DEFENDING DURBAN’S BEACHES – A RECIPE FOR SUCCESS?

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ABSTRACT

South Africa’s coastline is continually changing. It either accretes (builds seawards) or retreats (erodes), often with devastating consequences should development be located inappropriately or where coastal vegetation has been removed. The natural eroding process is further exacerbated by global climate change - with its coastal specific repercussions as a result of sea level rise and increased storminess.

In 2008 the KZN Department of Agriculture and Environmental Affairs published a guideline document entitled, “Living with Coastal Erosion: A short term, best practice guide”. This guide discussed mitigation of coastal erosion using a combination of techniques and schemes which included hard engineering techniques, soft engineering techniques and managed retreat, but ultimately recommended working with natural processes in responding to erosion. The preferred protection measure / soft solution proposed included constructing a berm consisting of geofabric or other suitable sand bags of suitable weight and to reach a height approaching that of the original frontal dune at a gradient of between 18˚ and 24˚. This berm was proposed to be covered with sand and vegetated with appropriate dune species as per the original natural zones. In some cases additional protection consisting of gabion baskets filled with bags was proposed to be used to protect the toe of the berm created. At that time this method of defence was deemed to be cost-effective relative to hard protection measures. While acknowledging that this method would require continuous maintenance, it was deemed effective in improving slope stability, reducing the impacts of wave energy and providing for the continuation of natural coastal processes and beach amenities.

Five years have passed since then, and many organisations and individuals have implemented various methods of coastal defence in keeping with the above guideline document. The use of geotextiles, in particular, has been the subject of technical review within the eThekwini Municipality and these failures and successes will be discussed.

Significant damage has been caused to Durban’s famous Golden Mile as a result of overtopping, inundation and erosion, as a result of storm events, most notably that of 19 and 20 March 2007. In addition, and in preparation of South Africa’s hosting of the 2010 FIFA Football World Cup™, eThekwini Municipality, as a host city, upgraded the Durban Central Beachfront by extending the promenade from uShaka to Country Club Beach and by redeveloping facilities at various nodes. This re-development has since been extended by the addition of a new promenade, from Country Club Beach to Blue Lagoon, effectively linking it to the Blue Lagoon Eco-hub. A background to and discussion of the City’s solution to its wind and wave problems will be discussed including how the City applied both smart, ecologically and environmentally sound principles by re-instating and rehabilitating coastal dunes. This application of the soft
engineering “sleeping defence” approach in respect to Durban’s Golden Mile, and the re-
creation of a vegetated dune cordon, will be used as a specific case study highlighting the cities
move to promoting green infrastructure and putting natural processes at the heart of this
specific defence strategy. This strategy is fully in-line with international best practice and the
recently adopted United Nations strategy (adopted on the 6th of May 2013) embracing green
infrastructure. Initial project motivation, strategies adopted and the approval and
implementation process as well as lessons learnt will be examined and detailed.

The presentation will conclude with a proposed ‘recipe’ for the way forward, detailing the
required ingredients and the tested methodology and ultimately award eThekwini Municipality
South Africa’s 1st coastal defence master chef™ trophy!

Modern man talks of a battle with nature, forgetting that, if he won the battle;
he would find himself on the losing side - E F Schumacher

OVERVIEW
Change in life is inevitable! Change in the coastal zone/environment, as with life, is also inevitable
and a completely natural process. Coastal environments either accrete (builds seawards) or retreat
(erode), often with devastating consequences should man-made structures/development be located
inappropriately or where indigenous coastal vegetation has been removed. Human-induced global
climate change, with its predicted sea-level rise and increased storminess further exacerbates this
process (Mather, 2008).

In keeping with KwaZulu-Natal’s (KZN) guideline document entitled, “Living with Coastal Erosion:
A short term, best practice guide” (hereinafter referred to as the “KZN Guide”) published in 2008,
eThekwini Municipality and other municipalities as well as private land owners have implemented
various methods of coastal defence. The successes and failures of the geotextile bag defence methods
adopted, to the re-establishment of a vegetated dune cordon adjacent to Durban’s Golden Mile, will be
detailed and a ‘recipe’ detailing the required ingredients and methodology proposed, which will, in
conclusion award eThekwini Municipality South Africa’s 1st coastal defence Masterchef™ trophy!

