REPORT ON THE MARCH 2007 COASTAL EROSION EVENT FOR THE KWAZULU-NATAL MINISTER OF AGRICULTURAL AND ENVIRONMENTAL AFFAIRS.

By
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1. BACKGROUND

This extreme wave event was generated by a low-pressure system off the coast, which occurred at a time when the maximum gravitation forces exerted by the Sun and Moon were also at their 18.6-year peak. This combination resulted in exceptionally high waves on top of a raised sea level causing widespread damage along the entire KwaZulu-Natal coast on the 19 and 20 March 2007. The Saros equinox spring tide predicted to occur on the 21 March 2007 had been identified as early as September 2006 as a possible period of vulnerability from increased erosion for the Durban coastline and in particular for properties located north of Durban along Eastmoor Crescent, La Lucia (Mather 2006).

Sea conditions prior to the event had been unseasonable, with an unsettled sea, with 2 to 3m swells running. The prevailing sea conditions prior to March had been influenced by three tropical cyclones (Dora, Favio and Gamede) located east of Durban. Of these, only Cyclone Dora and Gamede were significant. Cyclone Dora, which later combined with a well-developed cold front to the south, induced swells in the 2-3m range and impacted Durban on 11 to 13 February. Cyclone Gamede arrived several weeks later as this storm tracked westward towards Madagascar on 26 February, turned southward on 28 February and eventually stalled in the south Indian Ocean from 1 to 6 March. Despite being downgraded from a cyclone to an extra tropical depression cyclone Gamede was responsible for the first calls of concern from residents as it generated 2 to 4m swells from 1 to 5 March. This event caused local inundation and minor erosion along Durban's golden mile (the beachfront strip from the harbour entrance to the Umgeni river mouth) when these swells coincided with the spring high tides on 3 to 4 March. Minor erosion damage was also recorded up and down the KwaZulu-Natal coast.

2. THE STORM OF 19-20 MARCH 2007

The storm started as a frontal low, which passed south along the coast of South Africa on 16 March (Fig 1a). The frontal low intensified and rapidly developed into a cut-off low southeast of East London on 17 and 18 March (Fig 1b and 1c). From the dense isohyets around this low, it can clearly be seen to intensify to a peak on the 19 March (Fig 1d) where it remained trapped between two high-pressure cells until the 20 March. The system started to weaken by midday on the 19 March (Fig 1e) and was almost back to normal by 20 March (Fig 1f).

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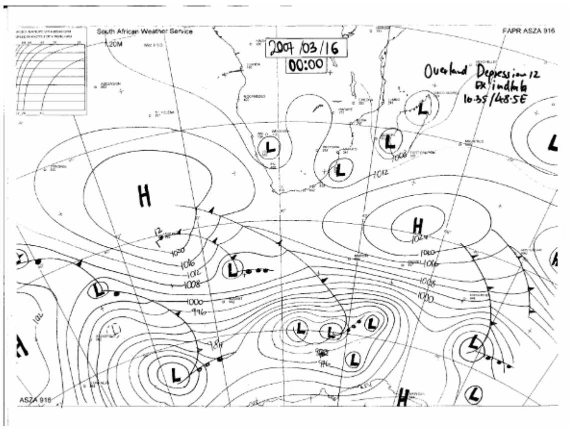

Figure 1a: Synoptic chart for 16 March 2007.

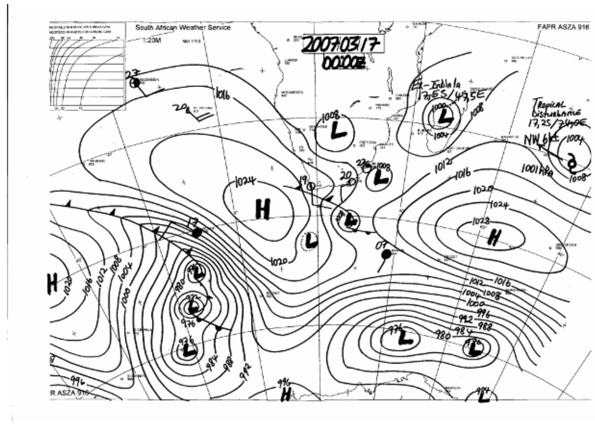

Figure 1b: Synoptic chart for 17 March 2007.

