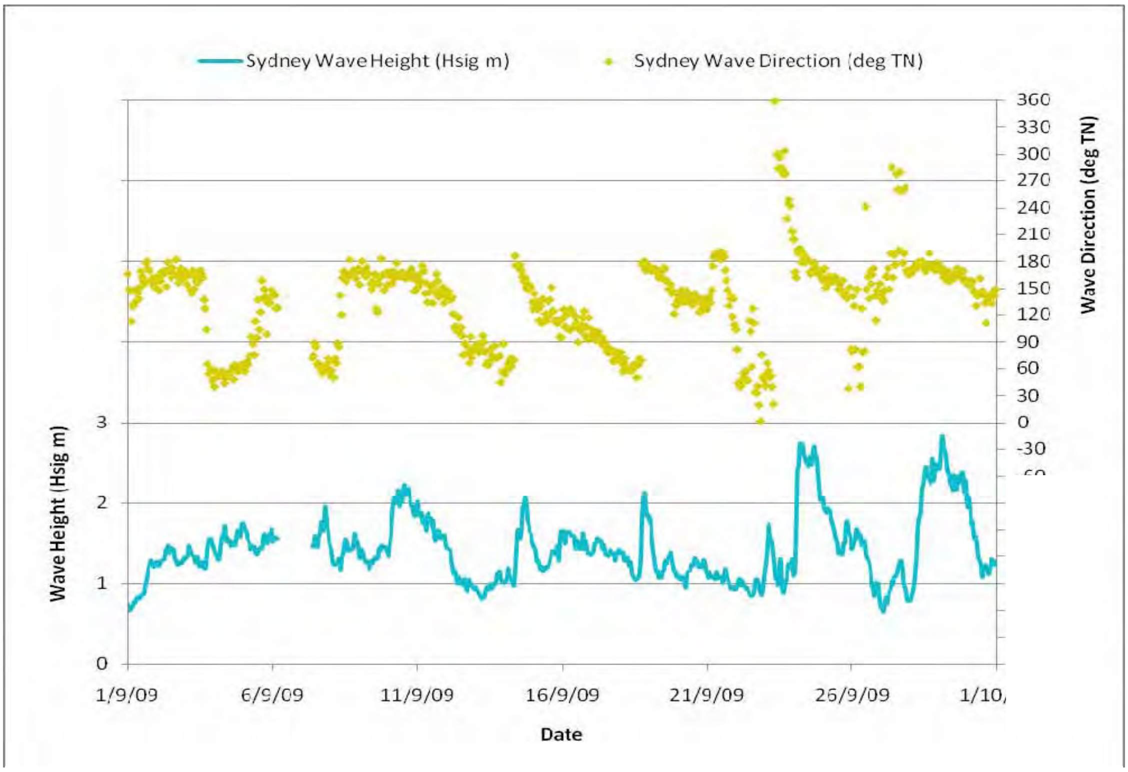


Figure 3-6 Offshore Wave Heights and Direction for Sydney, during September 2009

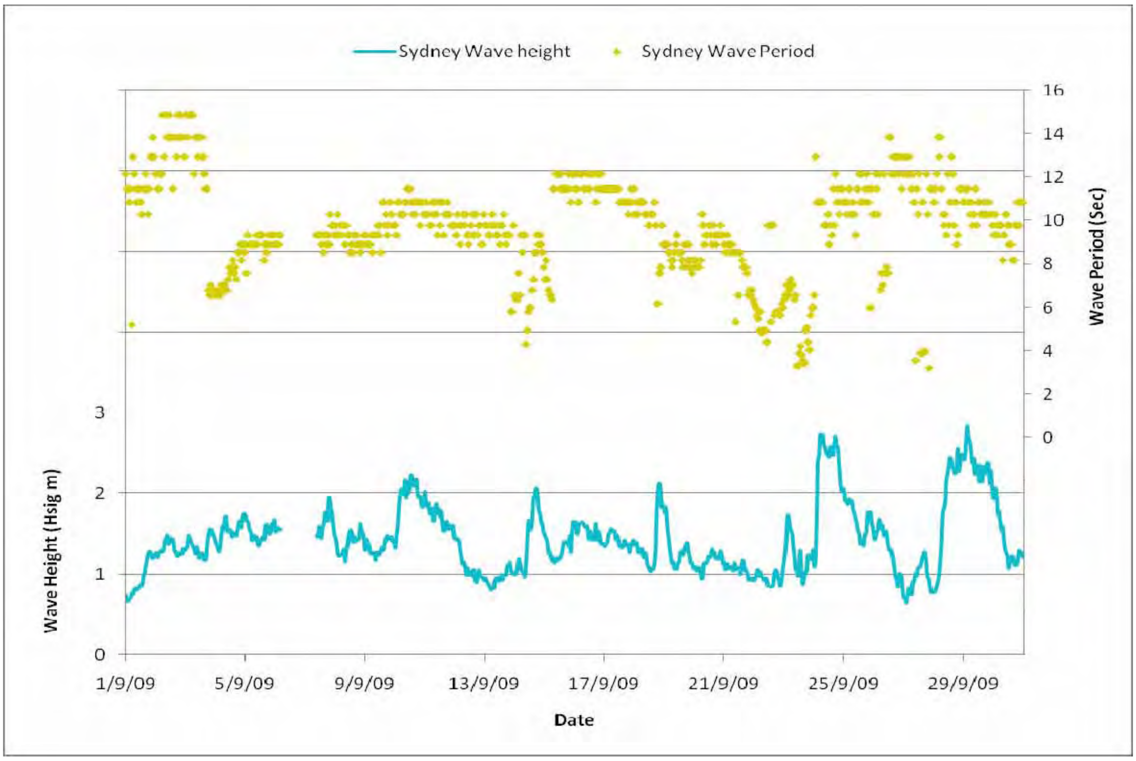


Figure 3-7 Wave Height and Wave Period for Sydney during September, 2009

3.3.2 Wind Waves

A 21 year long wind data record (1989 – 2009) from the Bureau of Meteorology's Williamtown weather station (approximately 30km south of Port Stephens) provides a good historical record for the site. Furthermore, MHL (1996) compared Jimmys Beach and Williamtown wind data, and found that Williamtown data is appropriate for use in Port Stephens.

