SEA + SURVIVAL

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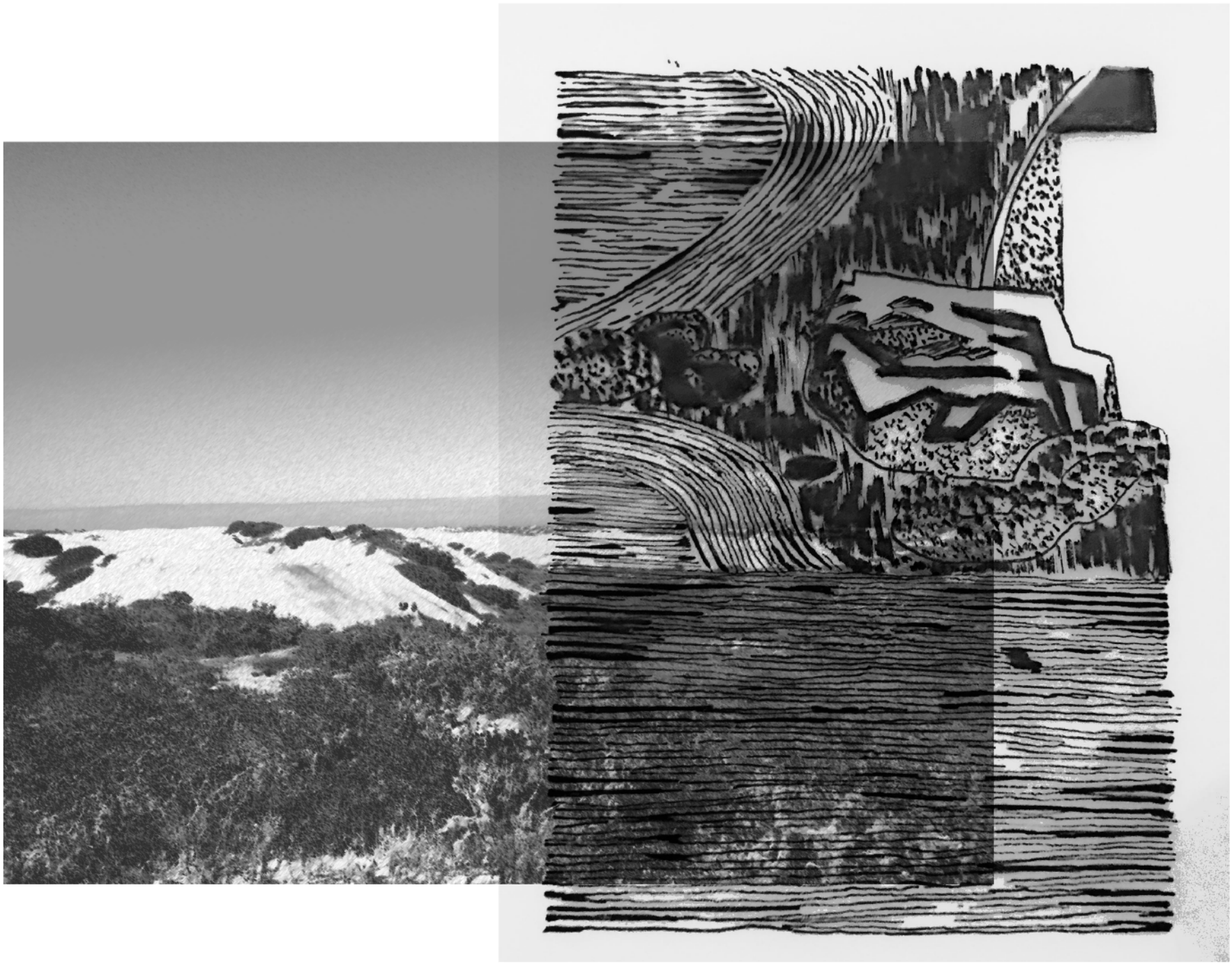
CHOREOGRAPHING DUNE SYSTEMS TO DEFEND AGAINST SEA-LEVEL RISE



ABIGAIL VICTORIA SENDALL | SNDABI001
MLA THESIS DISSERTATION DOCUMENT
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2020

SEA + SURVIVAL:

CHOREOGRAPHING DUNE SYSTEMS TO DEFEND AGAINST SEA-LEVEL RISE

Abigail Victoria Sendall
SNDABI001

Supervisor: Amy Thompson

Submitted in partial fulfillment of the Master of Landscape Architecture Degree
120 Credits

I further state that no part of this dissertation has already been or is currently being submitted for any such degree, diploma or other qualification.

Cape Town, 2020

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THESIS ABSTRACT |

[1]Sea-level rise is on the forefront of global climate change concerns with an estimated 800 million people at risk of experiencing the devastating social, economic, and environmental impacts of rising seas and storm surges (C40 Cities, n.d.). In particular, coastal towns and cities are under immense pressure as major solutions are needed to ensure the resilience of these spaces.

Langebaan, in the Greater Saldanha Region along the Western Cape, South Africa is suffering from the effects of poorly planned linear coastal development that has suffocated the protective dune systems and public beach space. Where, according to the Sea Level Rise and Flood Risk Assessment for a Select Disaster-Prone Area Along the Western Cape Coast Report, Langebaan is specifically mentioned for being highly susceptible to coastal erosion and storm swell damage (Blake & Chimboza, 2011).

The town is a fast-growing holiday destination and retirement area, which has led many of the new developments to be privatised, commandeering large portions of the coastal beachfront. The small portion of the beach that is then left for the local communities to enjoy is the most at risk to sea-level rise.

It is at this moment where my dissertation lands itself, in the investigation of the [2]pinch-point between human and nature; the human treatment of the coastal 'dunescape', and the ecosystem services of coastal dunes amid a climate crisis.

Due to the constrained nature of the coast, sea defences are required to take place offshore, therefore, I propose a land claim in the form of an ecological island. This thesis harnesses the existing ecological systems in and around the area to form a buffer between Langebaan and the sea. The defence system acts to unsuffocate dunes and public space in Langebaan by claiming land for ecological systems and humans.

Overall, this thesis illustrates the importance of the envelopment of the human and the natural in reacting to climate change and creates an accessible, sensitive, and meaningful space, revealing the memory of the site.

[1]Sea-Level Rise does not refer to the gradual rise in mean sea-level (msl) but rather the increase in frequency and intensity of storm surges (Blake & Chimboza, 2011).
[2]Pinch-point refers to a point where two seemingly opposing ideals collide or coexist.

CONTENTS |

1. CONTEXTUALISING + GROUNDING THEORY.

The balance of opposites.[a]

THE BALANCE OF OPPOSITES
[4]BURIALS, [5]EXCAVATION AND A REVELATION OF [6]DEEP TIME

//

The formation of the coast is a dance over billions of years between additive and subtractive beats and within a span of a few thousand years humans have shifted the rhythm. Through the increased awareness of deep time humans and earth can once again become in sync.

Coastal dune systems are the most visible story of deep time as they are ‘real time’ indicators of deposition and erosion. Dune systems grow and shrink, move and morph at a seemingly ‘human-timescale’ where there are distinct ‘before’ and ‘after’ changes. Essentially, they illustrate geological changes on a human timescale which have the ability to begin a dialogue between humans and nature.

This balance of opposites has been offset through the strain of human settlement, humans have gouged the earth in search of valuable minerals, fossil fuels and stone; they have buried ecologies for the placement of infrastructure, mono-culture and housing. Where humans have 'eroded' and excavated far more than what has been deposited and buried, taking away the essence and service of the coastal dune system. The essence of dune systems is intriguing, because these phenomena are simultaneously expansive, violent systems as well as sensitive and subtle organisms. They serve to protect the inshore ecologies, provide habitats for biodiversity and they are the buffer between humans and sea (McHarg, 1969).

Recent development along the coast have emerged as a response to the therapeutic character of this transition zone. The developments are invasive and have often grown irresponsibly, suffocating the dynamics of the natural systems. The effects of development onto the dunes have had negative economic, environmental and social consequences. Where the dialogue to be learned is that these systems are not tamable (McHarg, 1969), and that a crisis will arise if not treated correctly. This crisis is a result of the disjunction between science and design where ecological landscape design is a proposed way of bridging the divide and giving ecological integrity to design (Çelik, 2013).

The processes of coastal forming are understood as additive and subtractive processes, with dunes being live studies of them. I will begin to look at these processes in the abstract, then spatially (miniature and panoramic), temporally (deep time) and as a palimpsest. These studies are done as the basis of my design research and the initial inquiry into dune systems and sea-level rise.

burial + excavation.[b]

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[4]Burials an additive process which has two meanings in this study; the first refers to the geological phenomenon of sediment layering through deposition where the new sediment layers bury the old; and the second refers to the cultural practices of burying the deceased.
[5]Excavation is a subtractive process which refers to the human action of accessing materials and information, it is often seen as a reaction to burial and deposition.
[6]Deep-Time, coined by John Hutton in 1788 who claimed, “geological features were shaped by cycles of sedimentation and erosion, a process of lifting up then grinding down rocks that required timescales much grander than those of prevailing Biblical narratives.” (Farrier, 2016).

METHODOLOGY |

A combination of constructivism and post-constructivism methodology is applied in this thesis and organised through Christophe Girot's design methodology. Girot states that there are four key concepts that serve as tools for landscape design research: Landing, Grounding, Finding and Founding (Girot, 1999). The primary research methods for this study comprises of process-based experiments, precedents, spatial analysis, material studies and experiential modeling.

These methods were adopted to answer the following research question and sub-questions. How can an understanding of the coastal landscape forming lead to resilient coastal edges? and How can an understanding of dune systems defend against sea-level rise. Further questions were asked; What is the experience of the coastal landscape and its processes? What is the meaning behind these experiences? How can this meaning be translated into design? What forms and spatial arrangements can trigger a consciousness of the past environments, the conception of deep time?

METHOD |

1. LANDING

I began my inquiry by stating that coastal forming is essentially the interplay between additive and subtractive processes and more specifically the processes of deposition and erosion across various spatial and temporal scales. I looked at dunes and actions (burial and excavations) in both geological and human times-scales, as a way of understanding the function, use and experience of a coast and its [3]palimpsests. Where I modeled and experimented with these processes in the abstract and encapsulated the lessons into photographs and drawings. The models included, instinctive models based on a topic and process based modeling. This was important as it gave an initial understanding of systems without spatial constraints.

2. GROUNDING

Thereafter, I grounded my thesis by conducting a historical and ecological spatial and temporal analysis of the Greater Saldanha Region and Langebaan. Where I concluded that Langebaan's materiality can be summarised into water, sand and stone. I then performed a quantitative and qualitative study, through mapping, drawing and modeling the materials. This study led to an understanding of the performance of these materials in a larger system and the experiential quality and meaning of these materials to Langebaan and the Greater Saldanha Region. Informing how to present the bio-geophysical phenomena at a human scale.

3. FINDING

Process-based modeling experiments of the hydrodynamic and sediment influences on the Langebaan coastline have led do a greater understanding of the systems in the area and have ultimately been the backbone of my design. Through this modeling it supported my initial intuition on the idea of a land claim and the quality of dune systems. The experiments also gave me key clues to the form of the ecological island, by highlighting vulnerable points in Langebaan and performing the act of water on sand.

4. FOUNDING

The design. The experiments have allowed for form generation, where the study of systems and meaning have led to a coastal defence design that creates a sensitive, resilient and accessible edge between man and sea.

[3]Palimpsest involves the layering of different events/elements over-time.

WHY THE DUNES?

//

COASTAL RESILIENCE AND CLIMATE ADAPTABILITY |

Climate change and sea-level fluctuations are pressing environmental issues that landscape architects have the means to adapt and plan for. Dunes are critical buffer zones between humans and the ocean (McHarg, 1969), so there is a need for design that honours their integrity and understands their system dynamics.

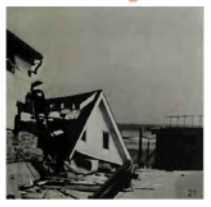
THE HUMAN RESPONSE |

People tend to over-look the pertinence of dune systems as their functionality is often nuanced and very subtle. The human response is often direct development onto these systems with little regard to the socio-economic and environmental impacts (and in the South African context, the socio-political impacts) or understanding of their functionality and purpose. This response results in devastating environmental impacts where people often attempt to control the dunes by planting large amounts of alien vegetation, for example Rooikrans. This vegetation out-competes and endangers indigenous dune vegetation (Meyer, 2007). It also changes the structure of marine benthic environments and results in habitat loss for many marine species. In Langbaan, the Greater Saldanha Region of the Western Cape, South Africa, the suffocation of existing dunes by development has lead to the development of groine in the form of sand bags to replenish the lost beach and dunes.

Adaptive design is needed to preserve the ecological integrity of these systems and the human treatment thereof.

SENSITIVE INTERACTION AND EXPERIENCE |

Due to the heavy environmental impacts of human treatment on dune systems, many of the undeveloped systems are now proclaimed as protected areas, resulting in the exclusion of people from the dune systems. There is a need to generate respect for these systems through the integration of humans and ecology, to allow for sensitive interaction between users and ecology and to stimulate an intellectual conversation about these systems, (i.e., there is a need to restore the culture and uncover the meaning buried beneath the dunes).



sea + survival.[c]

COASTAL FORMING
DUNES + ACTIONS (BURIALS + EXCAVATIONS) IN BOTH GEOLOGICAL + HUMAN TIME SCALES

//

Investigating the forming of the dunes and the notion of the ‘dunescape’, the geological and human reaction to addition and subtraction forming processes, and the miniature and panoramic dynamics of coastal forming.

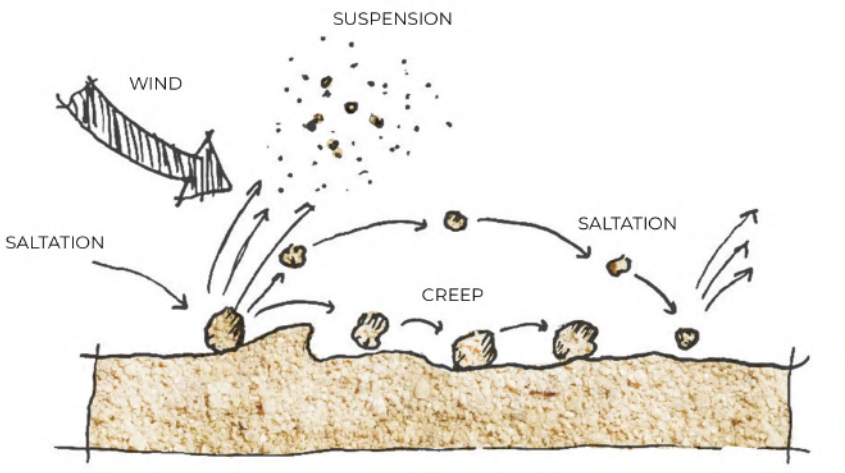
‘THE DUNESCAPE’ |

‘Dunescape’ — refers to dune systems viewed as both a process driven entity as well as an experiential space. Giving to the idea that these systems evoke a sense of place, meaning and memory toward the occupant.

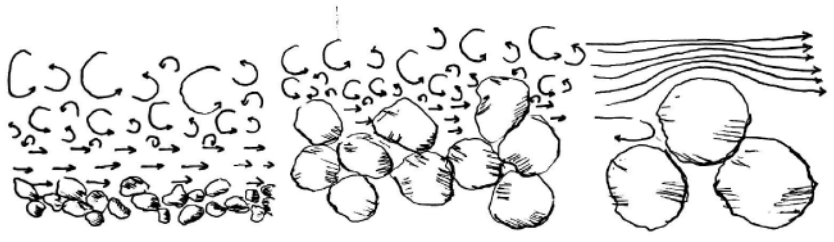
Dune systems are, by nature, defined as cosmic spaces (Norberg-Schulz, 1980). They are vast, with endless panoramic views, absorbing the body in the space. These systems are complex in both their experience and their processes. Dune systems are described as ‘soft landforms’ (Franceschini, 2003) giving significance to their essence and morphology.

Dunes rapidly adapt to their driving forces (like wind) making them significant and indicators of change (Franceschini, 2003). Their form is a direct derivative of these driving forces, controlling their active or passive energy.

Dunes are understood in terms of two categories, namely: mobile dunes or stable dunes. These categories are a result of wind energy and vegetation coverage, their subcategories are relevant to their form which is driven by the orientation of the wind to the coast (Franceschini, 2003).



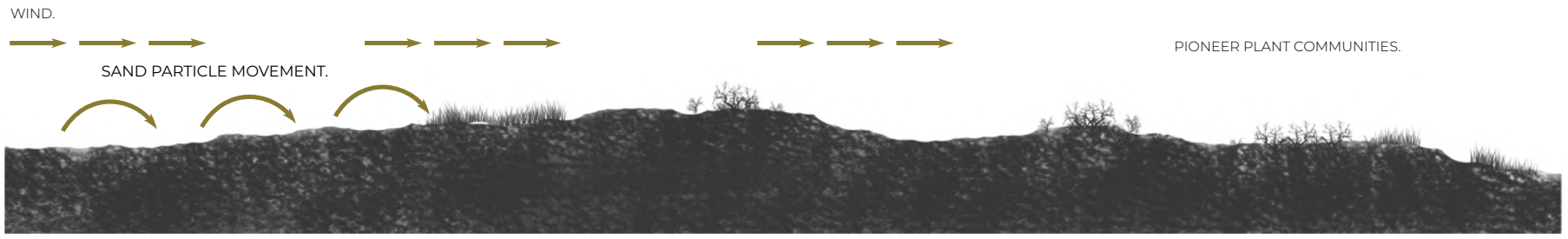
Sand Particle Transportation Types. The transportation type is dependent of the particle size and strength of the wind.



Particle Movement.

Sand grains will only be carried by the wind if the velocity of the wind is greater than the weight of the sand grain (Yamawaki, 2014).

DUNE FORMATION THROUGH WIND |

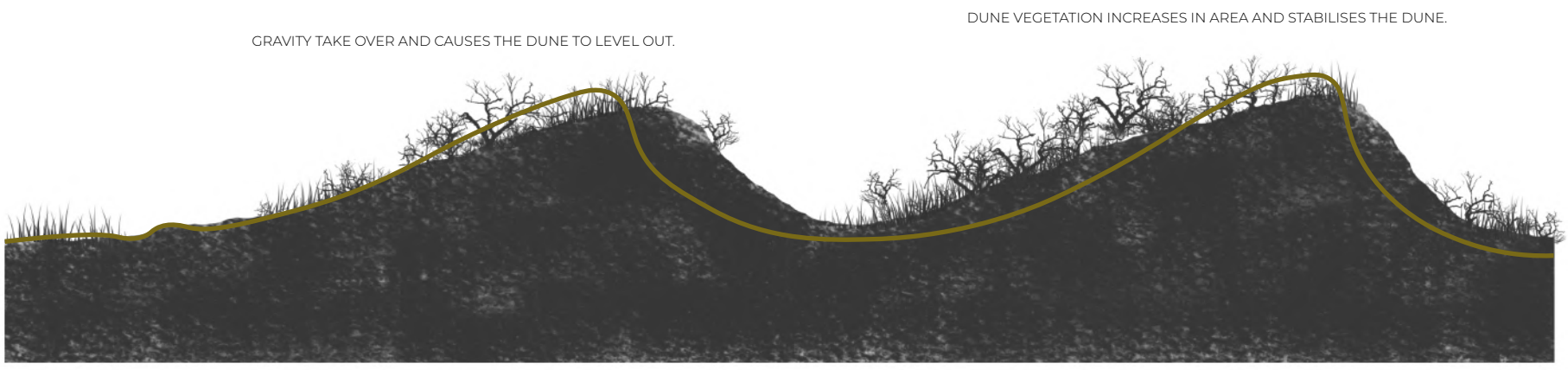


Stage 1: sand grains drifting by saltation. Saltation is the specific type of particle transport by the mediums of wind or wave, where the particle is lifted off a surface and then deposited back onto the surface.

Stage 2: sand grains piling up.

Stage 3: more sand grains piling.

Stage 4: dune begins to take shape.



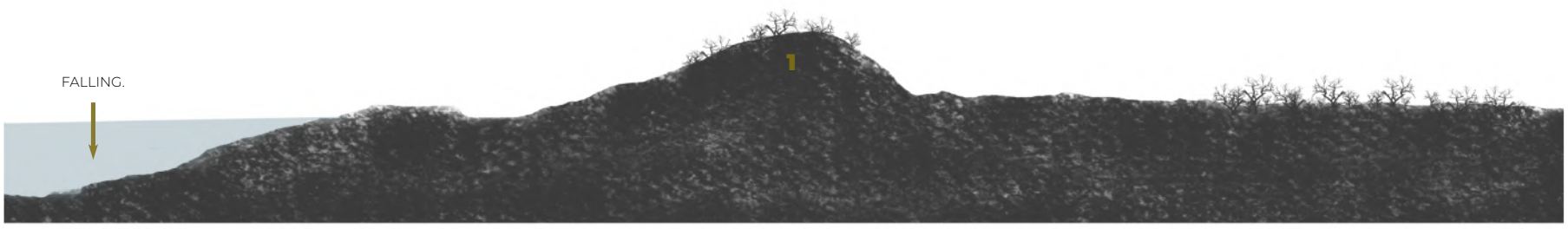
Stage 5: dune is leveled out and formed.

Aeolian Sediment Deposition: Formation of a Sand Dune via Wind.
(author's own).

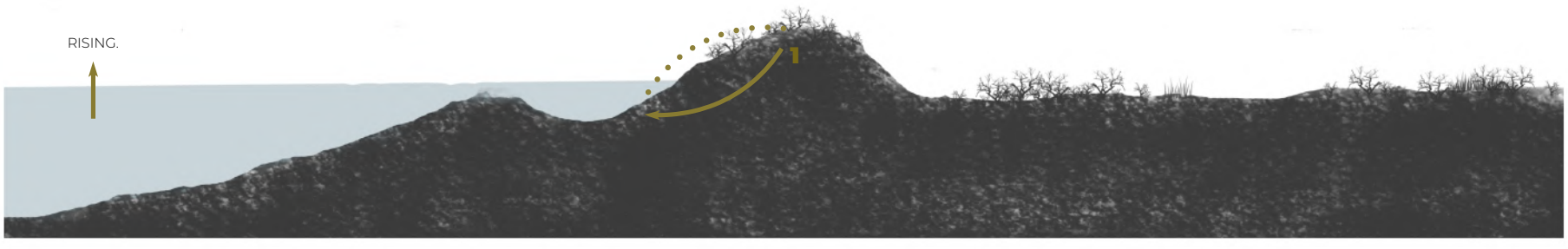
DUNE FORMATION THROUGH WATER |

Dunes are formed through the action of wind and/or waves. These mediums carry sand particles through suspension and then deposit the grains. The particles move via saltation and pile-up to begin to form the dune.

Foredunes are fed by water, where the water deposits sand and erodes sand during the rise and fall action of tides.

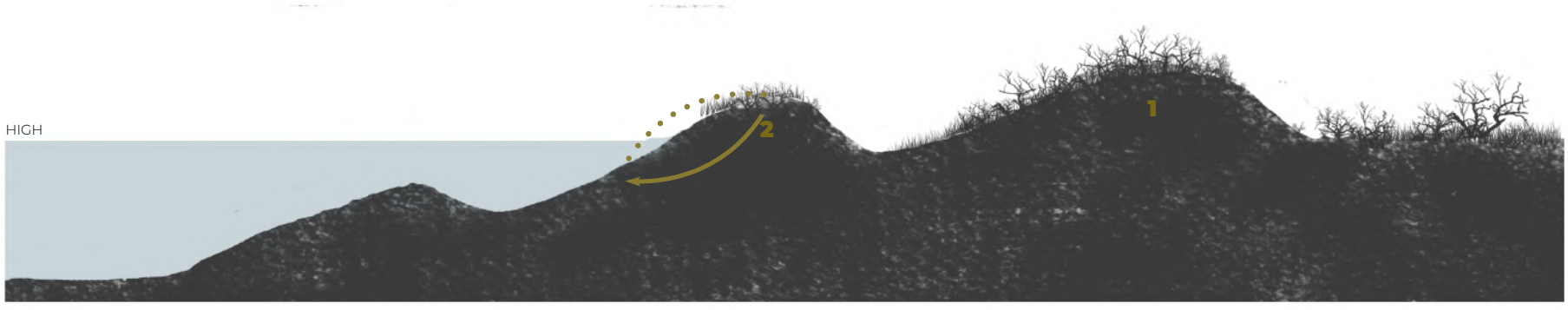


Stage 1: Sand is deposited on the beach during the falling of sea-level.



Stage 2: Foredune erodes as sea-level rises.

Stage 3: During the second phase of falling sea level, foredune no. 1 is replenished and a second foredune is formed in the prograding beach.



Stage 4: Sea level rises and the foredune is eroded.

Four episodes of sea-level fluctuations create a succession of four contemporary foredunes. This forms parallel dunes. The dunes can then be stabilised through the introduction of vegetation.

Formation of Sand Dunes via Water.
(author's own).

ADDITION + SUBTRACTION |
DEPOSITION + EROSION ; BURIAL +EXCAVATION

//

THE INTERPLAY BETWEEN EROSION + DEPOSITION |

Coastlines undergo continual forming through the interplay between deposition and erosion. These processes create the positive and negative spaces in the coastal landscape, with deposition being additive and erosion being subtractive. I like to think of this relationship in terms of the law of conservation of mass, where mass cannot be created or destroyed, only transformed.

In this sense, what has been eroded, is deposited and thus their function is transformed. Looking at dune systems the mass of sediment is eroded by a kinetic energy, be it waves or wind, and is deposited, transforming the sediment from a sea bed habitat to a terrestrial dune habitat.

Deposited sandstone layers revealed through erosion.

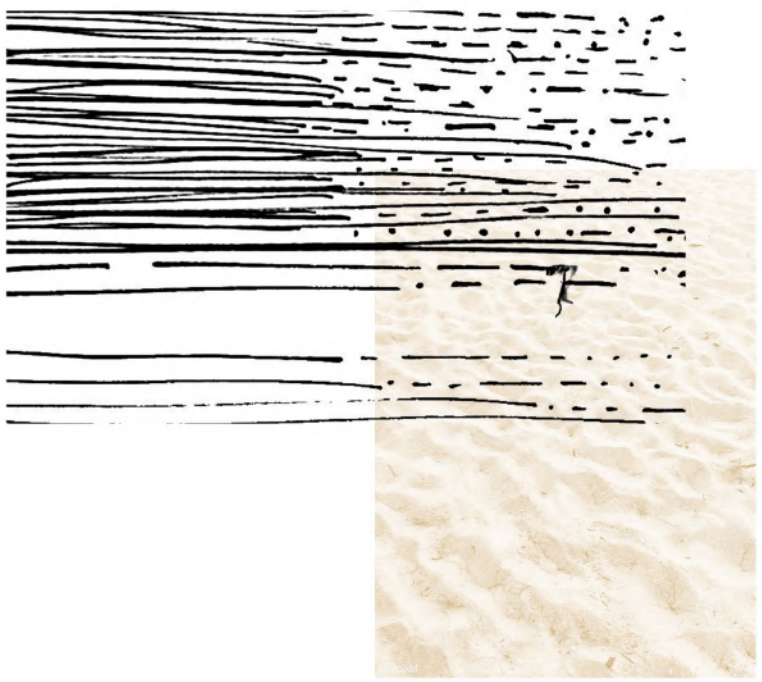
.

A sort of "onshore" sediment deposition; coastal forming (author's own).

Experiments that encapsulate the interplay between erosion and deposition.
(author's own).

MODELING + EXPERIMENTS |

I created a series of models to represent the process of deposition and erosion in attempts to gain a deeper understanding into their role of coastal forming. Whereby, I deposited many layers of different materials (magazines, newspaper, egg cartons, plastic, hay, etc.) and compacted them over-time. These cemented together and formed one solid object. The model was then eroded through cutting, burning and tearing to see what is revealed. I found distinct stratified layers where each piece is recorded in time of deposition. Sand grains were blown onto the artifact in various scenarios and observed the placement of the grains. Lastly, these processes were abstracted through drawing. Where I learned the continuous interplay between erosion and deposition, and the forming act that sediments play in preserving material memory and softening edges.



Parent material eroding through mechanical action and producing sand particles.

Simulated Stratified Layers. (author's own).

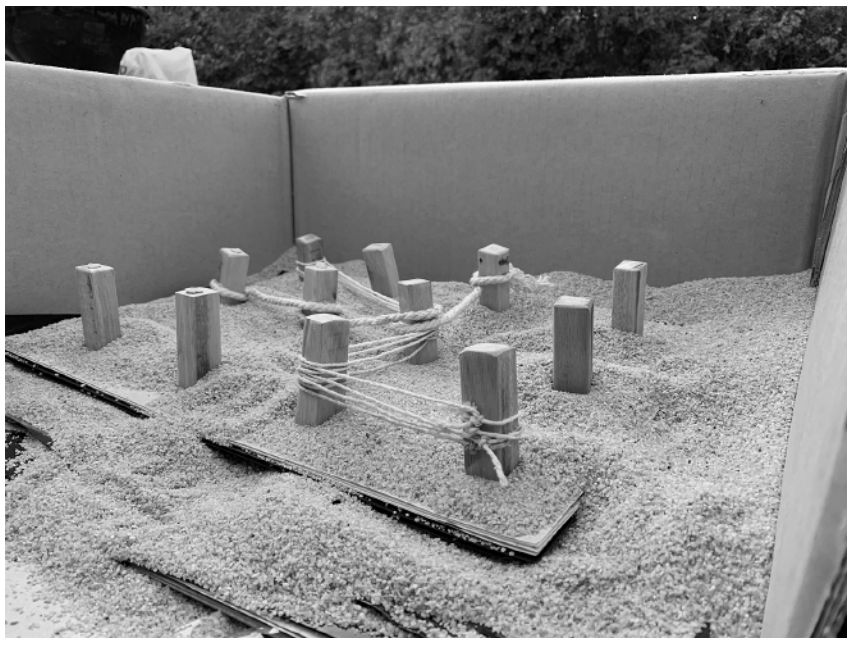
Experiment: the interplay of erosion and deposition.
(author's own).

Elandsfontein phosphate mine, Greater Saldanha Region, WC, South Africa.[d]

Excavate
"dig, gouge, cut out, bore, burrow, tunnel, quarry, mine"

Looking at exhumation in relation to burial.

gouging and digging (author's own).



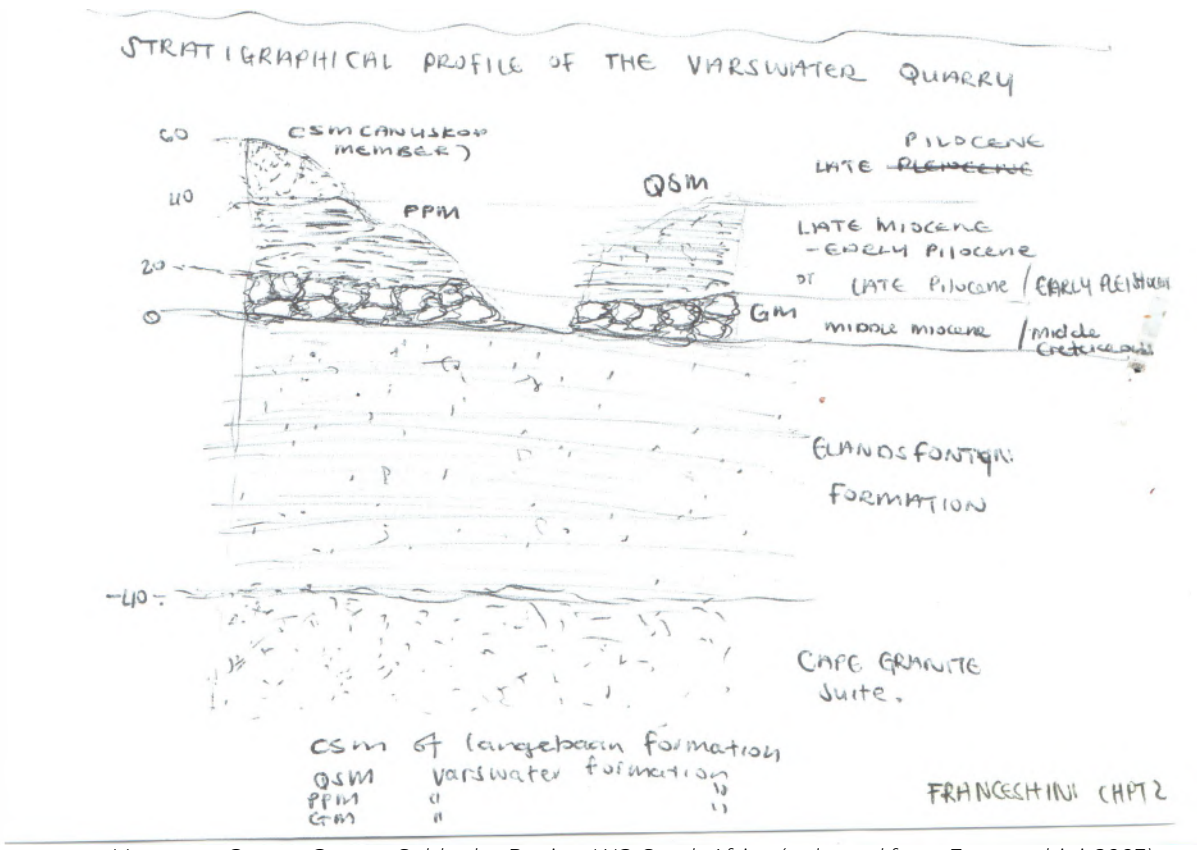
disrupting the excavation grid (author's own)..

THE HUMAN RESPONSE: TO BURY + TO EXCAVATE |

When a material deemed to be of value (be it a mineral or fossil) is buried beneath the earth the human reaction is to excavate, dig and bore. When something must return to the earth or be hidden, the human reaction is to bury it. These notions have along with them a sense of ritual/set of rules, a sort of programme, if you must. When a fossil is excavated a meticulous grid and set of events is set out; when a quarry is cut into series of ledges, sequences are followed. On the other end when something/or someone is buried, there's usually a ceremony attached to it. The notion of burial is further extended by the meaning of trying to hide or forget something, like forgotten/hidden aspects of our history. This is where the notions of palimpsest come to fruition, whereby in landscape design one may choose what is exposed or buried.

buried stories (author's own).

submerging layers (author's own).



Varswater Quarry, Greater Saldanha Region, WC, South Africa (adapted from Franceschini, 2003).

Bury
"entomb, plant, in-earth, sink, submerge, enclose"

"to hide or try to forget."

MODELING + EXPERIMENTS |

Instinctual experiments of the notion of burial and excavation were performed. These experiments were done as a design exploration and entry into the subject of the human response. The first was the modeling of gouging, digging and boring, a fast and messy process into understanding the nature of the human actions on acquiring ownership of an object.

The second was to set up a meticulous grid like the excavation grid, a much more tame and soft approach to extraction from humans, as it attempts to uncover and gain knowledge. I then decided to disrupt the grid bridging on my first experiment where I discovered that time acts to soften edges. This was done by tracing string in an disorganised manner across the grid, toppling some pillars as well as blowing sand onto the grid to observe the effects.

