ROWES BAY - PALLARENDA
FORESHORE RESPONSE TO CYCLONE TESSI
3 APRIL 2000

Prepared for Townsville City Council by:

Dr M.C.G. Mabin
School of Tropical Environment Studies and Geography
James Cook University
Townsville, Q4811

June 2000

EXECUTIVE SUMMARY

- Cyclone Tessi caused changes along the Rowes Bay - Pallarenda shoreline due to wave attack, wind erosion, and streamflow from the creeks.

- The Pallarenda Beach renourishment survived the cyclone very well due in part to the presence of a natural berm landform on the upper beach face. This feature has developed since the beach was renourished, and provides added protection for the scarp and dune landforms.

- The Rowes Bay renourishment site suffered a nett loss of ~1400m^3 of sand, mainly from the erosion scarp area. The beach face and dune landforms were largely unaffected by wave erosion. These changes were expected, and overall the project has worked very well to protect foreshore infrastructure.

- The Rowes Bay foreshore is starved of sand as there has been no natural supply of sediment to the beach for many decades. As a result the beach face is unable to form a berm landform which would provide better protection for the erosion scarp and dune areas.

- It is recommended that 20,000m^3 of sand be placed along the upper beach face between sites T30.5 and T32 to allow wave processes to naturally form a berm landform. This would provide a medium-term solution for the erosion problems here.

- To allow the berm landform to develop to its most efficient potential, the renourishment should be carried out as soon as possible, and should not be spread out over several years.

- Beach erosion caused by Cyclone Tessi was largely confined to the Rowes Bay sector, extending for about 1.5km north of One Mile Creek. Further north the beach changes that occurred resulted in a small build-up of sand on the beach face.

ROWES BAY - PALLARENDA BEACH RESPONSE TO CYCLONE TESSI, 3 April 2000

1. Introduction

This report documents assessment of the Rowes Bay and Pallarenda foreshore renourishment projects carried out in April - June 2000. It is based on several visits for field observations, and surveying of beach profiles. The assessment was requested to check on beach condition after the passage of Cyclone Tessi in early April 2000.

Beach profiles were measured in Rowes Bay at sites T30, T30.5, T31, T31.6, T31.7, and T32; near Three Mile Creek at T35, T37 and T38; and at Pallarenda at sites T40, and T40.5. Some profiles were surveyed by C&B Group in late May (T30, T30.5, T31, and T31.7), with the remaining profiles being surveyed by the author in early June. Raw data from the profiles is shown in the appendix. From these data transects were drawn, and measurements from these have been used to determine horizontal changes in the positions of various foreshore landforms, in particular the erosion scarp and beach face (Table 1). Estimates of changes in sand volume have been derived from the changes shown on the transects (Table 2).

2. Cyclone Tessi

Tropical Cyclone Tessi was a late season system that developed at 11am on 1/4/00 about 850km east of Cooktown. Over the next 2 days, it tracked in a quite regular southwesterly direction, and for most of its life was a Category 1 system, but did just reach Category 2 status in the early hours of 3/4/00, when it was in northern Halifax Bay. The eye crossed the coast 35km south of Lucinda (85km northwest of Townsville) at about 8am, and by 11.00am the system had been downgraded to a tropical low. Although the cyclone did not cross the coast close to Townsville, the city did suffer appreciable damage, as it was situated just to the south of the system, and was thus in the damaging front-left quadrant of the cyclone. Here, winds are at their strongest due to the forward momentum of the system, and the clockwise wind circulation around the centre.

Bureau of Meteorology weather data from the airport show that the strong winds associated with the cyclone lasted for about 12 hours from the evening of 2nd, until the morning of the 3rd of April. Heavy rains from the cyclone began in the early evening of 2nd, and continued for about 24 hours. The total rainfall for the event was 469mm, with 197.4mm recorded for the 24 hours ending 9.00am 3/4/00, and 271.6mm for the 24 hours ending 9am 4/4/00.