The strongest winds occur from the north-west / west during winter (offshore directed wind), and east / south east directions over summer (onshore directed wind) (WBM 2010, MHL 1999), while the north-westerly direction has the most common occurrence of strong winds (above 12m/s or 25 knots) (MHL 1999).

WBM 2010 found the Generalised Extreme Value probability distribution provided a good fit to wind speed exceedance data across all of the wind directional sectors. The distribution was used to derive wind speeds for the 1, 5, 20, 25 and 50 year Average Recurrence Interval (ARI) events, as given in Table 3-10. For some wind directions, the data record was insufficient to define values for ARI's greater than 20 years (e.g., NE, SS directions).

Wind speed and direction data were obtained from the Bureau of Meteorology for September 2009, and are plotted as Figure 3-8 and Figure 3-9 respectively. This period covered the most recent and useful tidal data collection campaign between 21st and 24th September 2009. , Validation of the numerical model using this data is described in Chapter 4. During this time periodic changes in low wind speeds occurred from the 21st – 23rd September, followed by significant southerly winds, on the 24th September, exceeding 15m/s.

Table 3-10 ARI Wind Speeds at Each Wind Octant

Average Recurrence Interval (years)	Wind Speed (m/s)							
	N	NE	E	SE	S	SW	W	NW
1	7.84	9.99	10.88	12.21	13.59	12.41	15.76	15.80
5	9.84	11.60	12.69	14.43	15.32	14.73	17.88	18.46
10	10.44	12.20	13.42	15.55	15.87	15.43	18.55	19.23
20	10.92	12.78	14.11	16.78	16.34	15.99	19.09	19.81
25	11.06		14.32	17.20		16.15	19.25	19.98
50				18.60				20.40

3.3.3 Boat Wake

The dominant wave energy along the Myall River upstream of Winda Woppa is from boat wake (MHL 1999). Of particular relevance are the larger cruisers and commercial vessels which travel along the Myall River between Myall Lakes and Tea Gardens. No measurements have been taken at this location however investigations elsewhere indicate large cruisers travelling at low speeds may generate wave heights of 0.5m with short wave periods (2 to 3 seconds) (MHL 1999).

