REDEVELOPMENT: CRABS CREEK

EFFECT OF HIGH ASTRONOMICAL TIDES AND LOW ATMOSPHERIC PRESSURES RAISING ESTUARY WATER LEVELS (Report for EIA)

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Rev. 01

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Revision Table

Rev.	Date	Description
0	22 September 2014	Original Issue
1	29 Sep 2014	Typo: 'astronomical' tides

1. Introduction

It is proposed to re-develop the area known as Crabs Creek. Crabs Creek is portion 29 of the Farm Uitkyk 219, Knysna. The area is situated on the southern bank of the Knysna Estuary, approximately 150m downstream of the N2 National Road 'White Bridge'(Bridge B1419). The area falls within the Municipal jurisdiction of Knysna. The locality diagram is shown as Fig.1. The layout and other general information are contained within the Environmental Impact Assessment (EIA) Report.

We have been asked to comment on the effect of extremely high tidal events on the proposed development.

2. Height Datum Levels

The Surveyor General of South Africa specifies a land levelling datum at various locations from where height above and below sea level is measured. This is the general datum used on land and can be read on topographical contour maps and would also be used for site and building layout plans. The land levelling datum is stated as meters above mean sea level (m amsl).

Maritime charts (maps) and ocean tidal heights in the maritime context are measured from a specific reference level known as the chart datum. The current chart datum is based upon what is referred to as the Lowest Astronomical Tide (LAT). This is the lowest level that can be predicted to occur under average conditions in a 19 year cycle at a given location.

There is an offset height between the lower chart datum and higher land levelling datum. The SA Navy (1999) (Hydrographic Office) published the value for the offset as 0.788m for Knysna. For various reasons, including the tidal water levels varying with a cycle of 19 years, the land levelling datum is not necessarily the average water level measured at sea. Table 1 gives the chart datum, and land levelling datum values for various tides.

Table 1. Chart Datum, Land Levelling Datum and Tidal Heights.

Description	Abb.	Chart Datum	Land Levelling Datum
Highest Astronomical Tide	HAT	2.21m	1.422m
Highest Astronomical Tide of the Year	HATOY	2.2m	1.352m
Mean High Water Spring	MHWS	1.91m	1.122m
Mean High Water Neap	MHWN	1.32m	0.532m
Mean Level	ML	1.06m	0.272m
Mean Low Water Neap	MLWN	0.82m	0.032m
Mean Low Water Spring(MLWS	MLWS	0.22m	-0.568m
Lowest Astronomical Tide of the Year	LATOY	0.04m	-0.740m
Lowest Astronomical Tide	LAT	0.0m	-0.788m

The LAT's and HAT's relate to a 19 year cycle. From here onwards we will be referring to the land levelling datum (m amsl) unless specifically stated.

3. Historical Context of Site

The building was constructed in 1958/59 by Mrs Hazel Chester of the Wenborne Family. It was designed as an old character house with yellowwood floors and beams. It was sold in 1969 to the Midway Family. A lot of the old building charm had been removed by the time the building was demolished in 2013.

4. Sea Level Variability

Schumann (2013), in the document 'Sea level variability in South African estuaries', describes the effect of sea conditions on estuary conditions. Wave heights in excess of 5m are commonly found offshore; however the extent to which these waves enter an estuary depends on local conditions such as sandbanks and mouth morphology, which can cause further breaking and loss of energy. Schumann (2013) states that given the shallow and narrow mouths of many estuaries in South Africa, surface gravity waves seldom reach more than a few hundred metres into such estuaries.

Schumann (2013) also describes the effect of atmospheric pressure on water levels. When there is a change in air pressure at one point over the ocean it causes a response in sea level termed the inverse barometer effect. Theoretically, an increase in air pressure of 1 millibar results in the surface lowering by 1 cm, but this level of change is seldom fully achieved because of the movement of the air pressure systems and the fact that water movement is required to accomplish the change. Similarly, a lowering of air pressure results in a rise of water levels.