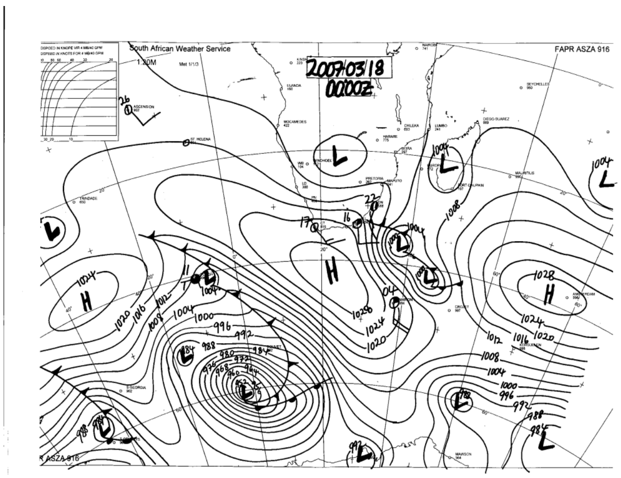

Figure 1c: Synoptic chart for 18 March 2007.

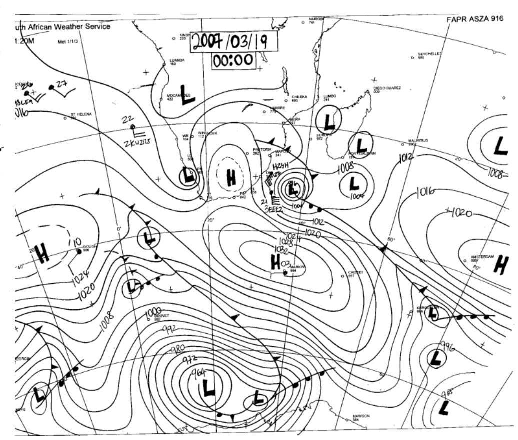

Figure 1d: Synoptic chart for 19 March 2007.

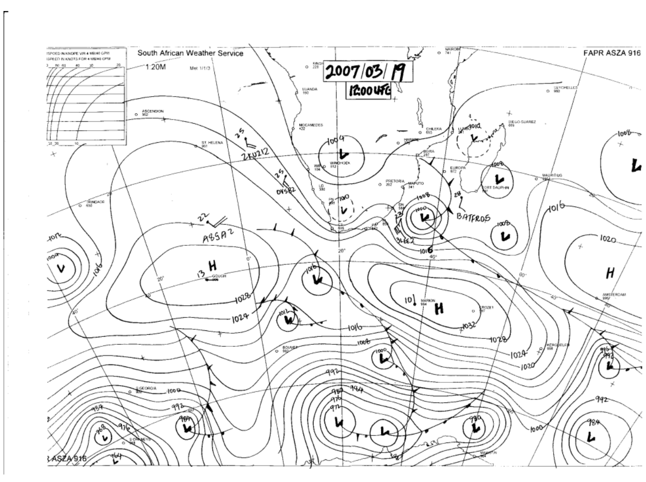

Figure 1e: Synoptic chart for 12H00 19 March 2007.

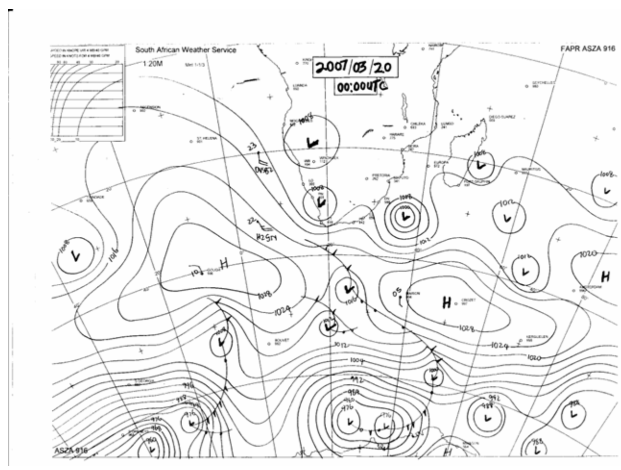

Figure 1f: Synoptic chart for 20 March 2007.