Figure 1: Living with Coastal Erosion in KwaZulu-Natal: A short-term, best practice guide
BACKGROUND
In March 2007 the KZN coastline was rocked by a huge storm which coincided with an extreme high tide event. The resultant erosion was as a result of the loss of sand and altered beach profiles, and continued long after the actual storm event. However the power and devastating effects of these extreme events are often forgotten soon afterwards.

The International Panel for Climate Change (IPCC 2007) predict that climate change along our coastline will be felt through extreme events and sea level rise. It is predicted that future sea-level rise will turn what was an average marine storm into an extreme event. When you combine this with the fact that rising sea temperatures are bringing our continent ‘closer’ to the cyclone belt it predicts hard times ahead for sea-side property and the related tourism industry.

What is coastal erosion?
Coastal erosion is the weathering of rocks and the removal of beach or dune sediments by wave action, tidal currents, wave currents, or drainage. Coastal erosion results in the loss of land and damage to the built environment; the destruction of natural sea defences such as dunes; or the undermining and failure of artificial sea defences (Breetzke et al, 2008).

The character and nature of the coast at any one place or time results from combinations of geological, climatic and oceanographic processes, as well as human intervention. Coasts are also continually changing and can either erode (retreat) or build seawards (accrete). The changes along the KZN coast since 2007 are therefore not the exception, but the rule. Most people perceive coasts as stable because coastal change is generally slow with only occasional exceptional events such as storm-induced erosion. Coastal change is constant and - over the long-term – inevitable (Breetzke et al, 2008).

Mitigation of Coastal Erosion
The KZN Guide, as detailed above, discussed mitigation of coastal erosion using a combination of techniques and schemes which included hard engineering techniques, soft engineering techniques and managed retreat. These were defined / discussed as follows:

- Hard engineering techniques – Using permanent concrete and rock constructions to “fix” or consolidate the coastline and protect the inland assets. These techniques – Usually in the form of seawalls, groins, detached breakwaters, or revetments - represent a significant share of historical coastal defences;
- Soft engineering techniques – Building with natural processes in mind, relying on natural elements such as sand dunes and vegetation to prevent erosive forces from reaching the built environment, and the use of sandbags and beach nourishment schemes; or
- Managed retreat – Removal and relocation of houses and other infrastructure away from erosion prone areas (Breetzke et al, 2008).

Ultimately, the KZN Guide recommended working with natural processes in responding to coastal erosion. The preferred protection measure or soft solution proposed included the construction of a berm consisting of [a single row of] geofabric or other suitable sand bags of suitable weight, to reach a height approaching that of the original frontal dune at a gradient of between 18˚ and 24˚. This berm was proposed to be covered with sand and vegetated with appropriate dune species as per the original natural zones. In some cases additional protection consisting of gabion baskets filled with bags was proposed to be used to protect the toe of the berm created (Breetzke et al, 2008).

1 Specification of a single row included by the authors
At that time this method of defence was deemed to be a cost-effective option relative to hard protection measures, and while acknowledging that it would require continuous maintenance, was deemed effective in improving slope stability, reducing the impacts of wave energy and providing for the continuation of natural coastal processes and beach amenities (Breetzke et al, 2008).

IMPLEMENTATION

Five years have since passed and, as of 2013, many municipalities and individuals have implemented various methods of coastal defence in keeping with the KZN Guide. Coastal defences implemented by the eThekwini Municipality, which have been technically reviewed, as well as those implemented in the recent Durban Central Beachfront (former Golden Mile) re-development, afford both an opportunity to review the recommendations made in the above KZN Guide and propose a ‘recipe’ for future soft coastal defence.

