ENVIRONMENTAL HISTORY OF ROWES BAY

REPORT

PREPARED FOR

TOWNSVILLE CITY COUNCIL

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ENVIRONMENTAL HISTORY OF ROWES BAY

1. Introduction

This report describes the environmental history of the Rowes Bay foreshore and its hinterland. The study area comprises the 2.3 km of shoreline from the Kissing Point headland, around inner Rowes Bay and north to the RSL Villas, and extends inland for 0.5 km. The original landscape of rocky headland, mudflats and beach, backed by dunes, estuaries, mangrove swamps, stream channels and ancient beach ridges has changed significantly in the 145 years since European settlement began. These changes have been caused by natural processes and human activities, and have resulted from environmental changes both within and external to the Rowes Bay environment. This report documents these changes, and shows how they have influenced the behaviour of the present environment with particular reference to the persistent beach erosion that has been occurring for the last ~45 years. This will provide an important context for planning the future environmental management of Rowes Bay.

The report begins with a description of the landforms of the Rowes Bay - Pallarenda area, and an examination of the environmental changes that have occurred in this embayment over the last 6000 years. From this, a pattern of sand movement can be derived, which will enable a long-term sediment budget for the system to be established. This will provide an important initial approximation of the rate of sand supply required to maintain a stable shoreline system. The landscape immediately prior to European settlement (1864) will then be described. This will provide a benchmark from which to measure the scale of subsequent environmental changes. Natural and human-induced environmental changes will be summarised separately, with detailed information being presented in Appendix 1.

2. Data Sources

The primary source of environmental change information is from vertical aerial photographs that are available from 1938, 1941, 1952, 1959, 1961, 1965, 1970, 1971, 1972, 1974, 1976, 1978, 1981, 1985, 1991, and 1995. These have been obtained from AUSLIG, TCC, BPA, and Queensland State Government as detailed in Appendix 3. Information from prior to 1938 is very sketchy, but has been complied from geological and topographic maps, hydrographic charts, historic maps and photographs, meteorological records, and literature on the history of Townsville. These resources are listed below in Section 9.

3. Landform History of Rowes Bay

3.1 Introduction

The Rowes Bay study area forms the southern part of a 7 km long embayment between the Kissing Point headland and Many Peaks Range, and over the last 6000 years a suite of coastal landforms has accumulated here. The long-term history of these landforms provides an important context for understanding the recent environmental history of Rowes Bay.

3.2 Landforms of the Rowes Bay - Pallarenda Embayment

The natural landforms of the area have been mapped and described by various authors (Hopley and Murtha, 1975; Trezise *et al*, 1986 & 1989; Trezise and Stephenson, 1990), and these are shown in Figure 1. The main landforms present are sand ridges and intervening swales that occur in belt extending up to 2.75 km inland from the present shoreline. Other landforms include the modern shoreline features of intertidal mudflats, beach, dunes, sand spits and estuarine areas at the mouths of streams, while further inland are supra-tidal mudflats, mangrove and freshwater swamps, and stream courses. At the foot of Castle Hill and Many Peaks Range are small alluvial fans. Most of

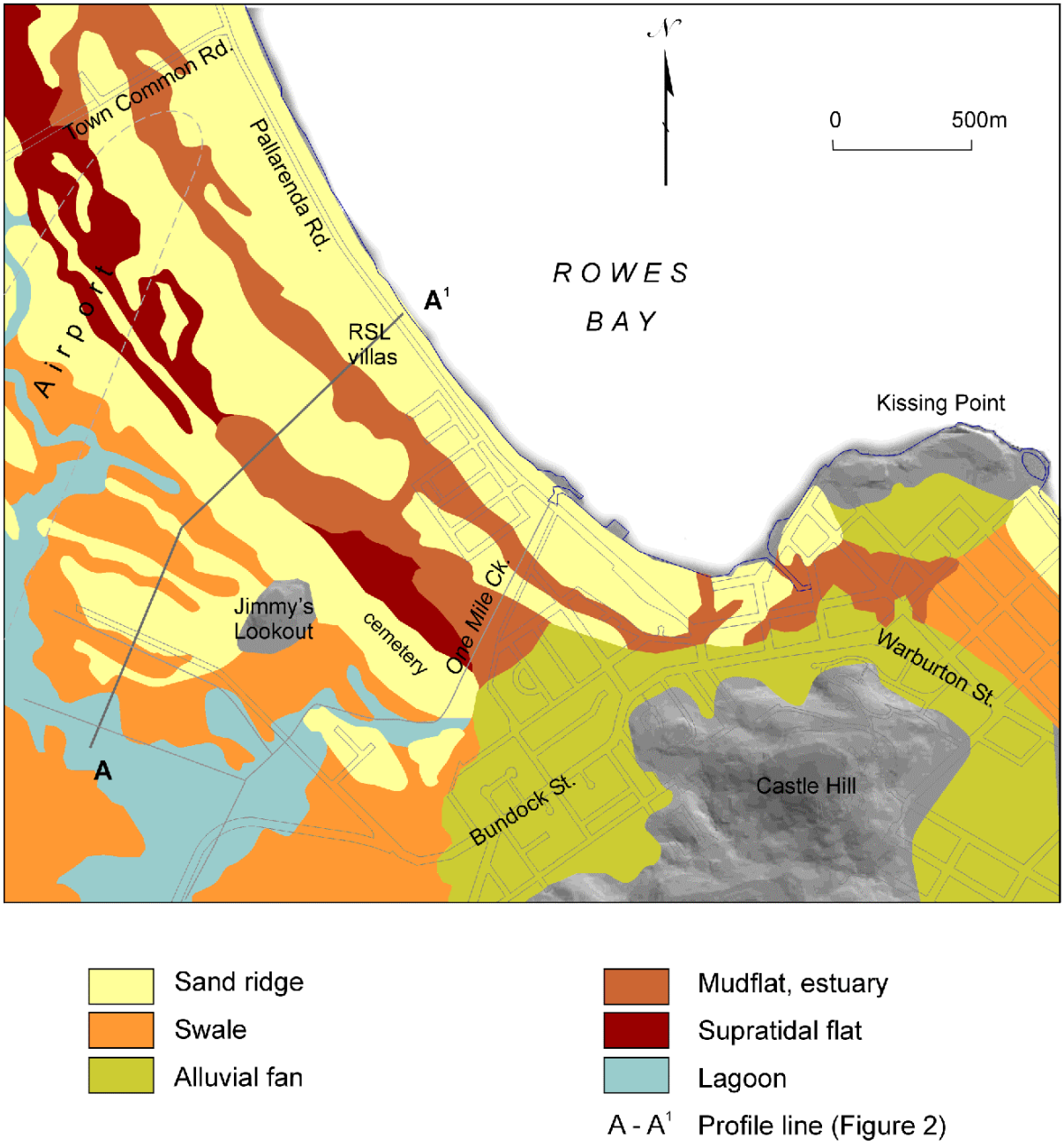

Figure 1 Landforms of the Rowes Bay area

these landforms remain today as much of the area is within the Town Common Environmental Park. However, construction of the airport runways has removed ~75 ha of beach ridges and swales, while the Rowes Bay Golf Course and suburban development at Pallarenda, Rowes Bay and Belgian Gardens, has partly modified some of the landforms.

3.2.1 Sand Ridges and Swales

The sand ridges consist of low sand accumulations up to 300 m wide, rising 3.5 – 6 m above mean sea level (asl), and aligned parallel to the present shoreline. Between these are low-lying swales at about 2 – 2.5 m asl. These depressions are usually composed of much finer mud sediments, and are typically occupied by swamps and stream courses, or nearer the present shoreline, supra-tidal

mudflats and mangrove swamps. Figure 2 shows a profile across the ridge and swale topography in Rowes Bay where at least seven ridges in two sets occur behind the modern beach. The innermost ridge set (BR 1-4) near Old Common Road is up 1.7 km from the present shoreline. These subdued landforms are only 3 – 3.5 m asl, and appear to have been partly eroded, with sand in-filling the swales between these older ridges. The outer ridge set (BR 5 – 7) are much better preserved landforms that rise more than 3 m above the intervening swales, and more than 5 m asl. Their extra height may be due to deposition of wind-blown dune sand. The suburbs of Pallarenda and Rowes Bay have been built on the youngest of the beach ridges (BR #7).

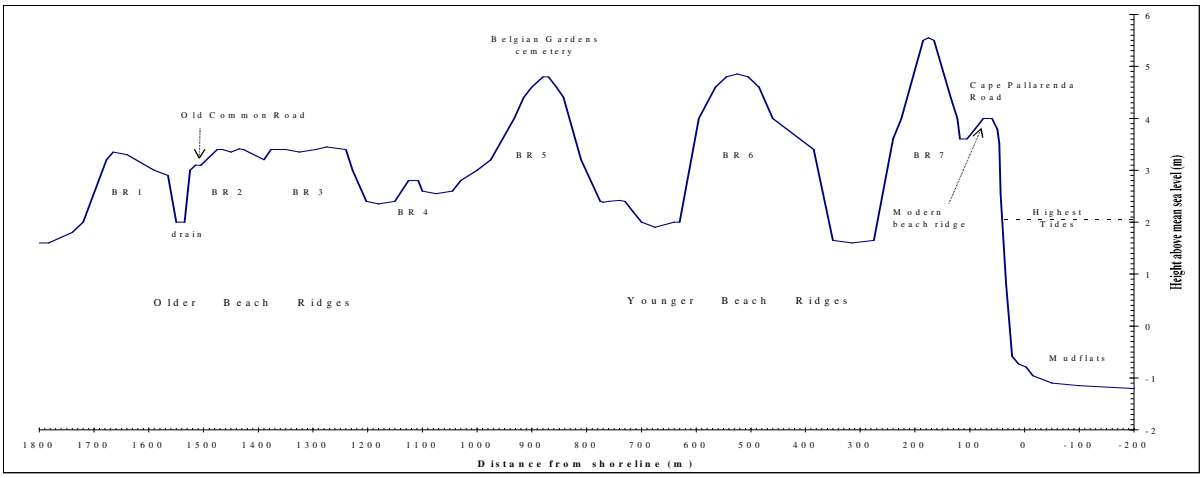

Figure 2: Profile across the Rowes Bay beach ridges (BR = beach ridge).

While the overall alignment of the ridges parallels the modern shoreline, in detail the inner parts of the ridges curve around to the northwest and north-northwest. From this, it is interpreted that the sand ridges are beach ridges that were formed by the northward extension of sand spits as wave action moved sand along the shoreline towards the Many Peaks Range. This line of hills acted as a barrier, trapping the sand and causing the shoreline to prograde eastwards as the shallow waters of the embayment were filled with sediment. Once the sand ridges had built out to Cape Pallarenda, progradation would have ceased, as the Many Peaks Range no longer acted as a barrier to sand transport. However, sediment supply to the embayment would not have changed. Sand entering past Kissing Point would have moved north along the beach to Cape Pallarenda, and then out of the embayment.