All the synoptic charts are courtesy of the South African Weather Service.

The central pressure of this low-pressure cell dropped to below 996 hPa. The strong pressure gradient between the low and high cells generated strong and consistent winds, which were recorded between 40 knots (21m/s) and 45 knots (23m/s) along the coast. As the system was trapped in position this allowed the wind to generate some impressive waves over the fetch length of ±450kms straight at the coastline of KwaZulu-Natal. The Acoustic Doppler Current Profiler normally used to record wave heights in Durban was out of commission during this event. Recorded wave heights for the event are therefore confined to the CSIR wave-rider buoy located off Richards Bay in 30m of water depth. This recorded a significant wave height (H_{mo}), defined as the average of the top third waves recorded, of 8.5m, with a period 16 seconds from the south-east to south-south-east, measured at the peak of the storm at 05h00 on 19 March (Rossouw M, pers. comm.). The maximum wave height was recorded at 14 m (Rossouw M, pers. comm.). At the same time, the Highest Astronomical Tide (HAT) occurred which happens only once in 18.6 years. This would have elevated water levels by approximately 20cm more then the normal springtide levels and when, synchronised with the wave event magnified this combination for the worse. Fortunately, the wave event very quickly dissipated and by the evening of the 20 March, the swells had reduced to less then 3m.

3. THE AFTER EFFECTS

The storm was significant enough to change the seabed profile and to remove all the previously positioned sand bars, which normally help reduce the wave energy arriving at the coast. Seabed changes in deep water were recorded in Richard's Bay where the existing dumpsite mound was eroded from -11m to -17m and the sediment distributed in a southeasterly direction to a depth of -22m (Ramsay Pers. Comm. 2007). These waves were energetic enough to move sediment offshore to a position where it is unlikely to return completely to the near shore and beach area. This combination resulted in a sand starved coastline with no protection stretching from St Lucia in the north to beyond Margate in the south. This situation resulted in a beach profile, which is out of its normal equilibrium and results in the sea attempting to readjust to its normal equilibrium profile (Figure 2).

The original beach profile (A) erodes to the post storm profile (B) during the event. In a sand starved environment, the near shore receives very little returning sand from deeper water and now has to rely on the accumulation of sediment normally built up along the shoreline in the form of coastal dunes (shown red). The sea moves this sediment into the near shore zone (shown blue) so that the seabed profile (C) is returned to the same slope as the original beach profile (A).