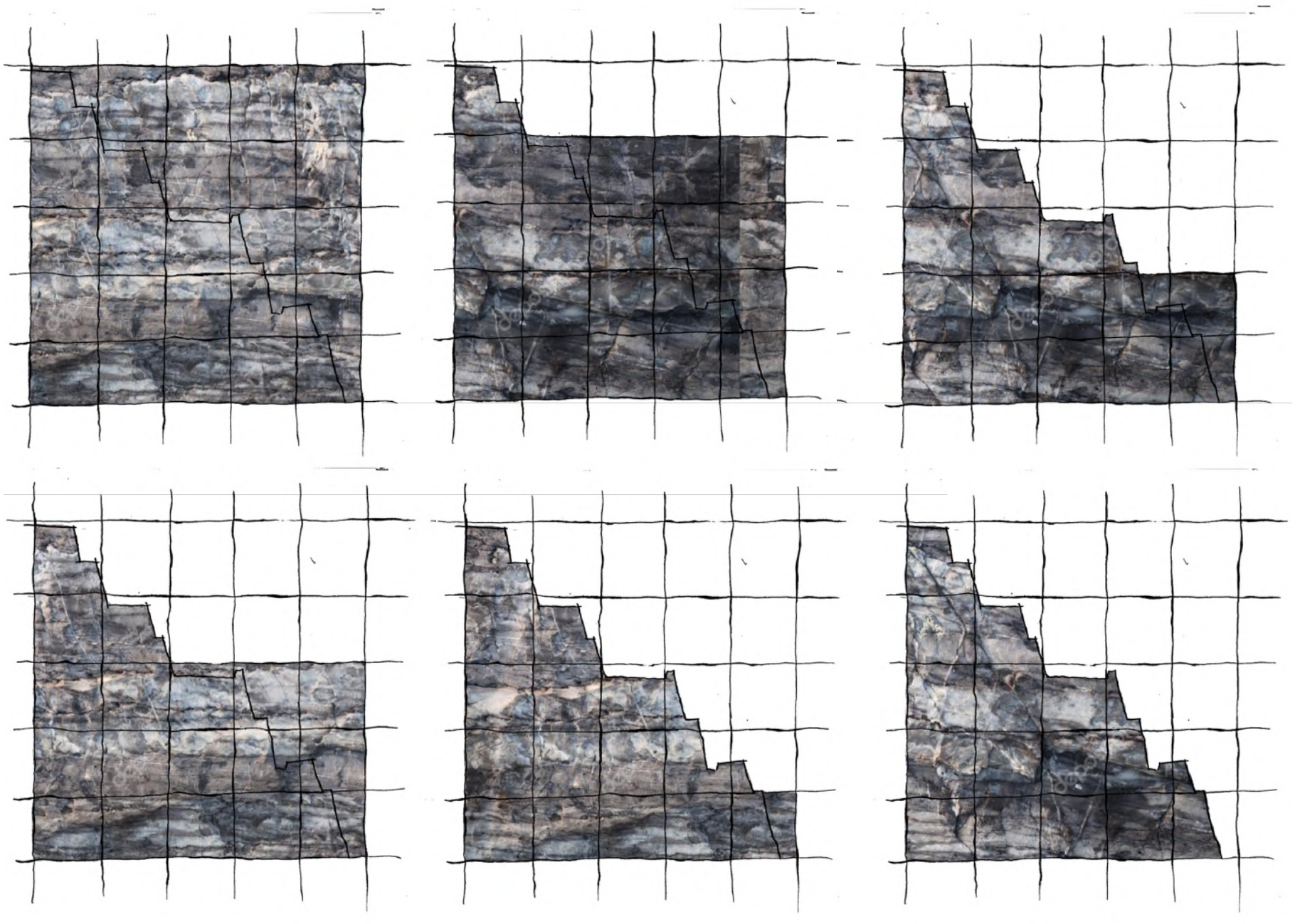
Lastly, I addressed burial by imagining that all the mass extracted from the gouging experiment had to be deposited somewhere, burying something, if not itself. Going back to the idea of layering and cementing I ordered the buried layers so that the darker, thicker and heavier materials were at the bottom (as if the process of compaction had already begun) and the lighter, whiter and thinner layers were added to the top as if their weight hadn't affected their form and composition yet. These experiments helped me in understanding the intention and action of the human response as well as the reaction of nature to human and human to nature.

Experiment 1: gouging and digging. (author's own).

Experiment 2: disrupting the grid. (author's own).

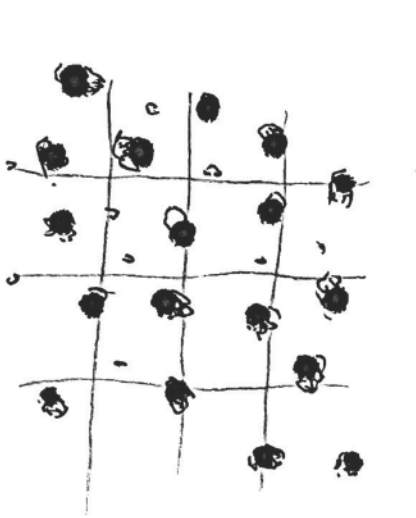
Experiment 3: understanding burial.. (author's own).

EXCAVATION UNDERSTANDING |



Creating Benches + Ledges through Quarrying.

Quarrying , investigating the process of excavation and extrapolation of stone. Quarrying begins by removing layers of earth over-time, where a series of benches and ledges are created with each layer removed.
(author's own).



Stone.

Roughout.

Stone Tool Form.

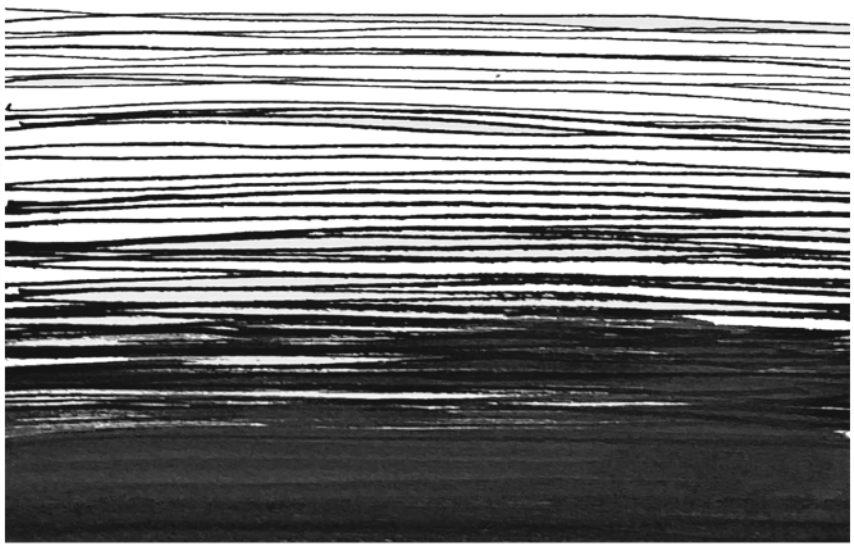
KhoeKhoe Stone Tools found in Langebaan.

(Schrire & Deacon, 1989)

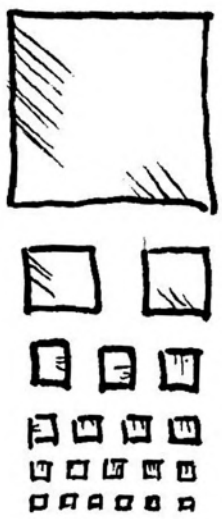
Stone Tool Shaping.

Knapping organises organic structures in stone (author's own).
Knapping is a technique to create stone tools, where the KhoeKhoe used Quartz to shape stones like Silcrete (Schrire & Deacon, 1989).

BURIAL UNDERSTANDING |

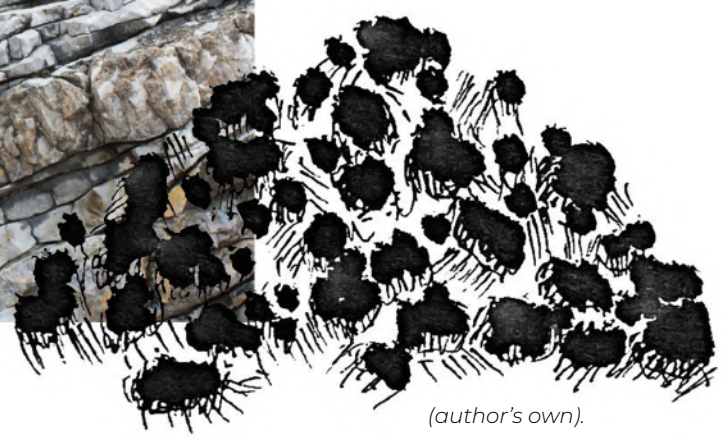


Formation of Sedimentary Geology. Where sediment is deposited onto surface and the pressure placed on the buried sediments, from the weight plus cementing agents, transforms sediments into a solid.
(author's own).



Where stone comes from. Pieces from parent geology break of and form boulders, which then form rocks, stone, then pebbles, etc
(author's own).

Looking at burial in cultural form and geological form.[e]
Geological burial occurs over millenia which is seen through rock layering.



(author's own).

The Khoekhoe were the first modern human occupants of the Greater Saldanha Bay Region. Adopting a historical-cultural lens to use o burial as a design tool where, the native KhoeKhoe traditional burials were to hand-lay stones, ceramics and shells onto the grave of the deceased (Boonzaier, 1996).[f]

MINIATURE AND PANORAMIC |
ADDITIVE AND SUBTRACTIVE PROCESSES IN COASTAL LANDSCAPE FORMING THROUGH DIFFERENT TEMPORAL + SPATIAL SCALES.

//

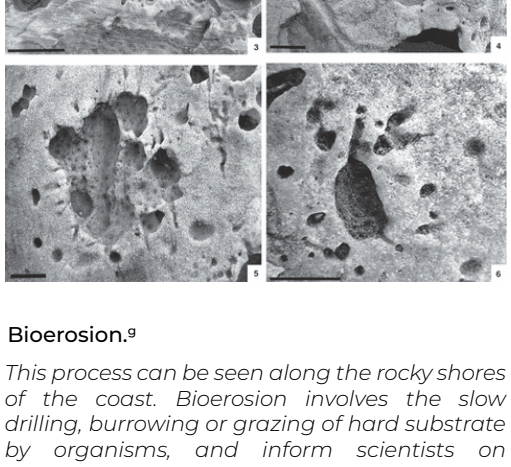
Miniature is the detailed and smaller constituents in the coastal forming. In design it is the scaling-down of larger landscape elements to create form (Herrington, 2017).

Panoramic is the larger and more expansive constituents in coastal forming. In design it is the scaling-up of smaller landscape elements to create form (Herrington, 2017).

MICRO-SCALE |

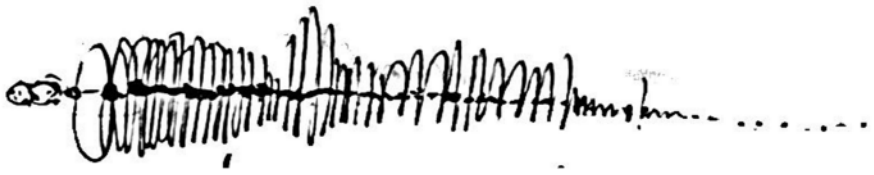
Bio-erosion, sand grain formation, and foraminiferal assemblages (Franceschini, 2003) are the micro-scale processes that form the coast and which, in turn, are influenced by surrounding environments and indicate past conditions. For a designer, understanding their processes of forming intricate textures and patterns, both temporal and material, is important. It is also important to develop a narrative of the miniature and uncover the significance of hidden layers and often over-looked layers, such as the journey of a sand grain. The images on the right shows patterns and textures created through the micro-scale erosion of rocks by marine organisms over a long period of time.

"...and that happiness could be found in a grain of sand from the desert, as the alchemist had said. Because a grain of sand is a moment of creation, and the universe has taken millions of years to create it."
— Paulo Coelho, The Alchemist



Bioerosion.[9]

This process can be seen along the rocky shores of the coast. Bioerosion involves the slow drilling, burrowing or grazing of hard substrate by organisms, and inform scientists on prehistoric water levels, climatic conditions, and evolutionary patterns (BuschSystems, 2015).



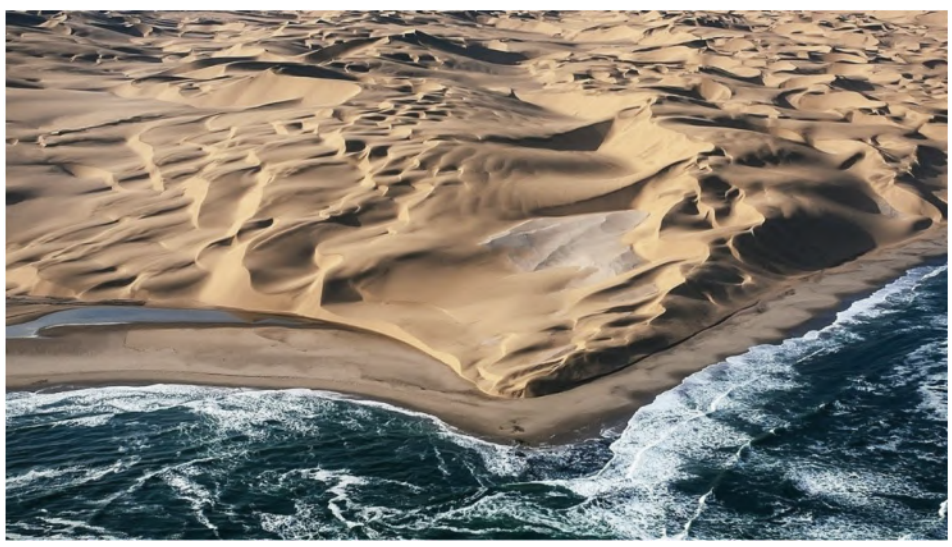
Calcareous sand forming in turbulent waters.

A sand calcareous sand grain begins its life as a shelled-organism. As the organism completes its life-cycle, the shell is what remains, this shell is transported through water and eroded along the way, leaving a microscopic sand grain.
(author's own).

MACRO-SCALE |

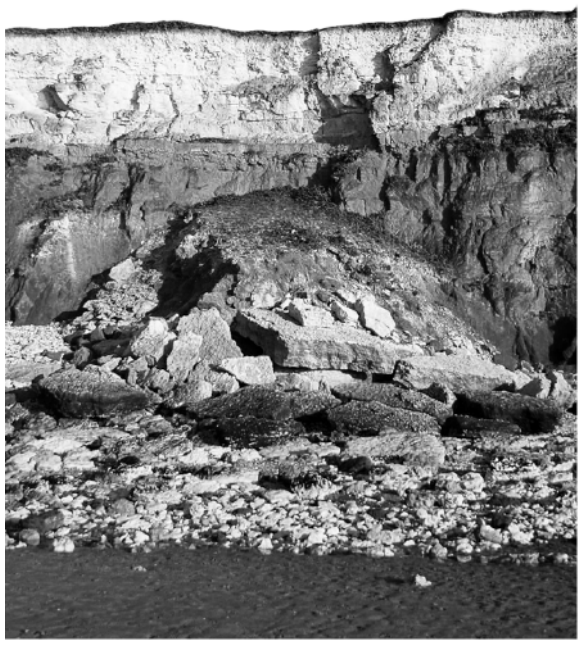
Coastlines are often vast and cosmic places (Norberg-Schulz, 1980) with extensive panoramic views where the human scale becomes insignificant. It is important to begin to understand the bodily experience of these places and their expansive geological systems and honour them in a functional design.

These macro-scale phenomena are a function of deep time (Clary et al., 2009) which is an interesting notion to grapple with and represent within a design. The phenomena of sea-level fluctuation, wave action and sediment deposition can be understood as follows; sea-level fluctuation is the predominant driving force behind the formation of the coast; wave action is primarily a subtractive process and aeolian systems are additive sediment deposition processes. Where mechanical erosion, resulting from wave action, aids the formation of caves, and examples of aeolian systems are dune systems and mineral deposits.



Dune Systems along the Namibian Coastline.[h]

Sea-Level Fluctuation patters in the Vale of Glamorgan, southern Wales, UK.[i]



Mechanical Erosion of the Hunstanton Cliffs, United Kingdom.[j]

PALIMPSEST |
[7]SCRIPTIO INFERIO + [8]SCRIPTIO SECUNDA

//

"Palimpsest originally refers to old parchment handwritings, where new text has been applied on top of effaced, but still discernible, earlier writing."
(Kjerrgren, 2011)

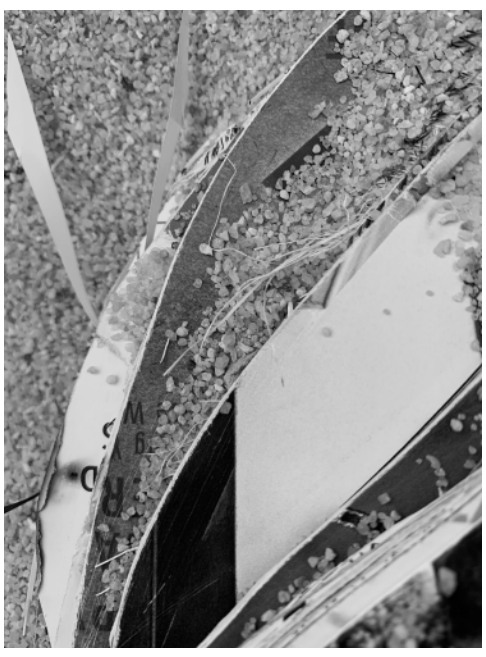
Process of transformation through time, where traces of material are left behind.
(Lee, 2016)

WRITTEN, ERASED, AND REWRITTEN

//

Palimpsest in landscape is thought as the material memory of the site. With this comes the notion of residuallity where layers are accumulated and removed, leaving residual material behind. Meaning, memory and history can be at the forefront and are experiential layers in a space, where traces of landscape are underwritten (*scriptio inferio*) and overwritten (*scriptio secunda*).

Material memory showcases the natural with human overlays, writing out the human and geological time-scales as one.



scribed.[k]

Underwritten, Over-written.

These photographs were extracted from my modeled experiments. They illustrate the dynamics of the human and geological intersections, with the continual writing, erasing and rewriting of the landscape.
(author's own).

---

[7]Scriptio inferio is the materials, memories and events of the past that have been buried, where some elements may be hidden or erased.
[8]Scriptio secunda is the materials and memories deposited onto the landscape, concealing other elements.

THE REVELATION OF DEEP TIME |

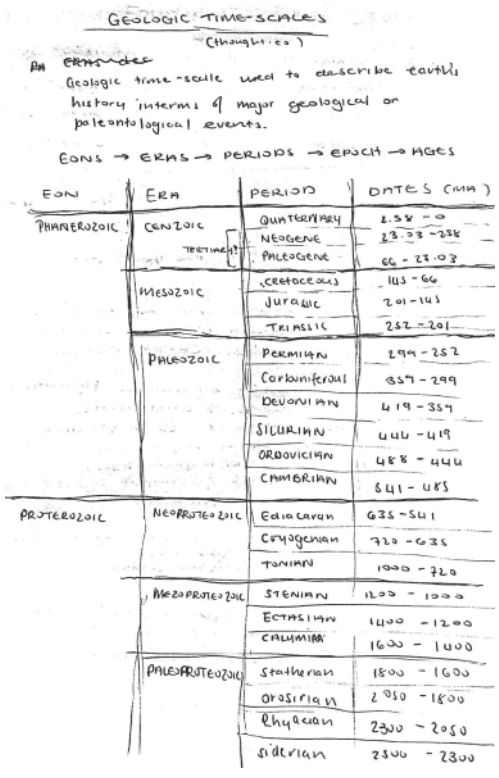
//

"An initial clue comes from Aristotle, who notes that our capacity to perceive time is interlinked with our capacity to perceive change. In his complex discussion of the nature of time in the Physics, he argues that in order to experience time, one first has to be able to notice a change and then make a comparison between two different moments, "before" and "after" the change."
(Bastian, 2012, 27)

We need to find ways that better represent the "full temporal complexity of specific culture-nature intersections in their in/visible and im/material expressions"
(Adam et al. 1997, 81).

Deep time refers to earths geologic time scale, which is a large and complex notion to comprehend in one go. This is thinking along the lines of billions of years, which makes it difficult to represent in form and space. This time is a large constituent to the aforementioned processes, of erosion, burial, palimpsest, scale, etc, and is important to understand to give context to design. One way of understanding deep time is through comparisons of Aristotle's "before" and "after"(Bastian, 2012, 27)which can be accentuated by Clary et al.'s finding that in landscape architecture, the representation of this deep time can be done by abstracting forms (Clary et al., 2009).

Saldahna Bay [9]Paleoshorelines showing prehistoric coastal forms.
(adapted from Franceschini, 2003)



The Geologic Timescale

set in time[1].
The recording of time in Earth's geological layering where each layer has a distinct before and after (top). Fossils are set in the record of deep time which give clues to the essence of life in each geological layer (bottom).

[9]Paleoshoreline refers to the historical shoreline during sea-level high-stands and sea-level lowstands. This helps to explain why we find marine deposited sediments and deposits on the now terrestrial landscape, it also illustrates what areas are susceptible to sea-level rise.

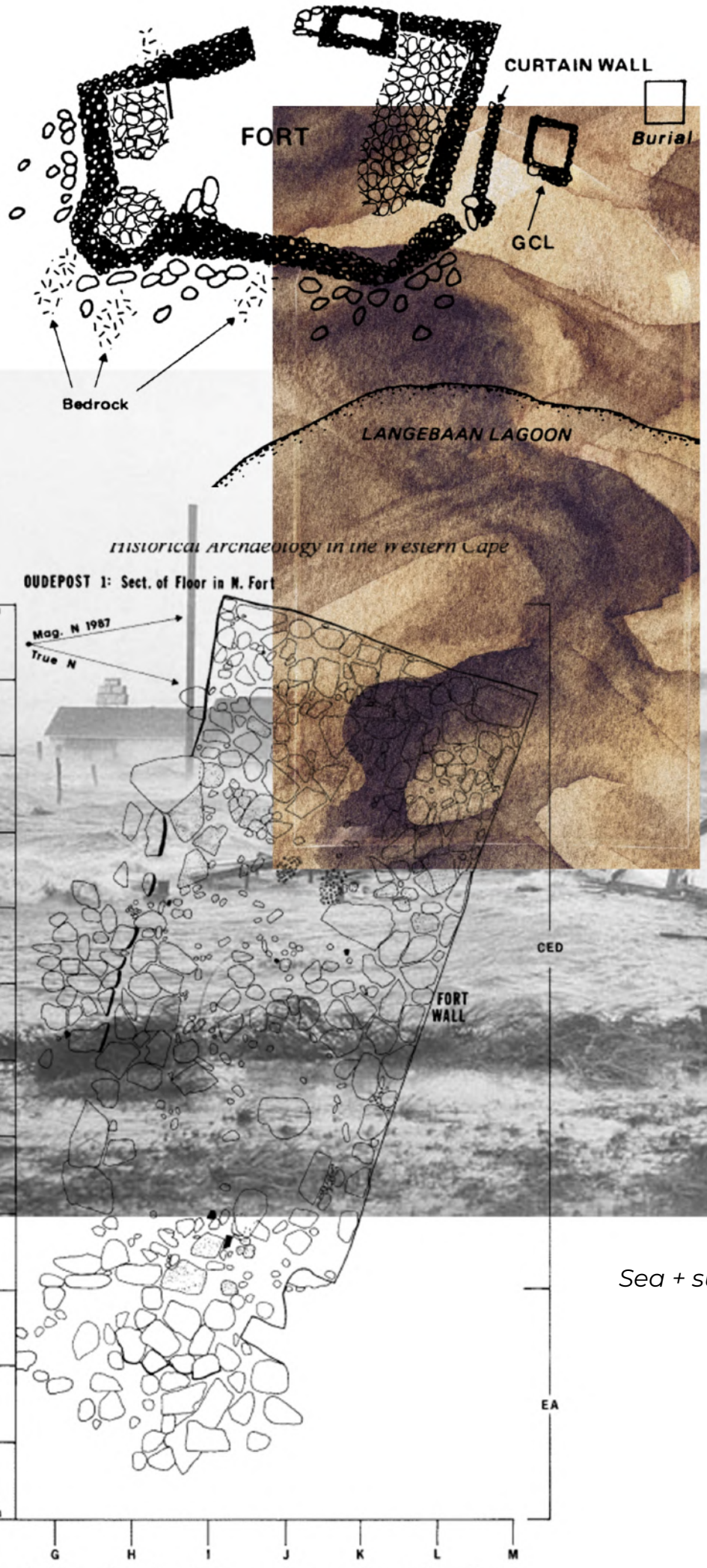


Fig. 5. Plan of paving in the northern section of the fort at Oudepost I, Cape, showing stones laid from the walls in to the centre of the enclosure.

2. FINDING + FOUNDING.

Sea + survival: fortifying langebaan against sea-level rise.[m]

SEA + SURVIVAL
CHOREOGRAPHING DUNE SYSTEMS TO DEFEND AGAINST SEA-LEVEL RISE

//

Sea-level rise is a growing concern for developments along the coast, and it has been fast approaching with the effects of climate change with an estimated 800 million people at risk of experiencing the devastating social, economic and environmental impacts of rising seas and storm surges (C40 Cities, n.d.). Countless efforts , mostly hard infrastructure, have been designed and put in place to protect vulnerable coastal towns from ruin. However, none so far encapsulate the unique pinch-point the coastlines of the West Coast in South Africa.

South Africa has a very recent and sombre history, where the wounds of Apartheid are still healing. Coastal towns along the West Coast are characteristically small fishing towns with a deep reliance and connection with the sea, unfortunately during the Group Areas Act of 1950 many residents of colour were removed from their culture and the towns were declared 'white' areas. This is an act of over-writing histories and culture embedded in the West Coast landscape. Langebaan in the Greater Saldanha Region along the Western Coast of South Africa is no exception to this Act.

Not only does Langebaan have buried histories, it is also suffering from the effects of poorly planned linear coastal development that has suffocated the dune systems that could protect the town. According to the Sea Level Rise and Flood Risk Assessment for a Select Disaster-Prone Area Along the Western Cape Coast Report, Langebaan is specifically mentioned for being highly susceptible to coastal erosion and storm swell damage (Blake & Chimboza, 2011).

The town sits on the crux of the West Coast National Park , an area of international ecological significance (SANParks, 2020), making it a hotspot for ecotourism. Langebaan is a fast-growing holiday destination and retirement area. This area type has led many of the new developments to be privatised, commandeering large portions of the coastal beach front. A small portion of the beach is then left for the remaining local communities to enjoy, this portion is most at risk to sea-level rise; the pinch-point between human and sea. Furthermore, the new developments do not embrace the character of the West Coast, this is causing the town to have a muddled sense of place.

It is important to create a design that responds to this pinch-point of protecting against sea-level rise, social inclusion and supporting local ecology. The restoration of dunes is to be a priority as they have the ability to act as a sponge and absorb the oncoming waters, whilst increasing public space and meaning. Therefore, a systems-based approach that challenges the hard infrastructural approach to sea-level rise is the proposed way of responding to the pinch-point and to climate change.

SALDANHA AS PALIMPSEST
ECOLOGICAL, HISTORICAL AND CULTURAL LAYERS

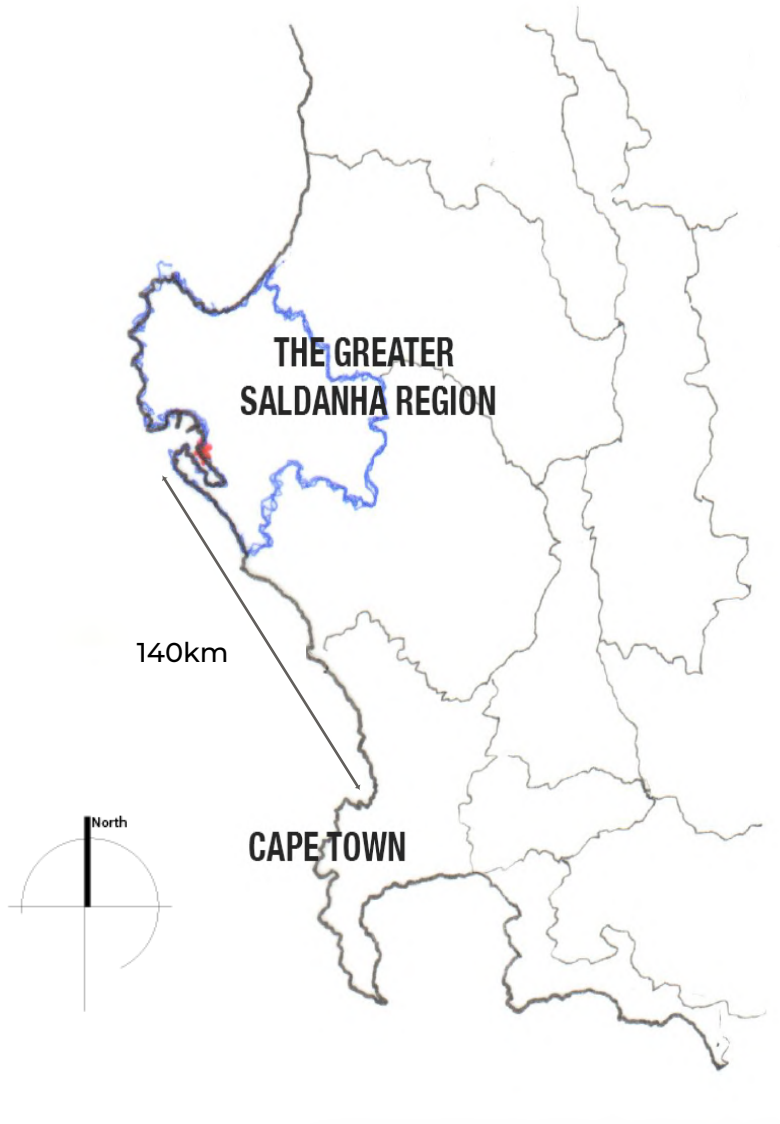
//

The Greater Saldanha Region is composed of an eclectic mix of historical evidence, beginning from the rise of the modern human. It has numerous fossils that were buried in the geological layering and gives clues to the deep time of the West Coast of South Africa.

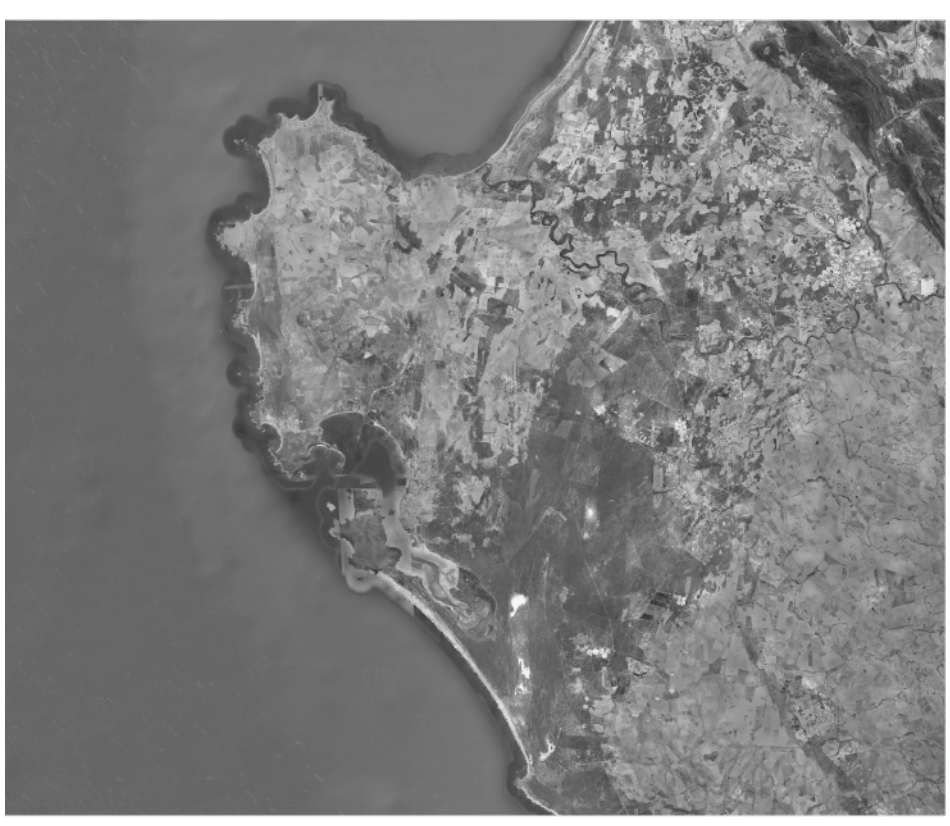
There is a significant collection of material memory embedded in Saldanha's landscape, where geology and ecology are large role players in this region. In the foundations of Saldanha lie the stories of the first hunter-gatherer communities to exploit marine resources, leaving traces of shell middens behind (Franceschini, 2003); it shows evidence of the coevals of the Khoekhoe and Colonialist through traces of stone tools and artifacts hidden in old military walls (Schrire & Deacon, 1989).

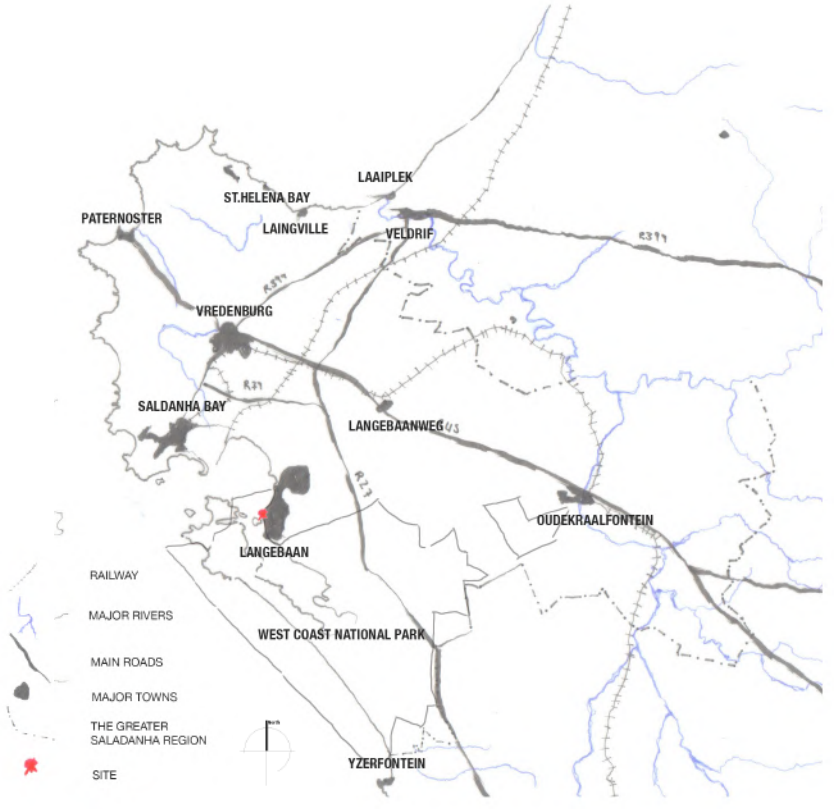
It is a water scarce region due to the low rainfall and lack of freshwater rivers, which has led to its more robust layers of military and industrial usage (Waag, n.d.). The Bay is one of the world's greatest natural harbours making it a prime location to defend and occupy (Waag, n.d.). Where the area faced a constant tug and pull of the French, Dutch and British occupancy of the land for fear of the other occupying the land. Sadly, due to its lack of fertile soils and freshwater availability, little investment was considered and the growth to becoming like Table Bay was stunted, leaving parts without a sense of place.

Saldanha is also home to the West Coast National Park (WCNP) and its ecology is of global significance. This is because it is home to the Cape Floristic Region (CFR), which has a large number of endemic vegetation species and over half the species in South Africa (Saldanha EMF, 2017).