Radiocarbon dating (Trezise *et al*, 1989) indicates that the overall period of accumulation of the ridges occurred between about 6000 and 1000 years ago. However, the presence of the distinct beach ridges separated by broad swales, suggests sand delivery to the embayment may not have been continuous. There were probably periods of enhanced sand supply entering the embayment when the ridges would have been forming rapidly. This may have been caused by periods of greater wave energy, and/or times of increased sand delivery to the coast. In addition, the morphological difference between the older and younger beach ridges in Rowes Bay may indicate that there may have been a significant time break between the deposition of these ridge sets.

3.2.2 Modern Beach Ridge

The modern beach ridge is a much smaller feature than the older beach ridges, being only ~100 m wide, and rising to ~4 m asl. It has been formed directly on the front of beach ridge #7 with only a small shallow depression marking the boundary between the two landforms (see Figure 2). The boundary between the active beach face and the present mudflats is marked by a very abrupt change in slope and sediment type. Where the foreshore area remains undisturbed, small dunes that increase in size northwards back the beach. The Rowes Bay-Pallarenda Road has been built along the top of

the ridge, and much of it has been landscaped for park areas. At its southernmost extent in Rowes Bay, the modern beach formerly consisted of several small, highly mobile sand spits at the mouths of two small creeks (see Section 6).

The modern beach ridge has been in place for at least ~1000 years, having formed when the older and younger beach ridges had built out to fill the embayment to the end of Many Peaks Range. Although shoreline progradation then ceased, sand supply to the embayment would have continued, and this would still have been worked northwards, but would be able to leave the embayment past Cape Pallarenda. Over time a steady-state would be maintained, and the shoreline would remain in a relatively stable position. Periods of erosion would occur during cyclones, or when sand supply from Ross River slowed. However, these would be followed by periods of beach recovery when sand supply was re-established and/or wave energy levels were lower and more conducive to beach accretion. This pattern of beach behaviour can be seen in the area south of Three Mile Creek over the last 30 years. During Cyclone Althea in 1971, ~15 m of beach erosion occurred, but since then the shoreline has built out more than 20 m. However, this process can only occur if there is a continuing supply of sand to the embayment.

3.3 Origin and Movement of Sand in the Kissing Point-Many Peaks Range Embayment

The origin and movement of sand in the embayment is crucial to understanding the erosion problems that are occurring in Rowes Bay today. Three issues are important:

- Where has the sand come from?
- What transport processes have moved the sand?
- Where was this transport process occurring?

The ultimate source of sand in the Rowes Bay beach ridges is Ross River. As the sand is predominantly composed of quartz, it must have been derived from erosion of the mainland. The only river of suitable size and proximity to transport the sand to the coast is the Ross River. Originally, the river had two mouths, with a small flood channel discharging through Ross Creek and the main mouth 2 km to the southeast. Sand would have been delivered to Cleveland Bay through both mouths, forming large sand bars. The delivery of sand would have been episodic, occurring mainly during floods.

Once at the river mouths, the sand would have been re-distributed by wind-driven wave processes, and as the dominant winds are from the southeast, the direction of transport would have been to the northwest towards Kissing Point. Observations of the sediment distribution in Cleveland Bay show that sand-sized sediments are distinctively confined to the upper intertidal zone on the beach face. Thus, movement of sand from the Ross River occurs predominantly along the beach face by the process of longshore drift.

Today, two of these three natural processes have been interrupted. Ross Creek is no longer a mouth of Ross River, and the weirs and dam upstream have reduced the size of floods. Thus, there is a greatly reduced volume of sand being carried to the coast. The port facilities have been built directly across the upper intertidal zone, blocking the movement of any sand along the shore from the river mouth. However, the sediment transport processes are still occurring, and there is now an imbalance between the supply of sand to the beaches, and the levels of wave energy that are seeking to move sand along the shore. This negative sediment budget results in beach erosion.

3.4 Long-term/natural Sand Budget for the Embayment

The above analysis of the landforms, sediments, and sand transport mechanisms allows a long-term sediment budget to be established. A sediment budget quantifies the volume of sand moving through a beach system, and can be used to determine the amount of sand supply required to maintain the shoreline in a long-term steady state condition. The long-term sediment budget for the embayment can be modelled as follows.

- Sand is delivered to Cleveland Bay by the Ross River. This probably occurs episodically during flood events.
- Sand is moved northwest along the shoreline by longshore drift processes in the upper intertidal zone of the beach face.
- Sand moves along the Strand Beach and around Kissing Point into Rowes Bay.
- Initially sand is trapped in the embayment by Many Peaks Range until the shoreline advances to be level with Cape Pallarenda.
- Today, sand moves northwards along the Rowes Bay - Pallarenda beach, and eventually leaves Cleveland Bay to the north past Cape Pallarenda.

Quantification of all the steps in this model is not possible. However, from the above discussion of recent geological history and sediment transport in the embayment, one step in this budget can be quantified - the in-filling of the embayment. This then allows the nett rate of long-term sand supply to be calculated as follows.

- Area of sand in the Kissing Point - Many Peaks Range embayment can be measured from the geological map (Trezise *et al*, 1989) = 8.3 km^2.
- Average depth of sand deposits is estimated to be between 1.5 – 2 m.
- Total volume of sand in the embayment is between 12,500,000 – 16,700,000 m^3.
- Sand accumulated over 5000 year period at a rate of 2500 – 3300 m^3 per year.

For the shoreline to maintain a long-term stable position there needs to be a nett supply of sand of that balances the rate of northwards longshore drift. As a first approximation, this longshore drift rate is probably the same as the rate at which the embayment filled - ie about 2500 – 3300 m^3 per year.

4. The Pre-European Environment

4.1 Introduction

There is little information on the pre-European environment of Rowes Bay. The early settlers did not make any direct record of the landscape that they found, however early sketch maps, charts, photographs and historical descriptions can be interpreted to give a probable picture of the coastal landscape. Figure 3 shows the shoreline in much the form it would have been at that time. The shoreline will be considered in three sectors:

i) Kissing Point headland (705 m);

ii) Inner Rowes Bay from the Esplanade, through Soroptimists Park to One Mile Creek drain (1,200 m); and

iii) North Rowes Bay extending from One Mile Creek drain (1,100 m).

4.2 Kissing Point Headland

The Kissing Point headland is a granite hill rising to 34 m above sea level, and separates Rowes Bay from the Strand beach. The shoreline consists of a 30 – 50 m wide rocky inter-tidal shore platform, with the upper part of this was mostly covered by sand. The earliest hydrographic chart of Cleveland Bay dates from 1886, and this shows a suite of sub-tidal bars extending for 2 km northwest from the point across into Rowes Bay. These were probably sandbars formed of sediment transported past Kissing Point by southeasterly waves.

4.3 Inner Rowes Bay

Around inner Rowes Bay, the shoreline consisted of constantly changing sandbars, sand spits and beaches formed across the mouths of two streams. The streams drained across estuarine mudflats that occupied much of the area between Kissing Point and Castle Hill. The eastern stream drained the sand hills of North Ward and the slopes of Castle Hill, and was probably the outlet for

Hambeluna Lagoon that lay behind the present Aquarius tower block. Its mudflats covered ~8 ha, extending for 800 m between what are now Mckinley and Ryan Streets. No name for this stream has survived, so it will be referred to here as North Ward Creek. The western stream was known as Mundy Creek. It had a much larger catchment area extending from the northern slopes of Castle Hill, through the tidal flats where the Lakes now are, and west to the beach ridges and swales towards the present Airport. It reached Rowes Bay through a small (~3 ha) area of mudflats in the area of the present Soroptimists Park.

4.4 North Rowes Bay

The north Rowes Bay beach was probably backed by small dunes that increased in height to the north away from the shelter provided by Kissing Point. Behind the main beach/dune ridge, the landscape consisted of alternating lines of swampy watercourses, and low ridges of sand hills described above (Section 3.2.1).

4.5 Coastal Sand Transfer Processes

The general pattern of sand transfer in the Kissing Point - Cape Pallarenda embayment has been described above (see Section 3). This section describes in more detail the processes acting on the modern beach ridge in Rowes Bay.

The longshore drift processes that move sand in the upper inter-tidal zone are driven by wind generated waves. In Cleveland Bay waves are mainly generated by the local wind regime, and sand moves along the shore away from the direction of wave approach. During the dry season the persistent southeasterly trade winds move sediment to the north and northwest, while sea breezes and wet season winds from more northerly directions would tend move sand to the south. However, the southeasterly winds are the strongest and most persistent, so nett sand movement would have been to the north. In this way, sand delivered to the mouths of Ross River would be moved slowly along the shore through the Strand Beach to Kissing Point, and then around the Point into Rowes Bay.

The Kissing Point headland shelters inner Rowes Bay from southeasterly waves, and sand can only enter this part of the bay under the influence of waves that approach from between the north and northeast. The bulk of the sand passing Kissing Point would have been carried northwest to form sub-tidal and intertidal bars before being worked onto the north Rowes Bay beach (see Section 4.2). Inner Rowes Bay would have been supplied by sand worked southwards by waves generated by the weaker northeast sea breeze and wet season northerly winds. Once deposited here, sand would have remained as Kissing Point protects inner Rowes Bay from southeasterly-generated wave action. However, north Rowes Bay is not protected from the southeasterly waves and sand here would continue to move north towards Cape Pallarenda.

Some sand may have been supplied to Rowes Bay by North Ward and Mundy creeks, but as these are small systems, there would not have been major sources of sand for the beaches.

The day-to-day processes described here would have been interrupted by occasional high-energy events associated with tropical cyclones that would cause significant beach erosion. However, with a continuing supply of sand along the shore this erosion would have naturally recovered in following years.

Sand supply from Ross River would probably have been episodic, with large amounts of sediment being delivered during infrequent major flood events. Thus, the movement of sand along the beaches was probably also episodic, with occasional large volumes of sand moving along the shoreline, interspersed with years of less sand supply. During the low sand supply years the shoreline would probably have suffered from some erosion, but this would have been recovered during the high sand supply periods. In this way the shoreline would have been able to maintain a long-term balance between erosion and deposition.

The rate of sand movement along the beaches by longshore drift was probably quite slow, as Cleveland Bay is a very low wave energy environment. Observations in recent years suggest that nett northward longshore drift rates are probably around 2000 m^3/year. At this rate it would take many years for sand to be moved from Ross River mouth north around Kissing Point and into Rowes Bay. This slow rate of sand movement is significant as it means there would be a long delay between changes in sand supply at Ross River mouth, and subsequent changes along the foreshore.