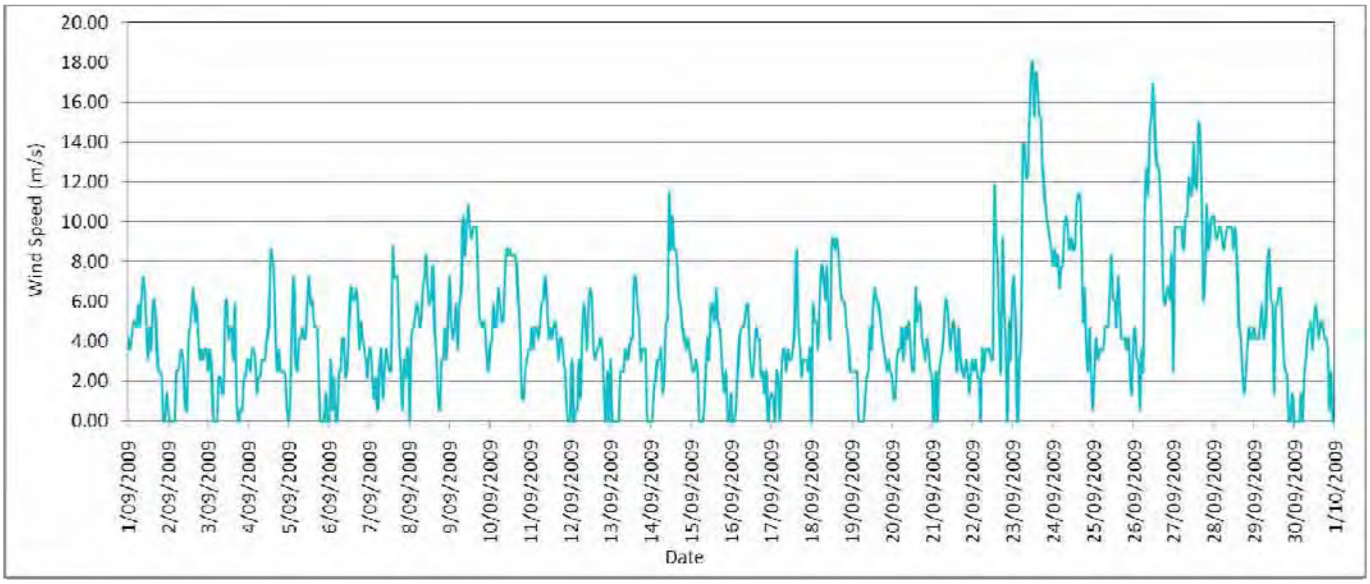


Figure 3-8 Wind Speed and Direction for September 2009

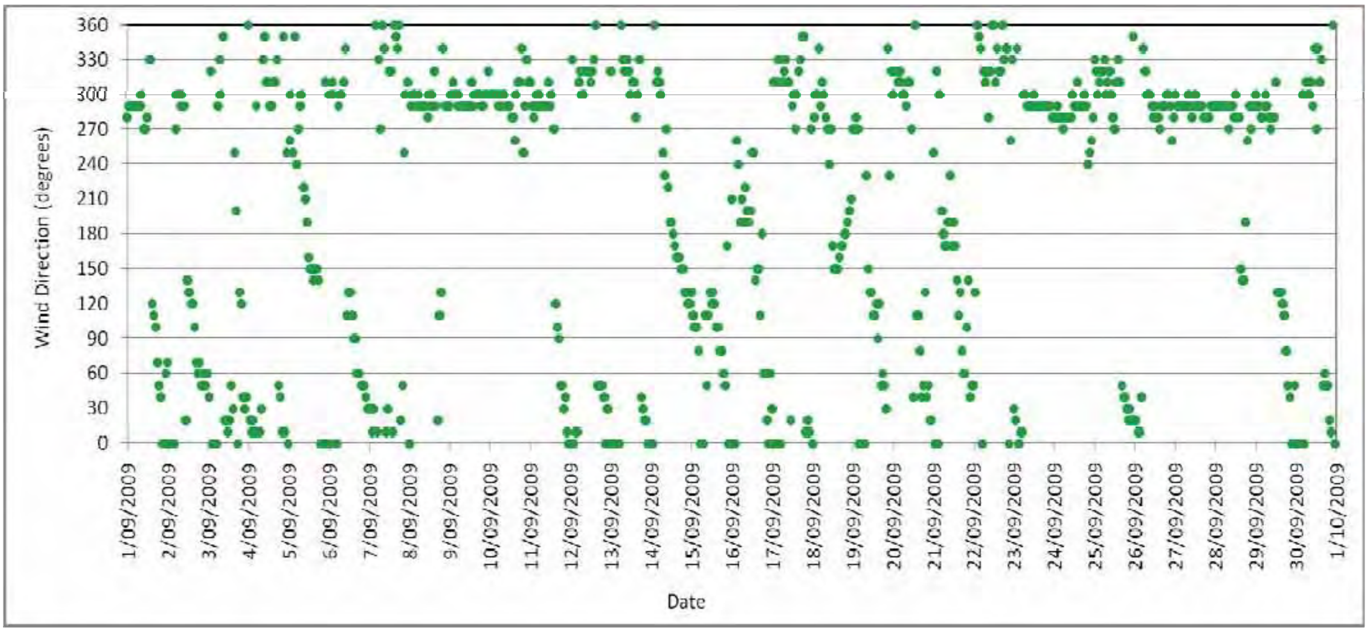


Figure 3-9 Wind Direction for September 2009

3.4 Aerial Photography

3.4.1 Existing information

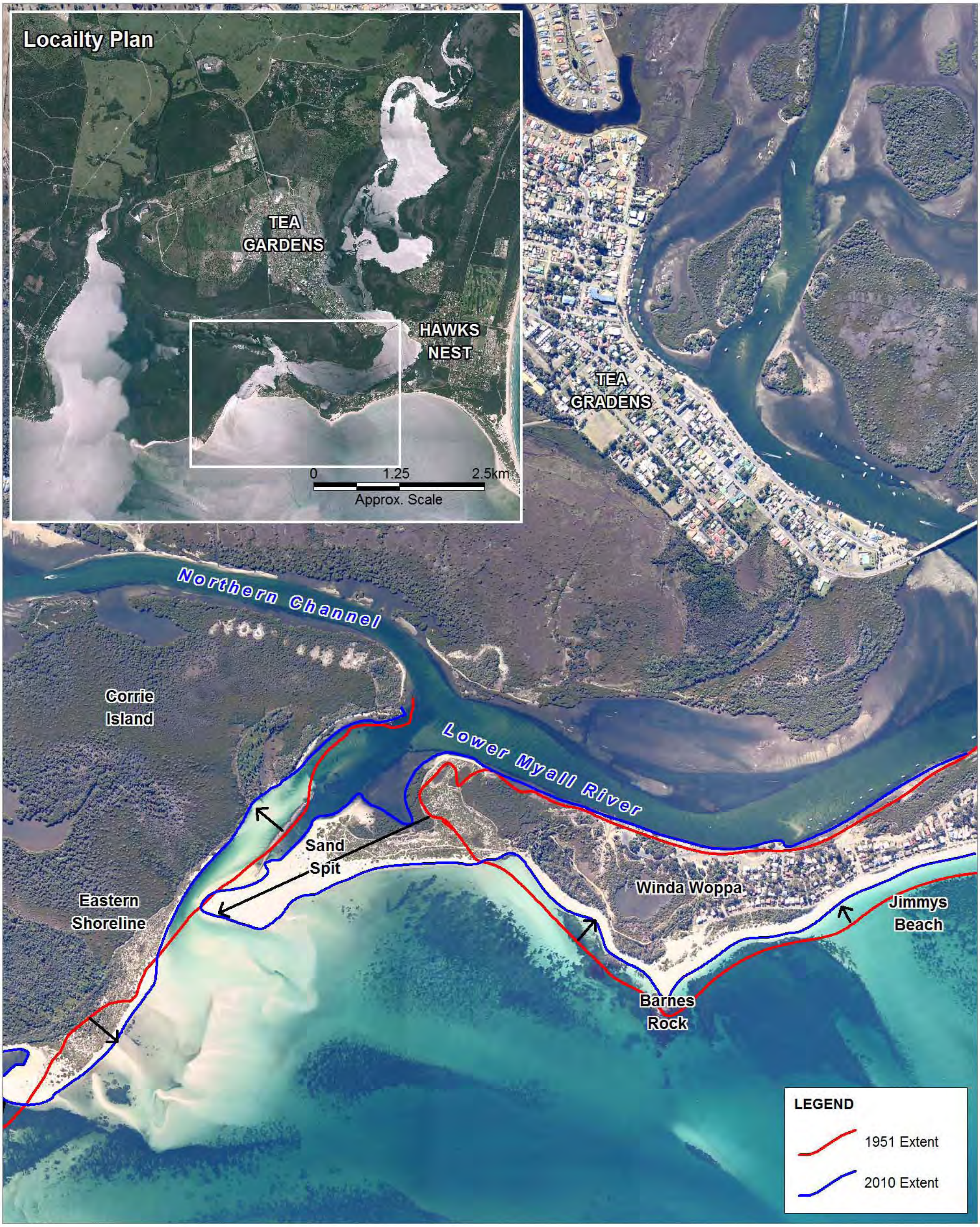
Aerial photographs of the Lower Myall River were obtained from DECCW, for a range of years spanning 1951 to 2008. An additional aerial photograph was obtained from Nearmap Pty Ltd (Nearmap 2010) for the year 2010. The images were geo-referenced to allow analysis in MapInfo, a GIS software package. The years include: 1951, 1963, 1966, 1977, 1979, 1980, 1986, 1991, 1993, 1994, 1996, 1999, 2001, 2006, 2008 and 2010.