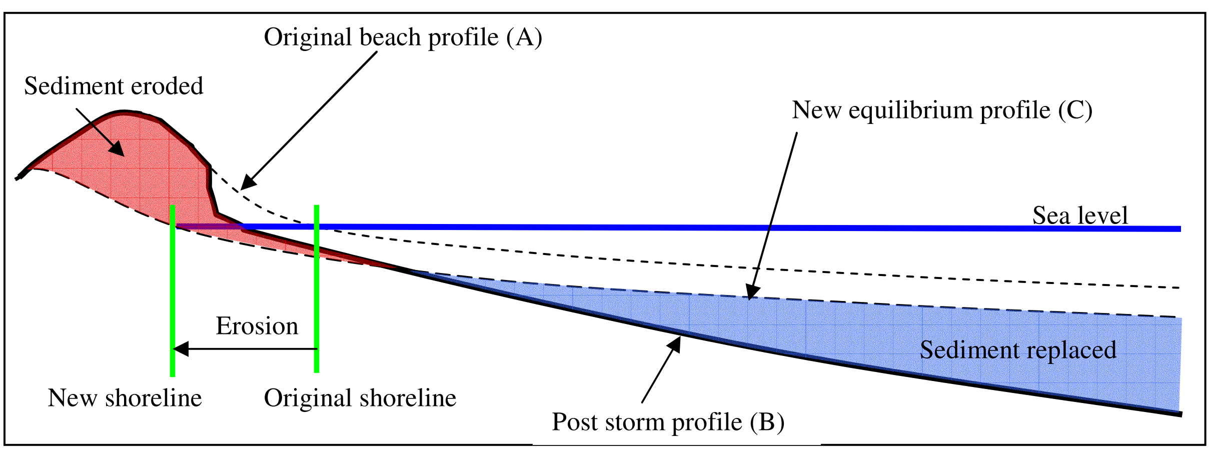

Figure 2: Beach response to storm events and the re-establishment of the equilibrium profile.

These dunes or "reservoirs of sand" acts as buffers in circumstances such as this. Unfortunately, human intervention along the coastline has resulted in these dunes being either being built on or cut down to provide a sea view resulting in a reduction of the coastal system to respond to severe storm erosion.

The erosion at Amanzimtoti was caused by the system attempting to get back into equilibrium. Normally the sediment bypassing the rocky headlands feeds the up drift beach keeping the equilibrium. As the winter storms started coming through from the south the sand started moving northward. However as the sand was lost across all beaches there was no available sand to feed the beaches north of the rocky headland, resulting in beaches accreting to the south and eroding to the north of headlands (figure 3). This cycle is repeated in each bay and explains why Amanzimtoti and Happy Wonders suffer extensive erosion. Amanzimtoti recorded over 90m of erosion in the space of two weeks.