2.1 Wave damage

When a cyclone crosses the coast there is usually great potential for beach erosion. This is caused by several factors:

- strong winds create large erosive waves
- strong winds cause water to "pile up" at the shoreline, temporarily raising sea level and allowing waves to attack upper parts of the beach, and the sand dunes behind the beach
- low barometric air pressure at the centre of the cyclone allows sea level to rise temporarily.

All of these factors add together and are collectively known as *storm surge*. For severe cyclones this can add several metres to the local sea level, and result in extensive beach erosion and saltwater inundation of low lying coastal land. If the storm surge is associated with a high tide, then the potential for damage is further increased.

In the case of Cyclone Tessi, the effects of most of these factors at Townsville were reduced due to the low category status of the system, and the distance of the centre from the city. The strongest winds occurred in the early hours of 3rd April, at a time when the tide was at its lowest (1:55am). Furthermore, tides were in the spring-tide part of the cycle so that the water levels were lower than usual that morning. This was very fortunate as the large waves that these winds would have created would have been harmlessly expended on the mudflats. However, the following high tide was higher than normal, being only slightly below 'king tide' levels. It occurred at 8.08am, just as the cyclone was crossing the coast. Wind speeds had declined considerably since 2am, but were still around 40-50kph. Thus, wave action would have been quite high, and it is probable that the main beach erosion occurred at this time.

2.2 Wind damage

The strong winds associated with the cyclone did cause some damage. The bark of many trees at Rowes Bay show the effects of sand blasting which reached to more than 3m above ground level. This is on the sides of the trunks exposed to the east and was thus probably associated with wind gusts from this direction. The Bureau of Meteorology recorded the maximum gust of 130kmph at 1.40am from this direction. At the car park opposite the RSL villas some 10cm of sand collected on the ground, and fresh sand 1-2cm deep was observed in the most of the Rowes Bay grassed dune areas. However, the sand does not appear to have been transported more than ~20m inland from the beach. This demonstrates the effectiveness of the dune re-vegetation programs in both stabilising the dunes, and allowing new blown sand to be trapped in the dunes rather than blowing further inland. Considerable quantities of sand were blown more than 30m inland from the Strand where the effects of the wind erosion would have been greater due to the absence of a well-vegetated dune to trap this blowing sand.

2.3 Stormwater runoff damage

A feature of the damage associated with ex-Cyclone Sid in January 1998 was the erosion caused by runoff of large volumes of stormwater. Cyclone Tessi also produced a large volume of rainfall in a short time with the 24hour total of about 450mm, making it probably the 3rd wettest 24-hour period on record. However, runoff damage at the Rowes Bay and Pallarenda renourishment sites was minimal due to the artificial dune landforms and stormwater detention ponds that allowed water to soak away and redirected surplus runoff to less sensitive parts of the beaches. Minor maintenance work quickly and cheaply repaired any damage.

3. Beach Changes in Rowes Bay Renourishment Area

Detailed observations of foreshore changes are have been based on interpretation of two sets of beach profiles taken about 5 months apart. The first set was measured in November-December 1999 as part of the on-going monitoring of the Rowes Bay renourishment project. There were no major high-energy wave events between late 1999 and early April 2000, thus these profiles are taken to represent the beach condition just prior to the cyclone. Profiles measured in May-June 2000 were taken 7 and 9 weeks after the cyclone while erosion effects were still clearly visible along the foreshore. Table 1 shows the linear amounts of change at the five measured beach profile sites, at various levels on the erosion scarp (between the beach face and the dune area), and on the beach face proper. Table 2 shows the volumes of sand moved in the various sections of the foreshore.

3.1 Changes Along the Erosion Scarp

From Table 1 it can be seen that the main area of erosion was along the scarp. This landform separates the upper beach face from the dune. Erosion occurred principally at the base of the scarp, and was worst at site T30 where 4m were lost. To the north, the linear erosion at the base of the scarp was less, declining to 1m at site T32. However, there was little or no erosion at the top of the scarp, thus the overall effect was one of scarp steepening, with no loss of sand in the dune area behind.