Technical review of Durban’s coastal defences

Corbella and Stretch, both now of the University of KwaZulu-Natal, undertook a review of Durban’s coastal defences in 2012, with particular reference to the performance of geotextiles as a sea defence. It is noted that, as of 2012, ±20 000 geotextile units valued at ±R70 million had been installed along a 100km long stretch of coastline in KZN (Corbella and Stretch, 2012a; Corbella and Stretch 2012b). These papers provide a detailed historical overview of Durban’s beach protection since 1857, evaluate Durban’s coastal defence experiences post the 2007 tidal event and detail their successes and failures. As such, they provide practical insight for this paper and its evaluation of the implementation of the KZN Guide. Corbella and Stretch note that Geotextile sand-filled containers (GSC’s), which are considered to be a relatively new and cost effective technology in South Africa, can still be afforded the ‘soft defence’ label, while in fact stabilising the coast, as they can be easily cut and removed if required (Corbella and Stretch, 2012a).

Table 1: Summary of Corbella and Stretch (2012a, 2012b) assessment of coastal defence with specific reference to geotextile bags

<table>
<thead>
<tr>
<th>Overview</th>
<th>Issues</th>
<th>Proposed solution</th>
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| Geotextile bags | • Use initiated in USA, Netherlands & Germany 50 years ago.  
• Initially only manufactured by Kaymac (Pty) Ltd trading as Kaytech as EnviroRock®.  
• Evolved to 2.1 x 1.8 x 0.55m two layer bag (inner polyester / geotextile and outer UV stabilised staple filament polypropylene) bonded together with two chutes for filling. | • Hand stitched portion needs to be faced landwards;  
• Hand stitching needs supervision to reduce quality fluctuations;  
• Pre-punching of holes allows for consistent spacing;  
• Nylon needs to be correctly knotted;  
• Use of hand held sewing machine was not deemed viable; and  
• Nylon cable tires used as an alternative. |
| Filling | • Initially used steel frame to fill. Done by dredge pumps or excavator & additional hand filling by shovel on the beach.  
• New manufacturers have since entered the market & bag dimensions have changed.  
• Seam = 80% of bag strength.  
• Loss of sand is the main cause of potential failure.  
• Stitching needs to be removed to fill new bags with tendency to run pulling bags open.  
• Chutes needing to be stitched by hand. | |
| Installation | • Initially filled to 80% capacity, flooded with water to compact.  
• Must not overfill as stability impacted by | • Installed to lowest scour level; and  
• Include self-healing Dutch-toe. |

2 Corbella and Stretch considered other defence options, including those using geofabric applications, but for this purpose only geofabric bags are included
‘rounding’.
- Orientated with longitudinal axis perpendicular to the direction of wave attack.

**Slope**
- Applicable slope debated internationally.
- Slope from 30° to 45° proposed in literature.
- Flatter wall = less wave loading but greater wave run-up.
- Walls vulnerable to vandalism & degradation by ultra-violet light.
- Slope initially calculated as between 18° to 26° which includes safety factor and is able to retain the most soil;
- Cover with sand and vegetate;
- Sufficient depth of growing medium must be provided as dune vegetation can root into GSCs;
- Needs to be >30° to retain sand; and
- Most stable slope determined as 45°.

**Bag performance**
- 1st substantial test on 26 July 2011 - 5m offshore significant wave height.
- Numerous short comings highlighted.
- Vandalised bags leaked sand causing weak spots.
- Lower bags shifted forward, slope of bag seawalls steepened near toe & flattened near crest.
- Life expectancy estimated at 30 years but literature estimates from 35 to 110 years.
- Movement of sand within bags identified as main cause, attributed to:
  - Bags not sufficiency filled;
  - Bags leaked sand; and
  - Bags elongated.

**Conclusions**
- Geofabric bags should be founded on rock or to a depth that ensures structural stability.
- Geofabric bags need to have Dutch-toe as additional defence.
- Geofabric bags need to be filled to capacity.
- Slope should be 45°.
- Geofabric bags need to be covered in sand and vegetated.
- Geofabric bags = sleeping defence – vegetation can be stripped during storm surges.
- Wraps are a viable substitute in severely restricted areas.
- Must include good monitoring system.