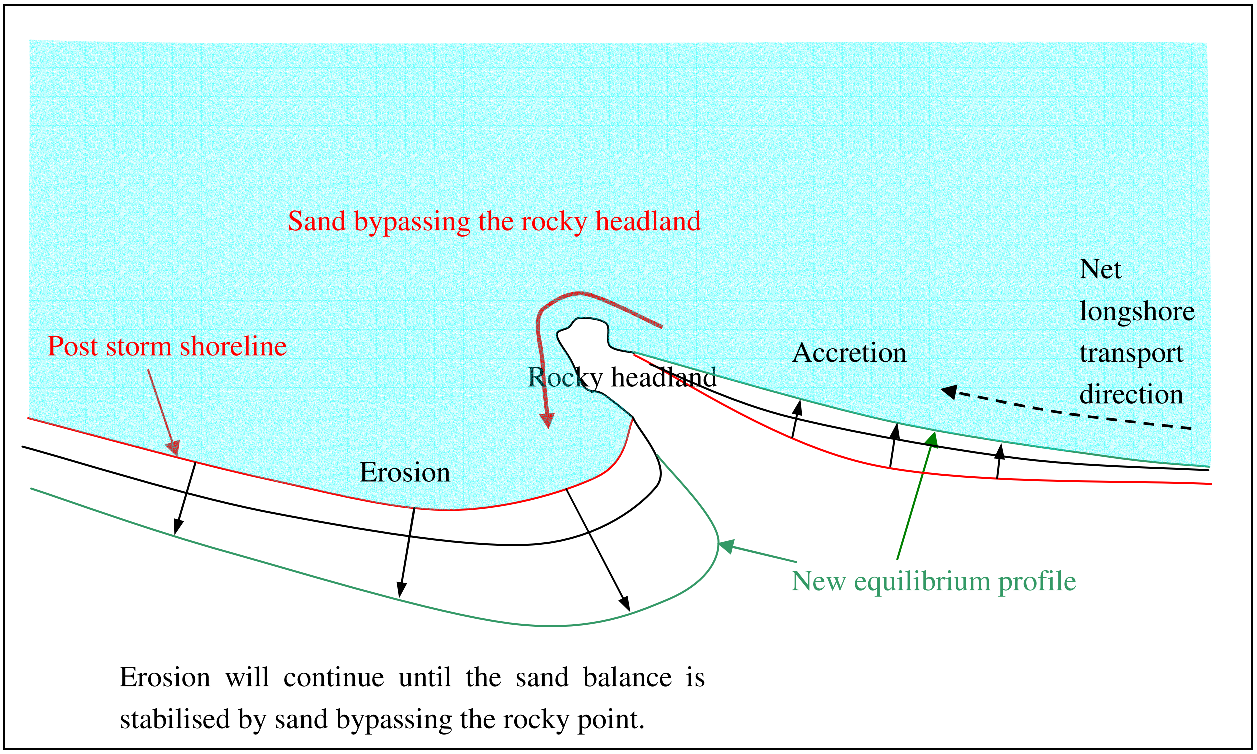

Figure 3: Sand bypass around a headland

This can be seen in the pictures of Amanzimtoti beach over the period prior to the March event (Figure 4a) and the current situation (Figure 4b).

Figure 4a: Amanzimtoti beach in January 2007

Figure 4b: Amanzimtoti beach in July 2007

4. THE LONGTERM EFFECTS AND CLIMATE CHANGE

The longer-term impacts in the region are cause for concern. The rate of sea level rise for Durban between 1970 and 2003 has been established as +2.7mm per year (Mather 2007). While this sounds inconsequential, when measured against a sloping beach profile, the retreat of the coastline is a multiple of this. This relationship is currently being studied to determine the likely shoreline regression under different sea level rise scenarios. The rate of global sea level has been shown to be accelerating (Church and White 2006) and this is likely to influence our shorelines. In addition, there is a view that the intensity and frequency of storm events is likely to change with more frequent extreme weather events being experienced (IPCC 2007).

5. COST OF DAMAGE TO INFRASTRUCTURE

Current estimates for damage to municipal infrastructure for eThekwini Municipality is approximately R100 million as detailed in the table below.

HIGH SEAS - DAMAGE TO INFRASTRUCTURE : ETHEKWINI COASTLINE		
	Capital Projects	**Schedule Project Cost**
1	**Umhloti,Westbrook & La Mercy.** Sections along this road has collapsed and one lane of the road has been closed off to traffic. Road barricaded and made safe. Lifeguard tower - damage to structure, garage and entrance doors. Damage to dunes, fencing, signage, stairways, furniture, plant and equipment. Ski Boat Launch Pad – Structural damage	R 12,222,930
2	**Umhlanga Promenade & La Lucia –**Damage to loffelsteinwall, stormwater infrastructute, roads, lifeguard tower furniture and lookout platforms. Replacement of poles and public address system and radio base sets, signage and bathing beachons. Damage to stormwater outfall.	R 34,160,625
3	**Central Beaches –** Damage to South Side Groyne – Rock Revetment required. Damage to thatch umbrellas, bathing beacons, wooden stairways, signage, litter bins and volleyball poles. Damage to lookout platforms,paving, pumps, piers, furniture and equipment. Damage to car park and canal	R 7,086,816
4	**Bluff, Cuttings and Isipingo Beaches –** Erosion along parking lot / stormwater infrastructure collapse. Damage to beach access walkway and roads. Damage to infrastructure surrounding paddling pool, reinforced boundary walls, security wall, building structures, filtration plant. Damage to storeroom, plant and equipment.	R 18,980,718
5	**Amanzimtoti and Winklespruit Beaches –** Collapse of retaining walls for recreation facilities. Excessive erosion along costline and collapse of life saving building. Damage to pool infrastructure. Washaway of outfalls and damage to boardwalk. Damage to infrastructure (Bins & Signage)	R 19,849,801

6	**Umgababa & Umkomass Beach** – Beach Access washaway. Sever damage to infrastrcture. Rolland Norris Road – Severe Erosion – Road barricaded /closed off. Launch Site: Damage to infrastructure, furniture and fitting.	R 5,881,450
	Totals	**R 98,182,340**

6. MEASURES TO REDUCE THE EFFECTS OF THIS IN THE FUTURE

While there are no measures to address the weather patterns, causing these storm events, which is warned will increase under climate change, there are several practical measures, which can be considered to "storm proof" the shoreline as much as possible.