5. Estuarine Response to Sea Conditions

Schumann (2013) states that estuaries have a sandy barrier in the form of a sandy ridge that lies parallel to the prevailing wave fronts and extend across the seaward section of the estuary, separating the estuary from the sea. Knysna has two such barriers, called the inner and outer bar, and they are shown on SA Navy (1999) chart SAN 1021.

Water only flows in and out of estuaries when a pressure gradient is established, or in other words, when there is a difference in water levels. The incoming rising tide has higher water levels over the sand bar, and therefore less resistance, and therefore flows faster than the outgoing tide at shallower levels.

Schumann (2013) states that episodic events, such as tsunamis, add an unknown dimension, and does not address them.

Russell, Randall and Kruger (2013) describe the Knysna Estuary Conditions. Russell et.al. (2013) state that wave action on the rocky shores of the mouth (Heads) is strong, though seas diminish rapidly as they pass through The Heads, and disappear entirely where the estuary widens upstream of Leisure Isle. Russell et. al. (2013) cite Reddering and Esterhuysen (1987) who state that the channel between the Knysna Heads is 120m wide and up to 15m deep. According SA Navy (1999) chart 1021, the depth at the inner bar is between 3.9m and 4.5m. Russell et.al. (2012) state that the channel follows the broad twists of the estuary, becoming progressively shallower, being approximately 2m deep at the end of the tidal reach. Wide inter- and sub-tidal sandbanks line the channel for most of the length.

From the above it is evident that Crabs Creek, unless unknowns such as tsunamis are included, will not be subject to the effect of sea waves, and will be subject to tidal and atmospheric pressure variations.

6. Peak Tidal Levels of the Knysna Estuary.

Russell et.al. (2012) do not give precise peak water levels. Russell et.al. (2012) cite Grindley (1985) who states that the highest level recorded between 1965 and 1985 was ‘MSL + 2.0m’. Russell et.al. (2012) then state that MSL is given by Grindley as 1.16m, which would equate to a water level in the estuary of 3.16m. We believe that there is a datum error in this value. Russell et.al. (2012) cite Marker (2000) who maintains that during a storm event on 16 June 1996, that was accompanied by extreme low pressure at spring tide, water levels at Thesen Jetty reached the highest level on record, 0.20m above maximum spring tide.. Furthermore, surges at

15 minute intervals added between 0.10m and 0.05m to the maximum water level. Marker does not give actual water levels.

A peak water level of 2.2m amsl was recorded at Steenbok Park, Leisure Island, on 25 August 2008. This was believed to be the highest level recorded in 25 years. A photograph depicting this is shown as Photograph A1 of Appendix A. This is 0.778m above the Highest Astrological Tide (HAT) excluding pressure variations. Further information was obtained from Parkes (2014). The Knysna Yacht Club (KYC) has been in existence since 1910 and there is no record of flooding. However during a particular Regatta of about 15 to 20 years ago, Parkes (2014) recalls waves generated by a strong wind lapping against the walls of the Clubhouse. The average level was below floor level, though the crests of the waves were above floor. The KYC floor levels are in the order of 2.2m amsl, and this is a benchmark that has no record of being exceeded, except by wind induced waves, and then not enough to flood the floor.

From the Steenbok Park and KYC information, it is apparent that the peak tidal levels, accompanied by extremely low atmospheric pressures, realize maximum tidal water levels of 2.2m amsl.

7. Potential for Flooding from Rainfall Events

We conducted an analysis of the rainfalls within the Knysna Estuary catchment and compared them with the statistical 50 year, 100 year and 200 year Recurrence Internal (RI) rainstorms. The comparison is shown in Appendix B and summarized in Table 2 below. It is evident that the rainfall of November in 2007 exceeded the 100 year RI rainfall, and that the catchment was significantly charged with rainwater from the day before.

Table 2. Statistical Rainfall Depths Compared to Recorded Rainfall Depths of November 2007 (Extract of Appendix B).