**Source:** Corbella and Stretch, 2012a; Corbella and Stretch 2012b

**Figure 2:** Images showing the 26 July 2011 event, filling and sewn up bags ready for installation (Corbella and Stretch, 2012a; Corbella and Stretch 2012b)

**Upgrade of Durban’s Central Beachfront / Golden Mile**
Significant damage has been caused to Durban’s famous Central Beachfront or Golden Mile as a result of overtopping, inundation and erosion caused by storm events, most notably that of 19 and 20 March 2007. In addition, and in preparation of South Africa’s hosting of the 2010 FIFA Football World Cup™, eThekwini Municipality, as a host city, upgraded the Durban Central Beachfront by extending the promenade from uShaka to Country Club Beach and by redeveloping facilities at various nodes. This re-development was then extended from Country Club Beach to Blue Lagoon, linking it to the Blue Lagoon Eco-hub. The re-development included the upgrade and establishment of a 7km long and (predominantly) 17m wide promenade from uShaka Beach in the south to Blue
Lagoon the in the north plus a pedestrian link to the Recreation Precinct (and Moses Mabhida Stadium) and Blue Lagoon Eco-hub; realignment and creation of sections of road and parking areas and the creation of traffic calming circles; upgrading of storm water infrastructure; installation of 15m high street lighting and street furniture; construction and upgrade of various development nodes; planting of vegetation and landscaping and dune stabilisation and rehabilitation works. The project commenced in June 2009 and concluded in July 2013.

A background to and discussion of the City’s solution to its erosion (wind and wave) problems will follow including how the City applied both smart, ecologically and environmentally sound principles by re-instating and rehabilitating coastal dunes, fully in keeping with the KZN Guide.

**Principles informing the beachfront upgrade**
Principles which informed the beachfront upgrade, as detailed in both expressions of interest for the Beachfront upgrade environmental authorisation process (ERM 2009, SSI 2010), included:

- The need to enhance the historical importance of the Central Beachfront;
- The need to recognise the social importance of the area for people living in, working in and visiting the city;
- The need to provide public spaces and facilities for people to use in many different ways;
- The need to prioritise and encourage a range of recreational activities;
- Taking consideration of key environmental issues, such as coastal management and safety, through environmental design; and
- Providing upgraded facilities in a way that would be in keeping with future phases for the beachfront.

**Background and assessment of the upgrade**
The Durban Central Beachfront or Golden Mile is the stretch of beach between the harbour entrance and stretching northwards to the Umgeni River/Blue Lagoon. It has been the most developed beachfront in the region, with development starting in the early 1900’s. It is now the main tourism attraction that Durban offers and as a result of the significant public and private investment made, needs to be defended against wave attack and erosion. Responding to this attack has required the implementation of a mixture of interventions dating back as far as 1857. The primary risk input consideration applied was the potential erosion lines and building set-back lines which, in Durban’s case, have applied since the mid 1980’s, amended in 1990 and recently updated just before the most recent beachfront upgrades in 2009 (Mather 2009). In keeping with the KZN guide, the approach adopted was a combination of sand replenishment, reinstatement of vegetated dunes and the installation of soft coastal defences (geotextile bags) at areas of higher investment (beach nodes).

A summary assessment of Durban’s central beachfront re-development is detailed in Table 2 below which includes an identification of the issues, what was re-developed and how as well as problems
encountered and solutions implemented. A cross section of the approved geotextile bag / EnviroRock® defence system is depicted in Figure 3.