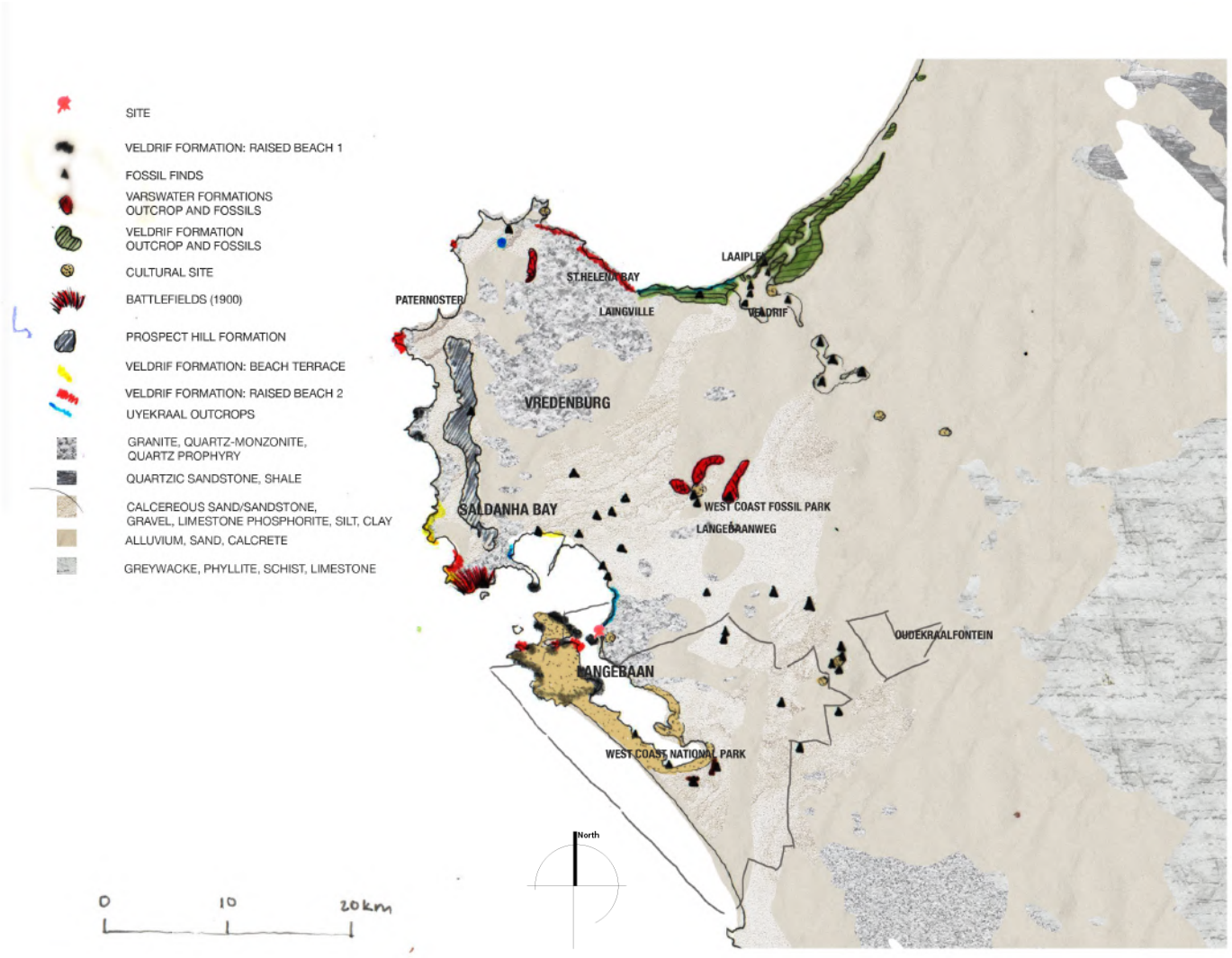


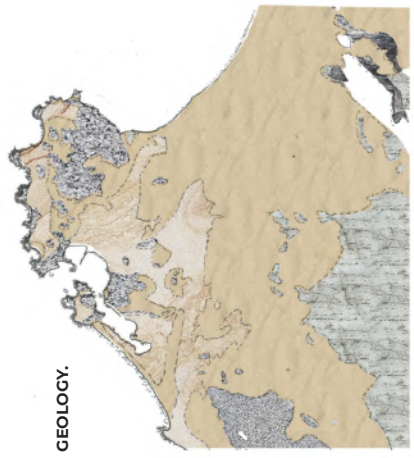
Note: In saying Saldanha I am referring to the Greater Saldanha Region which is the extent of the Saldanha Municipal bounds and not the Saldanha town.
(author's own)





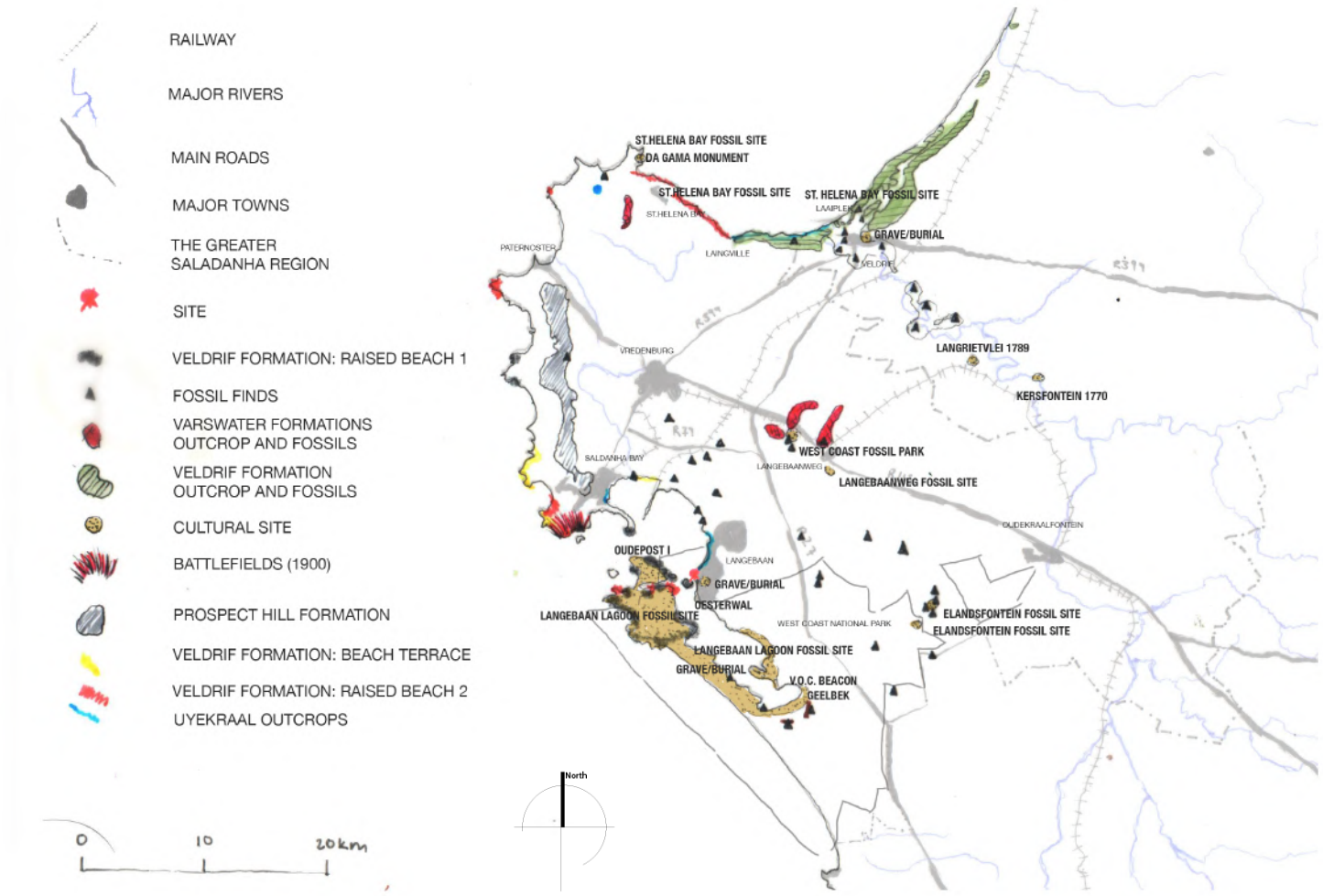
General Map of The Greater Saldanha Region. Left (Google Earth, 2020); Right (author's own).





PALEANTOLOGICAL, ARCHEOLOGICAL AND GEOLOGICAL LAYERING OF THE GREATER SALDANHA BAY REGION.

Fossilisation occurred depending on the underlying geology of the time. In the map above, we see that majority of the fossils occur in the sandy or sandstone regions. The fossils by Veldrif are fluvial fossils that were deposited by the Berg River. A large portion of the region is comprised of alluvial, calcareous sand which underpin the unique strandveld ecosystem. The region is also known for its large phosphorite reserve (even in the marine benthic environment) which attributes to the excessive mining and mining applications in this area, which has to be monitored. Granite outcrops are scattered throughout the landscape and link to a strong sense of place in the region especially when viewed alongside the wildflowers during August-September. (adapted from (Saldanha SDF, 2019)).
See Timeline on the following page when viewing this map.



PALEANTOLOGICAL, ARCHEOLOGICAL AND GEOLOGICAL LAYERING OF THE GREATER SALDANHA BAY REGION.

The region is well-known for its extensive range of paleontological and archaeological findings which document snippets of human history. Some of which show the first signs of marine exploitation of humans in the shell middens along the rocky- coastline. Evidence of the Khoekhoe and Neolithic hunter gatherers is also buried beneath the coast. At Geelbek, the first documentation of the Khoikhoi dictionary was conducted, comprising of roughly 400 words (SANParks, 2020). Oudepost I is significant as the walls contain material evidence of the coeval occupation of the area by both the Dutch and Khoekhoe. (adapted from (Saldanha SDF, 2019)).
See Timeline on the following page when viewing this map.

A BRIEF HISTORY OF SALDANHA.[n]

PRE-COLONIAL.

DUTCH COLONIAL PERION 1652-1806

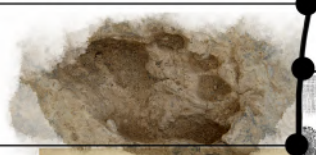
POST-COLONIAL

>1Ma
TOOLS
Elandsfontein.

700-400Ka
HUMAN SKULL
Elandsfontein.

MIDDLE STONE AGE (~280-25Ka)
ARTEFACTS, SHELL MIDDENS
Vredenberg Penninsula
Period of African Pre-history.

125Ka
MODERN HUMAN EVIDENCE
IN SEDIMENT
Hoedjiespunt.



~120Ka
EVE'S FOOTPRINTS
Dunes at Kraalbaai.

~12Ka
HUNTER-GATHERERS
Langebaan Shores.

LATE NEOLITHIC
KHOEKOE HERDERS & HUNTER GATHERES
MOVE TO ROCKY COAST - MARINE FOOD
Vredenberg Penninsula & Kasteelberg pastoral site for herders.

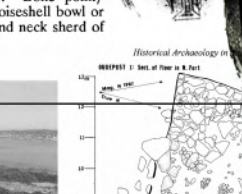
3-4Ka
SHELL MIDDENS
Paternorster and Jacobsbaai.

~
SHELLFISH, STONE TOOLS &REUSED COLONIAL
ARTEFACTS
Duiker Eiland and Britannia Bay.

3Ka-500ya
HUNTER-GATHERER SETTLEMENTS
Witklip.

1Ka
CULTURAL AND ECONOMIC ACTIVITIES
Kraalbaai, Preekstoel, Geelbek and Stobergfontein.

1497
VASCO DA GAMA NAMED
ST HELENA BAY.



1503
ANTONIO DE SALDANHA DISCOVERED
AGUADA DE SALDANHA (SALDANHA BAY).

17THC
DUTCH COLONIAL OUTPOST
ERECTED
Oudepost I, Kraalbaai.

1652
JAN VAN RIEBEECK CAME TO THE CAPE,
DUTCH TRADED WITH THE COCHOKWAS.

Fig. 2. General view of structures at Oudepost I, Cape, facing south-east. The lodge appears as a rectangular structure to the right of the tent. The fort lies on the promontory directly behind the tent.

1658
FREEBURGHERS
RIGHTS TO FISH WATERS

Fig. 3. General view of the fort, at Oudepost I, Cape, facing south-east.

Fig. 5. Plan of paving in the northern sec... Oudepost I, Cape, showing stones laid ... to the centre of the enclosure.

1666
V.O.C. ERECTED MILITARY POST.

1670
FRENCH TOOK OVER.

1673-1677
DUTCH-KHOIKHOI WAR.

19 APRIL 1672
ARNOUT VAN OVERBEECK PURCHASED
LAND FROM HOUT BAY TO
SALDANHA BAY FROM THE KHOIKHOI
FOR 4000 SPANISH MATS.

1679
COCHOKWAS DEFEATED.

1713
SMALLPOX WIPED OUT LOCAL
KHOI AND TRADE ENDED.

1795
FIRST BRITTISH OCCUPATION.

1801
DUTCH REGAIN BAY.

1806
BRITTISH OCCUPATION.

1820
IRISH SETTLERS.

1845
GUANO RUSH.

1922
WHALING STATION
LANGEBAAN TOWN.

1973
LANGEBAAN DECLARED
A MARINE RESERVE INTERMS OF THE MARINE FISHERIES ACT.

1975-1980
ORE HARBOUR AND RAILWAY .

1976
EXHUMATION OF PRE-COLONIAL BURIAL
St. James, Langebaan.

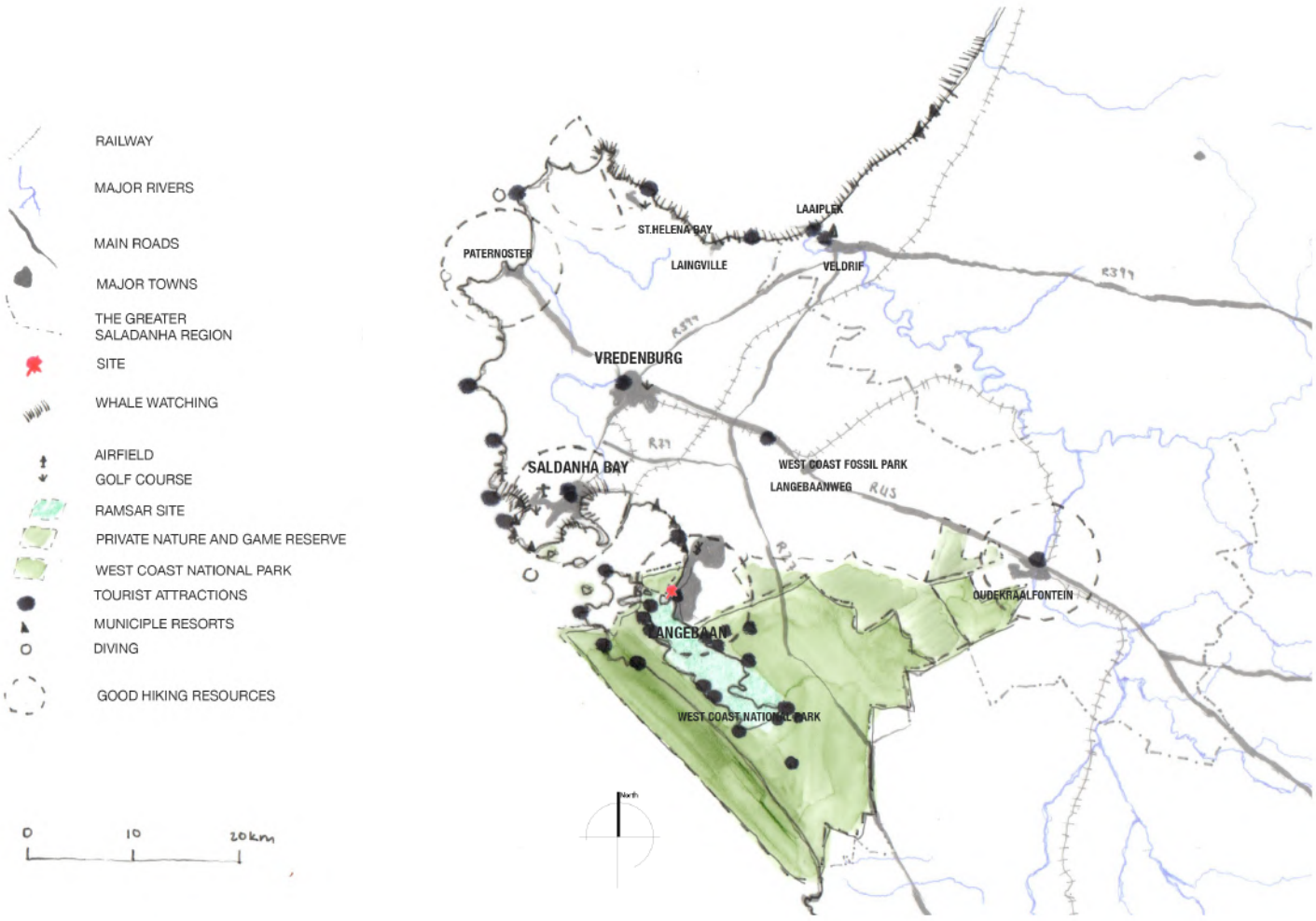
1985
WEST COAST
NATIONAL PARK *DECLARED.*

1987
DUNE RECLAIMATION SCHEME
AND PARK EXPANSION TO GEELBEK.

PA, MPA, CBA, ESA, ONA AND VEGETATION OVERLAY MAP OF THE GREATER SALDANHA BAY REGION.

The region lands itself in the Cape Floristic Region (CFR) which is home to almost half the plant species in SA (~9000spp.) and is considered a world Biodiversity Hotspot. Many of these vegetation types are endemic to this area so it is important to preserve them. The Saldanha Granite Strandveld towards the Vredenburg Peninsula is lacking in CBA classification, resulting in it being subject to development such as agriculture and wind-farms (Saldanha SDF, 2019).The Saldanha Flats strandveld remaining at less than 60% of its original extent is classified as a vulnerable ecosystem which is subject to irreversible habitat loss. The Dune Strandveld along the bay from Langebaan and Saldanha is face huge threats from linear coastal development which needs coastal consolidation.

The WCNP has an area of 362,6 km_ and is the reason for the large PA and MPA in the region, where the Langebaan Lagoon is deemed to have international importance and is thus a Ramsar site. The Lagoon is a nursery for important fish species including the endangered White-Stumpnose, along with being an important nursery it is also a highly important wading site for a number of bird species (SANParks, 2020). The islands are significant breeding grounds for bird species such as the endangered African Penguin and because of this Langebaan is deemed the ornithological capital of South Africa (SANParks, 2020). The Strandveld is given a 50 % irreplaceability rating. The areas around the National Park are CBA areas which are then buffered by ESA. The only ONA is located by the Industrial development zone (IDZ). The region is dominated by CBA zones which are endangered by the desire to mine the large phosphate reserve in the area (Saldanha SDF, 2019).
(author's own).



TOURISM MAP OF THE GREATER SALDANHA BAY REGION.

Tourism in the region is fast becoming one of the major economic departments, apart from the Fishing and Industrial sector. Over the years there has been an increase in weekend/ day-trippers migrating towards the Saldanha region. This can be attributed to the extensive natural beauty of the area, especially during flower season (August-September). Therefore, there has been a growth in ecotourism centered around the WCNP and surrounding reserves. The West Coast Fossil Park is also a huge attraction due to the fascinating fossil finds around the region.(adapted from (Saldanha SDF, 2019)).

LANGEBAAN AS A PINCH-POINT
THE CULTURE-NATURE INTERSECTION

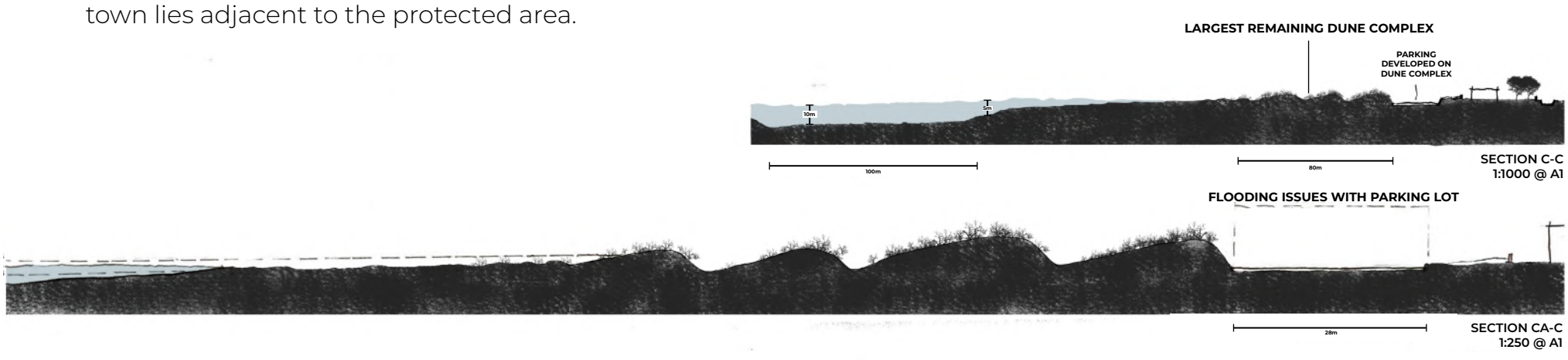
//

Langebaan was originally a small fishing town and home to many people of colour up until 1966, when Langebaan was proclaimed a White Group Area by the apartheid government. Many of the original occupants were removed and in 1976 a cemetery (near St. James Anglican Church) was exhumed and the human remains of people of colour were reinterred at a new site (Langhtry, 2020). This is an act of erasing/overwriting people's heritage. The town, now with a description of being 'white-washed', has recently gained popularity over the last few years as a weekend/day-trip and retirement settlement and risks losing its meaning and memory.

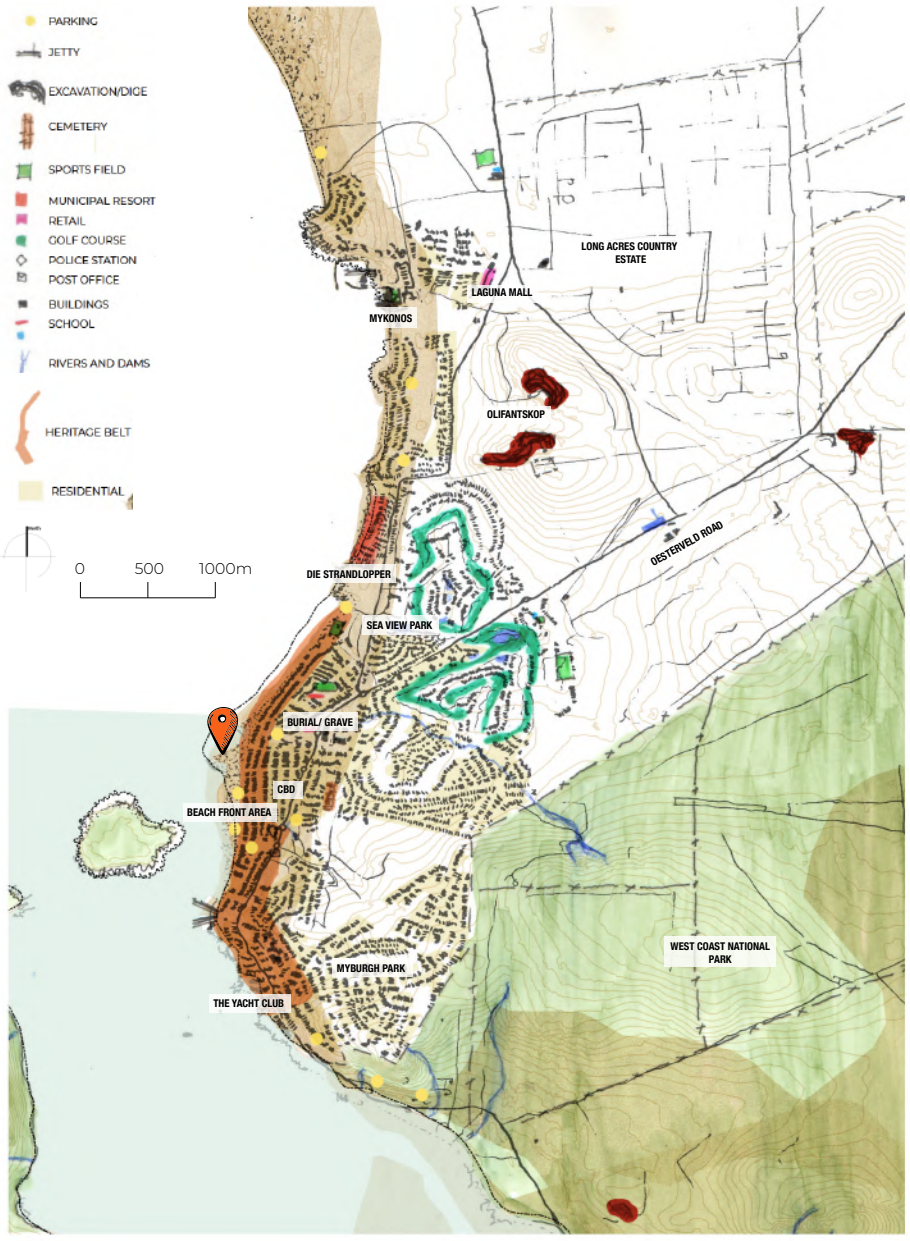
This popularity has resulted in a linear settlement growth along the coastline, with increases in privatisation and an encroachment on the dune systems. The progradation of the built environment has put Langebaan on the map for a high-risk zone of storm surges and flooding. According to the Western Cape Sea-Level Report Langebaan is at significant risk to storm-surges and flood events, where the 4,5 mean sea level rise is the 1:100year line. The report estimates that by 2050 these events are going to be more frequent (Blake & Chimboza, 2011). The area most affected by this is the CBD and the lower income houses. We can also see that the houses on the pinch-point between humans and sea are along the heritage belt (Saldanha SDF, 2019), presenting an interesting design challenge.

There has been a need for coastal consolidation (Saldanha SDF, 2019) as the foredunes are suffering from erosion and their ecological service as a buffer zone, downplayed.

Other than the need for coastal consolidation and bringing back sensitive cultural memories and meaning, Langebaan has a significant role in supporting surrounding ecologies. The lagoon is a vital nursery for many fish species including the endangered White Stumpnose and the flight path for a large number of marine and terrestrial bird species. Langebaan is in fact the ornithological capital of South Africa (SANParks, 2020). With Langebaan being on the crux of a RAMSAR site its ecosystem health is integral part to the health of the MPA downstream. Langebaan is also an important connectivity site for the dune strandveld in the WCNP as the town lies adjacent to the protected area.

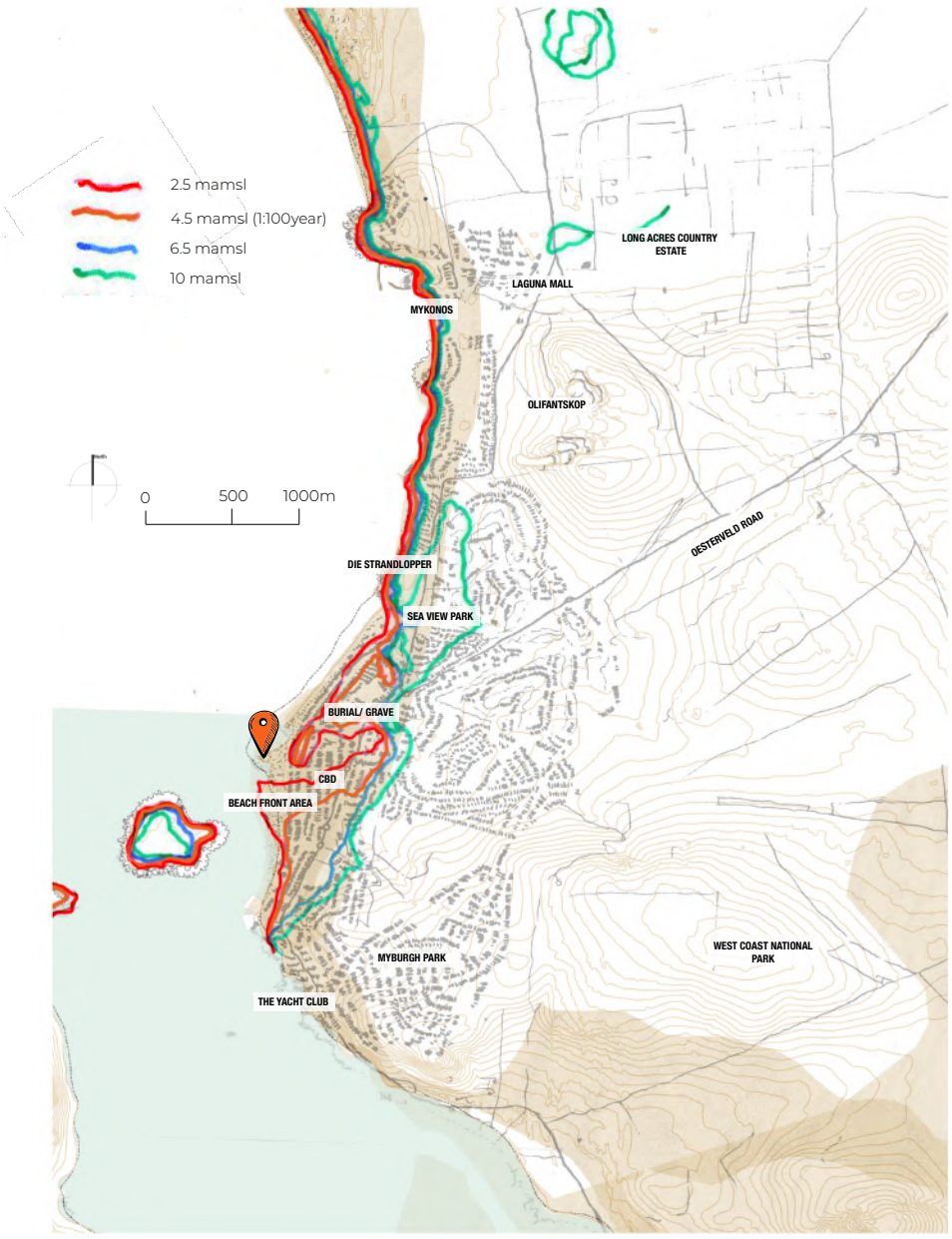


The widest and tallest extent of dunes on the beach front, but is this enough to defend against sea-level rise?



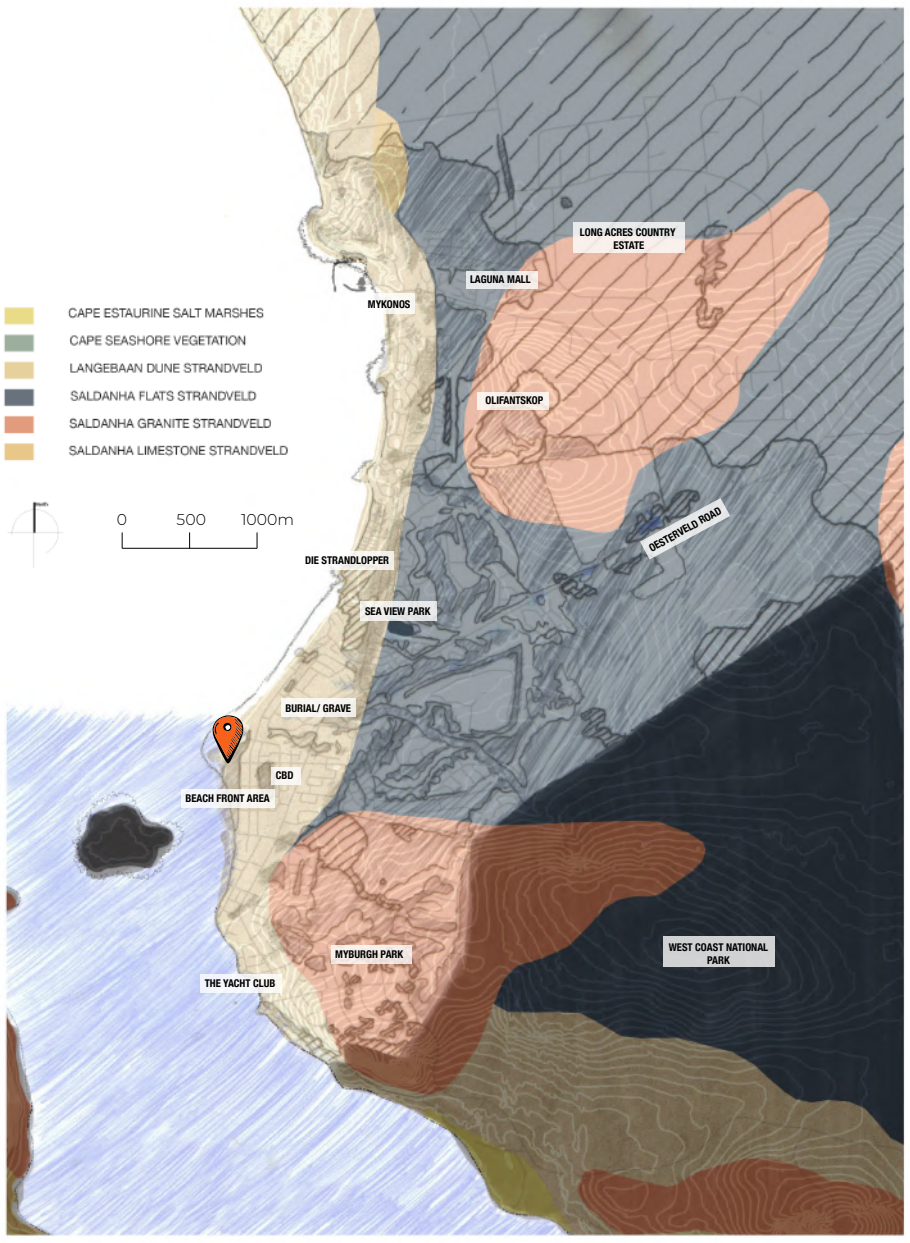
LAND-USE MAP OF LANGEBAAN

The nothern end of Langebaan, past Die Strandlooper is mainly private estates, of holiday houses and then the Laguna Mall. Towards the central CBD is the more public area where the resident community lives. Myburgh Park is a mix of holiday houses, retirement houses and residential houses. The yacht club area is very exclusive and is mainly holiday/ week-end trippers.
(author's own).



SEA-LEVEL RISE MAP OF LANGEBAAN

"A 2.5 mamsl swash run-up would cause erosion and damage to the first row of beach developments along both the northern and central coastal areas of Langebaan which is an ongoing hazard in the area. Current mitigation attempts include the construction of groines, rock revetments and geofabric bag barriers, although a 100 year storm event (4.5 mamsl) could over-top these and cause extensive damage to shoreline adjacent coastal property. The Saldanha Bay headlands do provide some protection however from extremely large storm swell. The extensive coastal development below the 2.5 mamsl contour in the area is evidence of poor coastal planning, and has resulted in the development of various highly visible coastal protection structures"(Blake & Chimboza, 2011).
(adapted from (Blake & Chimboza, 2011).



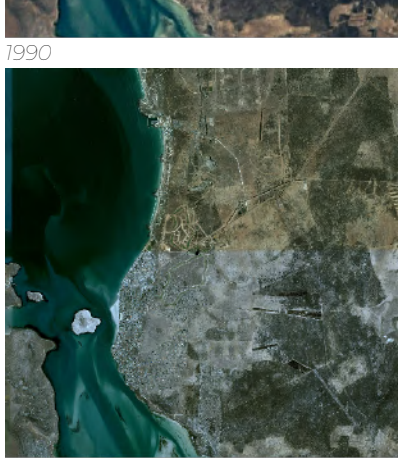
CBA-VEG OVERLAY MAP OF LANGEBAAN

Granite Strandveld occurs on exposed granitic outcrops and is endangered. The slither of Dune Strandveld is suffers from linear coastal development and if it is not maintained coastal erosion and wind erosion takes place. A large portion of the area is the vulnerable Saldanha Flats Strandveld (author's own).