Table 2 shows that the volume of sand lost from the scarp showed a similar pattern, with the greater volume loss being in the southern sector. A total of about 2700m^3 was eroded from the scarp, with nearly 40% of this occurring in the southern sector between sites T30 – T30.5. The 1043m^3 lost in this 331m long section amounts to 3.2m^3 per linear metre of scarp. This rate of scarp erosion declined to the north to be only 1.7m^3/m at site T32.

3.2 Changes Along the Beach Face

Tables 1 and 2 show a quite different pattern of beach face changes. Overall there was a significant increase of sand stored in the active beach face. This was probably mostly due to the sand that had been eroded from the scarp being deposited here. Most of the sand was deposited in the lower beach

Table 1 Rowes Bay foreshore linear changes Nov-Dec 1999 - May-June 2000

Profile #	Scarp changes (m)*	Horizontal beach face changes (m)*	Vertical beach face changes (m)*
T30	-4.0 (b); 0 (t)	0 (l); -4.0 (u)	0 (l); -0.5 (u)
T30.5	-3.5 (b); 0 (t)	2.0 (l); 0 (u)	+0.25 (l); 0 (u)
T31	-2.5 (b); 0 (t)	-1.25 (l); -0.5 (u)	-0.15 (l); -0.05 (u)
T31.6	-2.0 (b); -0.5 (t)	0 (l); +1.0 (u)	0 (l); +0.1 (u)
T31.7	-2.5 (b); 0 (t)	0 (l); +3.0 (u)	+0.35 (l); +0.3 (u)
T32	-1.0 (b); -1.1 (t)	0 (l); 0 (u)	0(l); 0(u)

* b = base of scarp; t = top of scarp; l = lower beach face; u = upper beach face

TABLE 2 Foreshore volume changes Nov-Dec 1999 – May-June 2000

Shoreline sector (length in metres)	Sand volume loss along scarp (m^3)	Loss/m	Sand volume changes along beach face (m^3)	Change/m	Total sand volume changes (m^3)
T30 – T30.5 (331m)	-1043	3.2	-576	-1.7	*-1619*
T30.5 – T31 (221m)	-575	2.6	+491	+2.2	*-84*
T31 – T31.6 (137m)	-321	2.3	+247	+1.8	*-74*
T31.6 – T31.7 (157m)	-345	2.2	+456	+2.9	*+111*
T31.7 – T32 (252m)	-416	1.7	+628	+2.5	*+212*
TOTALS (1098m)	*-2700*	*2.5*	*+1246*	*+1.1*	*-1454*

face, just above the mudflats. Thus, this sand has not been lost from the system, and is potentially available to be reworked by wave action back up the beach towards the erosion scarp. The only exception was at site T30, where considerable erosion of the upper beach face was recorded. Previous surveys at T30 show this is one of the most dynamic beach profiles along the Rowes Bay – Pallarenda foreshore. It has showed periods of both dramatic erosion and spectacular growth, and this may be due in part to its proximity to the mouth of One Mile Creek. It is quite likely that over the next few months sand will be returned to the beach face here.

3.1 Overall Foreshore Changes

From Table 2 it can be seen that there was a nett sand loss of ~1450m^3 from the renourishment site. The main loss was from the scarp area, while the beach face sand volume increased. There was no loss of sand from the dune area, thus the long-term integrity of this landform as an erosion buffer to protect foreshore infrastructure was not compromised. The bulk of the nett sand loss was from the southern sector between sites T30 and T30.5. This sand does not appear to have been stored on the mudflats in front of this section of beach. However, there is sand on the mudflats at the mouth of One Mile Creek, and new sand has accumulated on the beach face in front of the Rowes Bay caravan park. This has probably come from the renourishment area.

The behaviour of the Rowes Bay foreshore continues to demonstrate the long term problems that are faced here. The beach profiles are always in an eroded condition, unable to respond to withstand even moderate wave attack due to the lack of available sand on the beach face. There is now no natural sediment supply to the beach, and erosion will continue unless significant renourishment is carried out and continued at regular intervals.

4. Beach changes near Three Mile Creek

Observations of the beach north from site T32 show that minor scarp erosion occurred, but this declined northwards, and overall the cyclone appears to have added sand to the beach face. Profiles were surveyed at Three Mile Creek (T37), and at sites T35 (~1km south of Three Mile Creek) and T38 (~0.4km north of the creek).