3.4.2 Analysis

Key depositional features have been identified in each of the aerial photographs and changes over time discussed. The absence or presence of depositional or erosional changes provides an indication of “morphological” activity (erosion and/or deposition of sediments).

Three notably active sediment transport areas within the study region were identified from the aerial photographs. These key areas were the sand spit extending from Winda Woppa, the eastern shoreline of Corrie Island and the recurved spit extending from the southern end of Corrie Island Figure 3-10, Figure 3-11 and Figure 3-12.

The sand spit at Winda Woppa has grown considerably over the years from 1951 to 2010 (Figure 3-10) and now extends approximately 720m further to the south west, with half of the extension covered in dune vegetation. The greatest changes are evident between 1963 and 1977, and between 1991 and 2006/2010 (Figure 3-11). Spits typically grow in the direction of predominant littoral drift and can only exist through the continued longshore supply of sediment, analysis of available survey data indicates that most of this sand comes from erosion of Winda Woppa to the west of Barnes Rock (refer Section 3.7 and Appendix D).



Title:

Historical Sediment Transport Trends

Figure: **3-10**

Rev: **A**

N

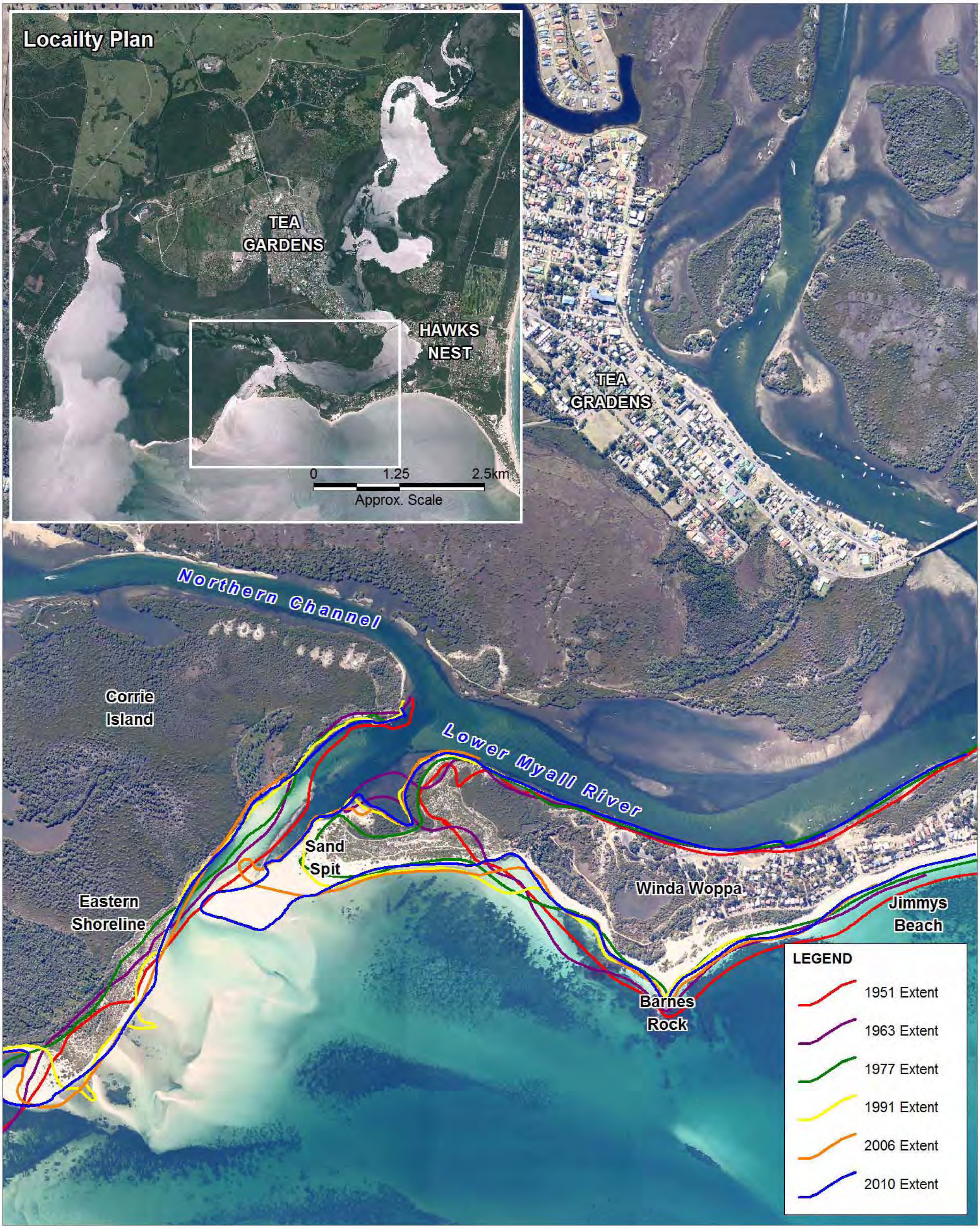
0 375 750m

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_007_101007 Sediment Transport.WOR