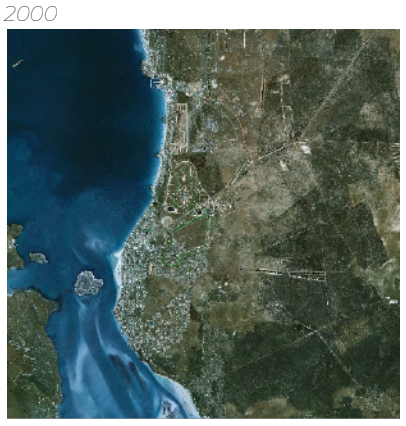
1986

1990

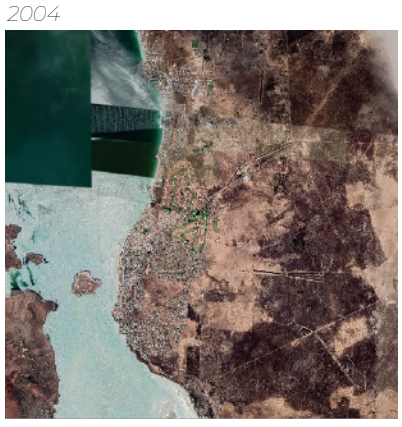
2000



2004



2006



2020

DEVELOPMENT OF LANGEBAAN OVER-TIME

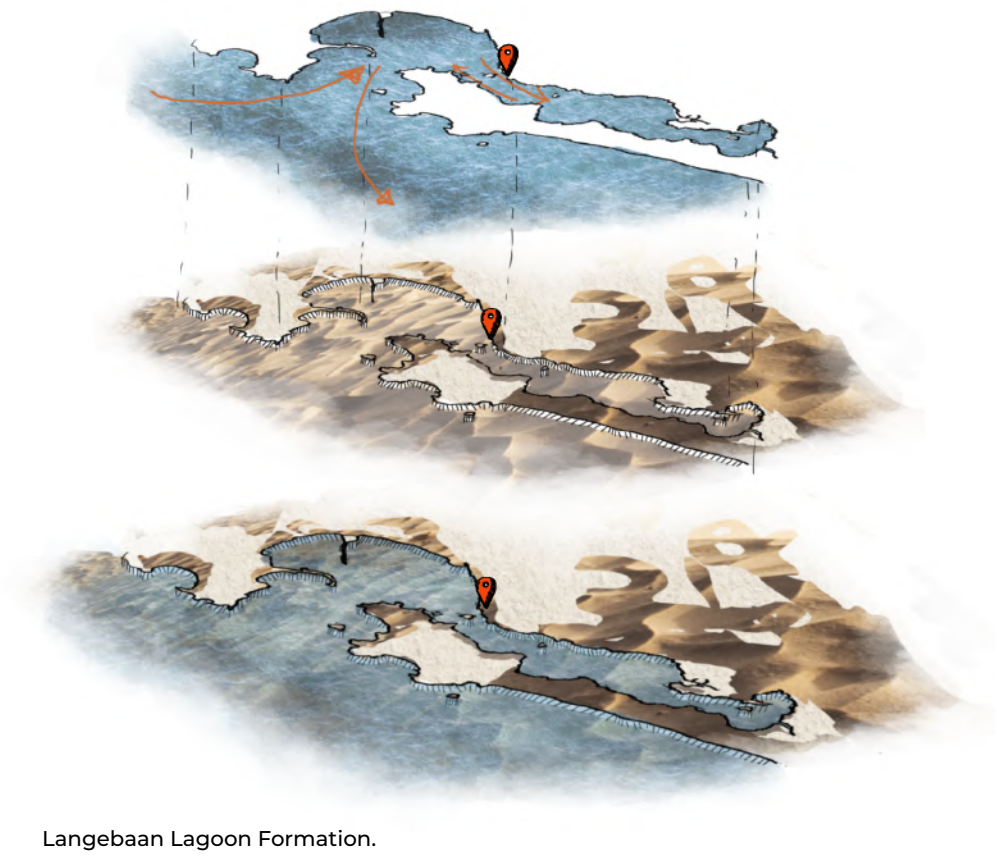
We can see that the original development is along the coast-line, near the belly of Langebaan, this is backed by the heritage belt indicated in the land-use map. As time goes on development continues inland of the original development and then proceeds to have privatised linear coastal development up north of the original Langebaan. (Google Earth, 2020).

WATER, SAND + STONE
THE MATERIAL DRIVING FORCES OF LANGEBAAN

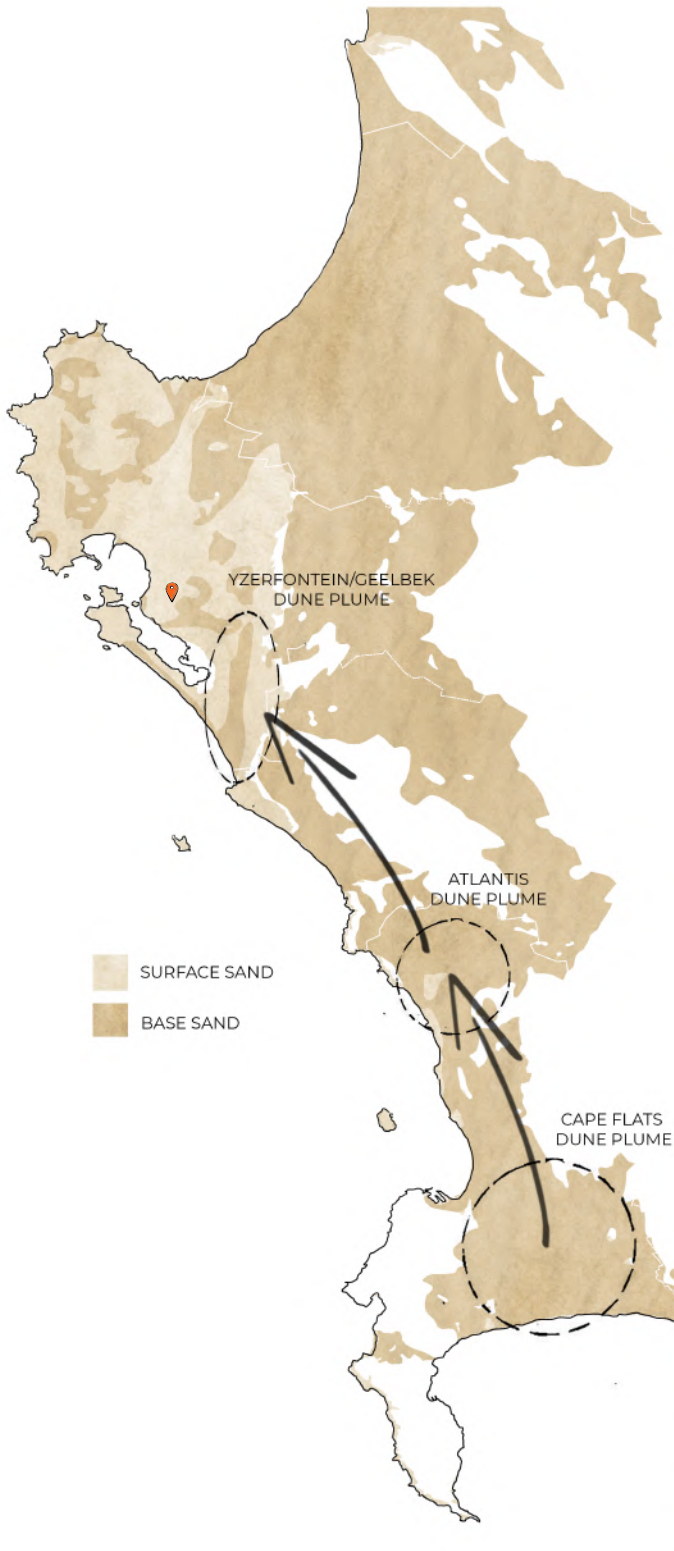
//

The Langebaan town sits at the mouth of the Lagoon, which is an area influenced by both tides and waves. Through a material study of Langebaan I have found that the landscape is defined by an interplay between water, sand and stone.

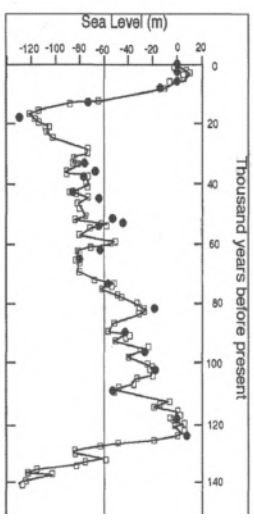
These components play an active role in the continuous forming of the Langebaan observed today. Where Langebaan was formed (and still is forming) through a series of sea level rise and falls which subsequently eroded and deposited sediments until the present form we see today (Franceschini, 2003). The Lagoon was originally a terrestrial dune system, fed by the larger west coast dune system, and in the advent of sea-level fluctuations, the dunes were submerged (Flemming, 2015).



Langebaan Lagoon Formation.
The Langebaan Lagoon was formed through the rise and fall of sea levels, where water subsequently filled in the depression zones (Flemming, 2015). Before the rise the surface was terrestrial dune systems. The lagoon has no fresh water input, making it a purely saltwater lagoon.
(author's own).



Sand Transport along the West Coast.
Surface sand refers to sand deposited onto the base rocks and base sand refers to sand acknowledged as the base geology.
(adapted from (Franceschini, Compton & Wigley, 2003).



120ka
Eemian.

10-9ka
Early Holocene.

6.8ka
Middle Holocene
(Theory 1).

5.5ka
Middle Holocene
(Theory 2).

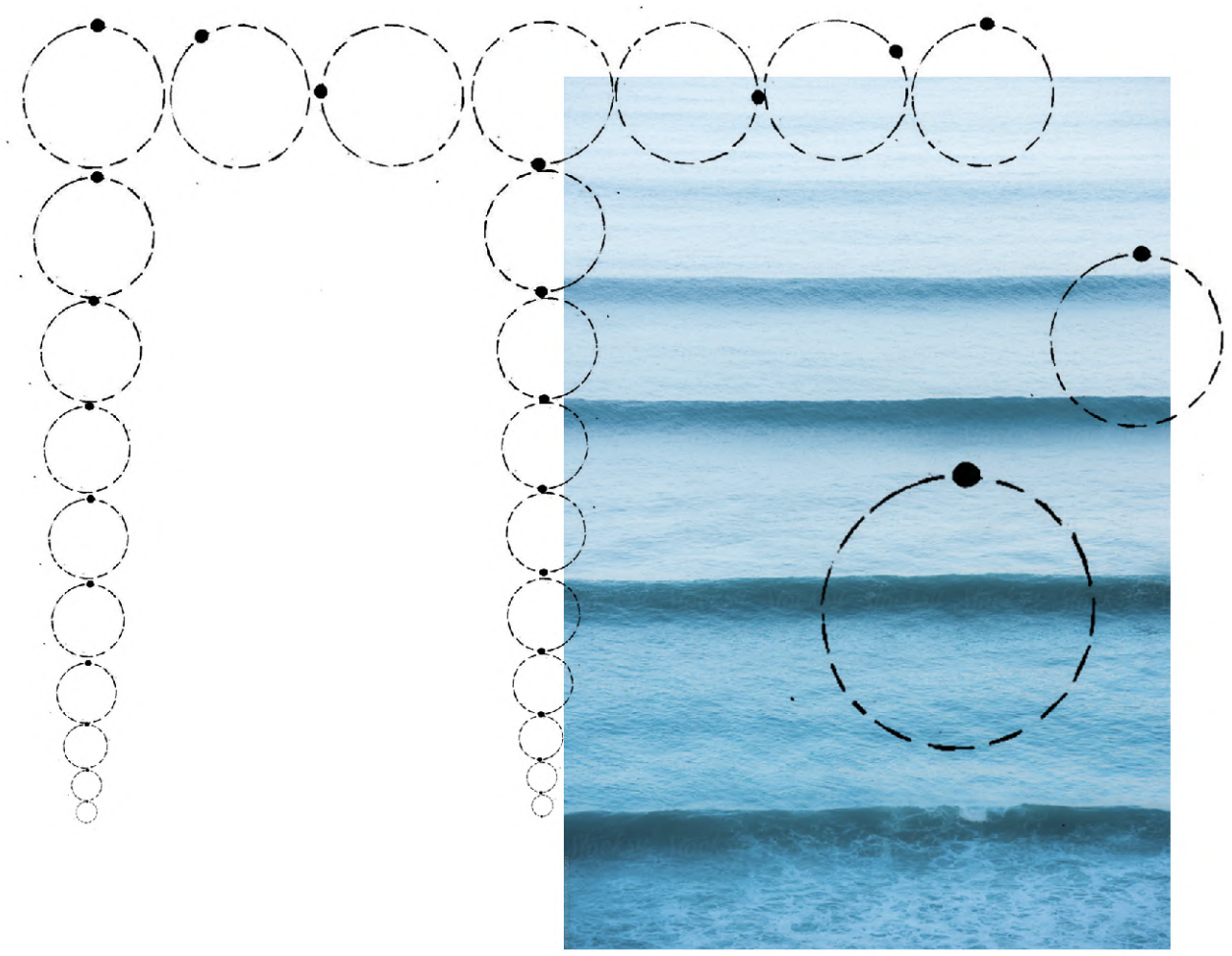
Present.

Langebaan Lagoon Late Quaternary Evolution.
(adapted from (Franceschini, 2003)).

WAVE DYNAMICS |

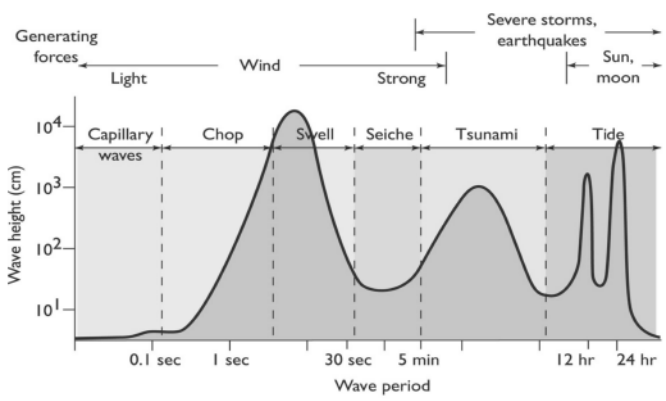
Waves are important to this study as they are the primary concern of sea-level rise, where sea-level rise is previously defined not as the gradual rise in mean sea-level (msl) but rather the increase in frequency and intensity of storm surges and flooding events. (Blake & Chimboza, 2011). Due to this definition, waves are an important measure for designing sea defences and their dynamics are necessary to understand.

Water is given movement by Earth's gravity, wind energy and gravitational attractions between Earth, moon and sun (Ansorge, 2017). Where wind transfers energy to water and moves particles in a sinusoidal movement which together forms waves. There are two categories of waves, namely deep-water waves (water depth > 0.5wavelength) and shallow-water waves (water depth < 1/20wavelength) (Ansorge, 2017). The waves we see from shore are shallow-water waves, whereas tides are deep-water waves.



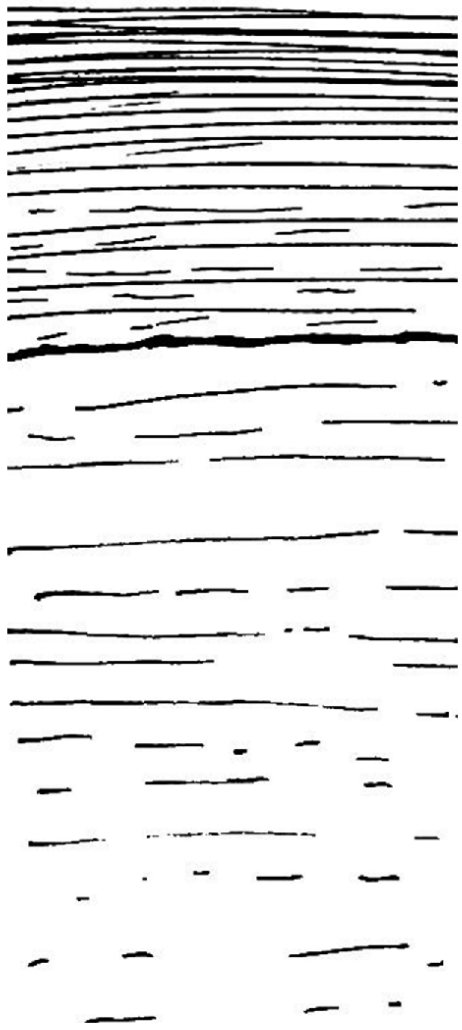
Wave energy, horizontal and vertical oscillations.°

The micro-scale rolling of waves through the water column. Water moves through sinusoidal wave movements, similar the temporal nature of tides. We can then look at mechanical wave and tide erosion in a series of crests and troughs both spatially and temporally.



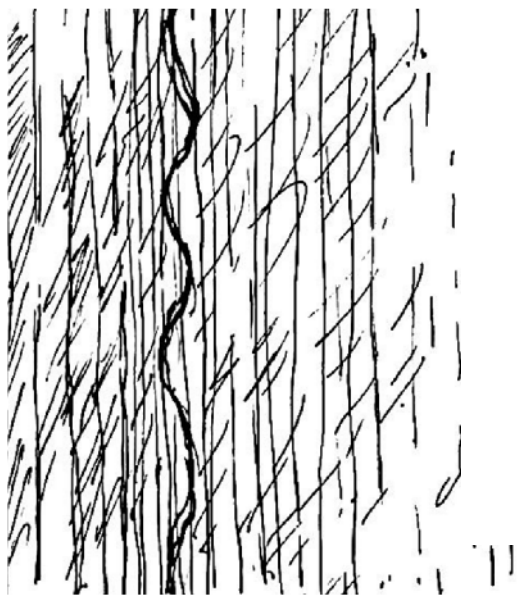
Idealised Wave Spectrum.

(Ansorge, 2017).



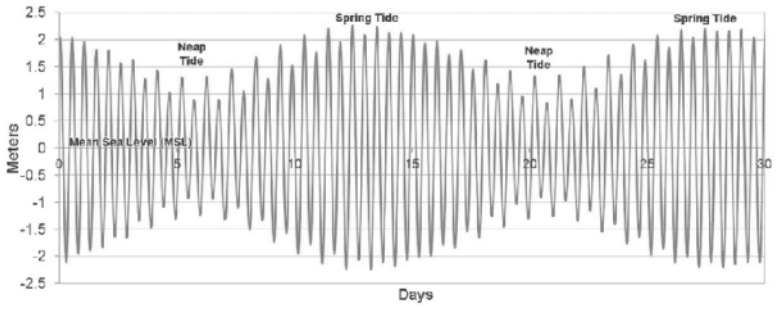
Transfer +Dissipation of Energy.

Wind energy is transfered to water creating waves. Wave energy is then dispersed down the water column. (author's own).



Aerial of Waves + Wind

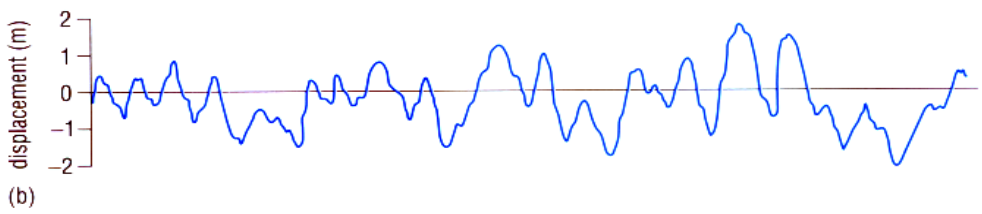
Water's tendency to break parallel to the shore and wind disrupting this dynamic. Where waves that do not break parallel to the shore, they will erode the surface until they do. (author's own).



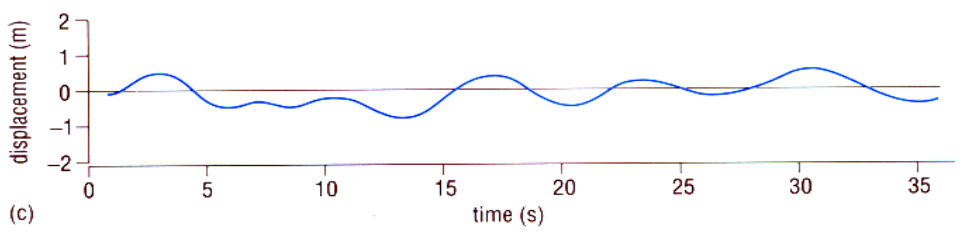
Tidal Frequency.[P]

The timescale of tides is a daily rise and fall of sea-level, quite distinct to the deep time of sea-level rise, which spans over thousands, if not millions of years. In relation to sea-level rise tides can be considered a micro-scale action of coastal forming, where they gently erode and deposit sediments along the coast.

Storm surges are large and destructive waves which flood low-lying land with oncoming water. This rapidly erodes the exposed elements of the coastline. Storm surges can be understood to be the super-positioning of multiple wave crests coincide and multiple wave troughs, building up the crests and deepening the troughs (Ansorge, 2017). This forms stronger and larger waves.



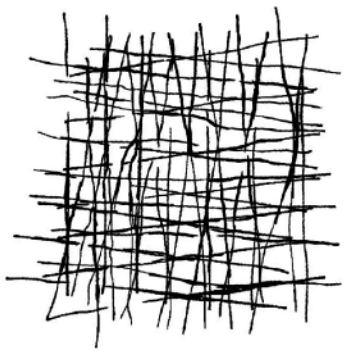
Storm Wave.

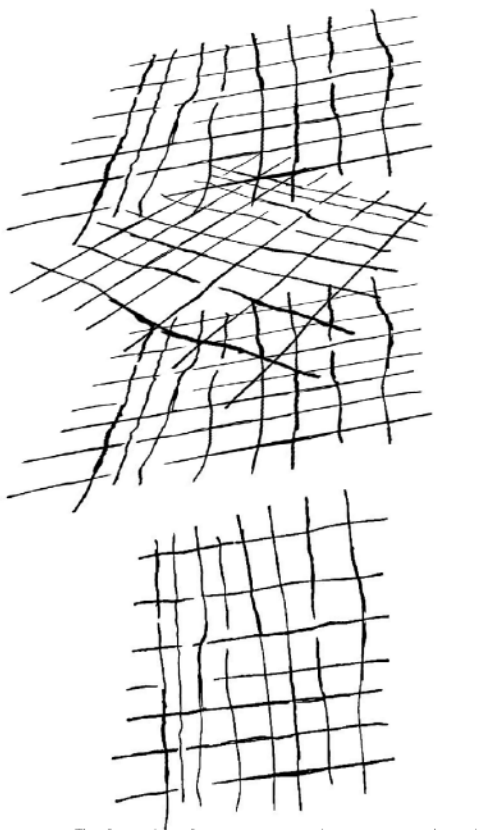


Swell.

The Instability of Storm Waves vs. the Steady Swell.

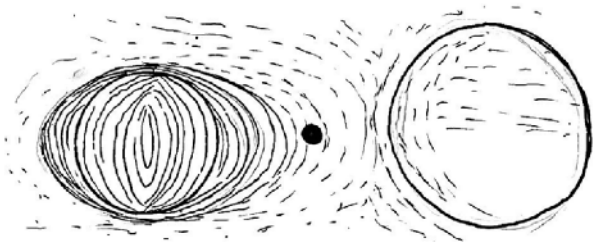
Both are progressive wave types, Storm waves are irregular waves in the area of generation; swell waves are regular waves beyond the area of generation.
(Ansorge, 2017).



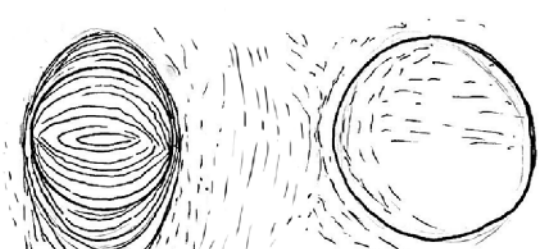


Storm Surge Formation.

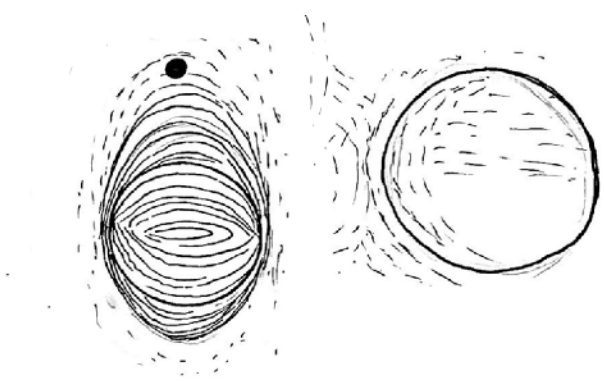
The formation of rogue waves and storm surges through the superposition of different waves. Different crests super-impose and form larger and more destructive waves. This can occur through increased energy transfer into water.
(author's own).

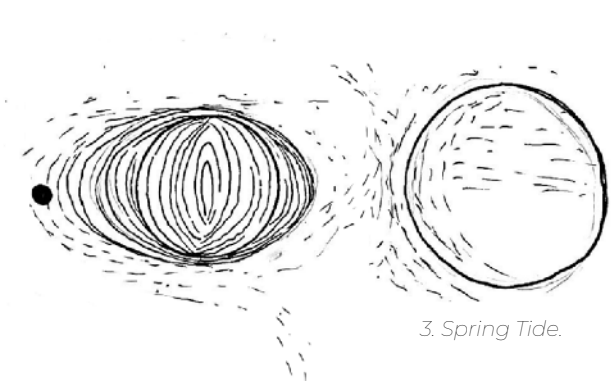


1. Spring Tide.



2. Neap Tide.





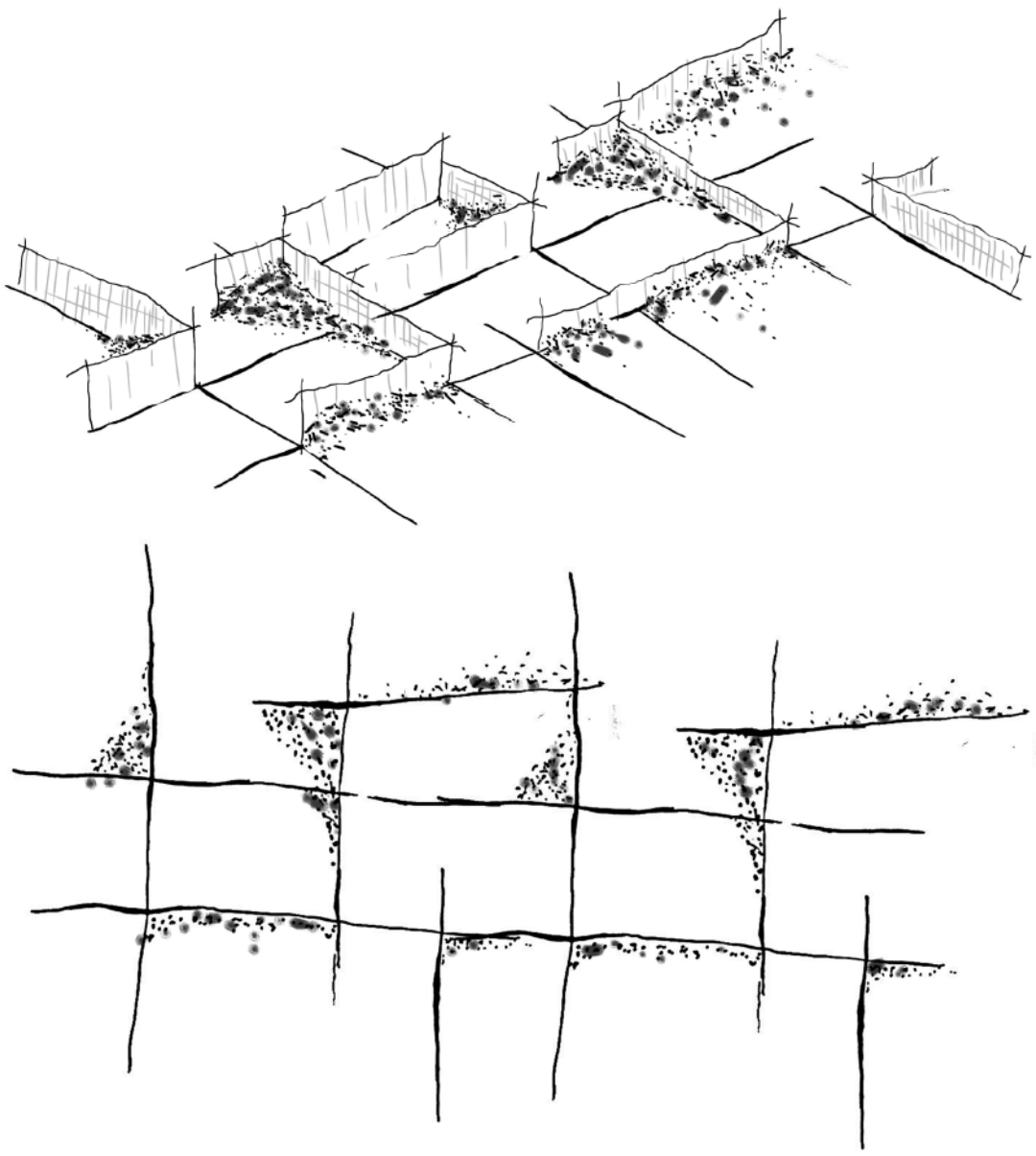
3. Spring Tide.

Tidal Pull.
Tidal patterns and the affects of the moon's gravitational pull, with the sun balancing centrifugal forces. Where spring tide is the largest tidal range, the crest and the neap is the smallest tidal range, the trough.
(author's own).

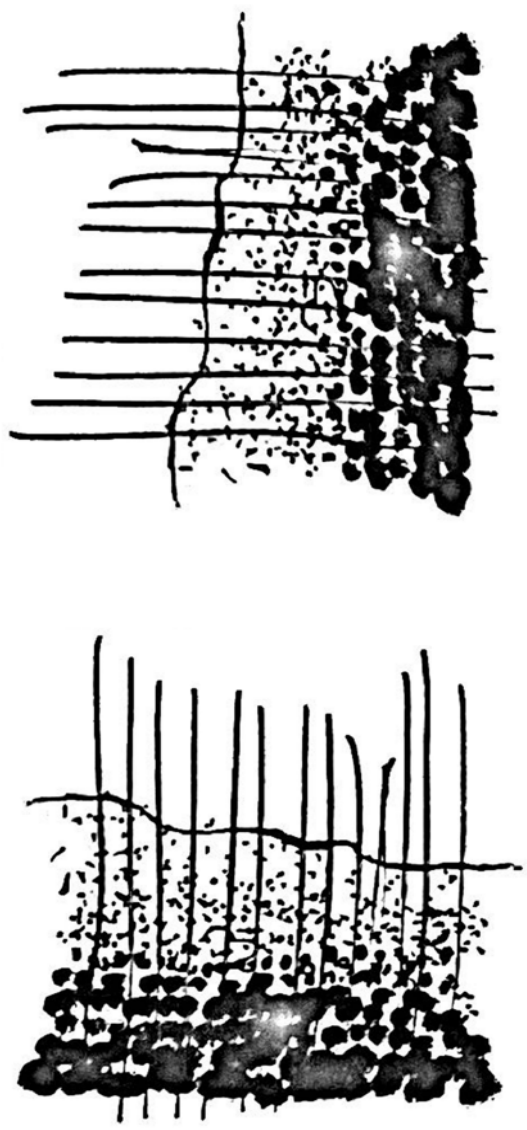
PROPERTIES OF SAND |

Through wind and waves sand particles are transported and confront man made structures. The reaction of sand to this confrontation is to soften edges, transforming rectilinear structures into organic configurations. This occurs through the process of deposition and accumulation. When designing with sand as a medium, it is important to be conscious of these tendencies. The image below is an exploration of what sand would do to human organisational attempts and what would happen if the grid was dune nets.

Large bodies of sand, like sand dunes have the ability to act as a sponge, absorbing water in both the horizontal and vertical planes. In the event of a flood or storm surge, sand is very beneficial as it rapidly, freely drains water. This is because sand is very porous and can absorb large amounts of water, quickly. Water retention is a vital ecosystem service that sand dunes can provide and are a critical buffer between human and sea. The image on the right is an exploration of this service as waves hit the beach, where the energy of the water is absorbed both horizontally and vertically, giving dunes the sponge-like characteristic.



Softening of Sand on Man-Made Edges.
Sand accumulation along vertical masses. e.g. dune nets. Seeing how the deposition of sand naturally softens sharp edges.
(author's own).



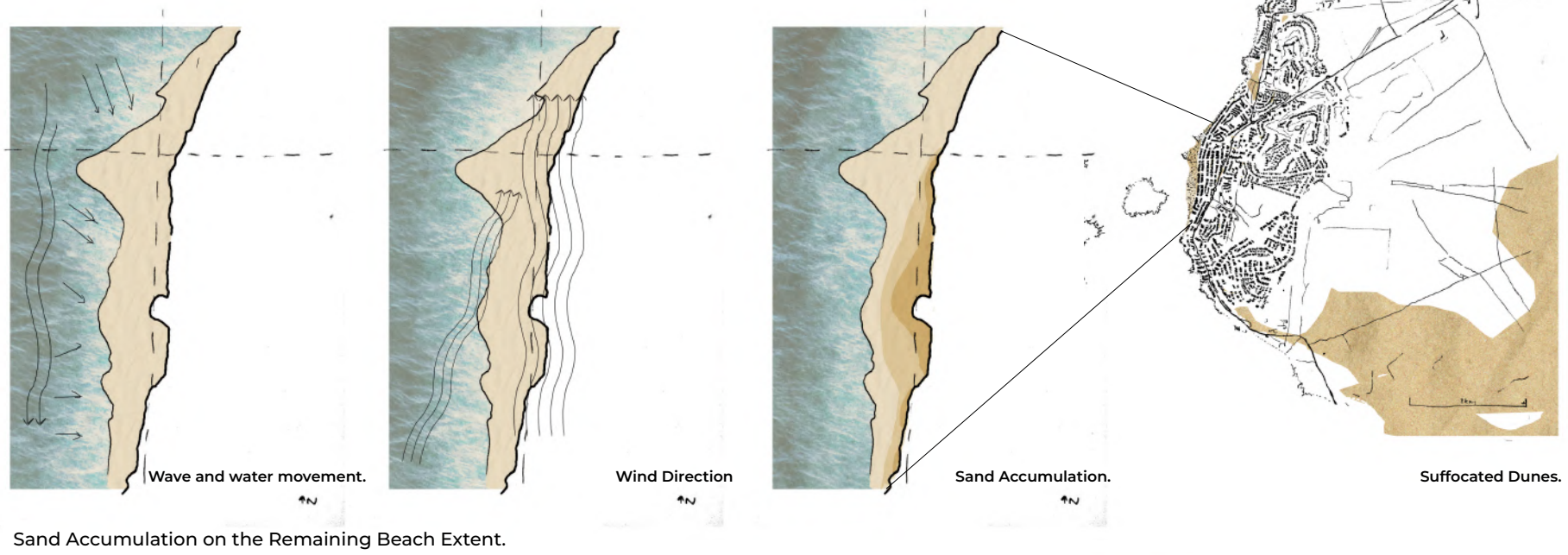
Sand Mass as a Sponge.
Saturation: Sand acting as a sponge and absorbing the oncoming waters as they rush over them on a horizontal plane and draining the water through the vertical plane.
(author's own)

SUFFOCATED DUNES |

In analysing the dune system, we can see that the shoreward development has suffocated the system, through the steady excavation and burial of the dunes. This suffocation renders the dunes inoperable and unable to perform the ecosystem service of protecting inland areas of the coast. Development begins at the main beach front, invading on the foredunes dunes, moving deeper inland enclosing the established dune bed. Finally, in a last hoorah, the dunes are suffocated with each built footprint moving north along the coastline trampling the dunes. Only a thin sliver along the beach front remains to protect Langebaan from the sea.