Description	**Stations**				
	Gouna	**Goudveld**	**Concordia**	**BuffelsNek**	**Composite**
Peak one day rainfalls (mm/day):					
50 year RI	185mm	181mm	179mm	226mm	200mm
100 year RI	220mm	216mmm	213mm	269mm	**238mm**
200 year RI	260mm	255mm	252mm	318mm	281mm
Rainfall Recorded in November 2007 (mm/day):					
21 Nov	234mm	201mm	123mm	156mm	190mm
22 Nov	199mm	202mm	164mm	325mm	**247mm**

However during the November 2007 flood event, the flood water levels at Ferry House, which is 1km downstream of Crabs Creek, were 200mm lower than that recorded during peak tidal

events accompanied by low atmospheric pressure. It is therefore apparent that the peak water levels are higher at times of high astronomical tides and extreme low pressure events than during 100 year rainfall flood events. This is valid for the Knysna Estuary below the White Bridge. This is as the Knysna Estuary has a large conveyance capacity and downstream of the N2 'White Bridge'. For instance, CSIR (1974), cited by Russell et.al. (2012), state that the average tidal flow through the Heads is approximately 1000m^3/s, with the maximum tidal flow about 2000m^3/s.

8. Estuary Water Levels at Crabs Creek

Crabs Creek is alongside the Knysna River Corridor and the peak water levels are caused by high astronomical tides accompanied by low atmospheric pressure. From recorded readings, and benchmarks not exceeded, the peak estuary levels of the Knysna Estuary have not exceeded 2.2m amsl. This 2.2m amsl level can also be used for Crabs Creek. From recorded information of November 2007, the 100 year RI rainfall induced flood water levels will be in the order of 200mm lower than the peak tidal levels. This is in the order of 2.0m amsl. The floor level of the previous Crabs Creek Restaurant was 2.38m amsl. This was never exceeded by estuary levels caused by tidal and atmospheric events, or rainfall events.

In line with reports by Schumann (2013) and Russell et.al.(2012), Crabs Creek is unlikely to be affected by ocean surges and waves as it is well away from the river mouth, and is further protected by a twisty channel and the railway bridge. The topography also protects it from wave run-up caused by extreme westerly winds. It is also protected from southerly and easterly winds, though these winds do not reach the extremes of the westerly winds. Northerly winds, although not extreme, will have any wind induced waves losing energy across the sandbank north of Crabs Creek.

The levels set for the Thesen Island development were researched. According to Badenhorst (2007), the Thesen Island minimum floor levels were set as 3.0m amsl based upon a highest recorded level of 2.1m, with 0.4m allowed for the possibilities of rising sea levels, and then a safety factor of 0.5m.

A barometer of Knysna water levels is attached as Figure 2. Note that the mean high water spring tide is 1.122m amsl which is well below the ground levels at Crabs Creek.

9. Development Opportunities at Crabs Creek

Crabs Creek is in the Knysna River Corridor and we therefore consulted the City of Cape Town Floodplain and River Corridor Management Policy (CCT, 2009). This document was published in May 2009 by the City of Cape Town (CCT) and outlines the procedures for managing development adjacent to watercourses and wetlands taking cognizance of the flood regime, aquatic and riparian ecology as well as socio-economic factors.

In the CCT (2009) policy a merit based approach is advocated for dealing with proposals within and adjacent to floodprone areas and environmental buffers. In addition, socio-economic considerations are also introduced whereby any permitted development will take cognizance of the presence of the watercourse/wetland and thereby holistically enhance the urban fabric of the area.

We recommend that any development at Crabs Creek consider the possibilities of climate change and rising sea levels as these possibilities can be designed into the development infrastructure.