At site T35 there was no appreciable erosion of the foreshore, rather there a small build-up of sand in the upper beach face, and a small erosion scarp from late 1999 was filled in.

Site T37 at the mouth of Three Mile Creek showed the main sand bar was shifted 7m towards the shore, and 0.4m of sand was added to the intertidal flat area.

At site T38 quite dramatic changes occurred with 4m of scarp erosion at the top of the beach, and 17m growth of the mid and lower beach face. This large volume of sand in the lower part of the profile is part of a large intertidal bar which is now being added to the beach face.

These observations show the highly dynamic nature of stream mouth systems in the coastal zone, and the important role they play in delivering sand to beaches. The combination of wave attack, and large volumes of stream water discharge through the mouth can cause dramatic coastal changes.

5. Beach changes in Pallarenda Renourishment Area

Documentation of foreshore changes in the Pallarenda renourishment area has been based on interpretation of beach profiles surveyed at the same time as those measured in Rowes Bay. Observations of the Pallarenda beach suggested there had been very little change associated with Cyclone Tessi, and this was confirmed by the profiles measured at sites T40 and T40.5. These showed that there had been no erosion in the Pallarenda renourishment area, rather, the foreshore was showing signs of very healthy behaviour.

At site T40 just south of the Pallarenda boat ramp, there was no erosion of the scarp, and the only change in the beach face was a slight repositioning of the berm. This berm is a 7m wide gently sloping ledge-like landform typical of those found near the top of a healthy beach face. It represents a build-up of sand that will act as the first line of defence during high-energy wave attack, and will help to protect the scarp and dune areas behind from erosion. The berm also provides an area above the usual high tide mark were sand can dry out and be more readily blown inland to help repair any erosion scarp, and to build up the dune area.

At site T40.5 just inside the Conservation Park boundary, the beach profile has grown since measurements were taken in November 1999. The beach face has advanced out nearly 2m, the berm is 4m wider, and the erosion scarp has been largely filled in by sand blown from the berm.

This behaviour of the beach profiles here is very encouraging and is probably due to a combination of natural longshore drift processes, renourishment, and a partial sheltering of the Pallarenda beach from the waves generated by Cyclone Tessi. However, the area cannot be regarded as immune from further erosion, and the current beach condition is still well short of its pre-Cyclone Althea status of 30 years ago. Continued beach renourishment would be a wise investment.

6. Summary of Cyclone Tessi Beach Changes

Cyclone Tessi caused a number of beach foreshore changes along the Rowes Bay - Pallarenda shoreline. These included both sand erosion and accretion associated with wave action, wind erosion, and stormwater runoff through One and Three Mile creeks.

Foreshore erosion did not occur in the Pallarenda renourishment area. The presence of the berm landform appears to have allowed the beach to accommodate the increased wave energy during the cyclone without causing erosion of the scarp or dune areas. Recent observations show that sand is actively moving up and down the beach profile, and along the shore in a very healthy manner. However, the longshore drift, while it is an entirely natural and necessary beach process, is causing some disruption of traffic on the boat ramp. Much of ramp is at present under about 0.3m of sand which wave action is working along the beach to the north.

Along the Rowes Bay renourishment area, the existing erosion scarp was further eroded, mainly by wave action removing sand from the base and causing its overall slope to steepen. Some 4m was lost in the south at site T30, but only 1m at site T32 ~1km to the north. The dune area was not affected, and may indeed have been slightly enlarged by sand blown from the beach face during strong wind gusts. The beach face overall gained sand that had been deposited from the erosion of the scarp.

The renourishment project that was begun in late 1998 has proved successful at protecting infrastructure from damage due to cyclone wave attack. This is despite it having now been affected by several erosive wave events. Foreshore infrastructure has been protected with no damage occurring to the road, bike path, fencing, sand ladders, and stormwater detention ponds. The vegetated dune remains intact, and is acting as designed, to trap sand blown from the beach face. The erosion scarp and beach face have suffered erosion, with the sand losses during Cyclone Tessi bringing the total lost from here to about $5000m^3$. There is no build-up of sand on the mudflats, thus it is probable that this sand has been moved as expected, by longshore drift along the beach face and out of the renourishment area. Some sand has probably moved north, while a significant proportion appears to have moved south and accumulated in inner Rowes Bay in front of the caravan park. In either case this is good for the beach amenity value in these parts of the foreshore.