- **Measures to reduce the impact of human damage to infrastructure and buildings**

  i. A shoreline management plan must be implemented by all municipalities. This is most efficiently done at a municipal level as the decision to defend or retreat is explicitly linked to the type and value of infrastructure in place. In the event of a municipality being unable to undertake this work then the Provincial authority must assist those municipalities. This will provide the public and government the framework in which to manage and respond to future events of this kind.

  ii. The implementation of development set back lines based on a long-term view of the coastline. For example to formulate development setback lines based on a 1:100 year storm combined with projected sea level rise to 2100. eThekwini Municipality has this in place by based on a 1:50 year storm and 50 years of sea level rise and this has been shown to have been exceeded in a number of location along our coast during this storm and the sea's subsequent readjustments to the shoreline. This set back line is not in place for the whole coastline at present and with the impacts of the storm on the eThekwini Municipality coastline, it is clear that a more conservative line is established for the KZN coastline. Based on our own work it is recommended that the KZN development setback line be set at a contour level of 10m above MSL (see Figure 5).

  iii. As part of the shoreline management plan, a specific retreat policy be implemented for all partially and totally damaged or lost infrastructure, facilities and buildings. This will result in the relocation of infrastructure and facilities back to a less vulnerable position. There will be quite a lot of buildings (private and public) within the new setback line and it is strongly recommended that a policy of expropriation or land exchange be put in place to address the inappropriately situated properties. At this point in time many of these owners have no choice but to defend their property and buy themselves time.

- **Measures to replenish the sand available to the coast**

  i. The practice of sand mining from our rivers and estuaries is having a negative effect on the amount of sediment arriving at the coast and which would normally be available for the coastal processes to supply sand to our beaches and dune systems. The approach to sand winning needs to be revisited so that we are not making the situation on the coast any worse then it is already.

  ii. The The damming of rivers for potable water for human consumption is necessary however; the dams are also trapping the sediment destined for the coast. Not only is this accumulation of sediment in our dams creating less storage of water, prompting the raising of several dam walls recently to counter this loss of storage, but it is also effectively cutting off the supply of sediment to the coastline. The extreme example is the Umgeni catchment, prior to dam building the maximum sediment yield was 6 800 000 tonnes per year however the construction of the Inanda dam now traps approximately 90% of the catchments sediment (Garland and Molefi 2000). The balance of sediment is extracted by a licensed sand winning operation effectively reduces the sediment yield to zero.The problem can be addressed by the bypassing of this sediment around the dams and thereby reinstating the sediment flow. This has been raised with officials in the Department of Water Affairs and Forestry in the recent past but they have not shown any need to address this issue. Ironically the issues of reserve determination in our catchments has receive much attention in recent years, particularly around it's contribution to ecosystem health, but unfortunately the sand contribution has been ignored to date although it is equally important.

iii. Importation of "new" marine sediment for offshore. If the supply of sediment from land sources is not possible, impractical or too slow to replace the lost sediment then this is a further option. The Americans have employed this practice for some time now and consists of dredging marine sediments from offshore and then pumping these back in to the beach zone. This acts to build up the beach profile and reverse erosion trends in the renourished areas. However, this process is normally expensive and would only suit areas of coastline with high value infrastructure i.e.beachfront areas. The downside is that this renourishment would need to be redone periodically to replace sediment, which is lost northwards and seawards.