4.6 Vegetation

The vegetation would have showed a distinctive character that reflected the underlying rock, soil and drainage conditions. The dunes behind the beach would have supported vines, with *Casuarina* forming the first line of trees along the modern beach ridge. Behind this, a narrow strip of vine thicket would have given way to mangrove and *Melaeluca* swamps, with *Eucalypts* on the drier beach ridge crests behind.

5. History of Urban Development along the Rowes Bay Shoreline

5.1 Introduction

The shoreline of Rowes Bay extends along parts of the suburbs of North Ward, Belgian Gardens and Rowes Bay. Urban development has resulted in this landscape being substantially changed from its natural state. Today, about 1800 people live within 0.5 km of the Rowes Bay shoreline (an area of about 160 ha), and urban development has covered over 70 % of the land area. Most of the landscape has been changed considerably over the last 135 years. Parts of Kissing Point and Castle Hill have been quarried away; the beach ridges and alluvial fans have been covered by suburban development; streams have been replaced with drains; sand spits have gone and the shoreline has eroded. Estuarine mudflats have been reclaimed, as have parts of the swamps, and of the original vegetation complexes probably only the wetlands behind the RSL Villas and Rowes Bay houses bear any similarity to the original vegetation. Mangroves have become established along the inner foreshore where before they were confined to the estuarine mudflats. Only parts of Kissing Point, Castle Hill, and the beach ridge and swale between Rowes Bay and the cemetery retain anything like their original character.

5.2 Early Settlement

Rowes Bay area has had European settlement since almost as soon as Townsville was established in November 1864, although it was not until the 1940s that major urban development began and the landscape began to be substantially changed. The original Townsville settlement was ~2.5 km to the southeast of Rowes Bay on the other side of Castle Hill. Initially, the main road north (the Dalrymple Track) went around this north side of Castle Hill. By 1865 a dairy farm and market gardens were established around lagoons near Jimmy's Lookout, and a vineyard had been planted near Kissing Point. By 1870, the vineyard had failed, and the market garden area was being called German Gardens. This name was changed to Belgian Gardens during World War One. North Ward had been one of the first Townsville suburbs to be established, but residential housing did not extend towards Rowes Bay until about 1900. Kissing Point was by then being used as a military facility.

5.3 Suburban Development 1900 - 2000

The main Warburton/Bundock Street route had been established by 1865, but it was not until the early 1930s that Heatley's Parade and the road to the Quarantine Station at Cape Pallarenda were built. In the late 1930's there were only a few side streets in addition to these main roads. However, by 1950 most of the Belgian Gardens and North Ward streets had been laid out, and the Rowes Bay street system was established by 1960.

The 1938 aerial photographs provide the first accurate picture of urban development in the Rowes Bay area (see Figure 3 which has been drawn from these photos.). In the strip 0.5 km inland from the shoreline there were only 16 houses in North Ward and 56 houses in Belgian Gardens.

Assuming 5.5 persons per dwelling, there were about 400 people living here. There were also some 35 small buildings in Rowes Bay on the western side of Heatley's Parade. These were probably holiday huts, and presumably were not permanently occupied. In 1941, there were only 25 of these left, and it may have been that some were lost during the cyclone of the previous year. Much of the area between Kissing Point and Castle Hill was tidal mudflat, and housing did not extend beyond Howitt Street until after these were reclaimed in the early 1940s.

Over the 1940s and 1950s, the area grew steadily, and by 1961 there were over 315 dwellings (North Ward 113, Belgian Gardens 129, Rowes Bay 76), with a population of about 1,600. The mudflats between Castle Hill and Kissing Point had been reclaimed in the 1940s and slowly that area was occupied. In the 1950s, the huts in Rowes Bay were removed. By 1959 the Rowes Bay Caravan Park had been established, and the new Rowes Bay suburb had been started, with this being almost fully developed (76 houses) two years later. In 1961 the One Mile Creek drain was nearing completion, replacing the lower 0.8 km of the Mundy Creek channel.

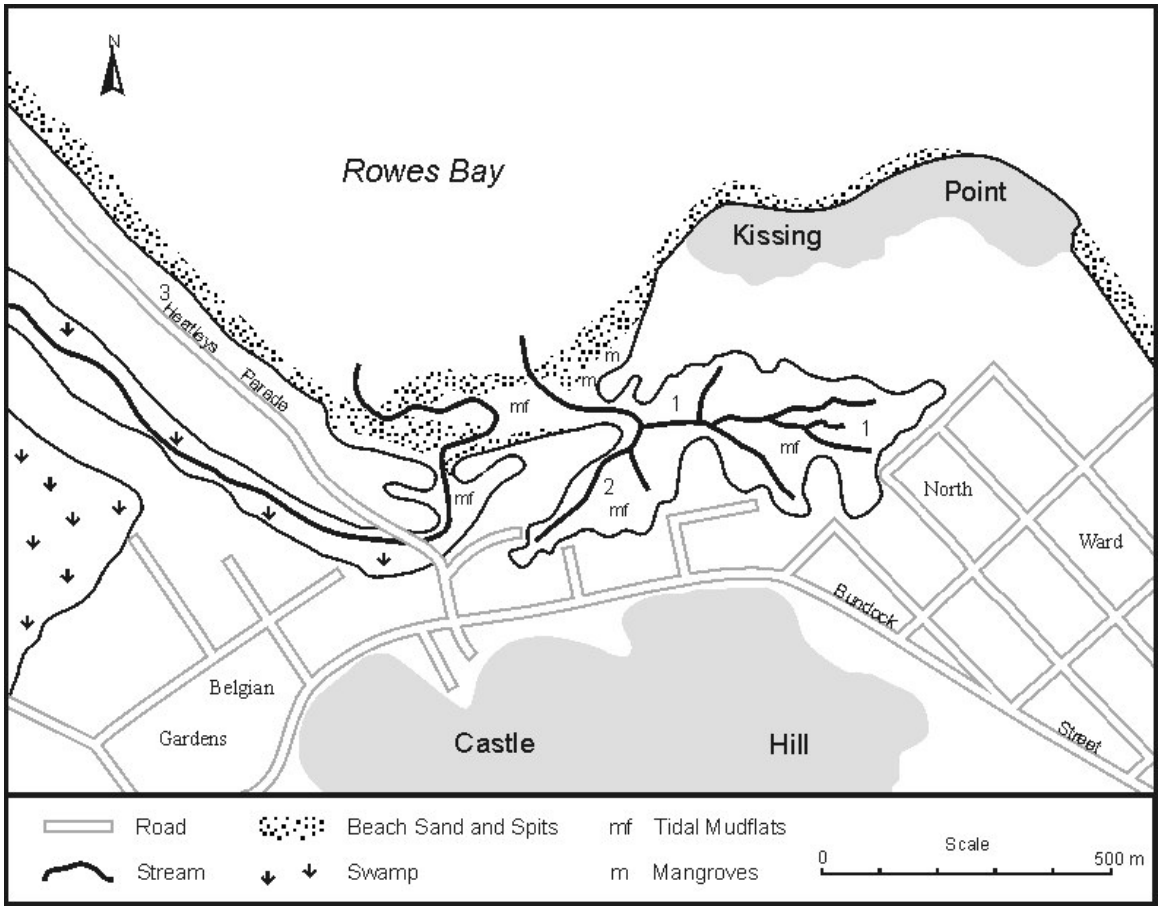

Figure 3 Rowes Bay in 1938 mapped from aerial photographs. (1 = mudflats reclaimed 1938-1941; 2 = mudflats reclaimed 1961-1962; 3 = mouth of One Mile Creek drain, constructed in 1961.)

By 1974 the suburbs around the Rowes Bay foreshore had been almost fully developed. The 0.5 km strip of shoreline between Kissing Point and the RSL Villas contained about 370 houses (North Ward 129, Belgian Gardens 151, Rowes Bay 88), with a population of ~1850. The last areas of mudflats and the Mundy Creek channel had been reclaimed and built on. The only area available for suburban growth has been along the Pallarenda Road in Rowes Bay, and on the lower slopes of Castle Hill. In the 1990s the RSL retirement village was built, and this currently comprises some 70 villas.

5.4 Reclamations

There has been some 18 hectares of reclamation of tidal flats, estuary, stream channels and swamps to accommodate the urban growth in these suburbs. The tidal flats between Kissing Point and Castle Hill were reclaimed in two stages between 1938 – 1941, and 1960 – 1962. About 8 ha of land were reclaimed, and the stream converted to a 400 m long drain. In Belgian Gardens, Primrose Street occupies the former channel of Mundy Creek. This 3.5 ha area was reclaimed in the late 1960s, with the last 0.7 ha of the Mundy Creek estuary being reclaimed by 1980. In Rowes Bay ~3 ha of swamp was reclaimed in the late 1950s when the suburb was first established, and a further 2.5 ha was reclaimed in the early 1990s when the RSL Villas were built.

5.5 Foreshore Changes

5.5.1 Introduction

Term foreshore is used loosely here to mean the modern beach ridge, which extends up to 100 m back from shoreline. The original nature of the foreshore is described above in Section 3. Most of the area has now been extensively modified, particularly after Cyclone Althea in late 1971. It will be described in three sections: the Esplanade foreshore of innermost Rowes Bay, inner Rowes Bay to the One Mile Creek drain; and north Rowes Bay.

5.5.2 The Esplanade foreshore

The Esplanade foreshore extends for 500m southwest from Kissing Point headland. This is the very sheltered innermost part of Rowes Bay. The 1938 aerial photographs show this as a highly mobile sand spit shoreline. However, in the early 1950s this was stabilised, and the Esplanade road constructed along the foreshore in two sections either side of the North Ward drain. Houses have been built to within 30 m of the high tide line, and no remnant of the original foreshore remains. Urban development has thus consumed all of the foreshore area here. Since the early 1980s the mudflats have become progressively colonised by mangroves.

5.5.3 Inner Rowes Bay foreshore

The inner Rowes Bay foreshore comprises a 600 m long by up to 60 m wide strip from Soroptimists Park to the One Mile Creek drain, that is now intensively managed public parkland. There is no direct information on the use of the foreshore until the late 1930s. By that time, although the vegetation had been changed, the foreshore still retained its original landforms of low dunes, swales, and sand spits.

The southern part of the area once contained the estuary of Mundy Creek, and its associated highly mobile sand spits. The creek was cut off in 1962 after the completion of the One Mile Creek drain, and the area was eventually filled and landscaped in 1978. One small remnant of the estuary survives today - a small depression 200 m long and 50 m wide which contains a total of about 75 mangrove trees, with approximately equal numbers of *Avicennia, Ceriops, Rhizophora* species. After the landscaping, the area remained undeveloped until the early 1990s when the Sorpotimists Park was constructed.