7. Recommendations

Renourishment of the Rowes Bay area should continue. Observations of beach face behaviour along the whole foreshore demonstrate the value of a healthy beach profile that contains enough sand to form a berm landform in the upper beach face. This is especially obvious in the Pallarenda renourishment area, which suffered no damage during Cyclone Tessi. The berm landform is a naturally formed feature that develops during low-moderate wave energy conditions. Storm wave attack will erode the berm, but it would help to partially protect the scarp and dune landforms, and is likely to re-form if there is sufficient volume of sand available. Renourishment of the Rowes Bay beach face should continue so that a berm landform can develop. A berm has been present at site T30 on several occasions, and it is very likely that one would form along this whole beach face if there was enough sand.

A further $20,000m^3$ of sand placed at the top of the beach face between sites T30.5 - T32 should allow a berm to begin to form. This would provide a more self-sustaining beach face that needed less frequent renourishment.

The most effective option would be to place this sand as soon as possible, and preferably not piecemeal over the next few years. This is necessary as smaller quantities of sand would be subject to erosion losses before the berm landform became established. This would also be more economical option as it would not be necessary to carefully shape the sediment on the beach face because wave action should rapidly rework the sand into an equilibrium shape.

The Pallarenda renourishment appears to be working well at this stage. No further renourishment is necessary in the short term.

Appendix
Beach profile data, November-December 1999, and May-June 2000

T30

Distance	Height	Distance	Height
	04/11/99		24/05/00
-22.57	6.187	-20.37	6.11
-21.37	6.175	-18.5	6.25
-20.37	6.14	-13.85	6.2
-13.37	6.185	-9.23	6.78
-9.37	6.775	-3.23	6.27
0.63	6.045	0.62	6.05
6.63	4.185	2.36	4.47
6.63	4.185	13.66	2.55
17.63	3.11	33.22	1.43
29.63	1.44	45.36	1.41
85.63	1.2	57.8	1.4
		84.15	1.4
		97.7	1.5

T30.5

Distance	Height	Distance	Height
	02/12/99		24/05/00
-10	*6.023*	*-10*	*6.023*
-6	*5.895*	*-6*	*5.895*
-1.6	5.852	*-1.6*	*5.852*
0	6.37	*0*	*6.37*
0.6	6.254	3.58	6.46
4.4	6.392	5.75	6.16
7.2	5.679	9.17	4.62
10.2	4.873	18.09	3.13
12.4	4.582	38.48	0.83
13.4	3.852	45.3	0.79
20.6	2.744	53.45	0.76
34.6	1.024	60.7	0.74
138.6	0.604	63.42	0.69

T31

Distance	Height	Distance	Height
	05/11/99		24/5/00
-14.98	5.95	-9.98	6.61
-9.98	6.53	-8.44	6.51
-2.98	5.76	-4.23	5.86
0	4.99	-2.32	5.71
1.02	4.08	-1.9	4.49
4.02	3.515	0.9	3.96
9.02	2.932	10.53	2.64
25.02	0.932	19.39	1.49
69.02	0.652	22.6	1.05
		29.61	0.82
		31.25	0.79
		42.43	0.75
		53.53	0.62
		64.51	0.66
		76.07	0.65

T31.6

Distance	Height	Distance	Height
	08/11/99		12/06/00
-6.00	6.01	0	6.43
-4	6.11	5.5	5.71
0	6.41	5.75	4.855
6	5.58	6	4.31
9	3.835	9.5	3.875
17	2.895	14.5	3.27
33	0.965	14.5	3.27
87	0.525	20	2.6
		28	1.62
		36	0.915
		81	0.49
		109	0.29
		127	0.64
		166	0.22