Table 2: Summary assessment of Durban’s Central Beachfront re-development

<table>
<thead>
<tr>
<th>Issue (why?)</th>
<th>What and how</th>
<th>Problems and solutions</th>
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<tr>
<td>The built environment is located too close to the shoreline and the high-water mark so measures needed to be taken to protect this extensive public and private investment.</td>
<td>Durban’s central beachfront redevelopment included:</td>
<td>• Planting problems experienced as a result of:</td>
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<td>• Installation of soft engineering defences (geofabric bags) adjacent to higher value investments (new nodes &amp; existing lifesaving facilities);</td>
<td>o Salt laden winds;</td>
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<td></td>
<td>• The stretches of promenade which do not have structures behind them would not be protected from erosion using geofabric bags;</td>
<td>o Windblown sand;</td>
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<td></td>
<td>• These stretches would be protected by rehabilitated vegetated dunes;</td>
<td>o Large number of people;</td>
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<td></td>
<td>• The soft engineering defences installed are considered to be sleeping defences, future damage to dune vegetation is anticipated;</td>
<td>o Pigeons; and</td>
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<td>• Future repair or reconstruction of the promenade is anticipated in the event of the erosion and damage in these stretches.</td>
<td>o Litter management.</td>
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<td>eThekwini’s central beachfront is an exception as a result of the Southern breakwater (Harbour mouth) interfering with natural sand movement and which prevents natural littoral drift and exacerbates erosion.</td>
<td>Soft engineering defences installed included:</td>
<td>• Environmental authorisation required sacrificial fencing to be curved to ensure dune rehab looked more natural. During implementation this was adjusted to straight line as the curved lines channelled sand directly onto the promenade.</td>
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<td>The best defence against the negative impacts of dynamic coastal processes is a vegetated dune cordon.</td>
<td>• robust geofabric / envirorock sandbags weighing approximately 4 tons;</td>
<td>• Wooden boardwalks were constructed at access points to:</td>
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<td>• geofabric bags were installed to approximately 13 bags deep (below the 2009 eThekwini Municipality erosion line (Mather 2009));</td>
<td>o Avoid trampling of newly vegetated dunes;</td>
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<td></td>
<td>• a double layer of bags was placed at a 1:1 (45˚) slope with a self healing toe (Dutch Toe);</td>
<td>o Allowing easy access from promenade to the beach;</td>
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<td>• creation of vegetated (man-made) dune cordon, both above geofabric bags as well as remainder of beach (except for Wedge beach, Durban’s events beach which was too narrow);</td>
<td>• Original shade cloth at access points was replaced with timber fencing (lipstick);</td>
</tr>
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<td></td>
<td>• 18 to 22m wide foredune created by using sacrificial shade cloth fence and included:</td>
<td>• In respect to planting:</td>
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<td>o The retention of a specific profile;</td>
<td>o The palate was simplified to accommodate unrelenting affects of wind-blown sand and salt;</td>
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<td></td>
<td>o Height of planting low (1.2 to 1.8 m) for security and aesthetic reasons (Don’t spoil view).</td>
<td>o Smaller trees were found to grow better than bigger trees; and</td>
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<td>• Existing high vegetation retained in certain areas, for example at Suncoast; and</td>
<td>o Different types of lawn grasses experimented with.</td>
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<td>• 4 km of green lawns.</td>
<td>• Stumps were placed on the beach to protect plants against waves. These were initially considered unsightly but will weather into aesthetically pleasing drift wood. It was noted that the Suncoast dune rehabilitation withstood 2007 tidal surge event.</td>
</tr>
<tr>
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<td></td>
<td>• In respect to Dun rehabilitation maintenance. This was much more than just weeding and watering. Also Includes slip planting, litter removal, fertilization and even managing vagrants.</td>
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<td></td>
<td></td>
<td>• In respect to the so-called Pigeon plague:</td>
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The purpose of such investment was to:

- provide insurance for the City investment by protecting new infrastructure;
- providing a buffer from wave inundation;
- protecting the investment and the neighbouring developments from the effects of sea level rise by dissipating wave action (buffer);
- providing protection from spring tides in March, August, October and December;
- providing protection from cyclonic swells from the north-east;
- providing a buffer from windblown sand;
- Saving ongoing maintenance costs during the windy season.

- 6000 pigeons at Addington beach alone;
- Unexpectedly attacked newly planted vegetation.
- Solution= thorny branches were placed over closely planted seedlings;
- Initially pigeons did not like the prickly effect and were then unable to manoeuvre through the dense vegetation.

Reasons for not creating a vegetated dune at Wedge beach:
- Too narrow and too busy;
- Considered to be Durban’s events beach;
- The consequences of this decision mean continuous sand build-up on new grass and increased maintenance.

Source: Urban Green File 2011

**Figure 3: typical cross section of defence structure (Pauselli 2013)**

*What makes Durban’s solution ecologically ‘smart’ and environmentally sound?*

Durban’s implementation of the KZN Guide is considered to be smart, ecologically and environmentally sound because:

- It is a green-efficient product and solution;
- It reduces strain on City maintenance requirements and service delivery needs;
- It reduces risk to infrastructure by creating a sustainable buffer against dynamic coastal processes;
- It is an innovative and proactive response to disaster management requirements;
• It can be considered to be a financially and environmentally sustainable investment;
• It created both short term and long employment;
• It proactively addresses waste, security and crime issues;
• It beautifies the City landscape / coastal zone;
• It improves public amenity and access to the coastal zone; and
• It adopts an innovative and best practice.