The northern part of this foreshore area has had a longer history of modification. A swimming enclosure had been built on the beach here by the late 1930s, and there were many holiday huts on the landward side of Heatley's Parade (see Section 5.3). However, the foreshore itself remained in a largely natural state until the mid-1950s when a replacement swimming enclosure and associated toilet blocks were constructed. The Rowes Bay Caravan Park was also built at this time, and recreational use of the foreshore greatly increased, although formal park facilities were not provided. In the late 1970s the area began to be more intensively landscaped and managed as a public park, and in the late 1980s the swimming enclosure was removed. By the mid-1990s almost the whole foreshore between One Mile Creek and Sorpotimists Park had been landscaped and the original landforms lost.

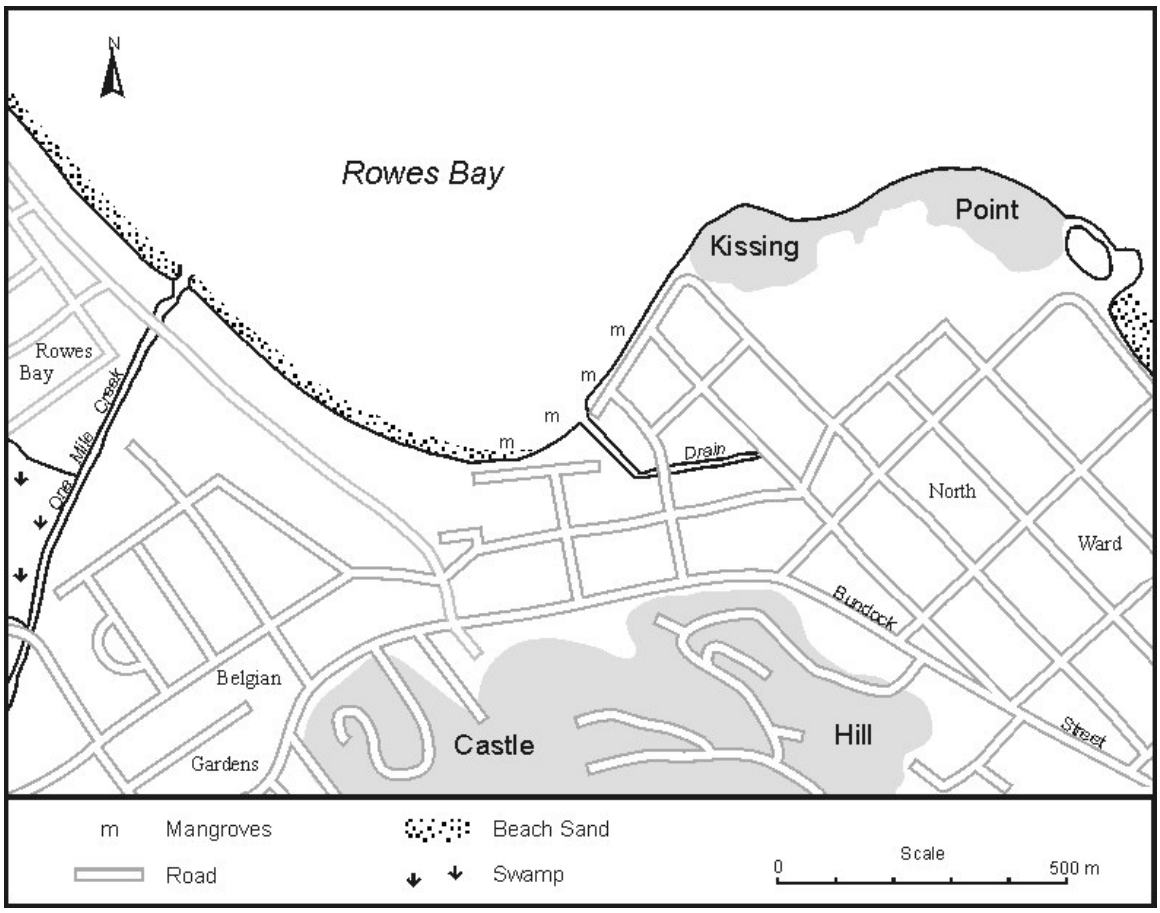

Figure 4 Rowes Bay in 2001

5.5.4 North Rowes Bay foreshore

The north Rowes Bay shoreline extends for 1.1km north from One Mile Creek. At the Creek the road is ~50 m from the shoreline, with the first row of houses a further 110m inland. However, to the north at the RSL Villas, the road comes to within 20 m of the beach, and the first houses are only 80 m from the beach. The area remained largely unmodified until the early 1970s. The beach was backed by a small dune and swale, and the Pallarenda road had been constructed along a higher dune ridge at that time 55-70 m from the beach.

During the late-1960s a distinctive circular toilet block was built on the foreshore opposite the present RSL Villas, and three small unofficial car parks had been established. In December 1971 Cyclone Althea severely damaged the foreshore, and subsequently the whole area north of One Mile Creek drain was reconstructed. Some fill was added to the foreshore, and the original dune and swale landforms were destroyed. The three car parks were hard-surfaced, but the rest of the foreshore was fenced off and left to re-grow naturally.

A cycle path was installed in the late 1980s. After shoreline erosion in 1990s the circular toilet block was removed, and in 1998 a foreshore renourishment program was initiated. One of the car parks was removed, and a sand dune landform was recreated.

5.5.5 One Mile Creek drain

The mouth of One Mile Creek is situated about 100 m southeast of Site T30 (see Figure 4), and beyond this is the inner Rowes Bay foreshore. Observations from aerial photographs taken over the last 40 years show that sand often builds up at the mouth of the creek, but this does not extend south

into inner Rowes Bay. The beach here showed no significant build-up of sand from the 1940s to the late 1990s.

Since the Rowes Bay foreshore renourishment project commenced in late 1998, sand has continued to move south and build-up across the mouth of the creek. However, this build-up now extends southwards and a new berm has formed along ~200 m of the inner Rowes Bay beach face.

The mouth of One Mile Creek has been a persistent problem area ever since is was constructed in 1961. Wave action shifts beach sand southwards, creating a berm landform that rapidly extends across the creek mouth and closes it off. This process has continued since the renourishment project began, and was initially reported in the *Rowes Bay Renourishment Monitoring Report #2* (p4).

The location of the creek mouth seems to be at a critical point in Rowes Bay where the predominant direction of sand transport by the longshore drift process is to the south. Along the Rowes Bay - Pallarenda foreshore, longshore drift processes move sand to the north and south along the beach face. The dominant longshore drift is to the north (driven by the prevailing southeasterly winds), while smaller amounts of southwards sand movement occurs when winds are from the north, northeast, and east (driven by sea breezes and wet season winds). Inner Rowes Bay is protected from the southeasterly winds by Kissing Point, thus longshore drift tends to occur only to the south. The boundary of this inner Rowes Bay protection zone appears to be somewhere between Site T30.3 and the mouth of One Mile Creek.

6. Natural Environment Changes in Rowes Bay

6.1 Introduction

This section summarises the natural environmental changes that have occurred in Rowes Bay over the last 135 years. These predominantly relate to changes that have occurred along the foreshore as periods of accretion and erosion have caused changes in the position of the shoreline. There is little direct information on shoreline change from before 1938. However, periods of erosion and accretion can be inferred from climate records of cyclones and floods. From 1938 onwards much more information is available from aerial photographs, and other records.

6.2 Shoreline Changes in Rowes Bay 1865 - 1938

A sketch map of the Townsville district from ~1865 shows the Rowes Bay area, but includes little information aside from noting the presence of mangroves in the Mundy Creek catchment. The first reliable map of the area is a navy hydrographic chart that dates from 1886. This notes that the area consists of low sand hills with grass and casuarina trees, and shows a sand spit at the mouth of Mundy Creek. It is ~250 m long and deflects the stream mouth to the NW to the area of the present toilet blocks. Bar morphologies are shown offshore from Kissing Point, interpreted as sand being transported from the Strand around into Rowes Bay. No other shoreline information is known until the first aerial photographs were taken in 1938 (see below). However, possible beach erosion and accretion can be interpreted from other sources.

Shoreline erosion is likely to occur with the passage of cyclones over, or close to the city. Appendix 3 lists all cyclones and tropical lows known to have approached within 100 km of Townsville. The list is doubtless incomplete, but it indicates that in the 73 years up to 1938 there may have been at least 12 shoreline erosion events (1867, 1870, 1876, 1878, 1881, 1890, 1896 "Sigma", 1903 "Leonta", 1910, 1916, 1929, and 1934). Damage to buildings or port facilities were reported for the 8 cyclones up to "Leonta" (1903), and beach erosion is very likely to have occurred as well. The remaining events in the early decades of the twentieth century were apparently much weaker systems, and no reports of damage have been found. Thus, there may have been several decades without significant beach erosion prior to the late 1930s.

Episodes of beach accretion in Rowes Bay are much more difficult to infer. Floods in the Ross River are likely to bring large volumes of sand to Cleveland Bay, but it probably takes some decades for this sand to be worked along the shoreline into Rowes Bay. After the first breakwaters

at the port were constructed, transport of sand from the river mouth would have ceased, thus only floods prior to 1875 could have contributed sand to Rowes Bay. Rainfall records give some indication of likely floods, but these records only began in 1871. The cyclones of 1867 and 1870 appear to have caused the river to flood, and rainfall records show that there were also probable floods in 1872 and 1874. However, 1874 does not mark the immediate end of sediment supply to Rowes Bay. Sand already in the system on the Strand Beach would still have been moved around Kissing Point, and there is evidence to suggest that this continued until the 1930s (see Section 6.3).

6.3 Shoreline Changes in Rowes Bay 1938 - 1998

6.3.1 Introduction

From 1938, a more detailed record of shoreline changes in Rowes Bay can be compiled from aerial photographs and beach profile surveys. Aerial photographs taken at ~5 yearly intervals from 1938 – 1995 allow detailed descriptions of shoreline features, and some measurements of shoreline position. Beach profile surveys from 1982 – 1998 allow accurate measurements of shoreline position and calibration of the aerial photograph data. From this data, two broad phases can be identified: shoreline advance from 1938 – 1952, and shoreline erosion from 1952 – 1998. Changes in shoreline position are very important as these show how much the shoreline is advancing or being eroded, and this has significant implications for the Pallarenda Road and utilities, and Rowes Bay housing and foreshore amenities.

6.3.2 Methods

General descriptions of shoreline change have been compiled from the aerial photographs that are available from 1938 (see Appendix 3). These images allow 3-D observation of ground features at large scales (1:15,000 to 1:5,000), and detailed descriptions compiled from these aerial photographs are presented in Appendix 1.

Accurate measurements of shoreline position have been complied for six sites along the foreshore (Tables 1 – 3), by measuring the distance from the centre of the Cape Pallarenda Road to the top of the beach. Close examination of the photographs showed that the road alignment had not shifted since 1938, and in most cases the centreline markings on the road could be seen in the images. The top of the beach was taken at the upper limit of normal wave action, and this was clearly marked on the images by a distinct change in slope at the seaward side of the dunes (in the earlier photographs), or the top of the beach erosion scarp (on later images).