Title:

Decadal Trends Around the Sand Spit

Figure:

3-11

Rev:

A

N

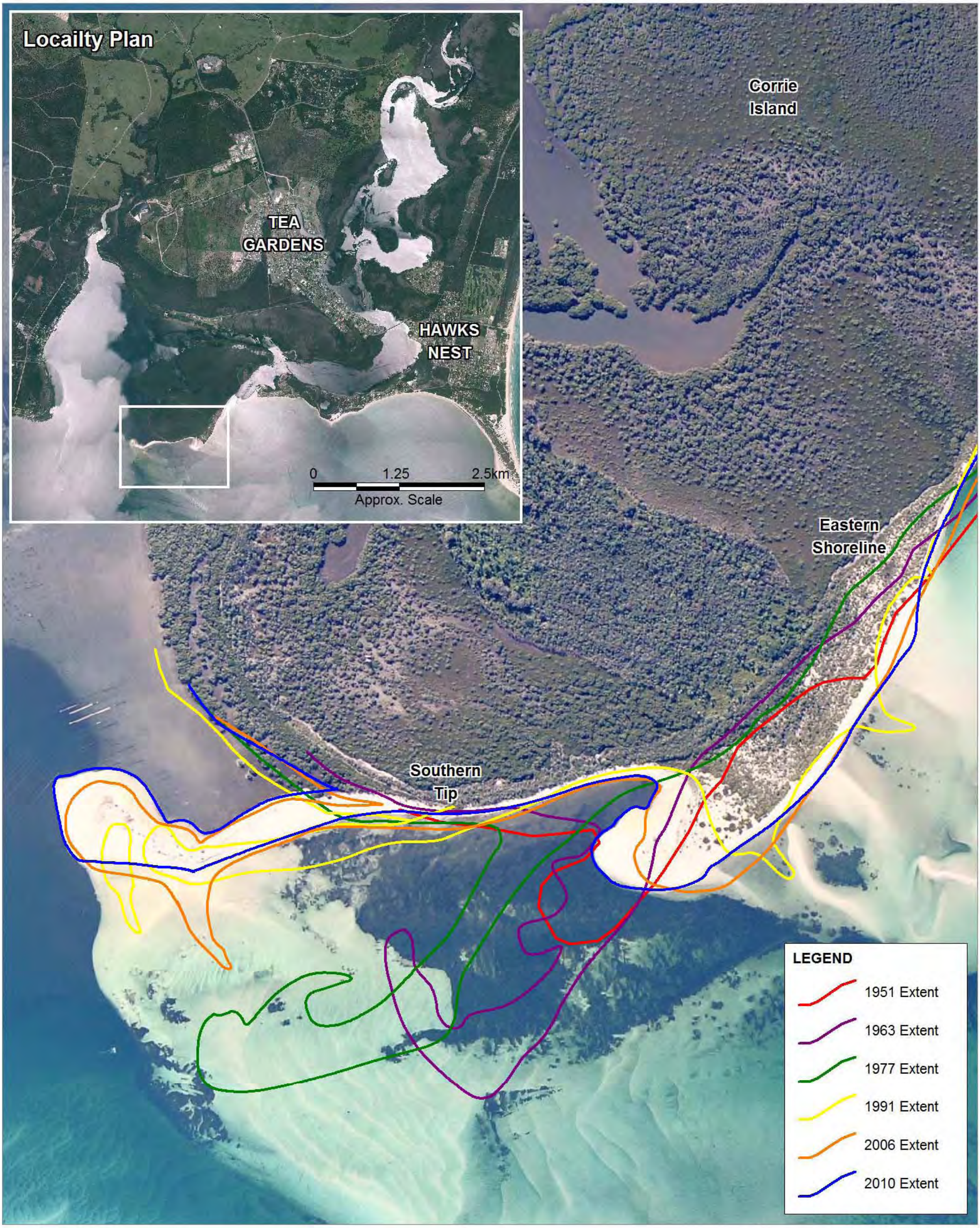
0 375 750m

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_004_100929 Sand Spit.WOR



Title:

Decadal Trends Around the Tip of Corrie Island

Figure:

3-12

Rev:

A

N

0 200 400m

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_008_101007 Corrie Island.WOR

The eastern shoreline of Corrie Island has undergone an anti-clockwise rotation towards a more north – south alignment, from 1951 to 2010 (Figure 3-11). The aerial photographs suggest erosion and accretion of approximately 130m, at the north and south ends respectively. The rotation is a likely consequence of increased erosion where the extension of Winda Woppa is pinching flows against Corrie Island, and deposition of some of this sediment towards the south along Corrie Island. The local wave climate may also be playing a role in the transport and affecting some of the change. Undulations can be seen on the eastern shoreline of Corrie Island in 1991 (Figure 3-11).

The recurved spit at the southern end of Corrie Island (Figure 3-12) has grown towards the southwest and west, between 1951 and 2010. In more recent years (1991 to present) another sand spit has begun to grow from the island, suggesting a significant ongoing longshore supply of sand.

Larger scale features in the estuary include the Sand Barrier known as the *Yacaaba Barrier* located between Yacaaba Head and Hawks Nest (Figure 1-2). This feature was present in all aerial photographs examined (1951 to 2010) with dune vegetation increasing over the barrier with time, suggesting increasing stabilisation.

Inside the estuary, the Flood Tide Delta (Figure 1-2) is the main depositional feature present in all of the photographs ranging from 1951 to 2010, with the western extent of the delta varying little over time.