The CCT (2009) document discussed flood management and public safety and differentiates floodplain areas as either high hazard or low hazard areas. Figure 3 shows the hazard zoning. The high hazard areas are areas where people can not gain vehicular access or wade, and the stability of structures may be compromised. Low hazard areas have flood depths between 400mm and 800mm, depending on the flow velocity, and flow velocity at a maximum of 2m/s. They also have easy evacuation opportunities. If there is significant rising sea levels of up to 800mm, the vast majority of Crabs Creek will be in the low hazard area.

The proposed building will be designed to withstand the effects of any rising sea levels. In this respect we recommend a conservative approach with floor levels above 3.2m amsl. Similarly any site infrastructure works shall also be appropriately designed for the possibilities of rising sea levels. Note that these peak tidal events accompanied by low atmospheric pressure, and the possibilities of rising sea levels, would only inundate certain sections of the site for short durations, and the water will not have any velocity.

The area is alongside a river. There has been insignificant river erosion, although nearby SANParks have lined the estuary with poles. Figure 4 shows possible preventative measures for the unlikely migration of the river. To allow for the possibilities of excessive rising sea levels, measures such as shown in Figure 5 will raise the ground levels well above the levels of any

extreme tides accompanied by extreme low atmospheric pressure events, allowing for the possibilities of rising sea levels.

The development will have no effect on any other areas should there be significant rising sea levels.

10. Conclusion

The levels of the estuary alongside Crabs Creek are higher at times of peak tidal events and extreme low pressure events than during 100 year RI rainfall induced storm events.

The peak estuary water levels alongside Crabs creek were estimated to be 2.2m amsl for high spring tide events accompanied with extreme low pressure events. For the 100 year RI rainfall induced events, water levels in the order of 2.0m amsl were recorded. The majority of the Crabs Creek site is above these levels. The levels of the previous restaurant, which was never exceeded by estuary water levels, was 2.38m amsl.

It is recommended that the possibilities of rising sea levels are taken into account. Over and above this allowance, a safety factor should also be added. To this extent we recommend floor levels for any buildings to be above 3.2m amsl.

The site infrastructure should be designed for the possibilities of rising sea levels.

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Appendix A. Photographs

Photograph A1. This board shows that a level of 2.2m amsl was reached on 31 August 2008 at Steenbok Park, Leisure Island, and is believed to be the highest level in 25 years.

Appendix B. Storm Rainfall Information

Description	**Stations**				
	Gouna	**Goudveld**	**Concordia**	**BuffelsNek**	**Composite**
Gauge reference	030088	029805	30090	030265	
Altitude (amsl)	259m	262m	198m	634m	
MAP (mm/year)	947mm	830mm	888mm	879mm	
Centre-of-Area Weighting	33%	23%	5%	39%	100%
Peak one day rainfalls (mm/day):					
50 year RI	185mm	181mm	179mm	226mm	200mm
100 year RI	220mm	216mmm	213mm	269mm	238mm
200 year RI	260mm	255mm	252mm	318mm	281mm
Recorded Rainfalls for Recent Rainstorms:					
1996 November:					
1-19 Nov	166mm	109mm	136mm	140mm	141mm
20 Nov.	38mm	29mm	A	30mm	33mm
21 Nov.	121mm	99mm	172mm C	102mm	111mm
2003 March:					
1-22 March	72mm	79mm	67mm	43mm	62mm
23 Mar	32mm	24mm	A	41mm	32mm
24 Mar	88mm	141mm	A	52mm	116mm
25 Mar	61mm	20mm	A	52mm	45mm
26 Mar			251mm C		
2006 August:					
1 Aug	135mm	129mm	200mm	114mm	129mm
2 Aug	A	144mm	73mm	203mm	164mm
	145mm C				
2007 November:					
1-20 Nov	40mm	40mm	32mm	45mm	42mm
21 Nov	234mm	201mm	123mm	156mm	190mm
22 Nov	199mm	202mm	164mm	325mm	247mm
23 Nov	A			80mm	45mm

Source of Information: Univ. Natal (2002), SAWS (2010).

Key:

A Data not recorded

C Data accumulated over a few days

Figures