The six sites, T29.5, T30, T30.5, T31, T31.7, and T32 were spaced at ~250 m intervals along the Rowes Bay shoreline (see Figure 5). These are the sites of marker posts that have been established by the BPA and TCC from which precision ground surveys of shoreline topographic profiles have been carried out at irregular intervals since 1982. The locations of these markers can be accurately plotted in the aerial photographs, thus allowing shoreline measurements at these sites to be extended back to 1938.

Buildings and bridges visible on the photographs provided a number of ground control dimensions from which the image scales could be accurately calculated. Using a micrometer calibrated to 0.1 mm, distances were measured to an accuracy of better than ±2 m. Measurements from the 1981 – 1995 photos were also checked for accuracy against the ground survey data.

Shoreline change data is presented in Tables 1 – 3. In these, the bay is subdivided into north and inner sections. North Rowes Bay extends for 1000 m northwest of One Mile Creek and is covered by sites T30 – T32. Inner Rowes Bay extends southeast for 715 m from One Mile Creek and is represented by site T29.5.

Table 1 Shoreline change at BPA/TCC beach profile sites along Rowes Bay foreshore, measured from aerial photographs (1938-1995) and beach profiles (1998). Distances in metres. For locations see Figure 5.

	Year	1938*	1941	*1952*	1961	1965	1971	1972	1974	1976	1981	1985	1991	1995	1998	1998*	Total since 1952
Location																	
North Rowes Bay	**T32**	59	-5	*13*	-1	-5	4	-19	3	2	-6	5	-4	-2	-1	43	-24
	T31.7	57	-5	*7*	-6	-5	-1	-13	2	2	-6	-3	-2	0	-3	24	-35
	T31	54	-7	*15*	-7	-6	-1	-11	1	1	-8	-2	-1	0	-4	24	-38
	T30.5	70	-1	*3*	-8	-6	0	-12	6	-2	-1	-2	-5	-3	-3	36	-36
	T30	66	-7	*12*	0	-9	7	-8	1	1	-2	-1	-1	0	-8	51	-20
Average		61.2	-5.0	*+10*	-4.4	-6.2	+1.8	-12.6	2.6	0.8	-4.6	-0.6	-2.6	-1.0	-3.8	35.6	-30.6
IRB	**T29.5**	59	-17	*30*	-2	1	-3	-5	1	1	3	-3	2	-2	-6	59	-13

* Distance in metres from centre of Cape Pallarenda Road to top of beach.
All other measurements are beach change since previous measurement.

Table 2 Summary of shoreline changes (in metres) at BPA/TCC beach profile sites along Rowes Bay foreshore, 1938 – 1998.

Location	1940 Cyclone	1941-1952	1952-1971	Cyclone Althea (24/12/71)	1972-1976	1976-1997	Cyclone Sid 12/1/98
T32	-5	13	-2	-19	5	-7	-1
T31.7	-5	7	-12	-13	4	-12	-2
T31	-7	15	-14	-11	2	-12	-3
T30.5	-1	3	-14	-12	4	-12	-2
T30	-7	12	-2	-8	2	-4	-8
T29.5	-17	30	-4	-5	2	-1	-5
Average*	**-5.0**	**10.0**	**-8.8**	**-12.6**	**3.4**	**-9.4**	**-3.2**
Years		**11.1**	**19.06**		**3.77**	**21.4**	
Rate*		**0.9m/yr**	**-0.5m/yr**		**0.9m/yr**	**-0.4m/yr**	

* North Rowes Bay (sites T32 – T30).

Table 3 Changes in sand volume along Rowes Bay foreshore 1938 - 1998. Calculated as follows: shoreline length × sand depth × average change from Table 1 (Nth RB = 1000m × 5m × av. change; Inner RB = 715m ×3m × av. change)

	1938-1952	24/12/1971	1952-1998	Rate
North Rowes Bay	+25,000 m^3	-65,000 m^3	-153,000 m^3	-3,300 m^3/yr
Inner Rowes Bay	+63,000 m^3 *	-11,000 m^3	-28,000 m^3	-610m ^{3}/yr
Total	+88,000 m^3	-76,000 m^3	-183,000 m^3	

* Includes 35,000m^3 from Kissing Point sand spits (see Appendix X)

6.3.2 Shoreline advance phase: 1938 – 1952

The 1938 aerial photographs show the beach system in a healthy state, with no evidence of erosion along north Rowes Bay, and significant shoreline accretion occurring in inner Rowes Bay. It is not known when this phase began, however, there had been no significant cyclones since Leonta in 1903, and so this period of shoreline advance could well have been underway for several decades. Figure Q shows the 1938 aerial photograph of Rowes Bay, and this is described in detail in Appendix 1. The most obvious shoreline features are the sand spit extending west from Kissing Point, and the large area of mudflats extending towards North Ward. The spit was some 650 m long and 25–30 m wide, and assuming it was 1.5 m high, contained ~35,000 m^3 of sand. It is interpreted

that this sand had been moved from the Strand around Kissing Point, and was being shifted onshore by northerly and easterly wave action.

The shoreline advance phase was interrupted in 1940 by an erosion event associated with a tropical cyclone. The 1941 aerial photographs shows the north Rowes Bay shoreline had retreated ~5 m (Tables 1 & 2), inner Rowes Bay by as much as 17 m, and the sand spit system had been moved ~50m closer to the shore. Extensive wave wash-over along north Rowes Bay had affected the vegetation behind the beach. This erosion was probably associated with the cyclone of 7th April 1940 which hit Townsville directly, although an earlier category 3 cyclone of 19th February which hit Ingham may also have affected the beach.

The 1952 aerial photographs show the Rowes Bay foreshore in its healthiest known condition. The erosion of 1940 has been completely recovered, and further growth has built the shoreline out to be more than 60 m from the Pallarenda Road. The north Rowes Bay beach grew ~10 m (Table 1) at a rate of ~1 m/year (Table 2), while the inner Rowes Bay shoreline has advanced 30 m. However, the sand spit system has almost disappeared, having been moved a further 30 m closer to the shore.
By 1952 a considerable volume of sand had accumulated along the Rowes Bay shoreline, and this has been quantified in Table 3. In the 14 years from 1938 – 1952 about 88,000 m^3 of sand had been added to the Rowes Bay shoreline, at an average rate of ~6,300 m^3/year. This is the last period during which substantial quantities of new sand were added to the beach.

6.3.3 Shoreline erosion phase: 1952 – 1998

From 1952 the shoreline has been in an overall erosion phase, with slow erosion punctuated by rapid beach loss during cyclones. The 1950s saw numerous cyclones pass close to Townsville, with the category 3 Cyclone Agnes in 1956 being a direct hit. Unfortunately there is no data available on beach erosion associated with these events, although the 1961 aerial photographs show that only about 4.5 m of beach erosion had occurred since 1952. From 1952 – 1971 the shoreline retreated at an average rate of ~0.5 m/year (Table 2).

Cyclone Althea on 24th December 1971 has been the single most important beach erosion event in Townsville over the last 50 years, and its effects are still being felt. North Rowes Bay beach was eroded ~13 m. The few hours of high-energy wave attack during this cyclone caused ~42 % of the total beach erosion that occurred in the 43 years from 1952 – 1995. Some shoreline recovery occurred after the cyclone, and the beach advanced nearly 3.5 m up until 1976. This was presumably due to sand that had been eroded from the beach onto the mudflats being returned to the beach by wave action.

From 1976 the erosion trend has again dominated, with two periods of more rapid erosion in the late 1970s, and late 1980s when a number of cyclones passed close to Townsville (see Appendix 2). On 12th January 1998 ex –Cyclone Sid struck Townsville with a record deluge of rainfall producing 549 mm in 24 hours. The rainfall runoff combined with wave erosion caused significant beach erosion, with 3.2 m of shoreline being lost. Unlike after Cyclone Althea, little beach recovery occurred after these events as the system has become increasingly starved of sand.

In the 46 years from 1952 – 1998 about 183,000 m^3 of sand has been lost from Rowes Bay (Table 3), and the shoreline has retreated nearly 31m (Table 2). The average rate of sand loss along north Rowes Bay has been 3,300 m^3/year. This rate of sand removal is essentially the same as the geological rate of longshore drift calculated from the last 6000 years of shoreline change (see Section 3.4). From this it can be seen that although natural sand supply to Rowes Bay has ceased, the wave processes continue, and they require an average of about 3,300 m^3 of sand to satisfy longshore drift requirements. In the absence of a supply of sand moving along the shore from the Ross River, the beach obtains its sediment by eroding the foreshore, which causes the shoreline to retreat. This situation will continue indefinitely, and the erosion zone will migrate northwards towards Pallarenda, unless a supply of renourishment sand can be committed to Rowes Bay.