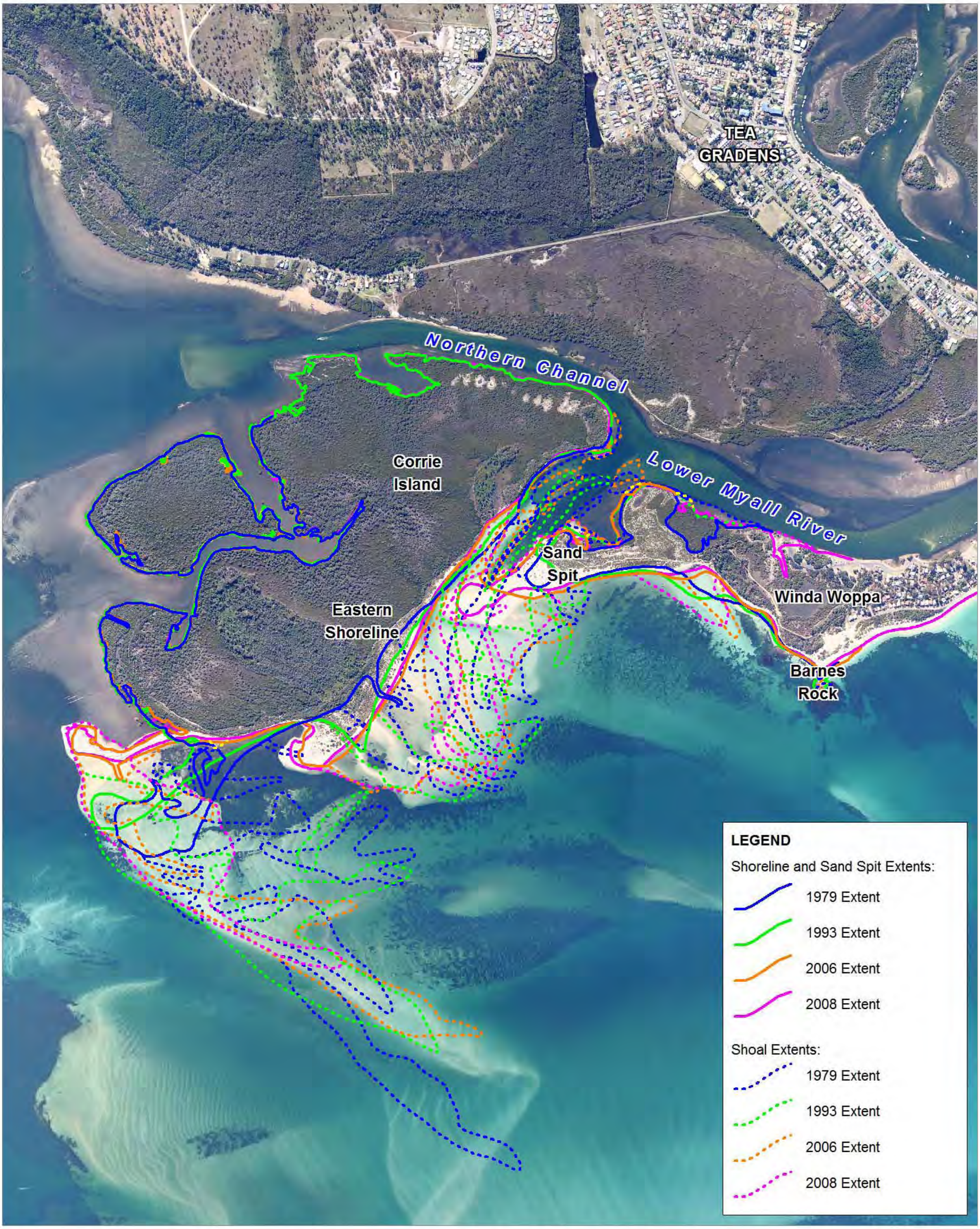
3.5 Photogrammetry

Photogrammetric analysis was undertaken by DECCW (2009) and involved the identification of sand spits and shoals in the study area (Figure 3-13). Submerged and emergent shoals, sand spits and shorelines were identified and mapped through stereographic analysis of aerial photographs from 1979, 1993, 2006 and 2008. There was consideration of water levels, and the extent of many features was limited to the extent of visibility on the aerial photographs. The numerous shoal outlines within the region to the south east of Corrie Island demonstrate the dynamic nature of this location. The southernmost submerged shoals indicate relocation to the north east from 1979 to 2008, and are likely to be providing a source of sand for growth of the sand spit at the southern end of Corrie Island. Evidence can also be seen of the migration of the remnant sands from Myall Spit. These processes have been documented previously (Section 3.4.2) in greater detail.

3.6 Sediments

Sediment types can be classified by their sand fraction and the four main sediment types relevant to the Lower Myall River entrance study area include the following (MHL 1993):

- *River Sand* – derived by terrestrial erosion and is relatively rich in lithic grains reflecting the rock types in the catchment.
- *Reworked Coastal Sand* – predominantly quartzose with very little lithic material. The sands are light grey to light brown, often with brown humic coatings. Grains are sub angular to well-rounded and moderately well sorted. Shells are generally absent and so it iron staining.
- *Beach and Near shore Marine Sand* – quartzose and fawn in colour due to iron staining. Shelly fragments are common, and the sand is rounded to well-rounded.