7. REFERENCES

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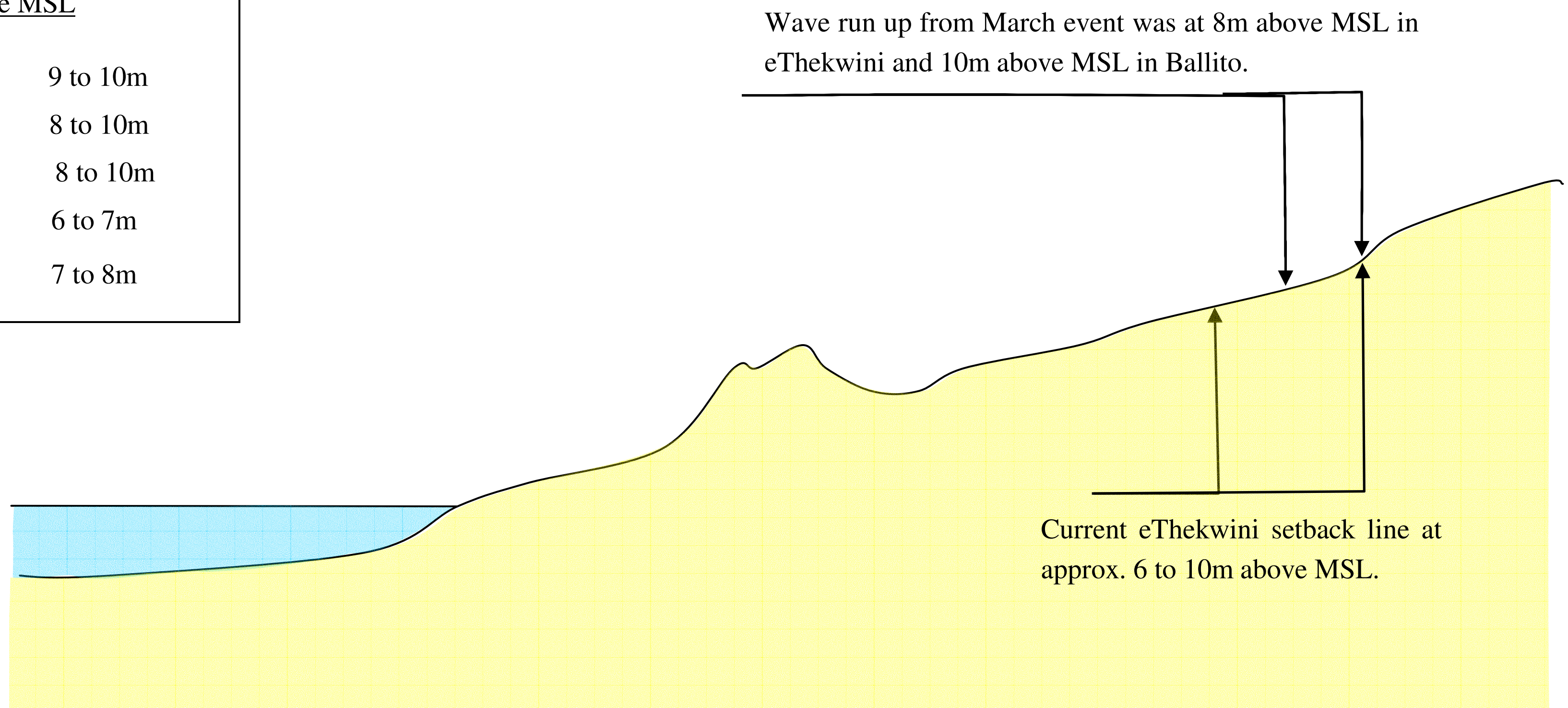
Diagramatical section showing key coastal levels.

<u>eThekwini Municipality setback line levels above MSL</u>

Umkomaas	9 to 10m
Umgababa	8 to 10m
Bluff	8 to 10m
Eastmoor Cres.	6 to 7m
Umhlanga	7 to 8m



The key criterion is the balance of risk verse the neutralizing of property rights. The eThekwini Municipality setback at ±6.5m at Eastmoor Crescent is borderline and too low. Damage was recorded above the 7 and 8m levels in Umhlanga. The Bluff section fared reasonably well at 8 to 10m, as did other sections of the coast where similar levels were in place. Therefore, it is logical to adopt the 10m contour as a first approximation to the rest of the Kwazulu-Natal coastline.

Figure 5: Diagrammatic layout of proposed initial setback lines for KZN.