These remaining dunes are small foredunes, reaching a mere two meters in high where, normally taller (max ~ 20m) and more expansive dunes act as a buffer to the sea, as development occurs behind the coastal setback line. Foredunes are primarily fed by diurnal tide fluctuation and secondarily by aeolian sediment deposition.

Historical Dune Extent.



Sand Accumulation on the Remaining Beach Extent.
(author's own).

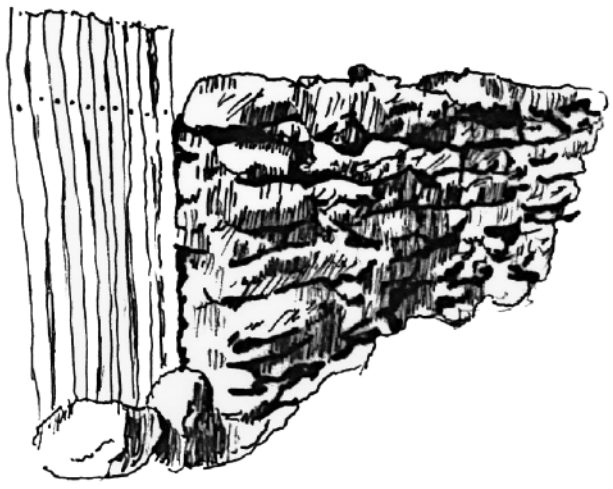
Remaining Foredunes on Beach Patterns.
(author's own).

MEMORY OF STONE |

Oudepost I (Old -post 1) was the first military post established by the Dutch in the Greater Saldanha region. It is located on the north-western banks of the Langebaan Lagoon and is significant due to its main role in many historical documentations of Saldanha. It illustrates the first intention of investing in the region and sets the scene for Saldanha's military future. The post was made from the natural materials from the landscape, like many of the artifacts in this region. This use of materials unfolds the reliance and connectivity of the occupants to nature. Similar material characteristics are now associated with the West Coast built environment.

Within its hand-laid stone walls hidden stone tools are set. These are theorised to be placed there by the local Khoekhoe for the event of an attack (Schrire & Deacon, 1989). This gives proof to the occupation of the area by both Dutch and Khoekhoe, where it was originally thought the KhoeKhoe moved in when the Dutch relocated to Table Bay.

There is significance in the stone as both the Dutch and Khoekhoe forged their tools out of Silcrete, some kilometers from the site (Schrire & Deacon, 1989). Silcrete is thought to have been of value to these groups and used because it is a surface geology, so its extraction is easier for an era with no industrialisation.



Stone Walls
West Coast characteristic hand-laid stone walls. (author's own).

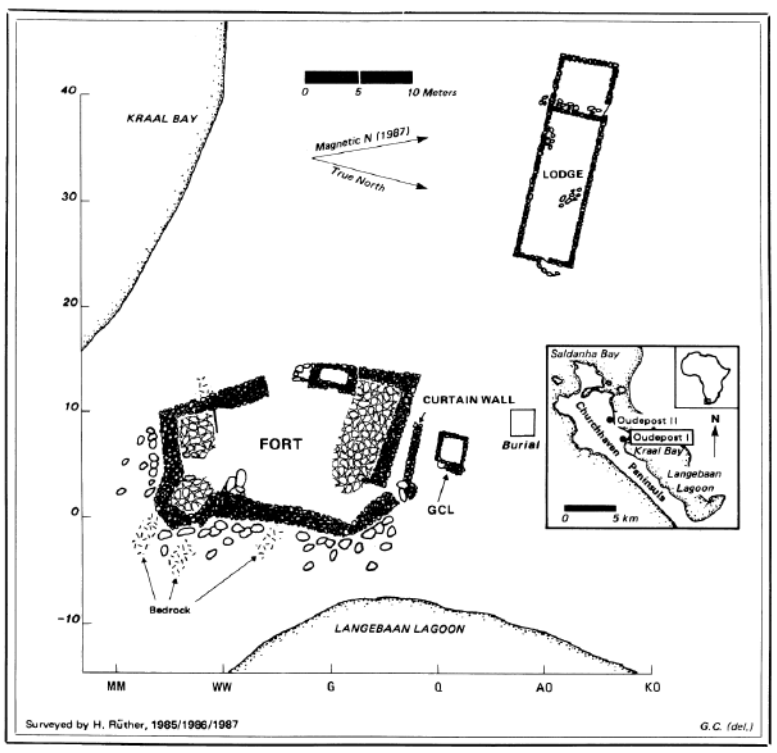


Fig. 1. Plan of the Oudepost site.

Site Plan of Oudepost 1
(Schrire & Deacon, 1989)

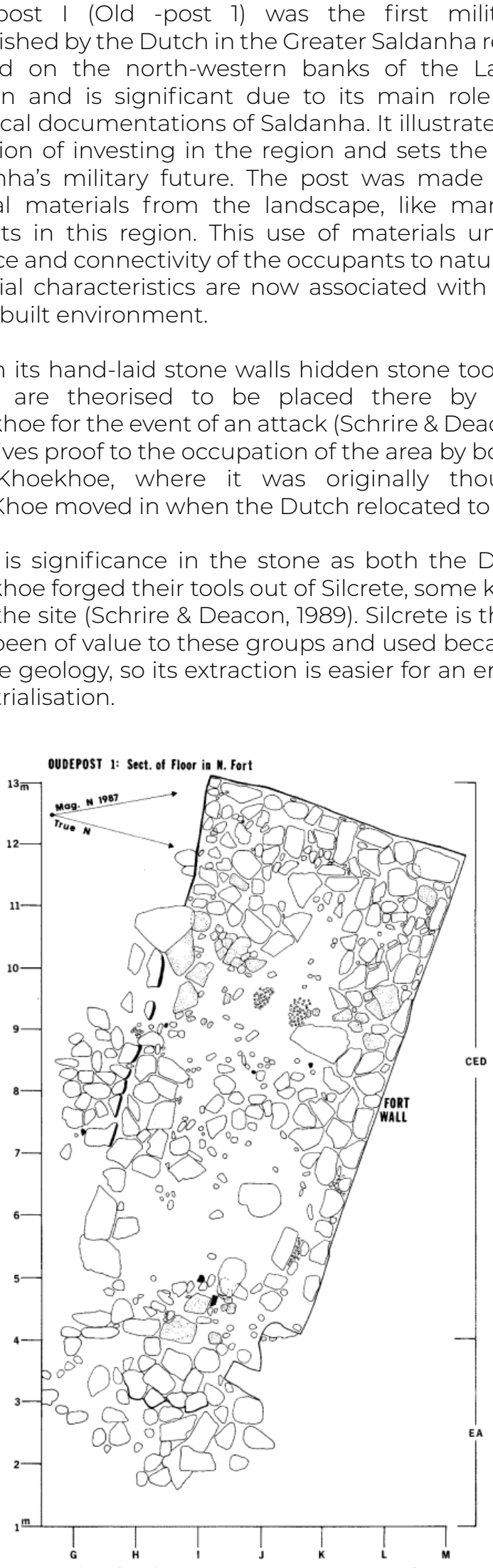


Fig. 5. Plan of paving in the northern section of the fort at Oudepost I, Cape, showing stones laid from the walls in to the centre of the enclosure.

(Schrire, Cruz-Uribe, & Klose, 1993).

Fig. 11. View of enclosure (NA) in the southeast corner of the fort, at Oudepost I Cape, where sea seepage occurs at high tide. Scale in 200 mm increments.

(Schrire & Deacon, 1989)

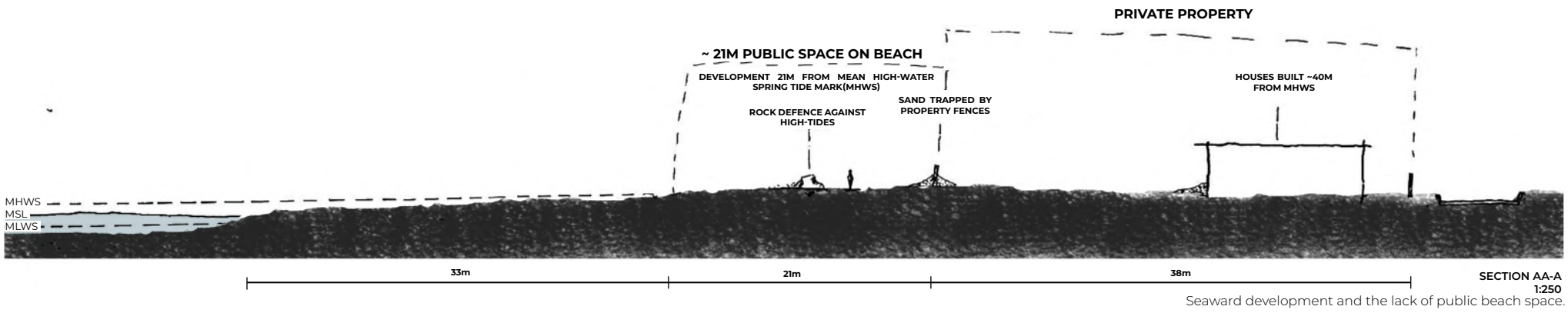
STONES OF CULTURE |

Stone is of more cultural significance to the site, whereby many of the characteristic walls are hand-laid stones (like the walls of Oudepost I) and the native Khoekhoe that lived in the area had traditional burials of stone piles (Boonzaier, 1996). Many stone artifacts are found along Langebaan Lagoon (Schrire & Deacon, 1989).

However, on the site, granite rubble was used in an effort to combat erosion and for sea defence; these materials are likely to have come from the Oliphantskop excavation site. These defences are clearly visible and a last resort to protect the remaining beach from eroding and the water flooding the first row of developments (Section AA-A).

Stone used to buffer sea-level rise in Langebaan. (author's own).

Geological Map of Langebaan, WC, South Africa. (author's own).



SECTION AA-A
1:250

Seaward development and the lack of public beach space.

SEA DEFENCES
DUNES + SANDY BEACHES

//

CRITERIA

The beach-front and the at risk to sea-level rise area in Langebaan is characterised by dunes and sandy beaches. Hard infrastructure is unfavorable as it negates the natural system's role in defending the coast, for example, sea walls reflect wave energy rather than absorb the energy. This means the wave's power is still strong and can erode the recreational beach complex. These responses can destroy the sense of place and natural beauty of the coastline which was one of the reasons for the seaward development in the first place. In order to land on a suitable sea defence system that challenges the hard infrastructural approach, I have set up a criterion for ecological requirements (left) and human requirements (right), which is then used to analyse existing sea defence methods for dunes and sandy beaches.

DUNE-SYSTEMS |

The defence system must incorporate the use of dunes and illustrate the ability of coastal dunes to act as a sponge during flood events.

ECOSYSTEMS BASED |

Since Langebaan is an important ecological area, the sea defence system should make use of the existing bio-geophysical systems in the area.

HABITAT CREATION/REHABILITATION |

The extreme seaward development in Langebaan has led to environmental degradation, especially of the coastal dune systems and intertidal habitats. The defence should allow for the rehabilitation of these degraded habitats and if possible, introduce new habitats for marine and terrestrial species.

SUSTAINABLE |

The defence should be constructed in a sustainable manner that does not create further damage to the ecosystem. The sustainability of the defence also refers to the maintenance and the long-term existence of the system.

PROTECTION |

The defence should successfully protect the inland coastal development from the 1:100-year swash line.

MULTI-FUNCTIONAL |

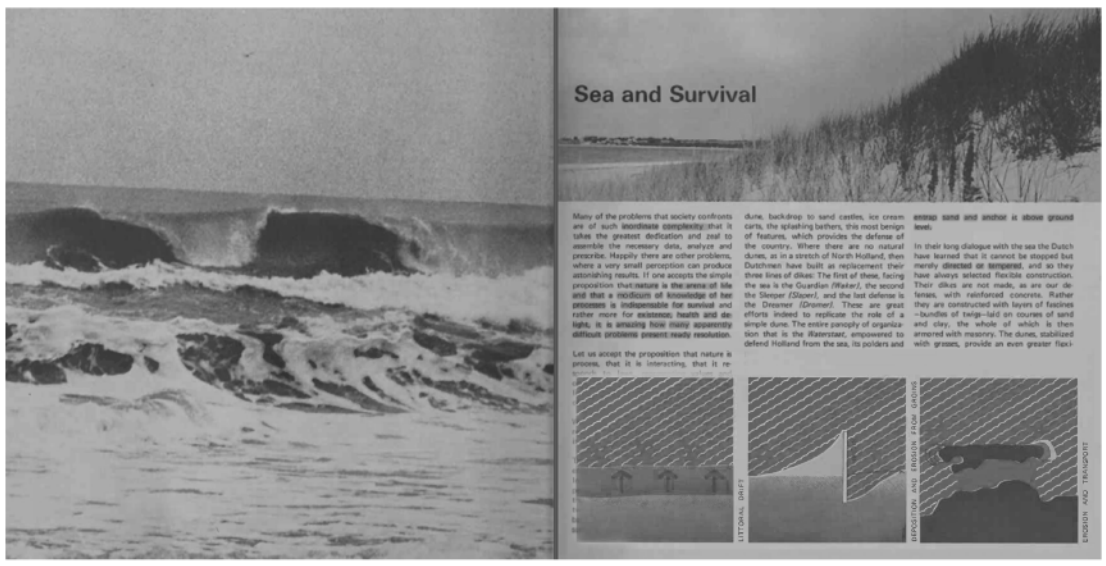
Due to the 'coastal squeeze' phenomenon in Langebaan, the sea defence should perform multiple roles in the space of one design. It should have a balance between ecosystem functioning, cultural identity and social needs.

PUBLIC SPACE |

Due to the lack of public-space and access to the coastal edge, the defence system should be designed in such a way that it increases the availability of public space.

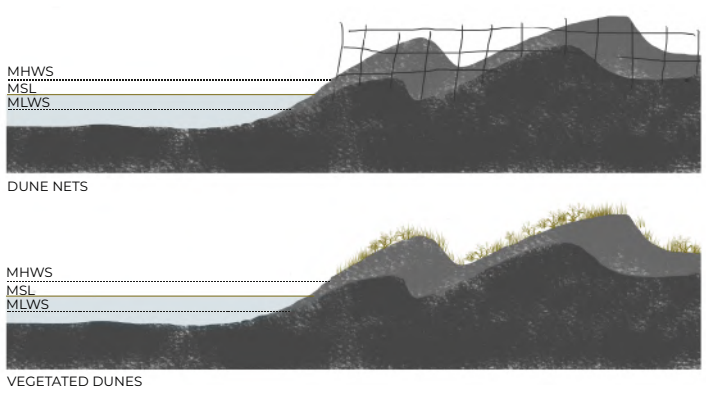
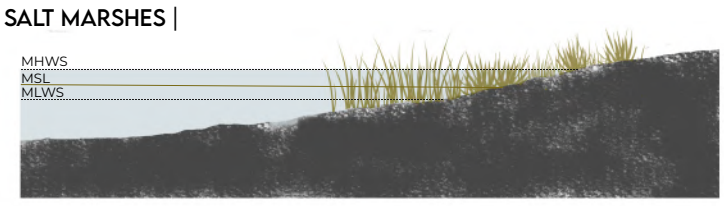
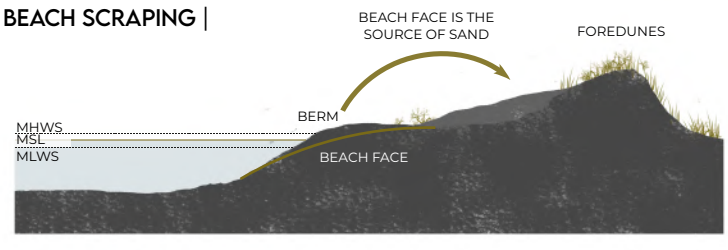
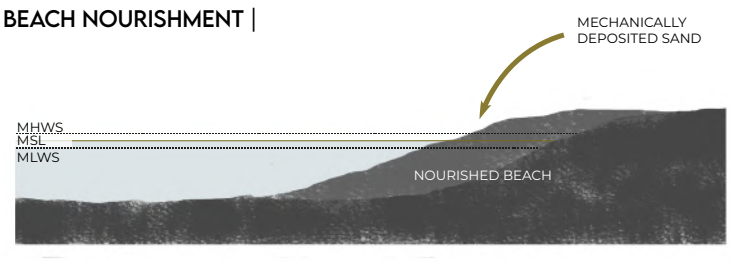
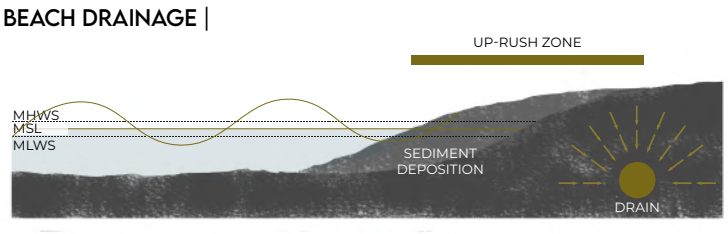
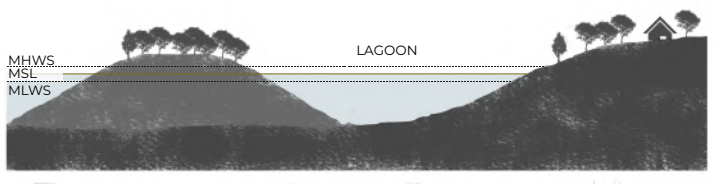
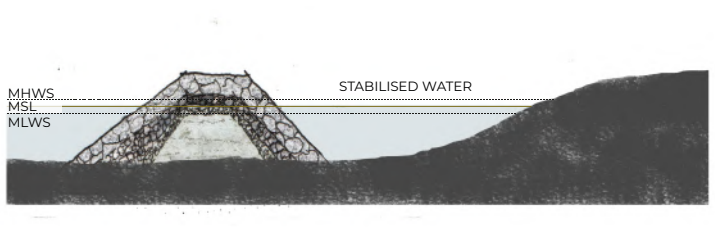
SENSE OF PLACE |

Most of the existing sea defence measures in Langebaan are clearly visible and detract from the coastal experience. The sea defence should fit into the character of Langebaan and evoke a positive sense of place.



Design with Nature by Ian McHarg, 1969.

SOFT DEFENCE TO HARD DEFENCE

CURRENT SEA DEFENCES FOR SANDY BEACHES (BAUSCH, 2019)	PROTECTION	TYPE	DEFENCE	APPROACH	ASPECTS
DUNE STRENGTHENING, REHABILITATION AND RESTORATION | 	· Coastal floods · Storm surges · Erosion	· Reduction	· Hold the line	· Combined approach (Grey + Green infrastructure) ·Ecosystems based approach	· Increases recreational value. · Works with dune systems. · **Langebaan suffers from 'coastal squeeze" phenomenon (not enough space to restore).** · Reduces dune trampling. ·Establishes/rehabilitate coastal habitats.
SALT MARSHES | 	· Riverine floods · Slow-rise floods · Estuarine floods · Coastal floods · Storm surges · Erosion	· Channel · Coastal · Floodplain.	· Managed	· Combined approach (Grey + Green infrastructure) ·Ecosystems based approach	· **Softens surges but is not enough to be a stand alone defence.** · Allows marshes to be partially submerged. · New intertidal habitat creation.
BEACH SCRAPING | 	· Erosion	· Channel · Coastal · Floodplain.	· Hold the line	· Combined approach (Grey + Green infrastructure)	· No dredging of seabed. · Works with dune systems. · **Not designed for intense storm surges and floods.**
BEACH NOURISHMENT | 	· Erosion	· Channel · Coastal · Floodplain.	· Hold the line	· Combined approach (Grey + Green infrastructure)	· Increases recreational value. · Works with dune systems. · Does not remove hazardous factors (e.g. erosion). · Dredging may be needed. · Management intensive. · **Needs additional measures to support it.**
BEACH DRAINAGE | 	· Coastal floods · Storm surges · Erosion	· Channel · Coastal · Floodplain.	· Hold the line	· Combined approach (Grey + Green infrastructure)	· Only for micro-tidal zones. · Works with dunes. · Only if no other options. · **Not useful against storm + flood events.** · Management intensive.
LAND CLAIM | 	· Coastal floods · Storm surges · Erosion		· Move	· Combined approach (Grey + Green infrastructure) · Can be an ecosystems based approach	· Defends the shore and near-shore areas. · Increases land for recreation, agriculture, housing, etc. · Can establish new ecosystem habitats. · May require dredging. · Dependant on hydrodynamic influences (esp. tides). · **Ecosystem effects dependent on size, construction and design.**
EXPOSED ELEMENT RELOCATION | 	· Riverine floods · Slow-rise floods · Estuarine floods · Coastal floods · Storm surges · Erosion	· Channel · Coastal · Floodplain.	· Removal · Relocation · Managed	· Grey infrastructure · Non-structural	· **In Langebaan the exposed houses are declared heritage buildings.** · **Does not utilise dune systems.** · Expensive in both time and money. · Safest option. · Social/Political conflicts.
BREAKWATERS | 	· Riverine floods · Slow-rise floods · Estuarine floods · Coastal floods · Storm surges · Erosion	· Channel · Coastal · Floodplain.	· Hold the line	· Combined approach (Grey + Green infrastructure)	· Hard infrastructure. · Does not utilise dune systems. · Does not directly defend against flood events. · Need additional supporting measures. · Management intensive. · Usually used for harbour creation.

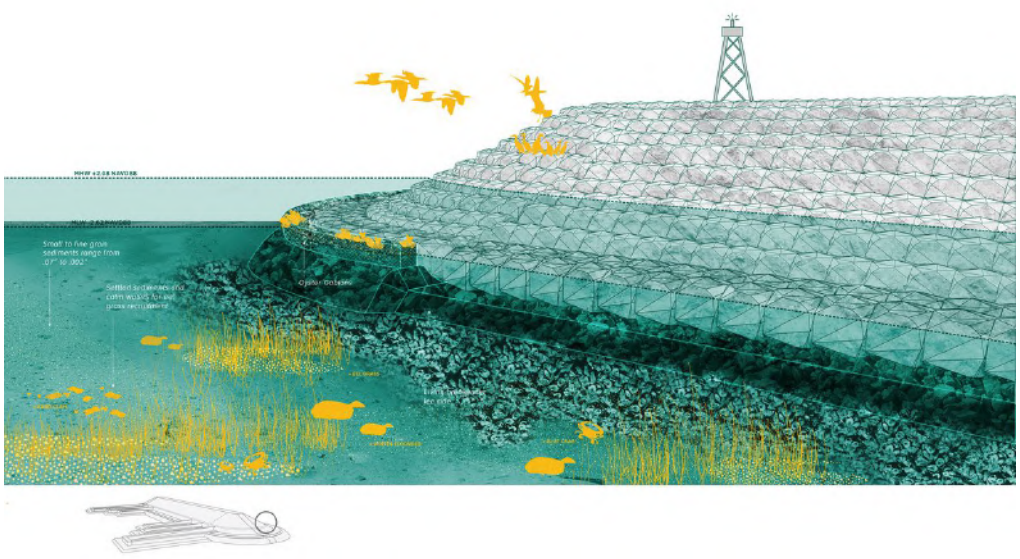
PRECEDENTS |
GREY INFRASTRUCTURE AS GREEN INFRASTRUCTURE.

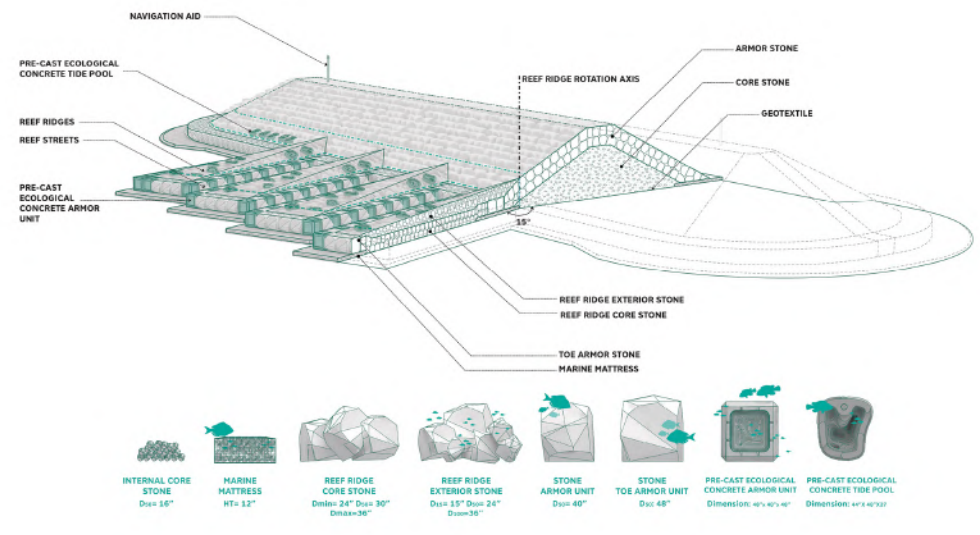
Figure 16. Location of the 13 transects (A to M) for assessing and re-profiling dune cross-sections on the Hout Bay beach. Transects N, O and P provide an idea of profiles across the system, for example the major blowout on transect G

DUNE REHABILITATION + MANAGEMENT: HOUT BAY, WC, SOUTH AFRICA[q]

The Hout Bay dune rehabilitation and management plan was aimed at managing the movement and migration of sand dunes. This was done through profiling, wind netting and planting dune vegetation in the hope of stabilising and growing the dunes. An area of approximately 50 000m2 of re-profiled, netted and planted dunes has been managed, where the re-profiled dune project is categorised into three areas, namely the fore-dune, buffer-dune and back-dune each planted with necessary vegetation (Low & van Eeden, 2013).

Lessons can be learned in the categorisation, organisation and methods of where to place the dune nets based on each need as well as the propagation and use of vegetation.





SCAPE'S LIVING BREAKWATERS REBUILD BY DESIGN COMPETITION

The proposal was designed to protect coastal developments from wave damage and erosion by installing a chain of breakwaters off the shore of Staten Island, USA. The project takes breakwaters from being purely infrastructural to one that supports biodiversity through the careful curation of materiality.

BLUE DUNES: REBUILD BY DESIGN COMPETITION

WXY architecture + urban design, West 8 Urban Design & Landscape Architecture, AIR Worldwide, ARCADIS, and Stevens Institute of Technology illustrating that a land claim can be ecological. The project designed an artificial island to protect mainland development from storm surges. The land claim is interesting as it uses a systems-based approach to inform the design of the island.

the choreography.[r]

THE CHOREOGRAPHY
SYNCING HUMANS + NATURE IN THE NAME OF CLIMATE CHANGE

//

The design proposal for an ecological sea defence in Langebaan directly responds to the pinch point created by irresponsible coastal development by responding to existing natural systems and processes, releasing the pressure on the existing public spaces in the town and reintroducing/ strengthening cultural practices, such as artisan fishing with the notion of sea to table.

The proposal is a hybrid of the afore-mentioned sea defence methods, namely: land-claim, dune restoration, breakwaters and salt marshes, with the aim of allowing dunes to act as a sponge for on-coming water. Essentially it is a land-claim in the form of an ecological island. A land-claim defence was chosen as the forward coastal development has left no space to provide onshore sea defences, without taking away the remaining public beach complex, it also creates sufficient space to create dune habitats and provide much needed public space. Breakwaters are chosen as a supporting role to the land-claim, to protect the new land from highly erosive areas and salt marshes are chosen because they absorb wave energy and increase intertidal habitats, where langebaan is known for its significant salt marsh zones.

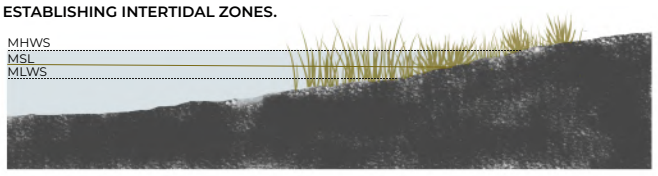
The island should challenge the traditional methods of sea defence by illustrating the importance of the envelopment of the human and the natural in reacting to climate change. The design is reliant on the health of the environment and the engagement of the community, as it illustrates the importance of the synchronisation of people and nature in the fight against climate change. By proposing the creation of an artificial island, ecological systems are harnessed to create an accessible, sensitive and meaningful space, revealing the memory of the site; and to dissipate the storm energy and protect Langebaan from being submerged.

TOOL-KIT |

CLAIMING LAND.

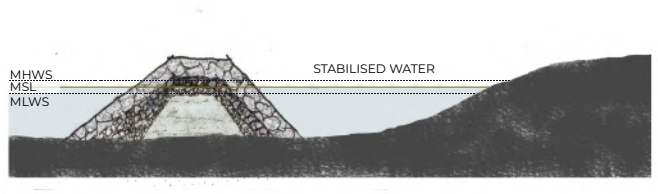
Langebaan suffers from the phenomenon of 'Coastal squeeze' where development has occurred directly onto the beach front. This has destroyed the dune system. Another problem is that most of Langebaan is privatised, leaving very little public space. By claiming land it allows for the development of new dune systems as well as the increased availability of public space.

ESTABLISHING INTERTIDAL ZONES.



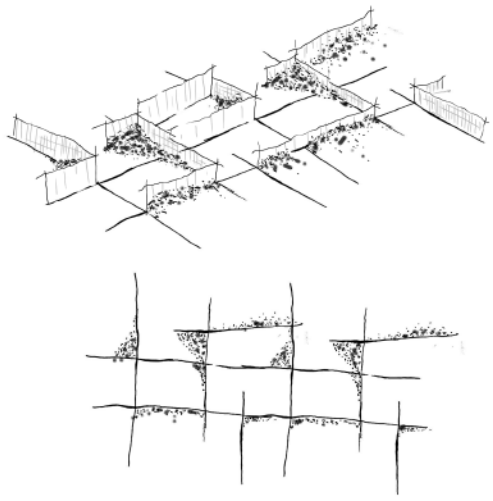
Salt marshes can help absorb wave energy and stabilise waters. They are also good for creating intertidal habitats for many bird and other species. Langebaan is home to large salt marshes which, together with the islands, makes great bird habitats, thus Langebaan is the ornithological capital of South Africa.

USING BREAKWATERS TO WITH-STAND STRONG CHANNEL CURRENTS.



To protect the dunes from the continuous erosion of the fast moving channel, breakwaters strengthen vulnerable edges. Stepping them down can help with sediment deposition on the steps and create intertidal habitats.

USING DUNE NETS AS A METHOD TO TRAP SEDIMENTS AND GROW DUNES.

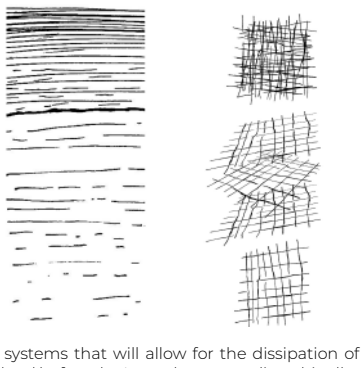


In order to assist with the establishment of the new dune area, dune nets are needed to trap aeolian sediment. Essentially this would trap sediment which has traveled from the dune plumes South of Langebaan. Once dunes are established, they can be planted with dune strandveld to stabilise them.

DUNES TO ABSORB EXCESS WATER IN FLOOD/SURGE EVENTS.

A large body of sand, like dunes, has the ability to absorb water, so in the event of a storm-surge or flood this characteristic can absorb the incoming water, acting as a sponge.

DISSIPATING STORM ENERGY THROUGH THE USE OF DUNES AND SALT MARSHES.



The goal is to use systems that will allow for the dissipation of storm energy. By establishing and island before the Langebaan coastline, this allows the island to act as the storm dissipater, whereby it bears the brunt of the storm.

SEA + SURVIVAL: FRAMEWORK PLAN
1: 25000 @ A1

The project relies on the ecological systems in the area to design a transient sea defence. These systems include the dynamics of tides, waves and aeolian sediment deposition to form a large dunescape on two ecological islands. The dunescape acts as a sponge and absorbs the oncoming storm-surges, protecting at-risk communities.

This project is a long-term dynamic project that allows the users of the space and returning tourists to witness a changing landscape and begin an intellectual conversation of ecological landscape design.

Island A is directed at supporting ecosystems from the WCNP with minimal access, except by ferry. This aims to increase the ecological tourism to the region and provide job opportunities. Island B acts to unsuffocate the lack of public space for poorer communities and brings back the fishing heritage of Langebaan, which is ingrained in many of the Cape Malay residents. This is done through the design of artisanal fishing facilities based on the historical use of the coast. The connection to the island is an easily accessible bridge and forms part of a larger coastal hiking route, proposed by the Saldanha SDF, which connects the WCNP hikes.

USING HYDRODYNAMICS TO INFORM ISLAND DESIGN |

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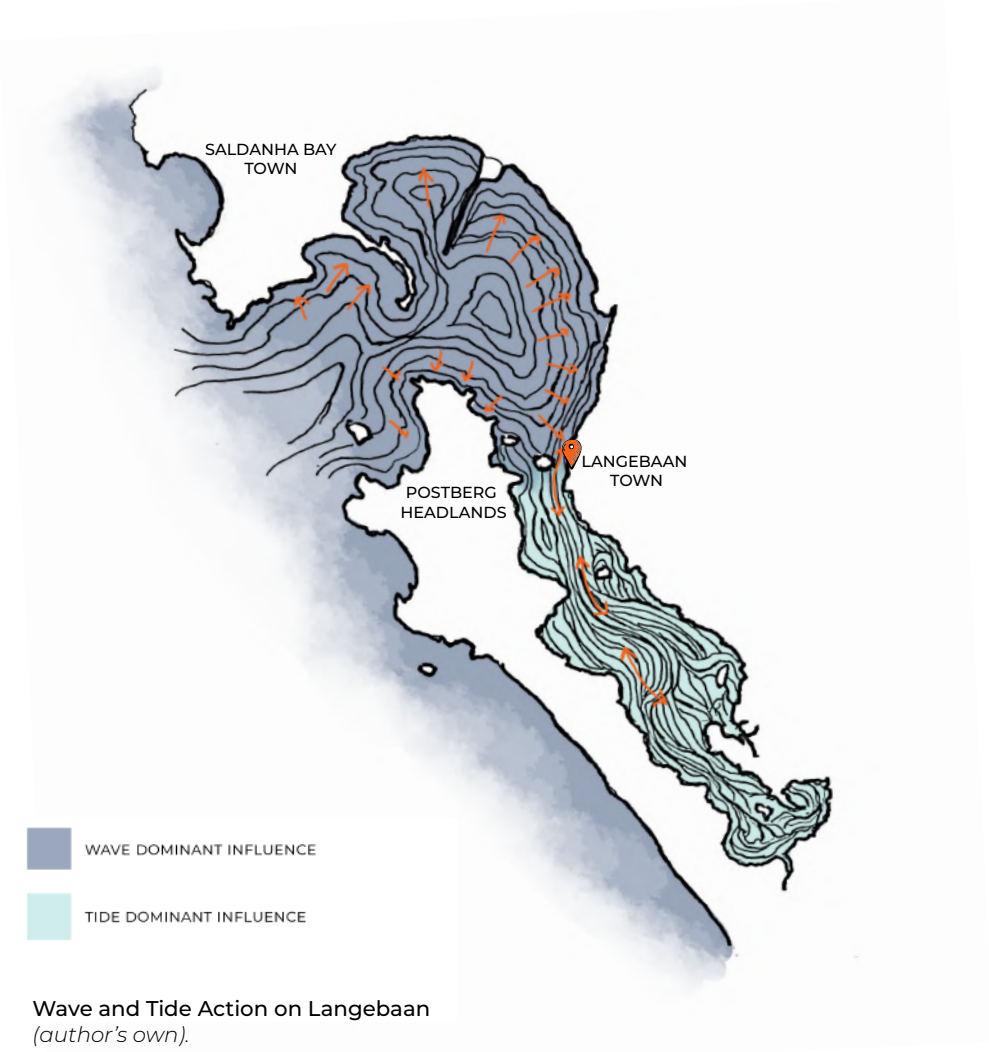
In terms of hydrodynamics, Langebaan is at another pinch-point. The Langebaan coastline is under the influence of both tides and waves, where the wave energy propagates from the northern Saldanha bay and tidal action is significant to the Langebaan Lagoon at the south.