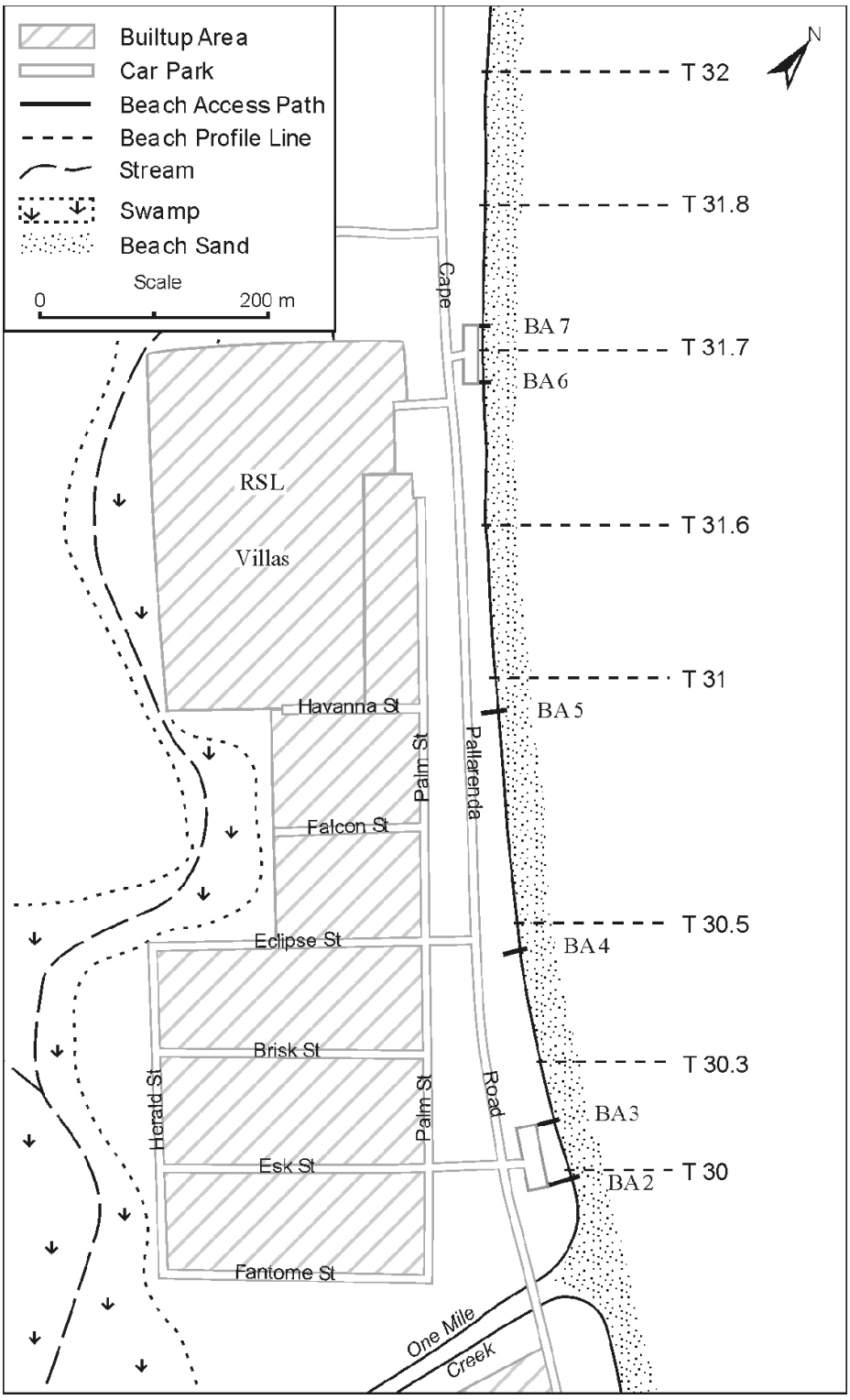

Figure 5 Location of foreshore change monitoring sites in north Rowes Bay.

7. Significant Events Affecting Rowes Bay Since 1865

The foreshores of Rowes Bay have been affected by a number of significant events over the past 135 years. These have combined to shape the landscape and its process regime as it is seen today.

1874-1891: Development of the Port breakwaters

From 1874 to 1891 the main eastern and western breakwaters were constructed at the Port. These extended some 1.5 km out from the shoreline, and have effectively stopped the natural transport of sand that originally took sediment along the shoreline from Ross River through to The Strand, and around Kissing Point into Rowes Bay, and subsequently on to Pallarenda. The breakwaters extend out into water depths that are beyond where sand transport can occur. Sand movement along the shore was slow and episodic, so the effects of the Port breakwaters were not seen for many decades.

Early 1930s: The last major input of sand around Kissing Point into Rowes Bay

A pulse of sand passed around Kissing Point into Rowes Bay probably sometime in the early 1930s. This was then slowly moved onshore by wave action, taking up to 20 years to reach the Rowes Bay shoreline. The 1938 aerial photograph shows about 35,000 m^3 of sand spits moving into inner Rowes Bay, and by 1952 some 53,000 m^3 had accumulated along north Rowes Bay. Thus this total sand input was probably about 88,000 m^3. No large amounts of sand have been naturally added to the foreshore since that time.

1952: Rowes Bay beach at its most advanced

The 1952 aerial photographs show the Rowes Bay foreshore in its most advanced condition ever recorded. Wave processes had worked sand up onto the beach recovering all of the erosion of 1940, and advancing the beach on average ~13 m beyond its 1938 position. This probably represents the shoreline condition after the last of the natural sand supply had been added to the beach.

Mid 1950s: Initiation of persistent shoreline erosion

The shoreline erosion phase of the latter part of the 20th Century began sometime shortly after 1952. This erosion has gradually worked its way northwards along Rowes Bay, as the starvation of sediment becomes more and more acute. The 1961 aerial photographs also show the north Rowes Bay beach with a clear erosion scarp. This is the first time this feature has been seen on the beach, and it has been a persistent feature since then. It probably signals the start of the long-term erosion trend as a result of the cessation of natural sand supply to the foreshore. This is more than 80 years after the sand supply from Ross River was originally interrupted by the construction of the first Port breakwater in 1874.

1961: Construction of One Mile Creek drain

The construction of the One Mile Creek drain completed the radical change to the drainage systems of Rowes Bay that had begun with the removal of the nearby North Ward Creek and mudflats. The lower kilometre of Mundy Creek and its estuary have also been almost completely removed from the landscape. The One Mile Creek drain was completed at the end of 1961, and subsequently its channel and mudflats have been reclaimed. The mouth of Mundy Creek had constantly changed position in response to the movement of sand spits, bars and beaches at the entrance. Similar processes have affected One Mile Creek drain and its mouth has required regular re-opening after being blocked by the migration of the beach and sand bars. This is not surprising, as artificial stream channels cut through beaches have almost always required the construction of training walls to keep them open. A similar process could be considered for One Mile Creek.

1971: Cyclone Althea

Cyclone Althea has been a very significant event in Rowes Bay, and its effects are still being felt. North Rowes Bay beach was eroded ~13 m, and there was only a brief period of recovery before the long-term erosion trend set in again.

Post Cyclone Althea

The landscape of the north Rowes Bay foreshore was completely reconstructed after the cyclone, and no natural features have remained along here. Inner Rowes Bay was also eroded, but not as extensively, and little reconstruction work was required. The foreshore here retained some features of its original form in the area at the mouth of the former Rowes Bay Creek. However, these mostly disappeared with the construction of the Soroptimists Park by the early 1990s.

Only one small natural landform remains on the whole Rowes Bay foreshore: remnants of a lagoon that was once part of the Mundy Creek mudflats. This can be seen today as a shallow depression behind the Soroptimist's Park beach, and it is still lined with a few of its original mangrove trees (see Section 5.5.3). The feature is obvious on the 1938 aerial photographs, and is probably considerably older than this.

Shoreline recovery after Cyclone Althea lasted for about 5 years, but since 1977 erosion has continued and a further ~ 13 m of foreshore has been lost. After ex-Cyclone Sid in 1998 a Townsville City Council foreshore renourishment program was been initiated and this has helped to mitigate the erosion trend.

8. Conclusions

This environmental history of Rowes Bay provides a useful context in which to understand the present erosion problems affecting the foreshore. Significant issues that emerge from this history include the following.

1. The Rowes Bay foreshores have been considerably altered by human activities, although most of these changes within the bay have had little overall effect on beach stability.
2. The present erosion problems began about 45 years ago. The overall rate of erosion during this time has been slow, but appears to be increasing as the system becomes increasingly starved of sand. More than half the total erosion occurred in one event, Cyclone Althea.
3. The causes of the erosion pre-date the first appearance of the problem, and relate to events beyond the immediate Rowes Bay area. The erosion problems are related to the construction of the Port breakwaters over 125 years ago, which stopped sand transport northwards from the mouth of Ross River.
4. The rate of foreshore erosion since 1952 has been about 3,300 m^3/year, which is very similar to the calculated long-term rate of sand longshore drift through the Rowes Bay – Pallarenda foreshore and beach system. Addition of sand to the foreshore at a rate equivalent to 3,300 m^3/year would provide for the long-term maintenance of this system.
5. The on-going problems associated with the mouth of One Mile Creek relate to its position across an active beach face. Natural longshore drift processes will quickly close the mouth of the drain whenever it is artificially opened.

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APPENDIX 1

Environmental changes along Rowes Bay foreshore, 1864-2000.

1864	Townsville established in November.
1867	8th March - first cyclone hits settlement. Probable beach erosion.
1870	20th February - cyclone demolishes most of the town. Probable beach erosion.
1874	17th February - cyclone damages much of Townsville. Probable beach erosion.
1874	First breakwater constructed at Townsville Port. The construction of this ~120 m long causeway between Ross Island and Magazine Island marked the beginning of the end of the natural supply of sand from Ross River to the Strand and Rowes Bay beaches. The Townsville Portmaster commented: *"Through this opening a constant supply of sand from Ross River had previously poured into the entrance of* (Ross Creek) *forming a series of bars and shoals. This movement of sand has been entirely arrested by the breakwater."* Breakwater on the north side of Ross Creek also constructed ("Fountains Folly"), extending ~400 m out into Cleveland Bay.
1876-1889	Construction of Eastern Breakwater at Port which eventually extends ~850 m out into Cleveland Bay. Wave action would be unlikely to be able to transport sand from Ross River mouth around this obstruction.
1884	First dredging of Platypus Channel. Any sand from Ross River mouth reaching the end of the breakwater would be intercepted by this dredging.
1886	Hydrographic chart shows a sand spit at the mouth of Mundy Creek. It is ~250 m long and deflects the stream mouth to the NW to the area of the present toilet blocks. Bar morphologies are shown offshore from Kissing Point, interpreted as sand being transported from the Strand around into Rowes Bay.
1891	Western Breakwater at Port completed.
1892	24th January – 488 mm rainfall event in 24 hours. Some beach erosion may have occurred.
1896	26-27th January - Cyclone Sigma causes damage over a wide area. Probable beach erosion.
1903	9th March Cyclone - Leonta severely damages Townsville. Probable beach erosion. 28th December – 381 mm of rain fell in 24 hours. This may also have caused some beach erosion.
1908-1943	Construction of weirs on Ross River. Gleeson's Weir (1908), 14.8 km from mouth. Aplin's Weir (1928), 10.5 km from mouth. Blacks Weir (1934), 16 km from mouth. Aplins Weir rebuilt (1943). Since 1908, the natural supply of sand to the mouth of Ross River has been restricted to the lower ~15 km of channel, and since 1928 further restricted to the lower 10.5km of channel. However, since 1875 any sand delivered to the mouth was being trapped to the east of the Port breakwaters.
1910-1934	Four weak tropical cyclones (1910, 1916, 1929, 1934) pass within ~50 km of Townsville. Some beach erosion may have occurred.
Early 1930s	Heatley's Parade road to Three Mile Creek constructed, and the fig trees (visible of the 1938 aerial photographs) along the seaward side of this were probably planted soon after. The Three Mile Creek bridge and road to Pallarenda were completed by the mid 1930s.
1938	5th July - aerial photographs. These are the earliest known vertical aerial photographs of Townsville, and they show that development of North Ward and Belgian Gardens suburbs was underway, and the original vegetation communities were largely gone.

However, the landforms retained much of their original character, as the few roads and dwellings had all been placed on the highest parts of the coastal flats. Figure 3 shows Rowes Bay as mapped from these aerial photographs. Reclamation of the North Ward Creek mudflats has just commenced along the north side of McKinley Street. A swimming enclosure has been built on the Rowes Bay beach next to the present toilet blocks.

The rock platform around Kissing Point is covered with sand, making a continuous beach from the Strand around into Rowes Bay. A subtidal bar extends to the northwest from the east end of the point, marking the continued transport of sand from the Strand into Rowes Bay.