T31.7

Distance	Height	Distance	Height
	05/11/99		24/05/00
0	5.72	0	5.72
3.6	5.734	3.03	5.69
5.2	6.084	4.23	6.24
8	4.954	11.36	6.07
9	4.053	15.1	3.62
9	4.053	25.16	2.14
16	3.063	37.22	1.04
25	*2.052*	48.97	0.71
33.5	*1.007*	59.25	0.51
46	0.813	70.45	0.4
112	0.403	79.95	0.32
		91.35	0.55
		104.85	0.35

T32

Distance	Height	Distance	Height
	05/11/99		08/06/00
0	5.31	0	5.32
2.6	5.095	6.4	4.846
6	5.016	7.1	4.391
7.8	*4.98*	9.1	4.046
8	*4.415*	13.1	3.641
10	*4.29*	21.1	2.691
10.6	3.945	21.1	2.691
22.6	2.565	26.7	1.928
36.6	0.805	35.2	0.978
41	*0.64*	46.7	0.648
46	*0.45*	77.7	0.278
100.6	0.175		

T35

Distance	Height 06/11/99	Distance	Height 08/06/00
0	4.89	0	4.94
3.4	4.983	5.5	4.985
5.4	5.363	5.5	5.4
8.2	4.791	8.5	4.787
9.2	4.745	10.5	5.325
11.2	5.164	13	5.124
13.4	5.063	15.5	5.28
16.4	5.245	20.5	4.77
20.8	4.697	24	4.88
25.4	4.863	26.5	4.545
25.6	4.304	32.5	4.085
32.8	4.193	38.5	3.985
39.4	3.423	38.5	3.985
47.4	2.998	42.7	3.507
72.4	0.973	50.7	2.477
147.4	0.238	56.7	2.122
		78.7	1.067
		91.7	0.867
		108.7	0.757

T37

Distance	Height 06/11/99	Distance	Height 08/06/00
0	4.25	0	4.25
3.4	4.384	10	5.58
9.5	5.395	12.5	4.583
12.8	4.356	20	3.485
18.9	3.49	23.7	2.963
24	2.7	29.1	1.565
24	2.7	30.1	1.245
28.7	1.675	37.7	1.583
38	1.475	46.1	2.173
45	1.55	48.7	3.173
47.4	1.831	59.7	3.723
52	3.338	79.7	1.803
66.4	3.872	102.7	1.733
71.5	3.415	127.7	1.393
87.5	1.39	147.7	1.193
94	1.244	171.7	0.993
94	1.242		
105.5	1.395		
133.5	1.115		
165.5	1.18		
192.5	0.89		
221.5	0.98		

T38

Distance	Height 06/11/99	Distance	Height 08/06/00
0	5.68	0	5.72
3.4	5.62	4	5.655
8	4.6	7.1	4.675
11	*4.81*	10	4.84
18.4	4.755	17	4.695
21.4	4.36	17.5	4.345
23.4	3.75	24	3.355
32.4	2.87	44.5	3.545
53.4	1.54	55	2.445
88.4	1.48	102	1.345
106.4	1.98		
140.4	1.4		
170.4	0.85		

T40

Distance	Height 07/11/99	Distance	Height 12/06/00
0	6.04	0	6.06
1.8	6.228	4	5.96
6.4	5.718	7	5.71
8.8	5.241	9	5.235
10.4	5.215	12	5.26
12.6	5.249	13	4.435
16.8	3.738	16	3.87
21.4	3.723	20	3.44
27.4	2.96	26	3.59
36.4	2.525	31	3.205
68.4	0.73	31	3.205
127.4	0.23	32.5	2.995
		39.5	2.22
		49.5	1.65
		64.5	0.975
		93.5	0.53
		101.5	0.3

T40.5

Distance	Height 7/11799	Distance	Height 12/06/00
0	5.05	0	5.09
6	4.855	6	4.945
8	3.875	8	4.49
10	3.89	14	3.685
13.4	3.897	19	3.705
13.4	3.897	25	3.135
23	2.834	36.5	1.945
38	2.009	58	1.345
77	0.784	84.7	0.595
123	0.194	97	0.265