The north-eastern lagoon mouth, just off the Langebaan beach front is the point of study. The beach front continues into a subtidal sandbar (~2m depth) which drops off into a channel (~15m depth) and another sandbar emerges just off Skaap Eiland, opposite the beach front. This channel is important for tidal action of the Lagoon by ensuring there is no lagoon back-wash onto the mainland from flooding, where there are strong ebb currents drain the channel. The channel functions as a homeostatic organ keeping the lagoon's salinity, water-level and marine life in balance. It is vitally important to keep the integrity of the channel to prevent flooding, preserve the sensitive salt marshes and maintain a migration route for marine species.

Concerns for building an artificial island are the hydrodynamic impacts on the Lagoon. The first one being the longevity of the island as South Africa is known for its untameable seas. Langebaan is affected by the waves coming through the bay, however due to the Postberg headlands the average wave energy is reduced (Blake & Chimboza, 2011; Flemming, 2015), this does not however, exclude Langebaan from the risk of storm-surges as the topography is extremely low-lying. Secondly is the hydrodynamic balance of the Lagoon, according to Flemming, a marine geologist, any changes in the system will result in the system trying to find a new equilibrium so where channels are narrowed the system would try to balance the ebb current by increasing its velocity (Flemming, 2015).



Wave and Tide Action on Langebaan
(author's own).

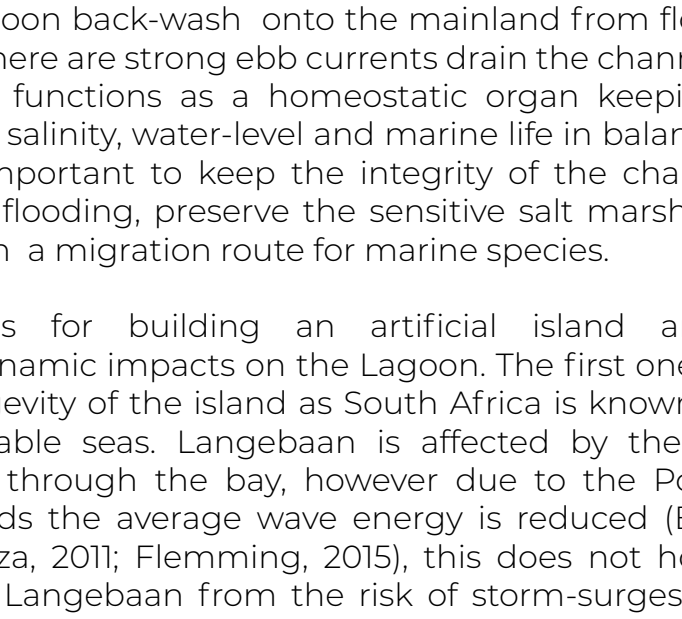
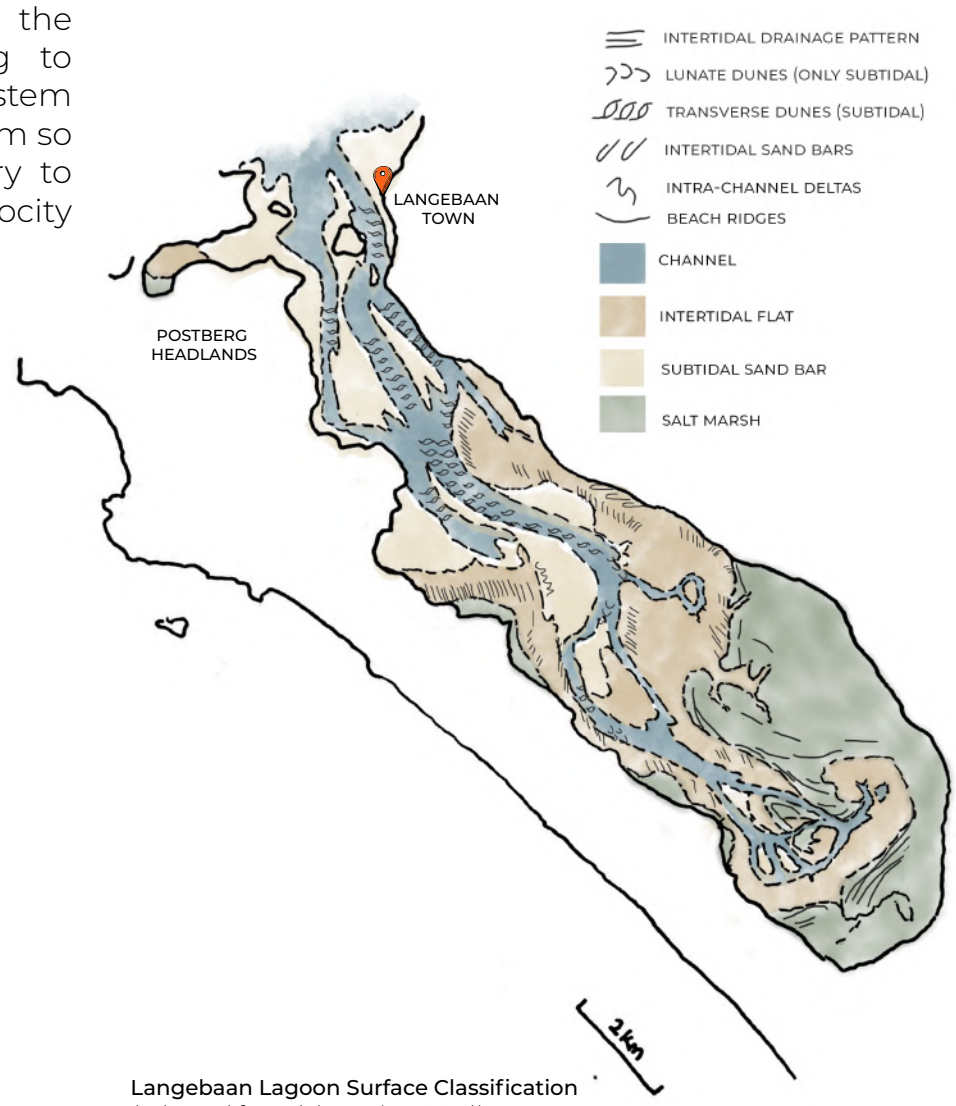


Table 7. Discharge rates through the mouth channels of Langebaan Lagoon.

Mouth	Average ($m^3 s^{-1}$)	Maximum ($m^3 s^{-1}$)
Eastern channel	2,390	3,744
Western channel	900	1,200

Currents in Langebaan Lagoon
(Flemming, 2015).



Langebaan Lagoon Surface Classification
(adapted from (Flemming, 2015)).

FORMING THROUGH PROCESSED-BASED MODEL-MAKING |

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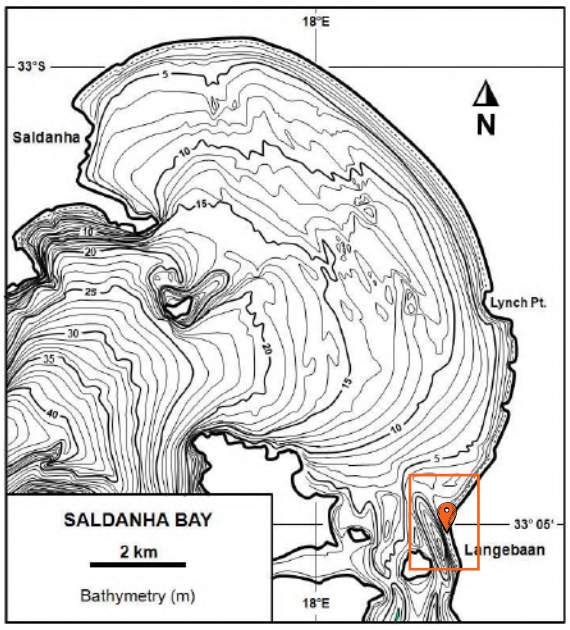
To further understand the hydrodynamics and their effects I built a process-based model of the Langebaan Lagoon north-eastern mouth where my site is located. The model was created with the bathymetry of the lagoon and the contours of the land and is based on the hydrodynamic processes occurring in the Lagoon/Bay area. With this model I performed three experiments: with just water; water and sand; water, sand and the non-formed islands. A 100m x 100m grid was added to track the events of the



Bathymetry
(Flemming, 2015)).

EXPERIMENT 1:

Water is flowed through the model, simulating the ebb current and drained into the ‘bay’.

EXPERIMENT 2:

Sand is placed on the model surface and water is flowed through the model.

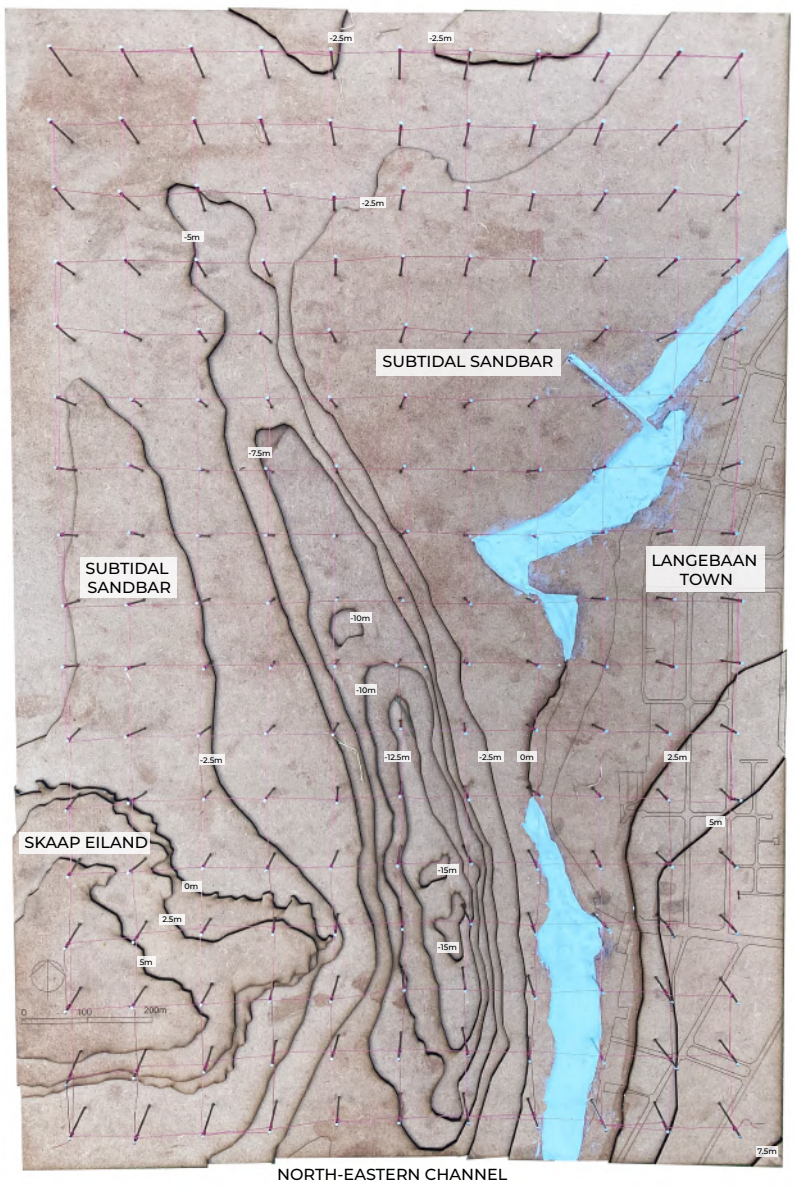
EXPERIMENT 2:

Two non-formed islands of a set size (500m x 400m) are placed 400m offshore and water is flowed through the model.

The water is rushed through the channel and then begins to fill slowly until every edge of the shoreline is reach. In the first and second experiments we see a similar result happening, where the vulnerable, low-lying shoreward developments become inundated upon the flooding of the model. In the last experiment we see a significant difference in the flooding of the model, where the rough island already begins to protect the vulnerable shore from being inundated.

These experiments performed the role of the channel and aided in a better understanding of the channel in relation to the sandbars. In the first two experiments the at-risk points were highlighted, and the extent of the island determined. The second experiment demonstrated the effects of an unbalanced system with excess sediments, where areas were clogged, and points of back-washing occurred due to the compromised channel. The last experiment supported my initial intuition on the idea of a land claim and the quality of dune systems and gave me key clues to the form of the ecological island.

Overall the experiments gave greater insight into the hydrodynamic processes driving the site and allowed me to create a functional form for the island that works with the natural processes in Langebaan.

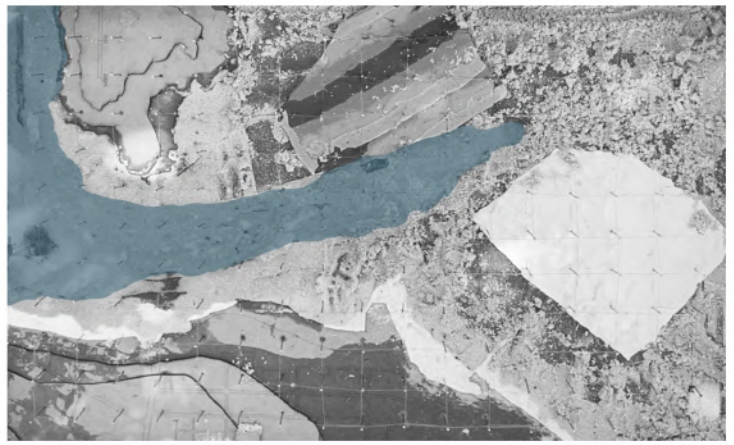
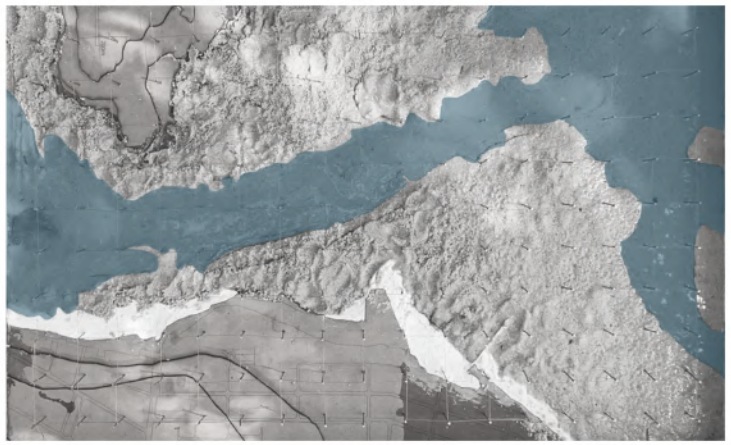
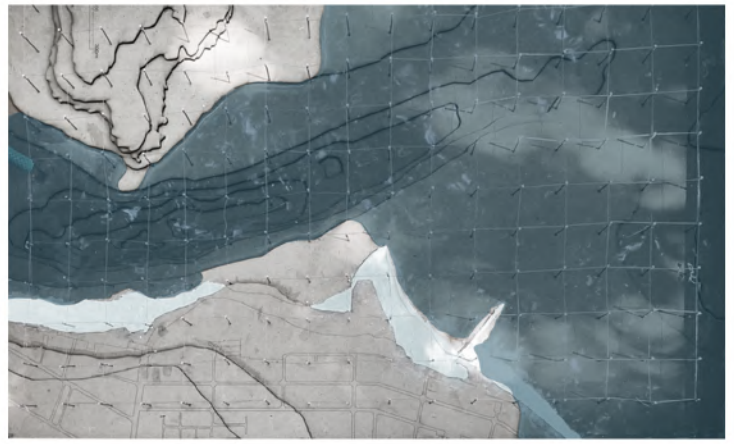
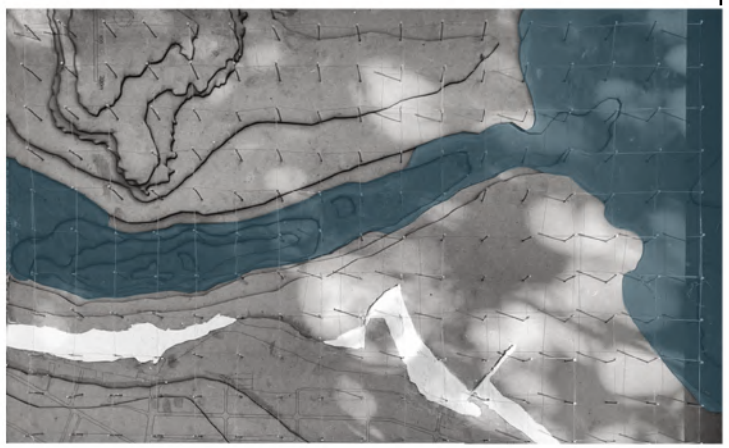
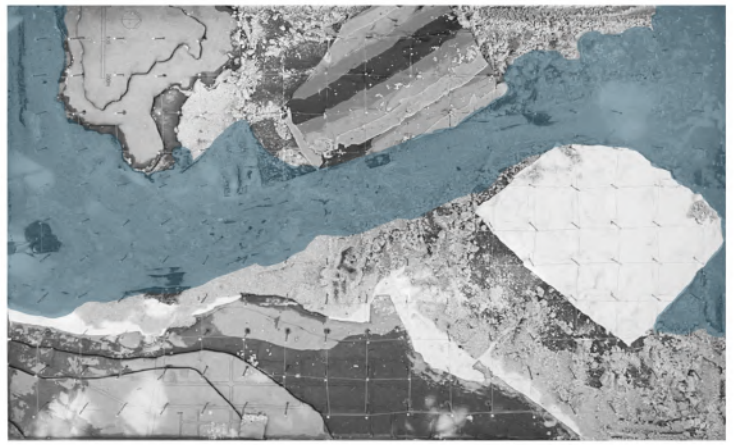
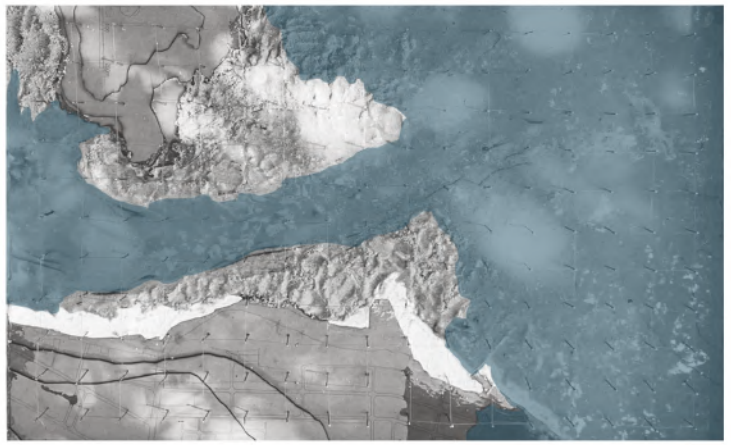
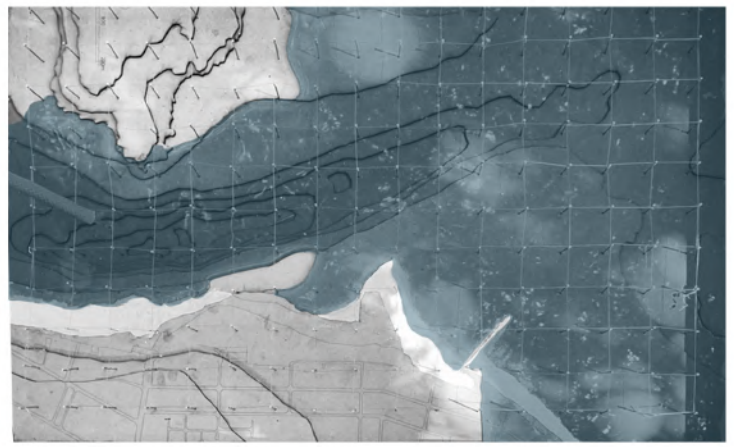
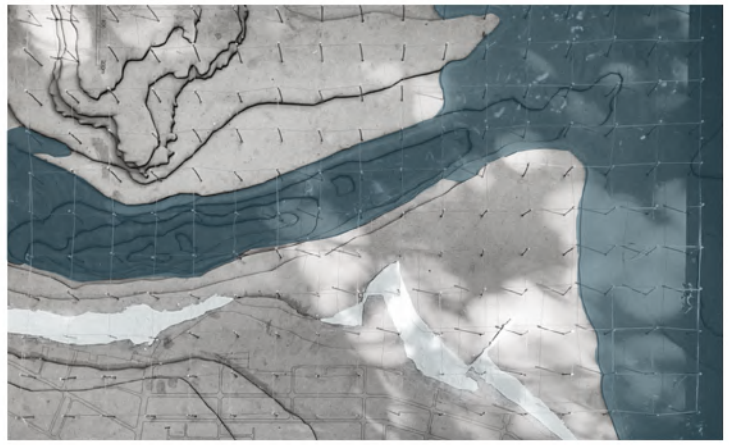
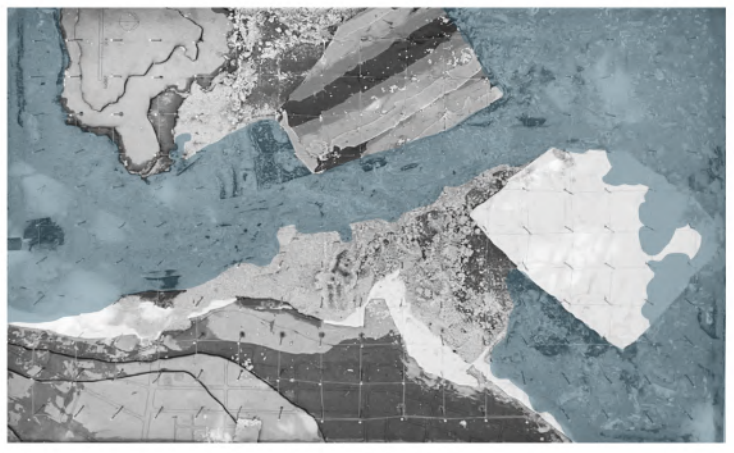
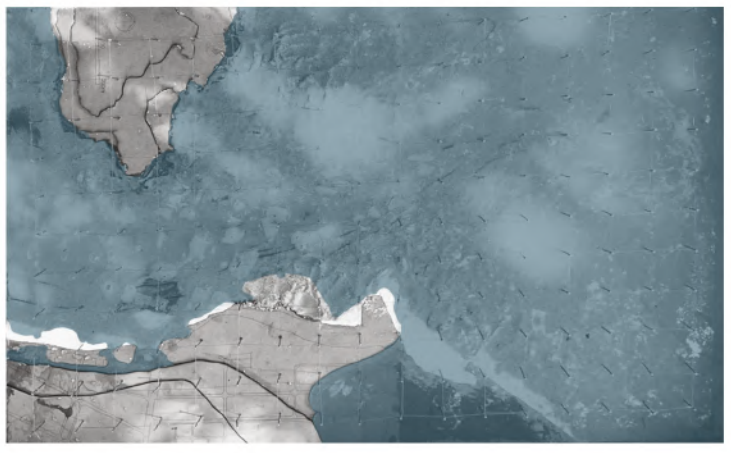
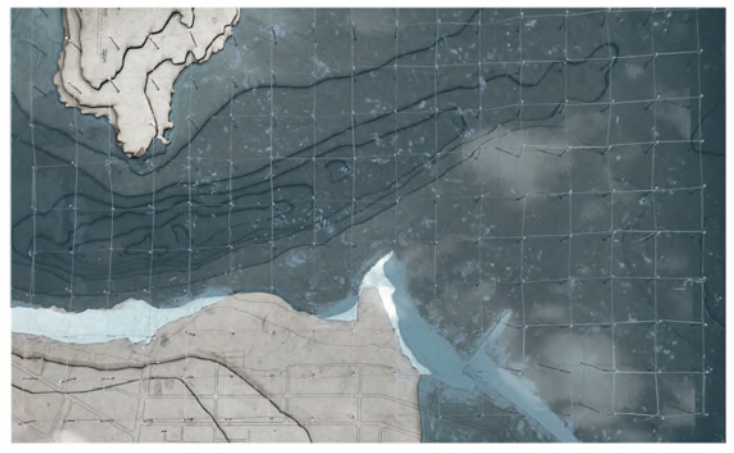
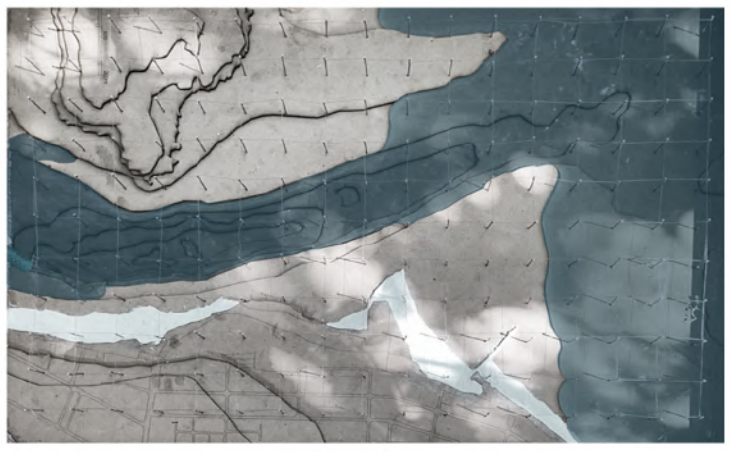


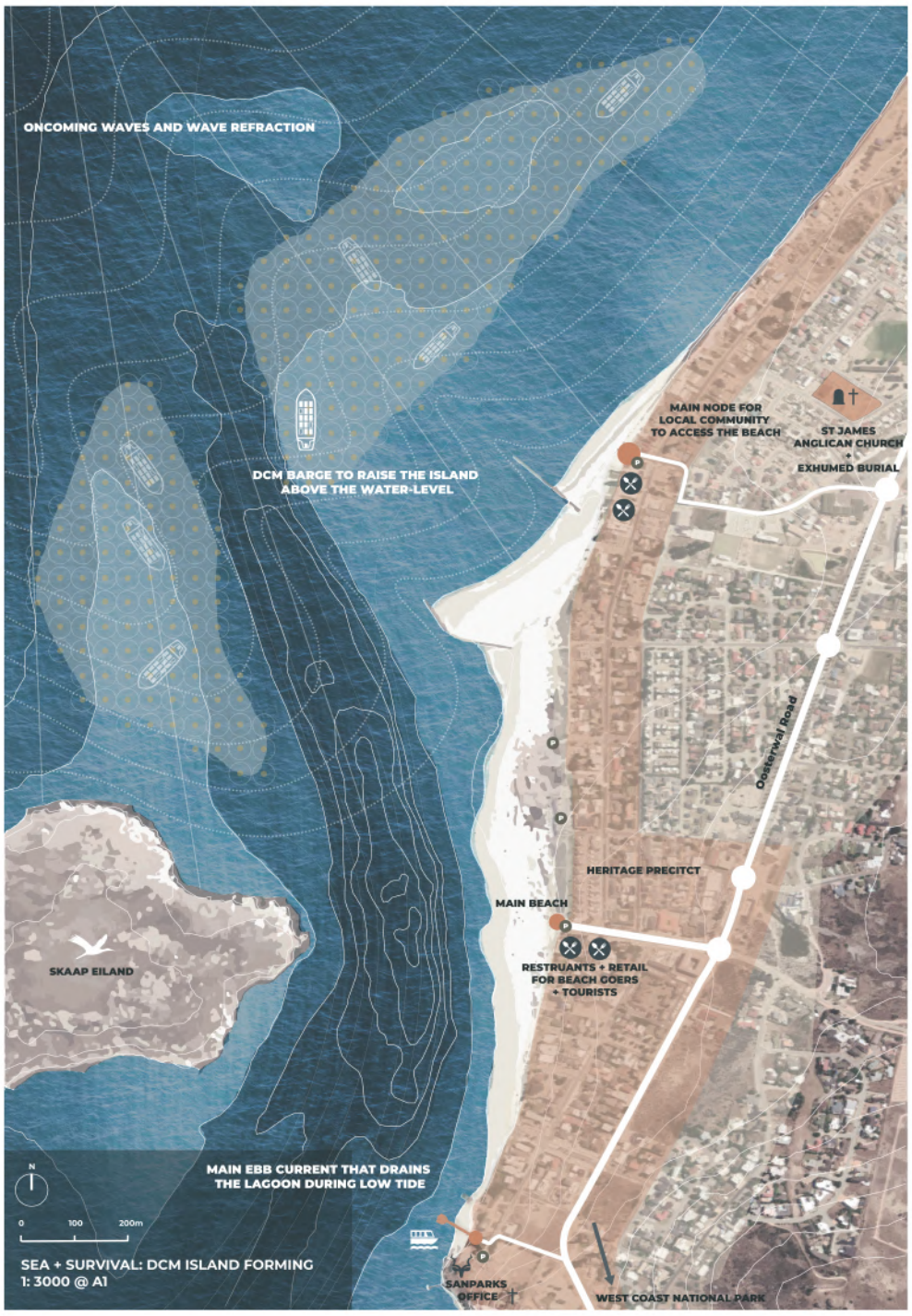
Model of the North-Eastern Langebaan Lagoon Mouth
(author’s own).

RAW FORM OF FIRST ISLAND INPUT + WATER IN THE LAGOON

SAND + WATER HILLING THE LAGOON

WATER THROUGH THE CHANNEL WITH JUST CONTOURS


ONCOMING WAVES AND WAVE REFRACTION
DCM BARGE TO RAISE THE ISLAND ABOVE THE WATER-LEVEL
MAIN NODE FOR LOCAL COMMUNITY TO ACCESS THE BEACH
ST JAMES ANGLICAN CHURCH + EXHUMED BURIAL
Oosterwal Road
HERITAGE PRECITCT
MAIN BEACH
RESTRUANTS + RETAIL FOR BEACH GOERS + TOURISTS
SKAAP EILAND
MAIN EBB CURRENT THAT DRAINS THE LAGOON DURING LOW TIDE
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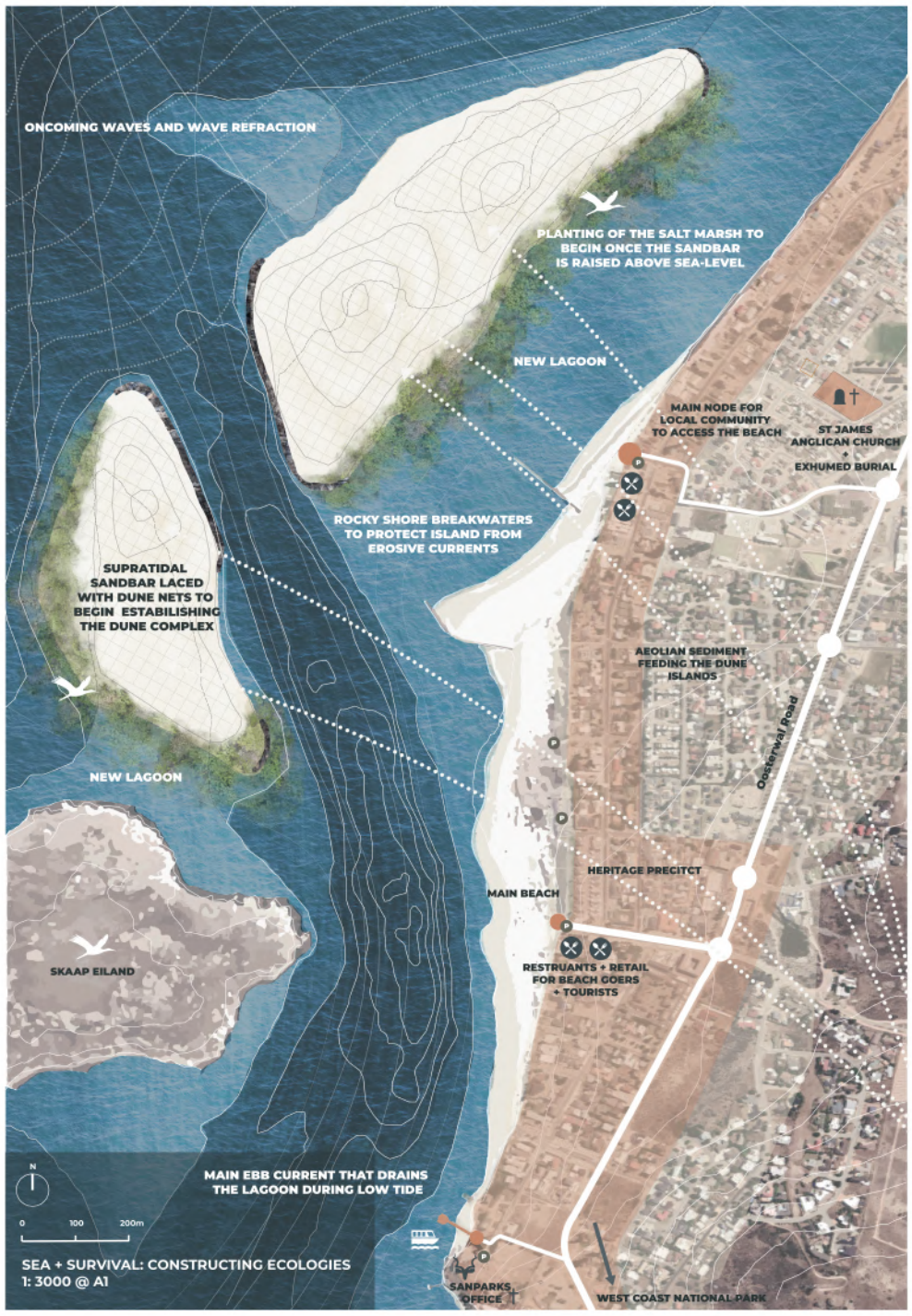
SEA + SURVIVAL: DCM ISLAND FORMING
1: 3000 @ A1
SANPARKS OFFICE
WEST COAST NATIONAL PARK


ONCOMING WAVES AND WAVE REFRACTION
PLANTING OF THE SALT MARSH TO BEGIN ONCE THE SANDBAR IS RAISED ABOVE SEA-LEVEL
NEW LAGOON
ROCKY SHORE BREAKWATERS TO PROTECT ISLAND FROM EROSIVE CURRENTS
SUPRATIDAL SANDBAR LACED WITH DUNE NETS TO BEGIN ESTABILISHING THE DUNE COMPLEX
MAIN NODE FOR LOCAL COMMUNITY TO ACCESS THE BEACH
ST JAMES ANGLICAN CHURCH + EXHUMED BURIAL
AEOLIAN SEDIMENT FEEDING THE DUNE ISLANDS
Oosterwal Road
HERITAGE PRECITCT
MAIN BEACH
RESTRUANTS + RETAIL FOR BEACH GOERS + TOURISTS
SKAAP EILAND
MAIN EBB CURRENT THAT DRAINS THE LAGOON DURING LOW TIDE
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SEA + SURVIVAL: CONSTRUCTING ECOLOGIES
1: 3000 @ A1
SANPARKS OFFICE
WEST COAST NATIONAL PARK


ARTISANAL FISH-WEIRS (VISVYWERS) ACTING AS A TIDAL POOL AND A FUNCTIONAL FISH TRAP.
PLAN B
PLAN A
ONCOMING WAVES AND WAVE REFRACTION
SALTMARSH INTERACTION PATH + BIRD HIDE
COASTAL HIKING ROUTE TO WCNP
VISVYWER EILAND
GATEWAY TO VISVYWER EILAND
ST JAMES ANGLICAN CHURCH + EXHUMED BURIAL
SALTMARSH INTERACTION PATH + BIRD HIDE
LANDSCAPING BEGINS AT FIRST CIRCLE TO ANNOUNCE THE GATEWAY ONTO VISVYWER EILAND
LIGHT FOOTPATH AROUND ISLAND.
VOËL EILAND
AEOLIAN SEDIMENT FEEDING THE DUNE ISLANDS
Oosterwal Road
HERITAGE PRECITCT
MAIN BEACH
RESTRUANTS + RETAIL FOR BEACH GOERS + TOURISTS
SKAAP EILAND
MAIN EBB CURRENT THAT DRAINS THE LAGOON DURING LOW TIDE
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SEA + SURVIVAL: VOËL N' VIS EILANDE
1: 3000 @ A1
SANPARKS OFFICE
WEST COAST NATIONAL PARK


ONCOMING WAVES AND WAVE REFRACTION
VISVYWER EILAND
A SANDBAR DEVELOPS WHICH BEGINS THE ISLAND'S CONNECTION TO LANGEBAAN
GATEWAY TO VISVYWER EILAND
ST JAMES ANGLICAN CHURCH + EXHUMED BURIA
VOËL EILAND
AEOLIAN SEDIMENT FEEDING THE DUNE ISLANDS
A SANDBAR DEVELOPS WHICH BEGINS THE ISLAND'S CONNECTION SKAAP EILAND
Oosterwal Road
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SEA + SURVIVAL: CONNECTING TO LANGEBAAN
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WEST COAST NATIONAL PARK

CONSTRUCTING ECOLOGIES

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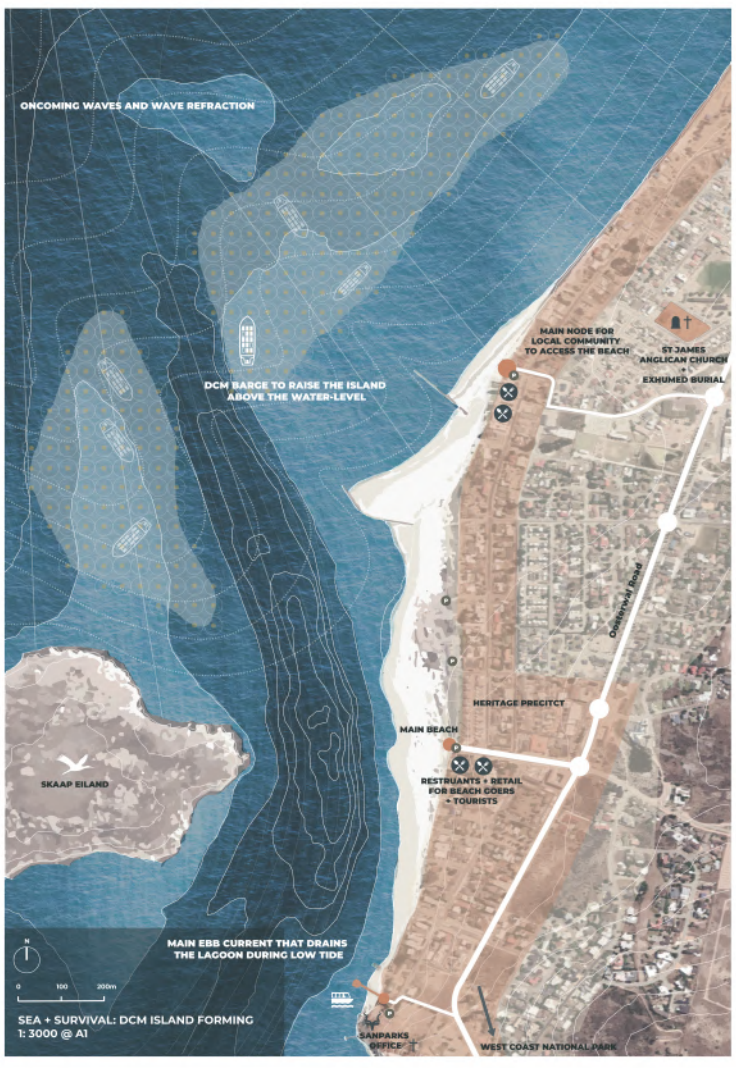
FORMING AN ISLAND

The idea of forming the island is based on Mcharg's theory of a naturally formed island from a subtidal sandbar. In the Sea and Survival chapter of Design with Nature 1969, McHarg explains the creation of a dune island from a subtidal sandbar, where eroded sediment from strong wave action is deposited onto a subtidal sandbar, to the point where it eventually emerges from the water. Then, through the action of wind and waves sand is transported and deposited onto the island forming dunes. The dunes are colonised by plant communities and the dunes are stabilised. The water between the mainland and island is subdued and is termed the lagoon. The other side is characterised as the cosmic coastal side.