Inner Rowes Bay is dominated bay a sand spit extending 650 m west from Kissing Point, enclosing at its eastern end a small mangrove community. The spit was 25-30 m wide, and assuming it was 1.5 m high, contained ~35,000 m^3 of sand. The western end of the spit reached to within a few metres of the Rowes Bay shoreline, and here enclosed a smaller spit that extended about 250 m to the east. This spit in turn enclosed an elongated tidal lagoon in the area of the present Sorpotimists Park. A little to the north, another narrow lagoon was situated behind the beach, probably a remnant of the NW trending sand spit that was mapped on the 1886 hydrographic chart.

The north Rowes Bay shoreline comprised a beach about 30m wide, backed by a belt of low dunes up to 15 m wide. These enclosed a small linear depression containing few scattered trees – the only trees on the foreshore at that time. The Cape Pallarenda Road had been placed on a slightly higher sand ridge about 55 – 77 m inland of the beach. Numerous bars are present on the intertidal flats.

1940 19th February - Category 3 tropical cyclone crosses the coast near Ingham. Some beach erosion may have occurred.

7th April - a cyclone hits Townsville. Beach erosion probably occurred.

1941 June aerial photographs. Since 1938 the eastern ~8 ha of the North Ward Creek mudflats between McKinley and Ryan streets have been reclaimed, and the creek converted to a drain. Changes (mostly erosion) are evident along the whole shoreline, probably caused by wave attack during the 1940 cyclones.

The Kissing Point rock platform had lost its sand cover for ~200 m near the east end of the point, but beach sand still covered the rest.

The sand spit system was still prominent in inner Rowes Bay, but has moved about 50m closer to the shore. It has disrupted the former mangrove community, while a larger area of mangroves had become established west of the mouth of the new drain. The Inner Rowes Bay foreshore has been eroded nearly 20 m (see Table 1) resulting in the loss of the 1886 lagoon.

North Rowes Bay has also suffered 5 – 7 m of beach erosion, with wave washover extending into the depression behind the low dunes and killing the vegetation. This had presumably been caused by the cyclones of 1940. At profile site T30.5 only limited erosion occurred (see Table 1), and a small bulge is evident in the shoreline here. The subtidal bars off Kissing Point are still evident, but high tide waters at the time of the photography obscure any evidence of intertidal bars.

1944-1950 Five weak tropical cyclones (1944, 1945, 1946, 1947, 1950) pass within 50 km of Townsville. Some beach erosion may have occurred.

1946 3rd March – 367 mm of rain fell in 24 hours. Some beach erosion may have occurred.

1952 5th July aerial photographs. These photographs show the Rowes Bay shoreline in its most advanced position. If the recent cyclones had caused any erosion, the beach had very quickly recovered. Heatley's Parade next to what is now Soroptimists Park has

been re-aligned to its present position, while the Esplanade road has been established east of the drain.

Kissing Point is not fully visible on these photographs, however sand still appears to lie on the western end of the rock platform.

The inner Rowes Bay shoreline south for 350 m from Kissing Point to the drain (along the new Esplanade) has lost its sandy beach, and this section of the shore has changed little since then. The sand spit system is still evident, although reduced in size, and it has moved a further 30m closer to the shore. Mundy Creek enters the bay ~150 m east of its former mouth. Mangroves have begun to grow on the outside of the spit, and also now line the creek for 350 m upstream of Heatley's Parade. The shoreline had advanced 30 m, more than recovering the losses from the cyclones of 1940.

North Rowes Bay had also accumulated more sand, the beach advancing between 3 and 15 m. (See Tables 1 and 2.)

1954-1956 Three Category 1 cyclones (1954, 1955 Carmilla, 1956) passed 50-70 km from Townsville. A small amount of beach erosion may have occurred.

1956 6th March - Cyclone Agnes (Category 3) passes E-W over Townsville. Beach erosion probably occurred.

1958-1959 Three cyclones (two in 1958, 1959) passed 50-80 km from Townsville. A small amount of beach erosion may have occurred.

1959 7th June aerial photographs. These photographs only show part of inner Rowes Bay, where the caravan park has recently been established, new toilet blocks erected on the foreshore, and a new swimming enclosure has replaced the previous structure. Primrose Street has been established for one block either side of Heatley's Parade. Swampy ground in the Mundy Creek channel has been reclaimed behind the north Rowes Bay beach to allow the Rowes Bay suburb to be laid out. The sand spit system has almost disappeared, with the last remnants having moved about 10m closer to the shore next to the Esplanade. Mundy Creek has formed a new mouth, cutting through the beach ~100 m west of its previous position and forming a small delta.

1959, 1961 Two small cyclones passed ~50 km to the E and NE of Townsville.

1961 8th November aerial photographs. This year marks a significant change in Rowes Bay with the construction of the One Mile Creek bridge and drain (Captains Creek). The aerial photographs show the construction of these in their final stages. The second branch of the Esplanade road has been built to the west of the North Ward drain, and the reclamation of the last ~3 ha of the mudflats is underway between Ryan and Marshall Streets.

The Kissing Point rocky platform has lost almost all of its sand accumulations, and there is no longer a continuous beach from the Strand around into Rowes Bay.

Inner Rowes Bay contains some small sand deposits extending 300 m west from the drain, the last remnants of the sand spit system. Rowes Bay Creek has formed a meander across the beach and its mouth is deflected ~100 m by a small NW trending sand spit. Since 1952 there has been some small erosion of the beach. Dense stands of mangroves line the creek for some 600 m, up to where it is cut off by the One Mile Creek drain.

North Rowes Bay shows the development of the new suburb. The figs are now the only surviving trees between the road and the beach, which has lost between 4 – 8 m since 1952 (see Table 1). An erosion scarp is prominent along the whole beach. This is the first time such a feature has been present.

1964 November aerial photographs. These only show Kissing Point and part of inner Rowes Bay. The reclamation between Ryan and Marshall Streets has been completed, and Primrose Street extended. Mangroves are being cleared from Mundy Creek near the new drain. The mouth of Mundy Creek is completely blocked by beach sand as there is no longer any significant flow reaching the shore here. The mouth of One Mile Creek is not shown.

1968 Rockpool constructed on Strand. This acts as a trap, blocking sand loss from the Strand. This may mark the very last time that any sand at all was able to move around Kissing Point towards Rowes Bay.

1970 1st November aerial photographs. These show inner Rowes Bay, and part of north Rowes Bay. Primrose Street has been extended along the former line of Mundy Creek upstream of Heatley's Parade. Northwest of Heatley's Parade the old creek line is occupied by a dense stand of mangroves.

The mouth of One Mile Creek is blocked by beach sand.

1971 16th February - Cyclone Gertie passed 80 km NNE of Townsville.

1971 23rd July aerial photographs. These only show the mouth of One Mile Creek (which has recently been opened by heavy machinery), and north Rowes Bay. A circular toilet block has been built on the foreshore in front of what is now the RSL Villas. Apart from the figs, the foreshore is still devoid of trees, and there are noticeable areas of bare sand around several informally developed car parks, and on the low dunes behind the beach face. Slow erosion has continued, with 3 – 6 m of beach lost since 1961, and the erosion scarp still in evidence.

1971 24th December - Cyclone Althea (Category 3) hits Townsville causing considerable damage. Much of the foreshore was eroded between 10 – 20 m.

1972 14th September aerial photographs. These show the aftermath of Cyclone Althea during a phase of foreshore reconstruction.

Inner Rowes Bay suffered less damage than elsewhere, with only ~5 m of beach lost. There appears to have been little reconstruction through this area, and there has been little change to the beach position along this foreshore since then.

There had been significant erosion of the beach north of One Mile Creek along north Rowes Bay. Measurements from the aerial photographs are difficult, as the foreshore has being extensively re-shaped by heavy machinery, and sand is being transported to the top of the beach from the intertidal flats. Erosion measurements can only be approximate, but indicate 8 – 19 m of beach were lost, amounting to a total of ~65,000m^3 (see Table 2). Most of the fig trees survived the cyclone, however the rest of the foreshore is completely devoid of any vegetation. One Mile Creek is blocked by beach sands that have formed a large delta-like accumulation across the mouth. The present foreshore landscape of north Rowes Bay largely dates from this period of post-cyclone reconstruction. As a result of the cyclone and the reconstruction, all traces of the original foreshore landforms (dunes, depression, old beach ridge) were lost, or completely modified.

1973 19th December - Cyclone Una (Category 3) passes 30 km east of Townsville.

1974 30th May aerial photographs. The first of the BPA aerial photographs.

Kissing Point has a narrow strip of sand on its rock platform.

Inner Rowes Bay has recovered from the effects of the cyclone, with the beach now permanently blocking the remnants of the outlet of the former Mundy Creek. Mangroves still occupy the old channel and lagoon north of Heatley's Parade.

The mouth of One Mile Creek drain is open, and there is a sand bar on the intertidal mudflats in front.

Along north Rowes Bay the foreshore still contains large areas of bare sand, particularly in the north. Some trees have been planted, and three car parks have been built close to the shore opposite Fantome and Falcon streets (car park #s 1 and 2), and in front of the present RSL Villas next to the round toilet block (car park #3). Some rock protection appears to have been placed on the beach in front of this car park. The beach has advanced up to 6 m in a small recovery since the cyclone, and the erosion scarp has not reformed at this stage.

There are a number of prominent sub-tidal bars offshore from Rowes Bay, possibly formed from sand lost from the beach during cyclone Althea.

1976 — 20th July aerial photographs. These only show Rowes Bay from the Esplanade north. There has been little change since 1974. Vegetation cover has improved on the reconstructed areas behind the beach north of One Mile Creek as far as the car park number three. North of here there is still much bare sand, although a foreshore replanting program appears to be underway. The beach has continued to advance a little. The One Mile Creek drain is open, with a sand bar on the mudflats is a similar position to that of 1974.

1976-1980 — Five Category 1 cyclones or tropical lows pass 10 – 95 km from Townsville. (Dawn 5/3/76; Keith 1/2/77; Otto 9/3/79; Kerry 2/3/79; Paul 7/1/80). Possible beach erosion.

1981 — 14th July BPA aerial photographs. The mangrove community in the former channel of Rowes Bay Creek has been cleared and this area reclaimed. The only remnant of the natural landscape here is an elongated depression that lies between the beach and Heatley's Parade. It is 180 m long and up to 20 m wide and is lined with mangrove trees. This feature and its mangroves remain to this day.

The mouth of One Mile Creek is nearly closed by a small sand spit that projects south across the entrance, and there are several small sand bars on the intertidal mudflats in front.

The north Rowes Bay foreshore is well grassed, and some scattered trees are now evident. Some erosion has occurred with up to 7 m of beach lost near car park #3, but the erosion scarp is still not well developed.