Title:

Sand Spit and Shoals Identified Through Photogrammetry

Figure: 3-13

Rev: A

N 0 0.5 1km

Approx. Scale

BMT WBM

www.wbmpl.com.au

Filepath : K:\N1926_Lower_Myall_River_Sediment_Hyrodynamic_Assessment\MI\Workspaces\DRG_010_1010 Shoals Pgram.WOR

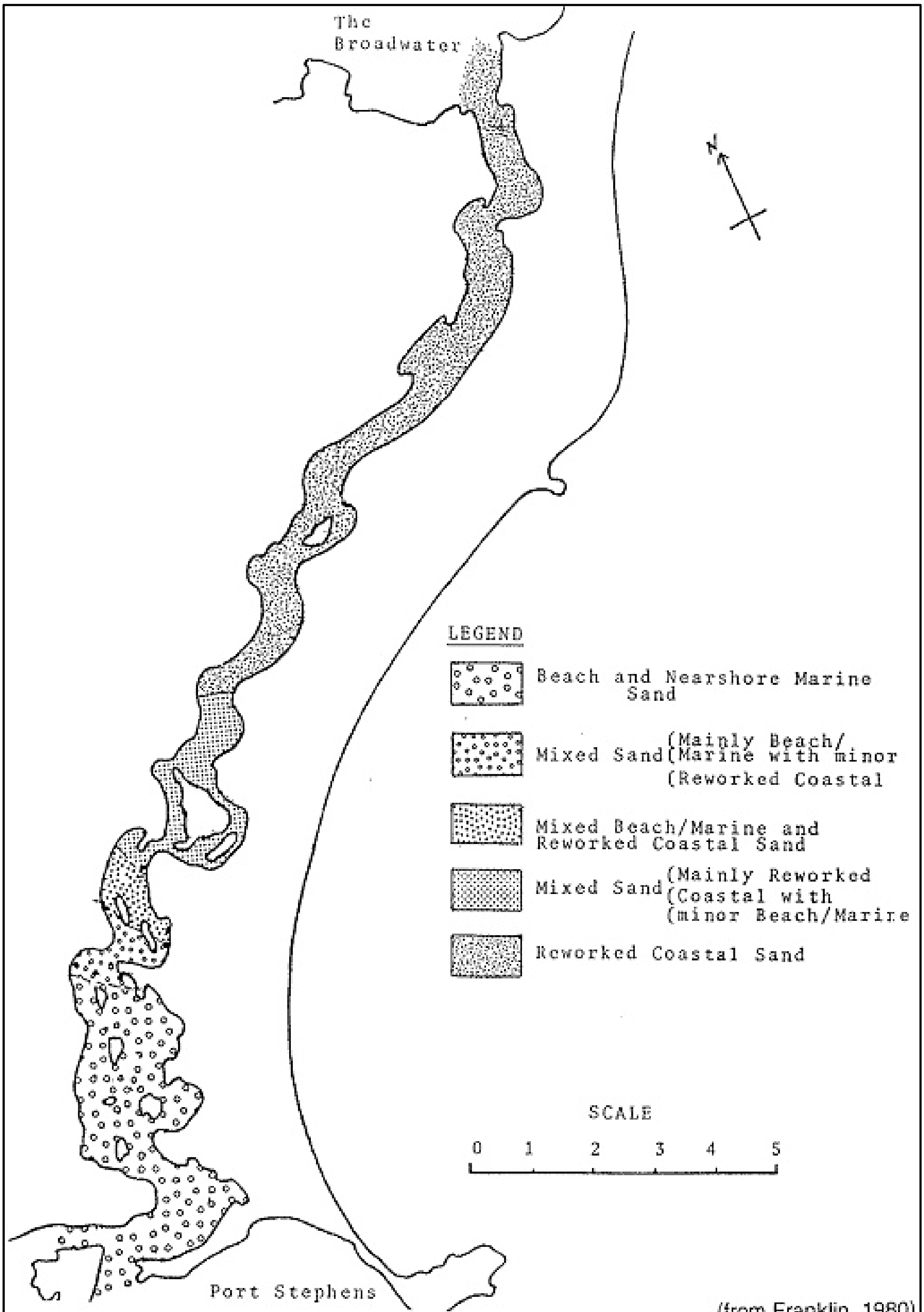
- *Offshore Sand* – ranges from quartz to lithic of similar composition to river sand. It is fine grained, moderately sorted with angular to sub rounded grains and fine shell fragments.

The distribution of sediment types in the Lower Myall River are shown in Figure 3-14. Locations for a set of sediment samples are shown on Figure 3-15 (MHL 1993). Data on the particle sizes at these locations can be found in Table 3-11.

The data shows the sand in the vicinity of the Eastern Channel and Winda Woppa spit to be typically coarse and moderately well sorted with D_{50} grain size of around 0.50 mm.

Table 3-11 Sediment particle sizes for the Lower Myall River entrance (MHL 1993)

Sample Site	Particle Size (mm)		Remarks
	Mean	D50%ile	
1	0.55	0.41	Coarse sand, moderately well sorted
2	0.50	0.41	Coarse sand, moderately well sorted
3	0.43	0.36	Coarse sand, moderately well sorted
4	0.55	0.47	Coarse sand, moderately well sorted
5	0.50	0.42	Coarse sand, moderately well sorted
6	0.53	0.43	Coarse sand, moderately well sorted
7	0.45	0.37	Medium sand, moderately well sorted
8	0.37	0.34	Medium sand, well sorted
9	0.55	0.47	Coarse sand, moderately well sorted
10	0.44	0.29	Medium sand, moderately well sorted
11	0.75	0.59	Coarse sand, moderately well sorted
12	0.54	0.36	Coarse sand, moderately well sorted
13	0.35	0.24	Medium sand, moderately well sorted



(from Franklin, 1980)

Figure 3-14 Sediment Distributions in the Lower Myall River (MHL 1993)