The islands, named Voël en Vis Eilande, were formed in such a way that they maintain the integrity of the channel and that they protect the vulnerable areas of the coast. It is important to note that the forming of the island is a continuous process that willl take decades to form, and due to the transient nature of systems they will continue to morph indefinitely.

For this to happen an initial step is required to induce the natural processes of island forming. This initial step is the use of deep cement mixing (DCM) as a means to raise the subtidal sandbar above the island. Deep cement mixing is a way of constructing the island without dredging the sea-bed and exposing contaminants. This method is very popular in Asia, where the Tokyo's Haneda Airport's 3km D-runway was constructed offshore using DCM (MacDonald, n.d.)



STAGE 1: DEEP CEMENT MIXING(DCM)

STAGE 1: DEEP CEMENT MIXING(DCM) 10 YEARS

Stabilising and Raising the Seabed.

STAGE 2: ROCKY SHORE BREAKWATERS

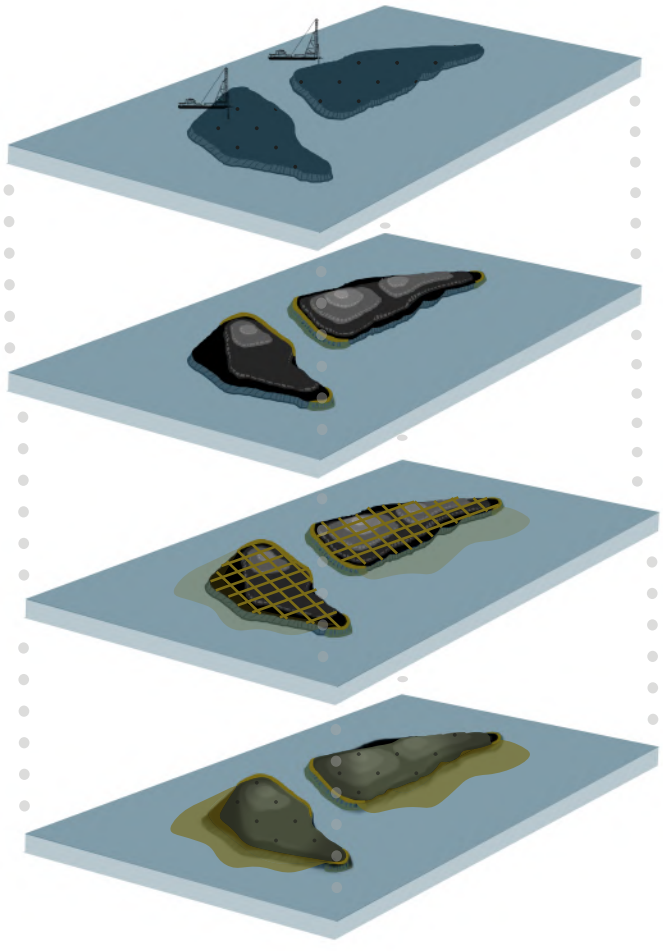
Protecting vulnerable points from erosive factors + creating an intertidal habitat.

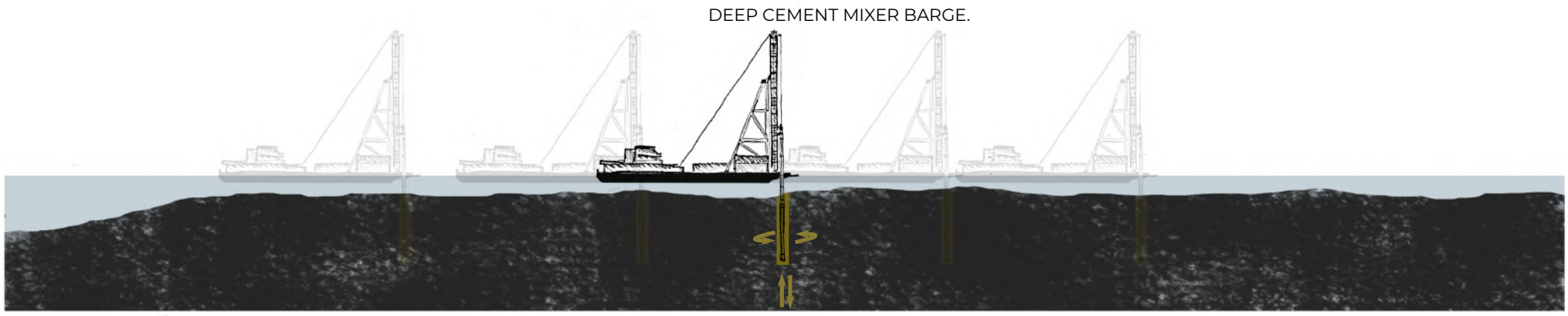
STAGE 3: DUNE CREATION + SALT MARSH 20-30 YEARS

Setting up biodegradable dune nets to grow a dune complex by harnessing the West Coast sediment transport system. Planting salt marsh along the new lagoon edges creating bird and intertidal habitats.

STAGE 4: STABILIZING THE DUNES 7 YEARS

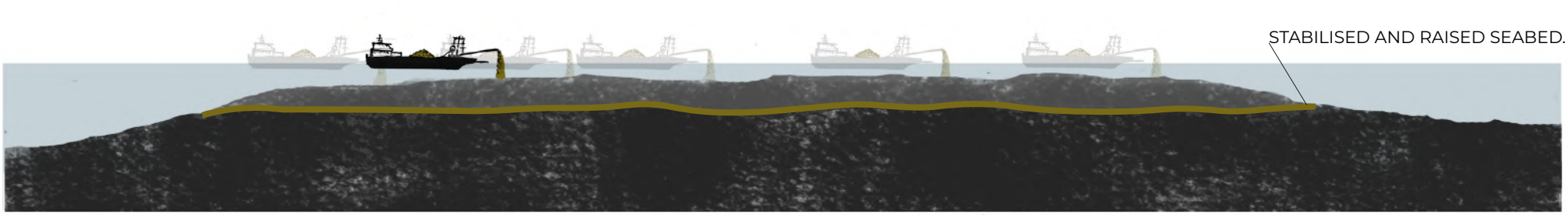
Using a mesh to stabilise the dunes to begin the propogation of dune vegetation. Once the vegetation has grown the dunes will be stabilised.





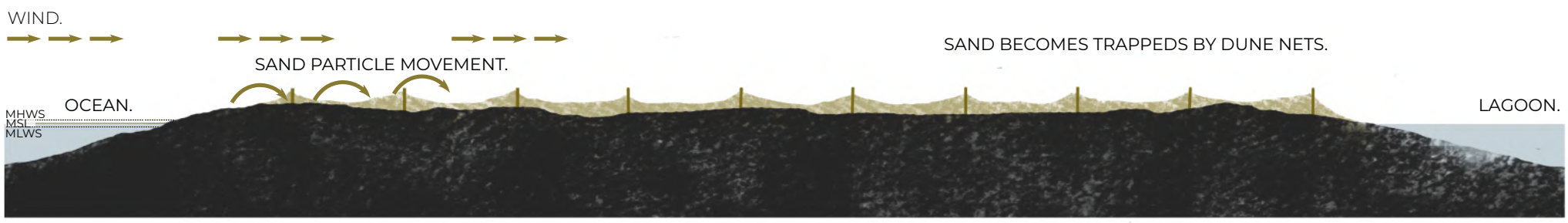
STAGE 1.1: DCM: STABILISING AND RAISING THE SEABED.

A deep cement mixer slowly injects and blends cement into the soft sandy seabed, leaving a stabilised cement coloumn that raises the bed. The points of injection are carefully calebrated through the use of GPS mapping co-ordinates and relayed to the barge to gain the highest accuracy possible.



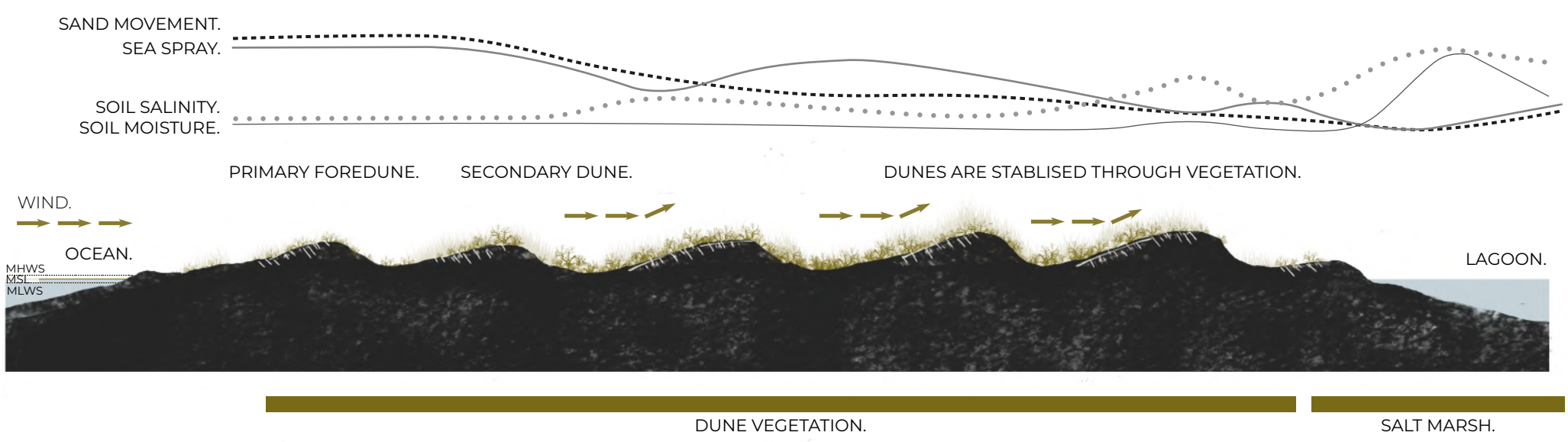
STAGE 1.2: CREATING A SUPRATIDAL SANDBAR..

(NOTE: this step may not be needed if the seabed from DCM is raised above the water-level due to developement on an existing sandbar).
Once the seabed is raised and stabilised, sediment is deposited onto the bed in order to raise it above sea-level.



Stage 3: DUNE CREATION + SALT MARSH..

Biodegradable dune nets are placed at specific angles and distances in order to trap aeolian sediment deposition as well as tidal deposition. This will aid in the growth and stabilisation of dunes. The growth of the dune complex can take around 10 to 30years. In saying that the dunes will continues to morph, such is their nature.



STAGE 4: STABILISING THE DUNES..

A fine, biodegradable mesh is laid over the dune complex to stabilise and prepare the dunes for vegetation. Dune vegetation is propogated over the course of the dune growth period and is planted according to vegetation zones. Once there is sufficient vegetation coverage the dunes with be stabilised.

DEEP CEMENT MIXING (DCM) AS A MEANS TO FORM A SUPRATIDAL ISLAND.

The DCM method is chosen because it is the most eco-friendly method of land reclaimation for the existing depth to the subtidal sandbar in Langebann Lagoon. It does not require the dredging of the seabed, it does not release contaminents or polluted water into the water coloumn. DCM also helps create a stable foundation, able to withstand a heavy load.

THE DUNE ISLAND |

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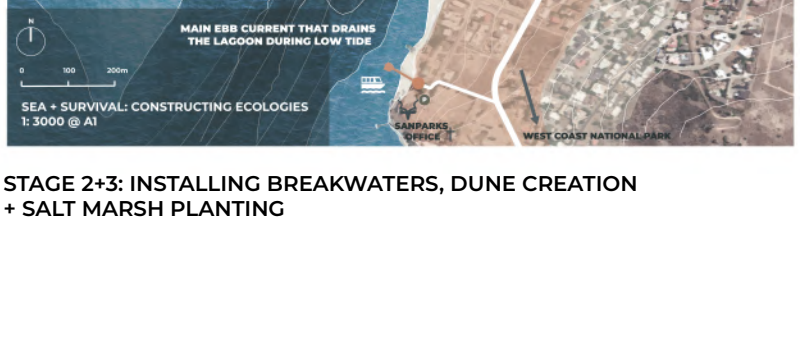
My proposal is to use the sand bars on either side of the Langebaan Lagoon channel and raise them above the water's surface through DCM. This will act as the foundation of the island and induce the growth of dunes. With the aid of dune nets, the aeolian sediment transportation along the West Coast of South Africa will be harnessed to advance the growth of the dunes and ensure a self-sustaining dune system. The rise and fall of spring tides will feed and grow the foredune complex of the island.

The dunes will then be stabilised, naturally, through the use of planting. The principles for the planting were derived from Mcharg's chapter and adapted for the Southern Hemisphere through the use of indigenous dune vegetation according to the City of Cape Town's beach and dunes management plan (Colenbrander, n.d.). Consideration is specifically taken towards flowering plants as the region is wildly popular for the wild flower season in August to September.

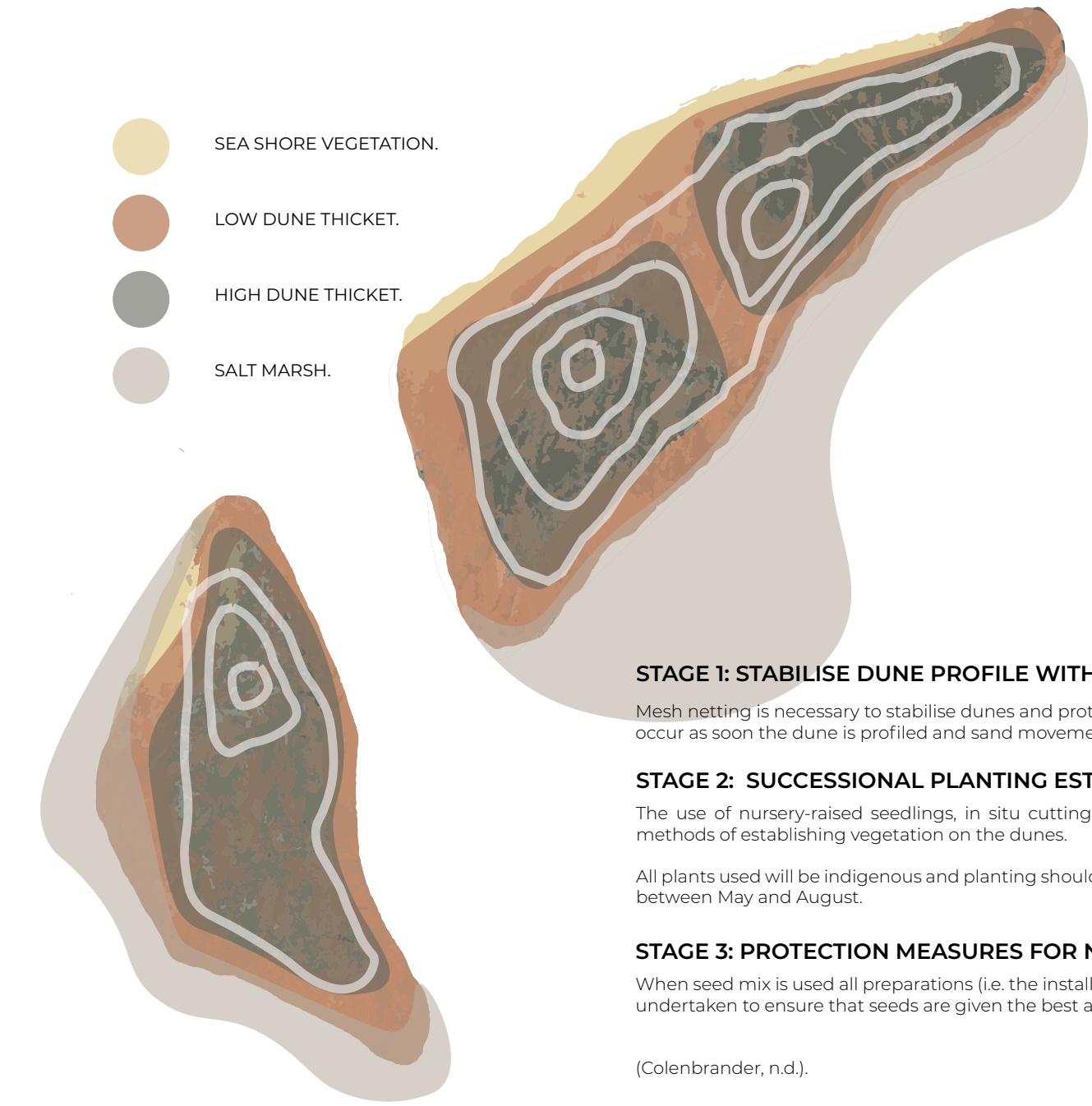
New coastal habitat is then created upon the for settlement of the dunes and the users of the space as well as frequenting tourists can witness the morphing of dunes. This factor illustrates the liveliness of the earth and its deep time on a human scale. This begins the intellectual conversation between humans and nature.



STAGE 2+3: INSTALLING BREAKWATERS, DUNE CREATION + SALT MARSH PLANTING

Sand Transport along the West Coast.

Surface sand refers to sand deposited onto the base rocks and base sand refers to sand acknowledged as the base geology.
(adapted from (Franceschini, Compton & Wigley, 2003).



STAGE 1: STABILISE DUNE PROFILE WITH BIODEGRADABLE MESH

Mesh netting is necessary to stabilise dunes and protect seedlings from winds. Planting will occur as soon the dune is profiled and sand movement is stabilized.

STAGE 2: SUCCESSIONAL PLANTING ESTABILISHED WHERE NEEDED

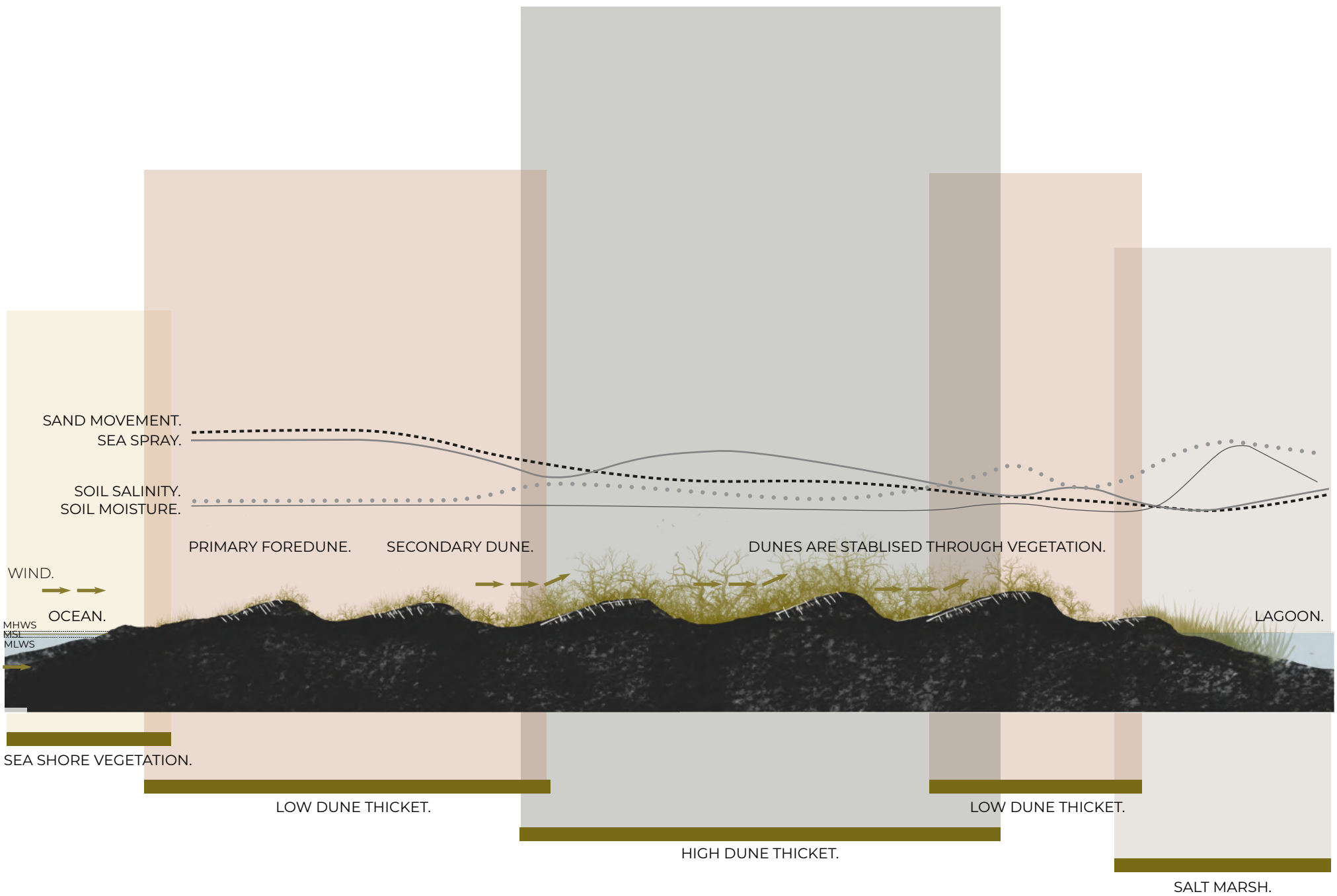
The use of nursery-raised seedlings, in situ cuttings and seeding are the most common methods of establishing vegetation on the dunes.

All plants used will be indigenous and planting should be done in the Cape's growing season; between May and August.

STAGE 3: PROTECTION MEASURES FOR NEWLY PLANTED VEGETATION

When seed mix is used all preparations (i.e. the installation of wind breaks and mulch) will be undertaken to ensure that seeds are given the best available chance of germinating.

(Colenbrander, n.d.).



STAGE 4: STABILISING THE DUNES.

A fine, biodegradable mesh is laid over the dune complex to stabilise and prepare the dunes for vegetation. Dune vegetation is propogated over the course of the dune growth period and is planted according to vegetation zones. Once there is sufficient vegetation coverage the dunes with be stabilised.

CONECTING THE NEW + THE OLD |

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The islands are named Voël en Vis based on their programs and connectivities to mainland. The connections to mainland are provided by the use of a ferry and landcsaping is proposed along the roads that connect the mainland to the islands to visually cue the entry to the island space. Where Voël Eiland (meaning Bird Island) is a low activity nature-based island with hiking and bird watching as the primary engagement with the island. Vis Eiland (meaning Fish Island) aims at releasing the pressure on the existing public spaces in the town and reintroducing/ strengthening cultural practices, such as artisan fishing with the notion of sea to table.

The traditional Khoe Vis-vywers/fish weirs are put in place acting as both a functional fishing method and a recreational tidal pool. The activity is directed to the coastal side along the coast and then unraveled along the left and right with fishing spots provided along the edges and on the breakwaters.


PLAN B
PLAN A
ARTISANAL FISH-WEIRS (VISVYWERS)
ACTING AS A TIDAL POOL AND A
FUNCTIONAL FISH TRAP.
ONCOMING WAVES AND WAVE REFRACTION
SALTMARSH INTERACTION PATH
+ BIRD HIDE
COASTAL HIKING ROUTE TO WCNP
VISVYWER EILAND
GATEWAY TO VISVYWER EILAND
ST JAMES
ANGLICAN CHURC
+
EXHUMED BURI
SALTMARSH INTERACTION PATH
+ BIRD HIDE
LANDSCAPING BEGINS AT
FIRST CIRCLE TO ANNOUNCE
THE GATEWAY ONTO VISVYWER EILAND
LIGHT FOOTPATH
AROUND ISLAND.
VOËL EILAND
AEOLIAN SEDIMENT
FEEDING THE DUNE
ISLANDS
Oosterwal Road
HERITAGE PRECITCT
MAIN BEACH
SKAAP EILAND
RESTRUANTS + RETAIL
FOR BEACH GOERS
+ TOURISTS
N
MAIN EBB CURRENT THAT DRAINS
THE LAGOON DURING LOW TIDE
0
100
200m
SEA + SURVIVAL: VOËL N' VIS EILANDE
1: 3000 @ A1
SANPARKS
OFFICE
WEST COAST NATIONAL PARK

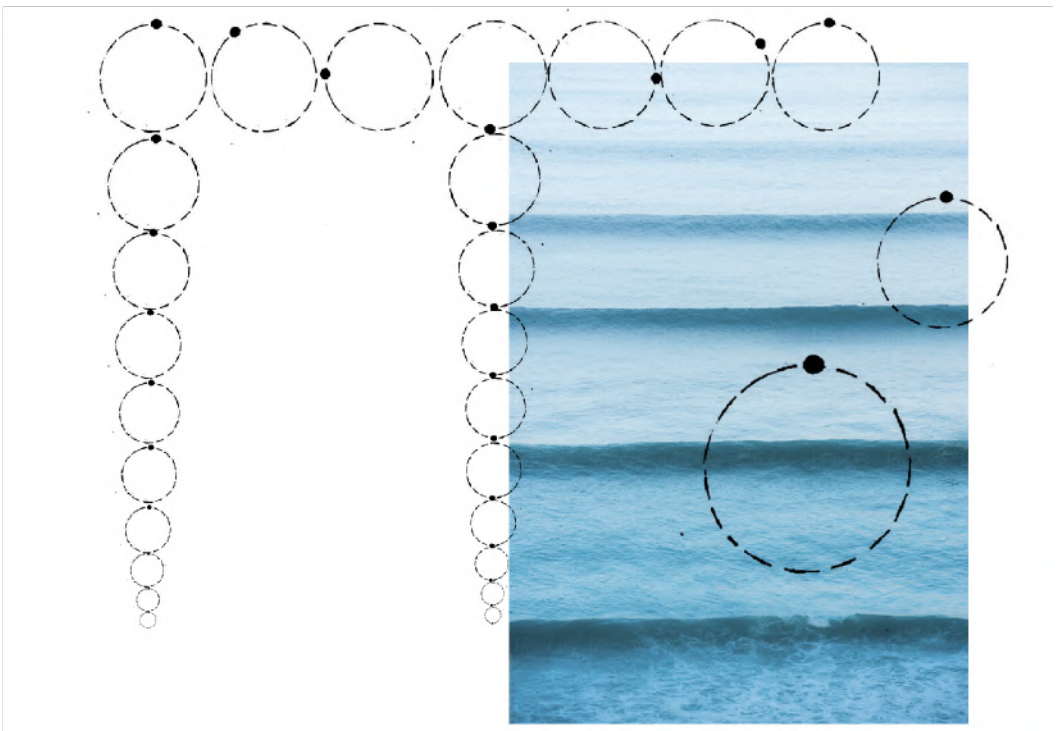
ROCKY SHORE BREAKWATERS |

//

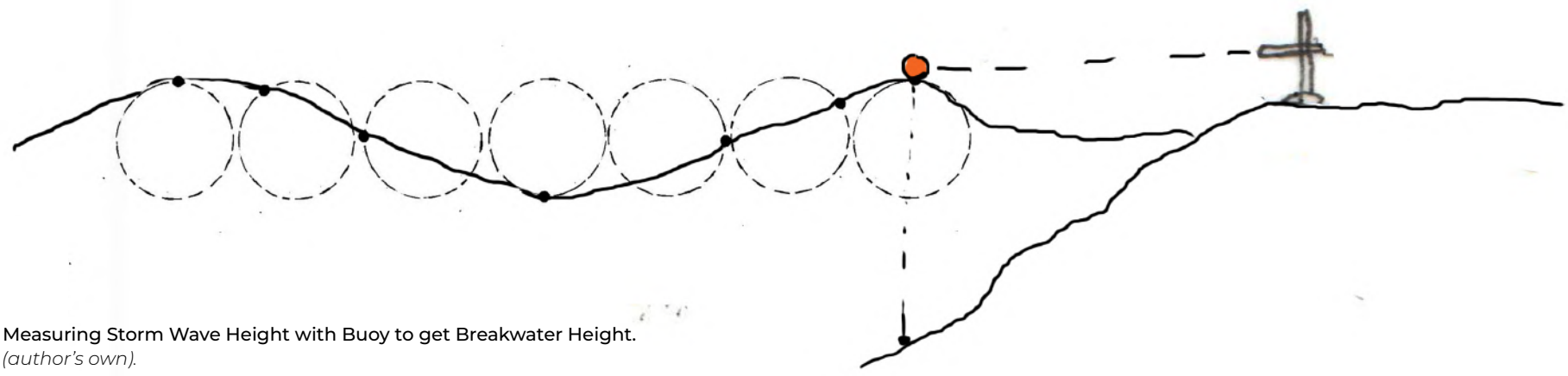
In the initial construction of the island, breakwaters should be placed along the highly active zones (along the channel edge and narrow tips of the island) to reduce risk of erosion and stabilise the edge. Rubble breakwaters are ideal for a sandy subsurface and can be constructed using natural stone.

To begin the design of a breakwater, storm wave height is crucial for the high and width of the breakwater. Wave height can be measured from shore, where a buoy is used to signal the height of a wave crest.