1985 — 16th June BPA aerial photographs. Little change since 1981. One Mile Creek drain mouth is blocked by a narrow bar that curves across the entrance. A cycle path has been built north from car park #3, and there is more rock protection on the beach here. There have been small adjustments to the beach position with 1 – 3 m of erosion and 5 m of accretion at various points along the shoreline (Table 1). This has left the foreshore with a slight bulge in the area around car park #3. The erosion scarp is present, but not prominently developed.

1988-1990 — Four Cyclones or tropical lows pass within 70km of Townsville. Charlie 29/2/88; Aivu 4/4/89 (Category 3); Ivor 24/3/90 (tropical low); and Joy 26-27/12/90 (tropical low). Some beach erosion probably occurred, and there was increased public awareness of the erosion problems.

1991 — 10th September BPA aerial photographs. On the inner Rowes Bay foreshore the Soroptimists Park has been constructed in the area of the former mouth of Mundy Creek, and the swimming enclosure has been removed. Mangroves are beginning to colonise the shoreline along the Esplanade.

There is a large bar complex at the mouth of One Mile Creek, and the entrance is open. Rock has been placed on the beach to protect the foreshore to the north of the drain mouth. The RSL Villas are under construction, and the cycle path has been extended south from here to One Mile Creek. There has been significant erosion along the whole foreshore with up to 5 m of beach retreat occurring. The erosion scarp is now prominent, although some recovery is apparent north of car park #3.

The erosion was probably caused by the recent cyclones, and it prompted renewed interest in the erosion problems by the City Council and Beach Protection Authority.

1995 23rd August aerial photographs. These are the most recently available aerial photographs. Mangrove growth along the Esplanade has continued, and the mouth of One Mile Creek has a very narrow opening. Only a small amount of erosion has occurred since 1991. The erosion scarp is still clear, but has been filled with beach sand north of car park #3.

1997 Three cyclones or tropical lows pass within 55 km of Townsville. Gillian 12/2/97; Ita 24/2/97; Justin 23/3/97. Some beach erosion occurred.

1998 11th January - ex-Tropical Cyclone Sid. 549 mm of rain fell in 24 hours, causing significant erosion of Townsville's coastline. This erosion was caused by wave attack, and runoff of surface floodwaters. An average of 4m was lost from the Rowes Bay shorleine.

1998 November-December renourishment program began along north Rowes Bay. ~16,000m^3 sand used to replenish the beach and build a new dune landform. The dune area is re-vegetated, and car park #2 has been removed. This partially restored the foreshore landforms to their pre-Cyclone Althea condition of 27 years previously.

2000 3rd April - Cyclone Tessi causes some erosion damage to Rowes Bay beach, but the renourishment remains largely intact. The shoreline today is shown in Figure 4.

APPENDIX 2

Tropical Cyclones Near Townsville 1867 - 2000

The table on the following page lists cyclones that have passed close to Townsville since 1867. The record is likely to be incomplete prior to about 1940, and especially before 1900. From World War 2 onwards it is probably more reliable, and with the development of weather satellite technology after 1960 it is likely to be substantially complete.

The category column refers to the category of the cyclone at its closest approach to Townsville. Categories have the following characteristics:

Category	Average wind speed (m/s)	Strongest gust (m/s)	Central Pressure (hPa)
0	<17	-	~1000
1	17-25	<35	1000-985
2	25-33	35-47	985-970
3	33-44	47-62	970-945
4	44-56	62-78	945-920
5	>56	>78	<920

Categories 3, 4, and 5 can cause considerable damage. Category 0 is essentially a tropical low (*tl*). Those listed as *r* (reformed) were tropical cyclones that had crossed the coast and decayed to tropical lows, then passed back out to sea and reformed.

The movement column refers to the direction the cyclone was moving, and the distance to centre notes the kilometres and direction to the cyclone centre. The front left quadrant (assessed in the direction of cyclone movement) is the most damaging part of a cyclone.

Likely beach erosion from these cyclones is a complicated function of cyclone category, wind strength and direction, distance and direction to cyclone centre, speed of cyclone movement, and state of the tide.

Cyclones passing 100 – 50 km from Townsville will probably only cause beach erosion if they are strong, and the resulting waves are able to enter Cleveland Bay directly.

Cyclones passing within 50 –25 km are more likely to result in beach erosion, especially if Townsville is in the front left quadrant.

Cyclone passing within 25 km of the city are very likely to cause extensive beach erosion.

Name	Date	Category	Movement	Distance and direction to centre	Townsville in front left quadrant	Notes
	8/3/1867					Houses demolished
	20/2/1870					Most houses demolished
	17/2/1876					Much damage in Townsville
	?/3/1878					Jetty construction delayed
	?/3/1881					Port jetty damaged
	?/3/1890					Port breakwaters damaged
Sigma	26-27/1/1896					Much damage over a wide area
Leonta	9/3/1903					Nearly wrecked Townsville
	29/1/10	r	WNW-ESE	20 km, N	no	Passed just to north of Magnetic Island
	27/12/1916	1	NE - SW	65 km, NW	yes	Passed over Palm Island
	25/2/29	tl	NW - SE	30 km, SW	no	Ex-tropical cyclone passed along Hervey Range
	20/2/1934	tl	NNW - SSE	0 km	-	Direct hit, ex-tropical cyclone?
	19/2/1940	3	NE - SW	95 km, NW	yes	
	7/4/1940		NE - SW	5 km, NW	yes	Direct hit
	28/3/1944		ENE - WSW	35 km, NW	yes	Passed between Palm and Magnetic Islands
	6/3/1945	r	NW - SE	45 km, NE	no	Passed over Palm Island
	3/3/1946	r	NW - SE	10 km, NE	no	Ex-tc? Passed between Magnetic Island and mainland
	5/2/1947	tl?	SW - NE	50 km, SE	yes	Passed near Ayr, reformed?
	8/3/1950	tl	W - E	10 km, NW	no	Ex-tropical cyclone, reformed later?
	7/2/1954	1	?	50 km, E	?	
Carmilla	12/3/1955	1	?	60 km, SW	?	
	20/1/1956	1	?	70 km, SW	?	
Agnes	6/3/1956	3	E - W	0 km	-	Passed through Bowling Green Bay
	21/2/1958	1	?	60 km, ESE	?	
	3/4/1958	tl	?	80 km, SW	?	
	16/2/1959	2	?	50 km, E	?	
	29/12/1959	1	?	55 km, NE	?	
	3/1/1961	1	?	40 km, NE	?	
Gertie	16/2/1971	1	SE - NW	80 km, NNE	yes	
Althea	24/12/1971	3	NE - SW	15 km, NW	yes	
Una	19/12/1973	2	N - S	30 km, E	no	Passed over Cape Cleveland
Dawn	5/3/1976	tl?	NW - SE	10 km, NE	no	Ex-tropical cyclone
Keith	1/2/1977	1	NW - SE	30 km, NE	no	
Otto	9/3/1977	1	N - S	95 km, E	no	
Kerry	2/3/1979	1	S - N	60 km, E	yes	
Paul	7/1/1980	tl	WNW - ESE	70 km, SSW	yes	Ex-tropical cyclone
Charlie	29/2/1988	1	NE - SW	30 km, ESE	no	
Aivu	4/4/1989	3	NE - SW	60 km, SE	no	
Ivor	24/3/1990	tl	NNW - SSE	45 km, E	no	
Joy	26-27/12/1990	tl?	E - W	0 km	-	Ex-tropical cyclone
Gillian	12/2/1997	tl	N - S	0 km	-	
Ita	24/2/1997	1	NE - SW	55 km, E	no	
Justin	23/3/1997	tl	NW - SE	20 km, NE	no	
Sid	11/1/1998	tl	NW - SE	0 km	-	Ex-tropical cyclone
Tessi	3/4/2000	2	NE - SW	80 km, NW	yes	

APPENDIX 3

Rowes Bay Aerial Photographs

This list details known vertical photographs of the Rowes Bay beach system from 1938 to 1995, mostly at scales of 1:15,000 or larger.

1.
Date: 5/7/38
Scale: 1:15,000
Orientation: North - South
ID #: Map 1692/Run 2/Nos 1-2
Source: AUSLIG

2.
Date: June 1941
Scale: 1:14,400
Orientation: East - West
ID #: Map1340/Run15/Nos33689-33690
Map1340/Run16/Nos33589-33590
Source: AUSLIG

3.
Date: 5th July 1952
Scale: 1:10,400
Orientation: North - South
ID #: Run 541/Nos 160 - 163
Source: ADASTRA, for TCC

4.
Date: 7th June 1959
Scale: 1:11,700
Orientation: East - West, in 4 runs
ID #: 988/Run 4/Nos 17 - 19
989/Run 5/Nos 16 - 17
Source: ADASTRA, for TCC

5.
Date: November 1961
Scale: 1:6,017
Orientation: East - West
ID #: QA 18/Run 6/Nos 121 - 127
Source: QASCOPHOTO

6.
Date: 1st July 1965
Scale: 1:5,010
Orientation: East - West
ID #: Q1523/Run 7/Nos 150 – 153
Q1523/Run 8/Nos
Source: Austn. Aerial Mapping, TCC

7.
Date: 1st November 1970
Scale: 1:11,980
Orientation: East - West
ID #: QAS 193/Run 1/Nos 9314 - 9317
Source: QASCOPHOTO

8.
Date: 23rd July 1971
Scale: 1:4,850
Orientation: East - West
ID #: Q 2506/Run 3/11149 - 11151
Source: Mapmakers, for TCC

9.
Date: 14th September 1972
Scale: 1:4,425
Orientation: East - West
ID #: Q 2638/Run 2/Nos 1274 - 1275
Source: Mapmakers, for TCC

10.
Date: 30th May 1974
Scale: 1:12,000
Orientation: North - South
ID #: Q 2858/Run 81/Nos 28 - 30
Source: BPA

11.
Date: 20th July 1976
Scale: 1:6,235
Orientation: Northwest - Southeast
ID #: AAM1110/Run3/Nos7716-7718
AAM1108/Run4/Nos7856-7862
Source: AAM, for TCC

12.
Date: November 1978
Scale: 1:12,000
Orientation: North - South
ID #: QP 3435/Run 81/Nos
Source: BPA

13.
Date: 14th July 1981
Scale: 1:12,000
Orientation: North - South
ID #: QP 3888/Run 81/Nos 86 - 88
Source: BPA

14.
Date: 15th June 1985
Scale: 1:12,000
Orientation: North - South
ID #: QP 4461/Run 81/Nos 42 - 44
Source: BPA

15.
Date: 10th September 1991
Scale: 1:12,000
Orientation: North - South
ID #: QPc 5024/Run 81/Nos 25 - 32
Source: BPA

16.
Date: 23rd August 1995
Scale: 1:12,000
Orientation: East - West
ID #: QPc 5268/Run 1d/Nos 232-233
QPc 5268/Run 1e/Nos 207-208
Source: BPA