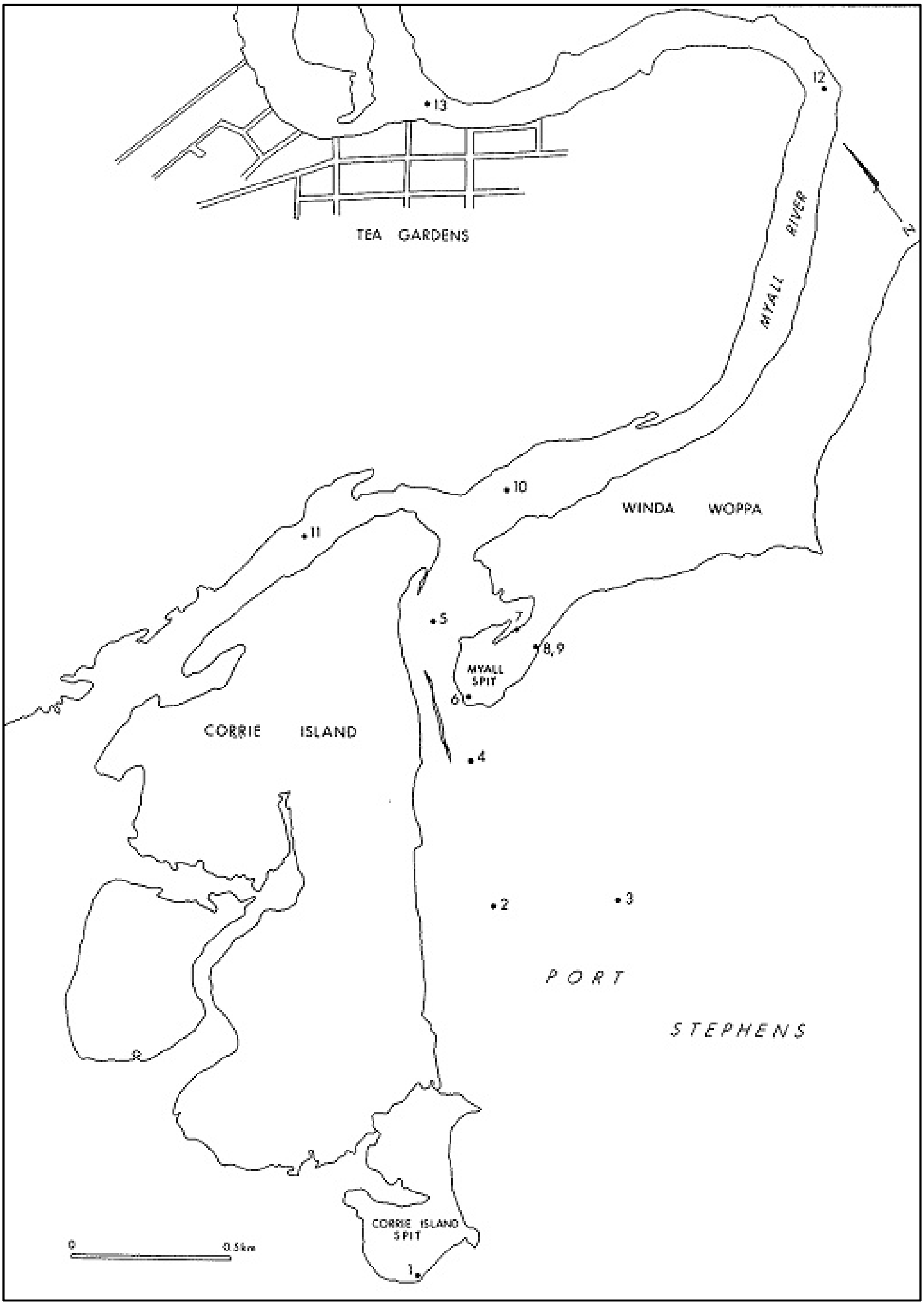


Figure 3-15 Sediment Sampling Sites for 1975 Study (MHL 1993)

3.7 Source of Sand Accumulation in the Eastern Channel

Appendix D provides a detailed assessment of Longshore Sediment Transport along the Winda Woppa peninsula. Volumetric analysis is also used and presented in Appendix D to compare the quantity of sediment accumulation within the Eastern Channel (and the new recurved spit) with the observed erosion occurring to the west of Barnes Rock. The results of this assessment suggest that the area west of Barnes Rock is a mostly-confined sediment cell. This means that the progradation of the spit and accumulation within the Eastern Channel has primarily been sourced from erosion of the foreshore of Winda Woppa Spit west of Barnes Rock. There is little net transport of sediment from Jimmy’s Beach into the Eastern Channel of the Lower Myall River.

Detailed processes associated with the erosion of Jimmy’s Beach have not been examined as part of this study. It is suggested that more research is required to gain a better understanding of the sediment transport processes of Jimmy’s Beach, including the fate of introduced sand for nourishment purposes. Notwithstanding, based on the assessments carried out to date, it is reasonable to conclude that the sediment transport processes of Jimmy’s Beach are not having a significant influence on the Lower Myall River.

3.8 Summary

The evidence from our review of background data supports many of the observations raised by the community. The bathymetric data illustrates the historical context of Winda Woppa spit extending westwards. The Eastern Channel is closing and a significant storm event could provide the catalyst that complete closes this channel.

The evidence suggests that erosion of the shoreline to the west of Barnes Rock is the primary source of sand that is currently extending the sand recurved spit and infilling the Eastern Channel. The dominant swell direction on the New South Wales coast enables waves to penetrate the entrance to Port Stephens and impact the shoreline. These swell waves are the most likely driver for erosion of the foreshore west of Barnes Rock, and for the longshore transportation of the eroded sand westward onto the new recurved spit across the Eastern Channel.

Tidal data shows that, over the past 30 years, the proportion of tides carried by the Northern Channel has doubled. In 2009, a tidal gauging indicated that approximately half of the tide is now carried by the Northern Channel. In the late 1970’s it carried only 25% of the tides.

Aerial photographs and photogrammetry support the assertion that the area between Barnes Rock and the southern tip of Corrie Island is very dynamic. This dynamism introduces significant uncertainty when predicting the changes that may occur from intervention using some of the options suggested by the community (structures, dredging etc.). Numerical modelling is a useful tool to assist in reducing this uncertainty. The development and validation of numerical models is described in Section 4 and their use to assess different management options in Section 5.