CONCLUSION
The KZN Guide was intended to be implemented along with a detailed and holistic business plan looking at short, medium and long term responses to the erosion crisis in KZN and was widely used to prepare and assess applications for rehabilitation, re-development and development of properties along the KZN coast ravaged by continued erosion. The KZN Guide, as anticipated in 2008, did contribute to the national and provincial coastal set-back ‘conversation’ and could be considered to be the starting point for the application of the soft engineering response to coastal erosion in KZN (Breetzke et al 2008).

Since 2007, a lot of practical lessons have been learnt and adjustments made to suit local conditions and geobag installation has undergone three important changes in design, namely:

• The angle of the sea facing slope has been amended to optimise the amount of frictional contact between the bags with the resultant change in slope from 18-24º to 45º;
• A second row of geobags behind the frontal defence layer has been included to reduce the potential failure of the geobag structure if the front row of bags was damaged or sucked outwards during wave down-rush on the front slope;
• A self healing Dutch toe has been included at the lowest scour level as an additional defence.

The principles of the KZN Guide remain valid today, namely:

• Accept and live with erosion;
• A collective response is required;
• Establish a coastal set-back line;
• Work with natural processes in response to erosion;
• Replace lost sand with sand;
• Consider hard engineering solutions in exceptional cases only;
• Be prepared, monitor and react;
• Appropriately reconstruct coastal infrastructure and amenity; and
• Avoid and reduce risk.

This application of the soft engineering “sleeping defence” along Durban’s Golden Mile and the recreation of a vegetated dune cordon highlight the city’s move to promoting green infrastructure and putting natural processes at the heart of this specific defence strategy. This strategy is fully in-line with international best practice and the recently adopted United Nations strategy adopted on the 6th of May 2013, embracing green infrastructure.

3 The coastal set-back or management line ‘conversation’ is not discussed in this paper but is intended as a proactive legal afforded provincial government tool.
Recipe for the way forward

RECIPE
Sweet phyllo pastry topped with a indigenous herb garnish
For successful soft defence

Ingredients:

- A mindset and willingness to do things differently;
- An eroded or vulnerable sandy coastline;
- A structure/asset worth defending;
- Phyllo pastry bags (Geobags);
- Sugar (Sand);
- Herbs for garnish (Indigenous plants); and
- Baking paper (Bidim®).

Method

1. Prepare the pan (base of the structure). Establish level at predicted scour depth (erosion line).
2. Prepare the phyllo pastry (geobags) bags by placing them in a vertical holder and filling with sand using water as the compacting agent.
3. Once filled to correct level stitch up bag and set to one side to rest.
4. In the excavated hole place a layer of baking paper (Bidim®) on the base of the pan followed by the “Dutch toe” bag evenly along the base. A poorly placed base will not allow the phyllo (Geobags) bags to rise evenly so special care is need to set this absolutely level.
5. Wrap the baking paper (Bidim®) layer around the Dutch toe and back inland.
6. Layer a double row of phyllo bags with the long edge of the bags seaward. Place a further layer of baking paper (Bidim®) and then fill behind each bag for support.
7. Complete the whole first layer before setting the next double row of phyllo bags on top and slightly landward to achieve the desired front slope. The next row of phyllo bags must straddle the ends of the bags below. This is to prevent losing some of your pudding to the sea as it has a nasty habit of stealing bits where it can.
8. Continue adding new rows as per steps 6 and 7 above.
9. When you have reached the desired pudding height it now time to garnish it. Place a sugar coating (sand) over the phyllo bags and slope it seaward at a slope of approximately 1:3.
10. Over the sugar (sand) layer garnish with an assortment of specially selected ingenious herbs (plants) and seeds mixed into the sugar layer. Apply sufficient water to enhance the growth and flavour.
11. Marinate and set, checking regularly to ensure garnish does not wither away.
12. Wait for large sea storm to evaluate results!
BIBLIOGRAPHY