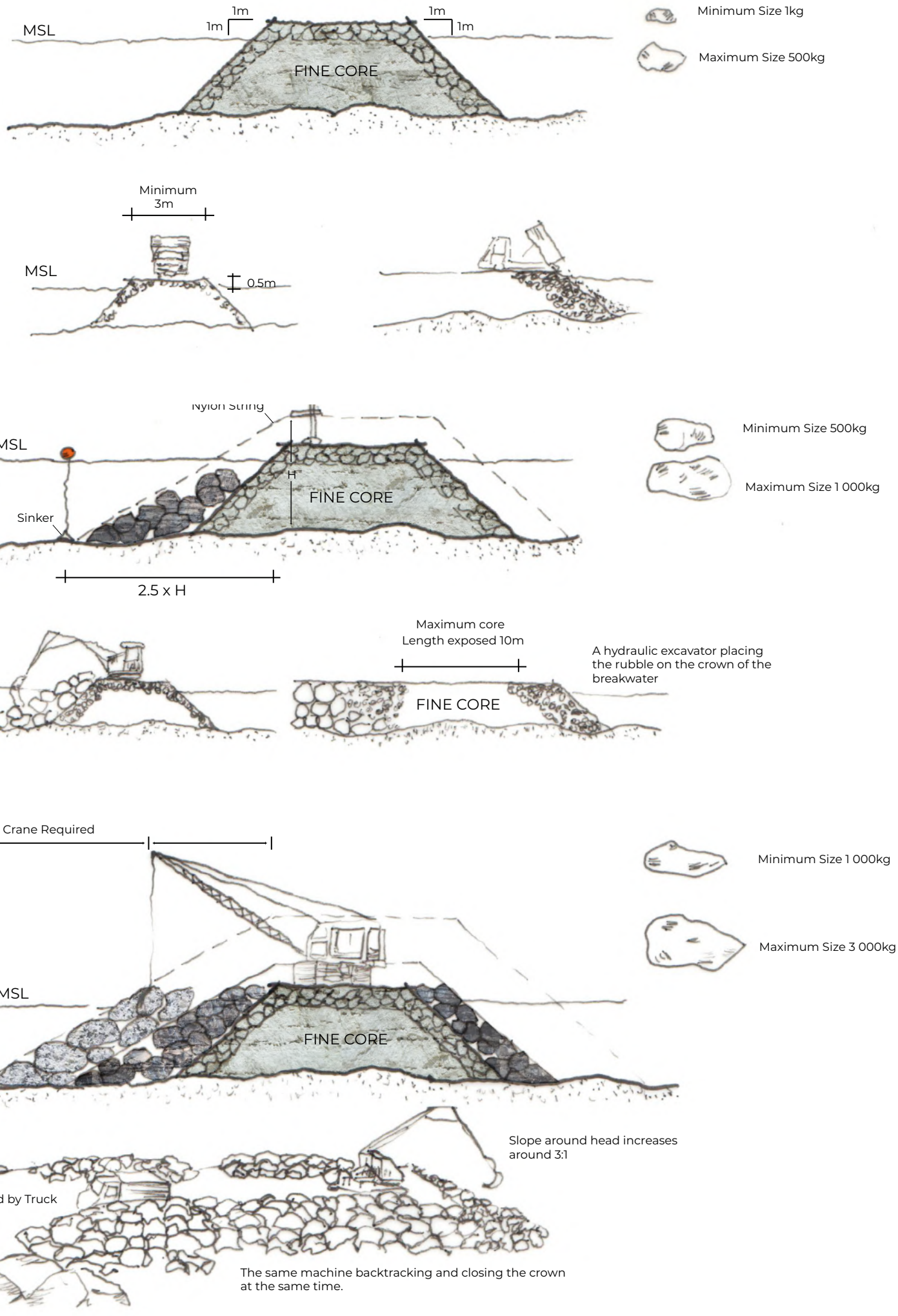
The stone from the Oliphantskop excavation site can once again be used for defending Langebaan, where each stone is tightly fit together so that they can withstand high wave energy.



Wave energy, horizontal and vertical oscillations.[r]



Measuring Storm Wave Height with Buoy to get Breakwater Height.
(author's own).



TYPICAL BREAKWATER CONSTRUCTION ON SOFT GROUND

Rubble breakwaters can be constructed from natural rock found in the vicinity and concrete. These breakwaters are best for sandy bottoms and large waves (Sciortino, 2010). It's important to note the minimum and maximum widths of the breakwater as well as the base width on the seaward side of the breakwater.
(adapted from (Sciortino, 2010).

THE ROCKY SHORE COMMUNITY |

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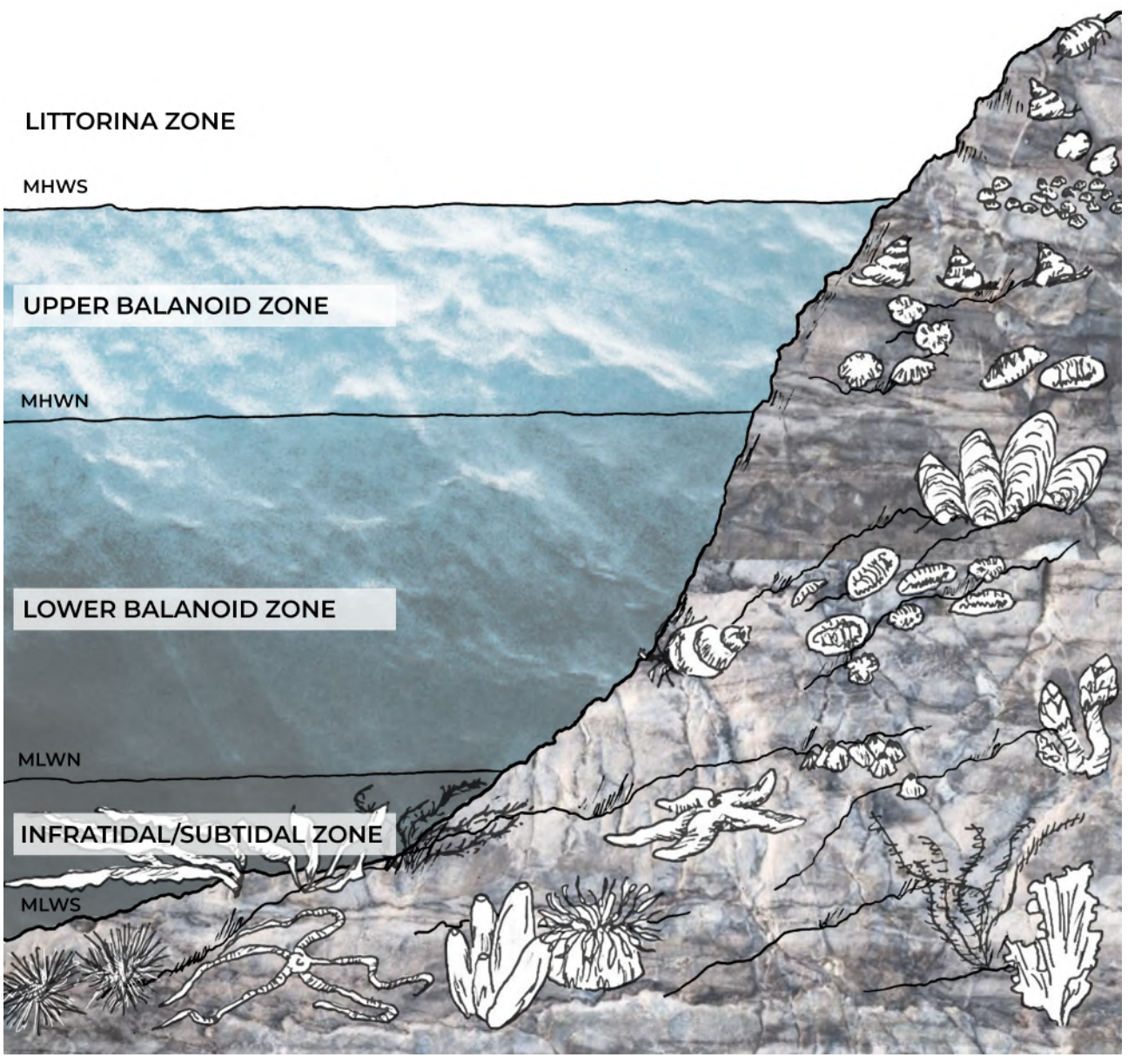
The South African coastline has some amazing intertidal rocky shore habitat which presents a good opportunity for designing with nature. These communities exhibit a great degree of specialisation for the rise and fall of tides. Each organism is uniquely adapted for the daily inundation and exposure to water and air, all visible in their physiology. The tides are a driving force for these species, which occur along distinct intertidal bands.

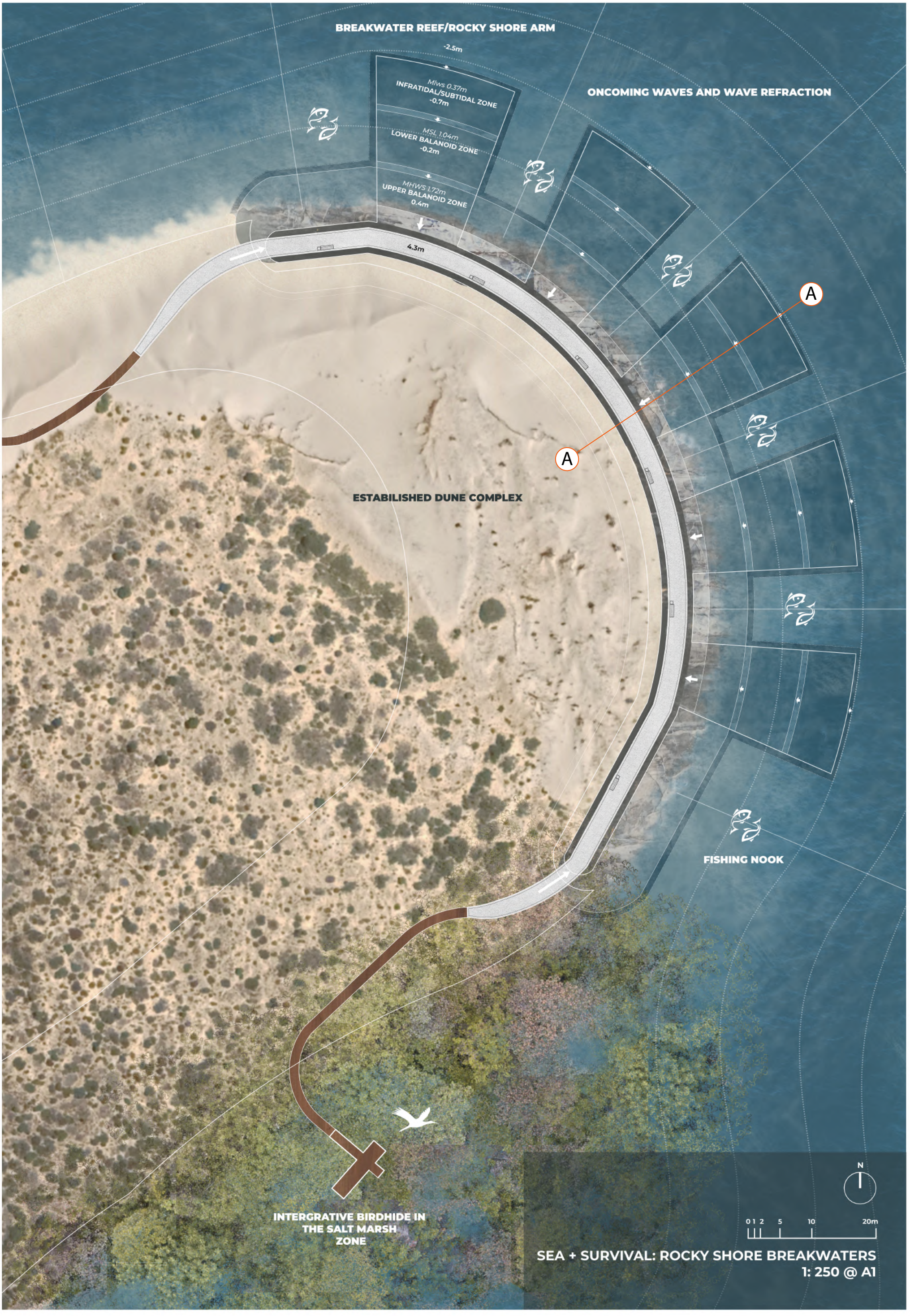
The duration of exposure to inundation determines the species along each band, where their breathing, feeding and protective apparatus align with the environmental pressures. The more exposed organisms tend to have more calcareous bodies to protect them from drying-out and are strongly fastened to the rock to protect against wave-action. Since many of these creatures are fastened, they tend to be filter feeders, filtering particulate matter as it washes over them. Softer bodied organisms and seaweed are found below the mean low-water spring tide mark as they do not face the pressure of drying out and wave action. These species are more mobile, and their feeding style varies. Many species can be found in the cracks and crevices of the rocky shore and juvenile settlement is determined by conspecific signals. Therefore, the design aim of breakwaters is porosity to increase surface area for intertidal species settlement.

The Rocky Shore Community.[5]

Hard bodied, Calcareous Species.



Soft Bodied organisms and Algae.


BREAKWATER REEF/ROCKY SHORE ARM
-2.5m
MIws 0.37m
INFRATIDAL/SUBTIDAL ZONE
-0.7m
MSL 1.04m
LOWER BALANOID ZONE
-0.2m
MHWS 1.72m
UPPER BALANOID ZONE
0.4m
4.3m
ONCOMING WAVES AND WAVE REFRACTION
A
A
ESTABILISHED DUNE COMPLEX
FISHING NOOK
INTERGRATIVE BIRDHIDE IN
THE SALT MARSH
ZONE
N
0 1 2 5 10 20m
SEA + SURVIVAL: ROCKY SHORE BREAKWATERS
1: 250 @ A1

HABITABLE BREAKWATER |

//

The unraveling of the island path wraps itself onto the breakwaters and tapers off into a bird hide located within the salt marsh complex. Birding is a key nature-based activity as Langebaan is the Ornithological capital of South Africa.

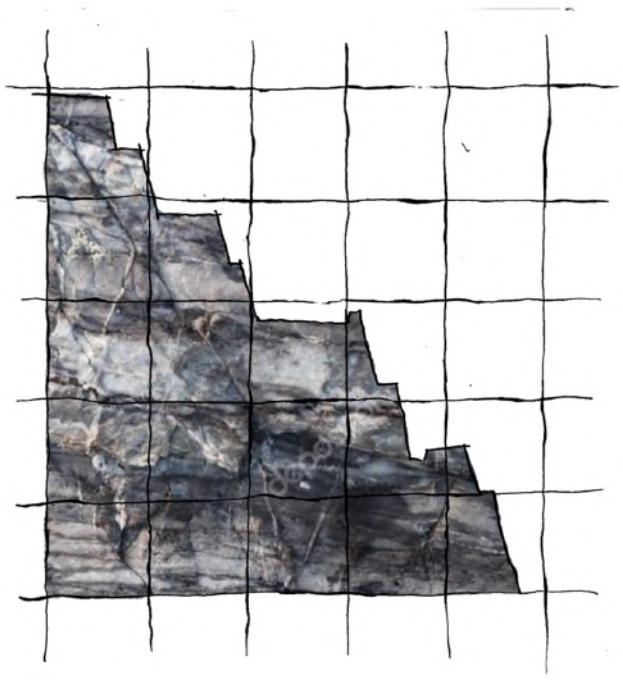
The breakwaters are designed to be a supporting role to the sea defence where they aim to protect the vulnerable edges of the island and create a fishing edge for the local community. Since breakwaters are mainly grey-infrastructure the challenge was to green them up. Rubble breakwaters with extending reef arms were ideal for the use of breakwaters as an rocky shore intertidal habitat on a soft seabed.

The idea of benches and ledges, taken from the study of quarrying, has generated the breakwater as a rocky shore design. The benches and ledges are placed on the shoreward side of the breakwater to form the intertidal zones. The benches are set according to mean tidal heights and adequate surface area is provided. The rocky shore breakwater challenges the notion of mono-purpose, hard infrastructure sea defence by using it as a species habitat and settlement ground, which is inspired by Scape's Living Breakwaters.

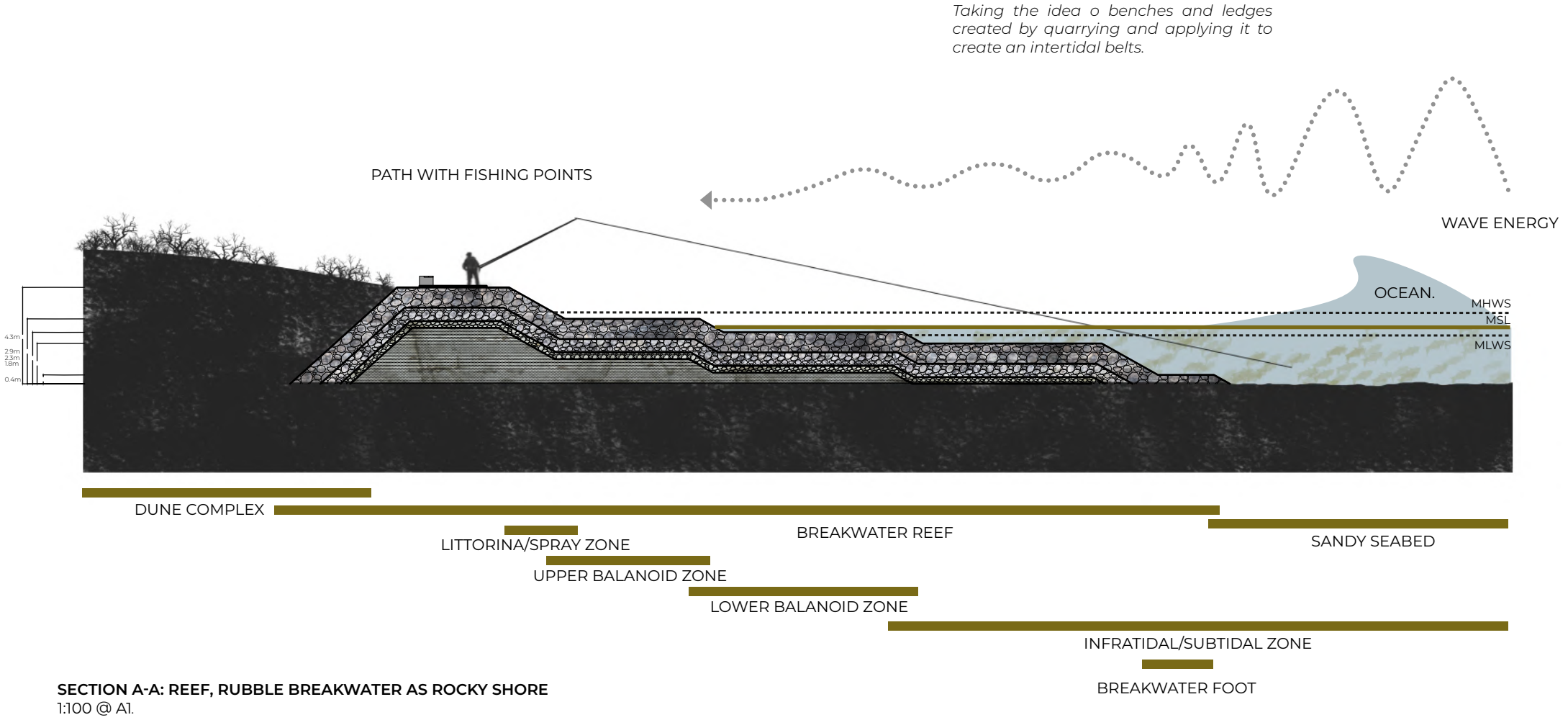
TIDAL ELEVATIONS FROM (FLEMMING, 2015).

A. Tide levels in Langebaan Lagoon (over 10 000 observations)

HEIGHTS	Lagoonal Mouth	Southern Lagoon
HATOY (1977)	2.01	2.20
MHWS	1.72	1.62
MHWN	1.29	1.24
ML	1.04	1.04
MLWN	0.79	0.85
MLWS	0.37	0.47
LATOY (1977)	0.23	0.07
RANGES		
SPRING TIDE	1.35	1.15
NEAP TIDE	0.50	0.39



Taking the idea o benches and ledges created by quarrying and applying it to create an intertidal belts.



SECTION A-A: REEF, RUBBLE BREAKWATER AS ROCKY SHORE
1:100 @ A1.

VIS-VYWER TIDAL POOLS |

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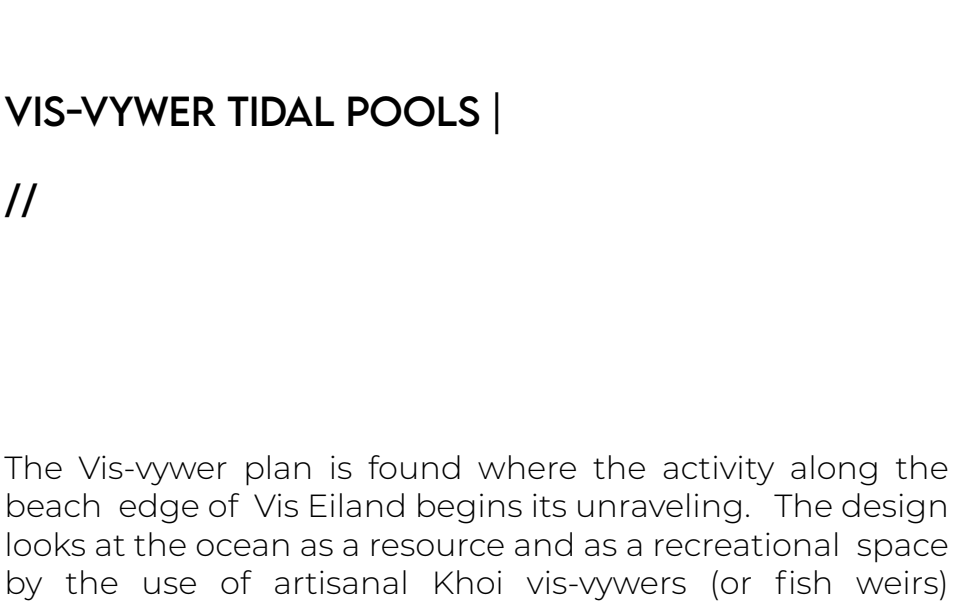
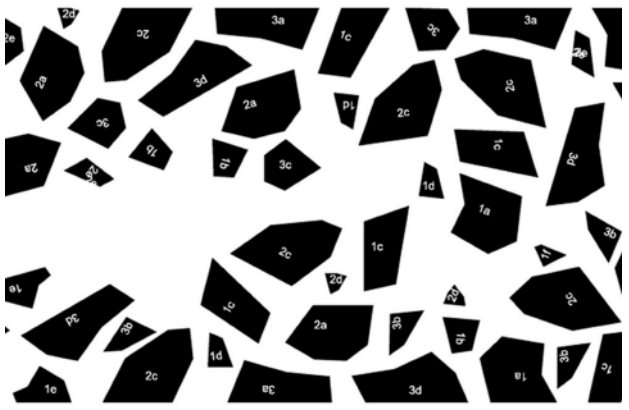
The Vis-vywer plan is found where the activity along the beach edge of Vis Eiland begins its unraveling. The design looks at the ocean as a resource and as a recreational space by the use of artisanal Khoi vis-vywers (or fish weirs) principles found in Still Baai up the East Coast of South Africa, and designing them to function both as marine food provision and as a tidal pool. The shapes of the weirs were derived f rom the patterns created by Oudepost 1 paving ruind. Quarried stone from the old sea defences is repurposed as adventure play and surface area to engage with the rocky shores.



Khoi vis-vywers in Stillbaai, WC, South Africa.



Roombeek the Brook, Netherlands.

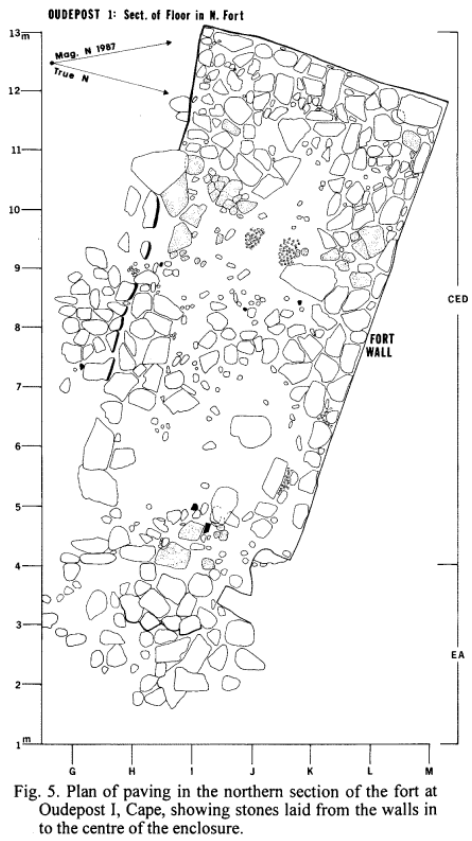
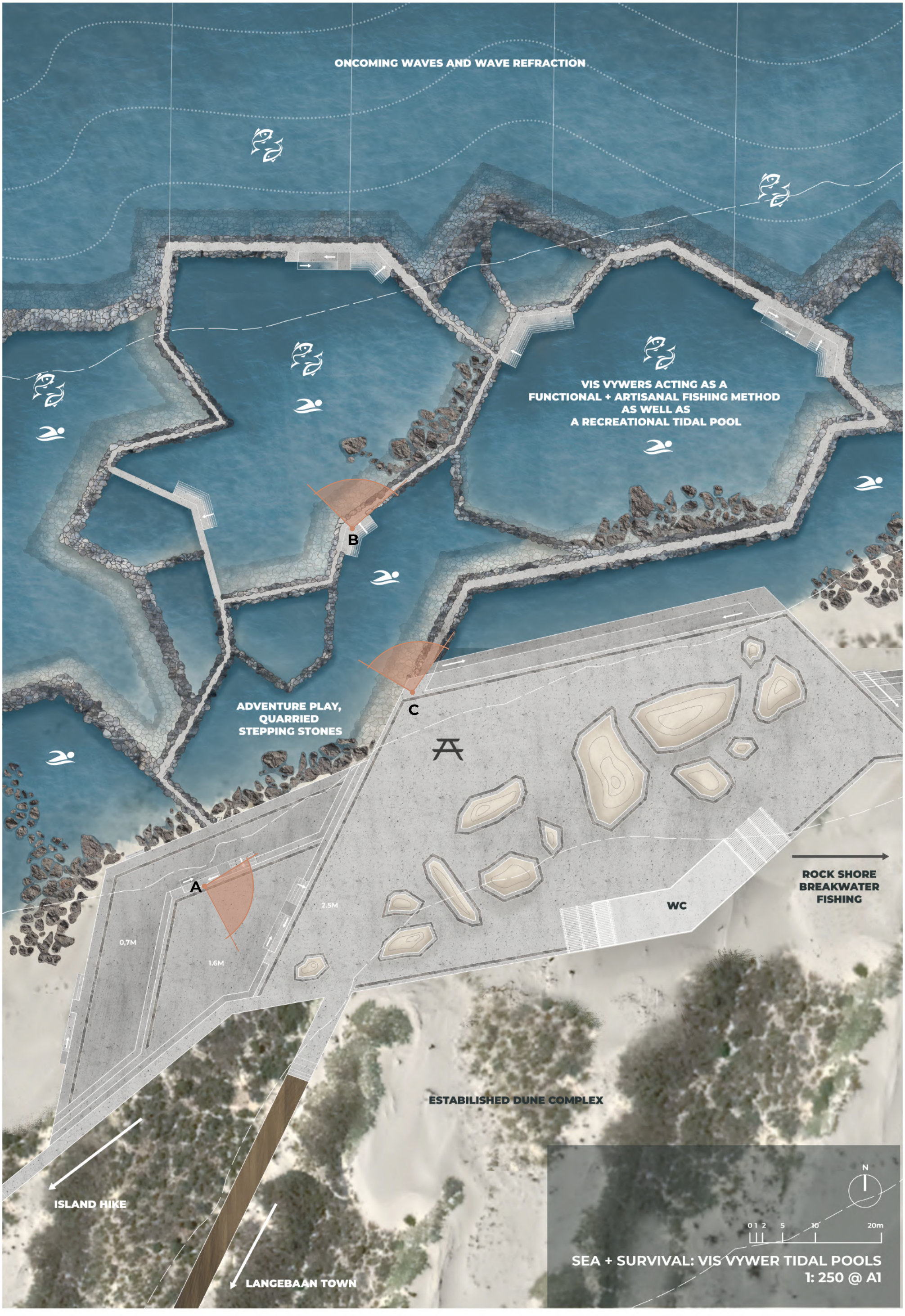


Fig. 5. Plan of paving in the northern section of the fort at Oudepost I, Cape, showing stones laid from the walls in to the centre of the enclosure.

Site Plan of Oudepost 1, Langebaan, WC, South Africa.

(Schrire & Deacon, 1989)


ONCOMING WAVES AND WAVE REFRACTION
VIS VYWERS ACTING AS A
FUNCTIONAL + ARTISANAL FISHING METHOD
AS WELL AS
A RECREATIONAL TIDAL POOL
B
C
A
ADVENTURE PLAY,
QUARRIED
STEPPING STONES
2.5M
0,7M
1.6M
WC
ROCK SHORE
BREAKWATER
FISHING
ESTABILISHED DUNE COMPLEX
ISLAND HIKE
LANGEBAAN TOWN
N
0 1 2 5 10 20m
SEA + SURVIVAL: VIS VYWER TIDAL POOLS
1: 250 @ A1

SUBMERGED LANDSCAPE |

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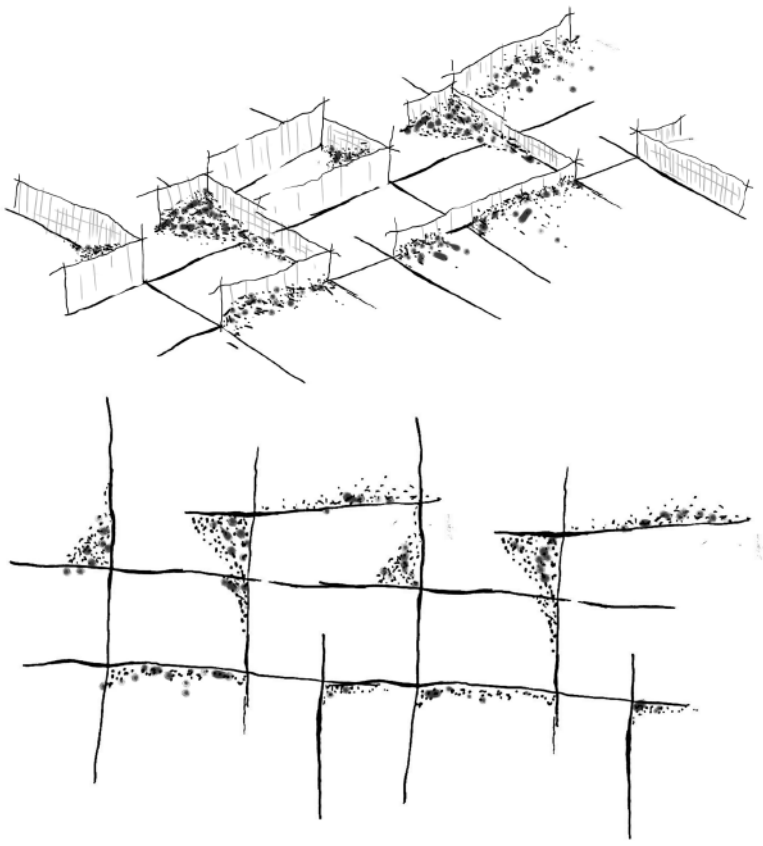
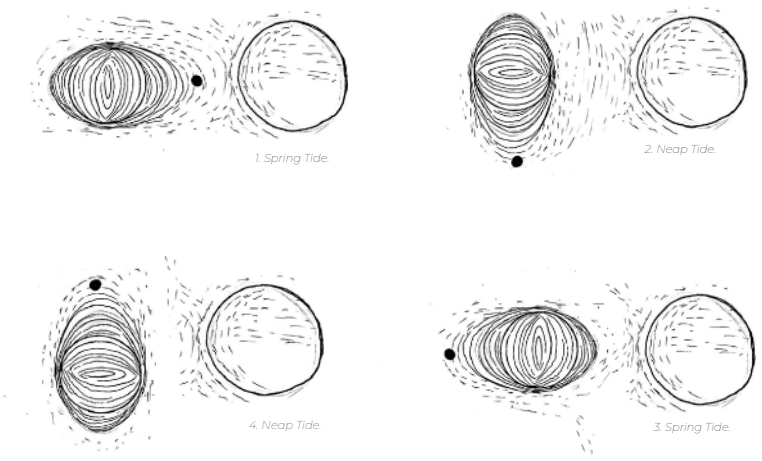
The design takes on the temporal realm by submerging the landscape in the passage of time. The landscape is concealed and revealed through tidal action and the dunes eat away at the edges of the geometric, human-made edges, exploring how the deposition of sand naturally softens sharp edges.



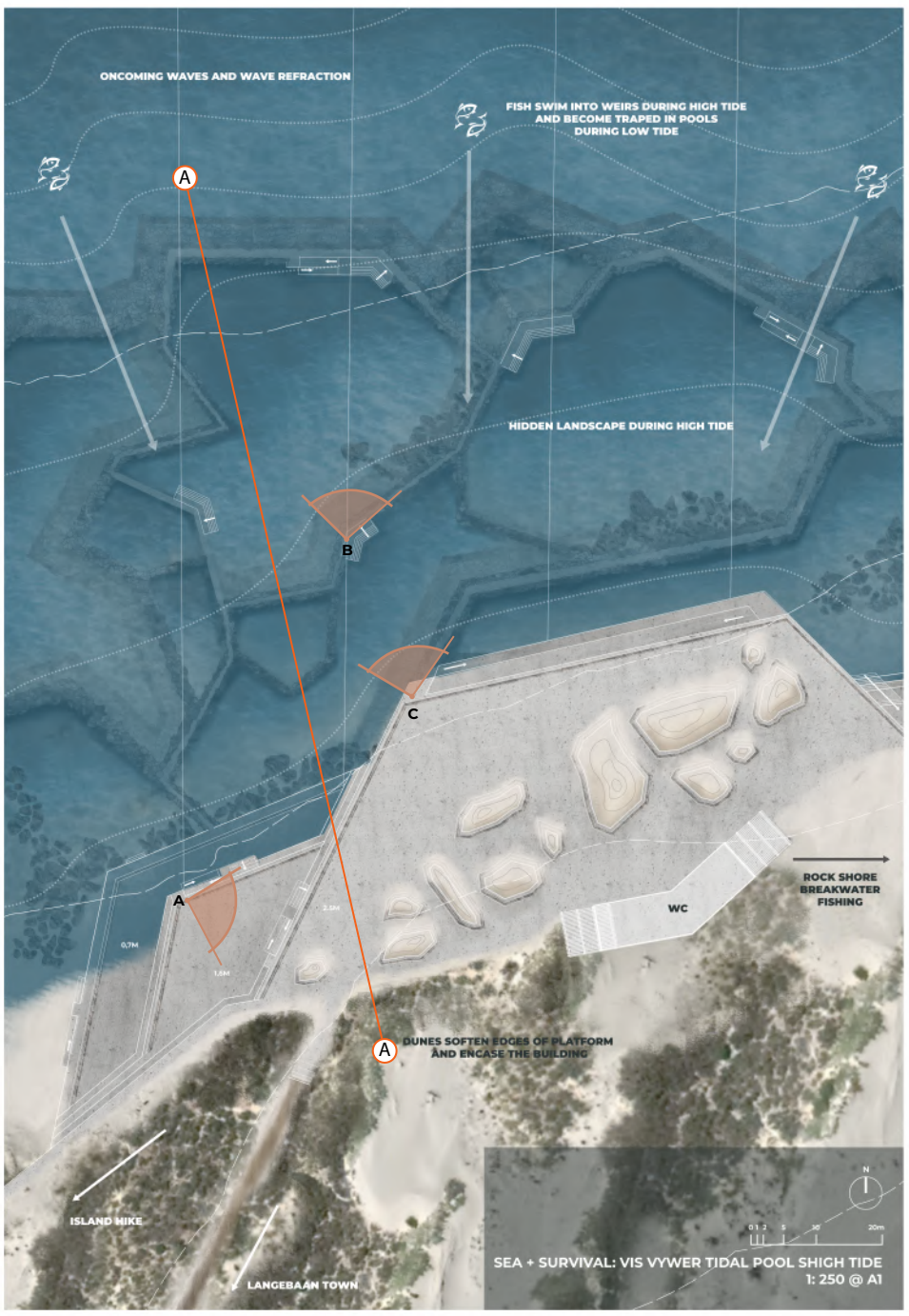
Softening of Sand on Man-Made Edges.

Sand accumulation along vertical masses. e.g. dune nets. Seeing how the deposition of sand naturally softens sharp edges. (author's own).



Tidal Pull.

Tidal patterns and the affects of the moon's gravitational pull, with the sun balancing centrifugal forces. Where spring tide is the largest tidal range, the crest and the neap is the smallest tidal range, the trough. (author's own).



Pools Hidden by the Tides.

THE HUMAN + THE NATURAL |

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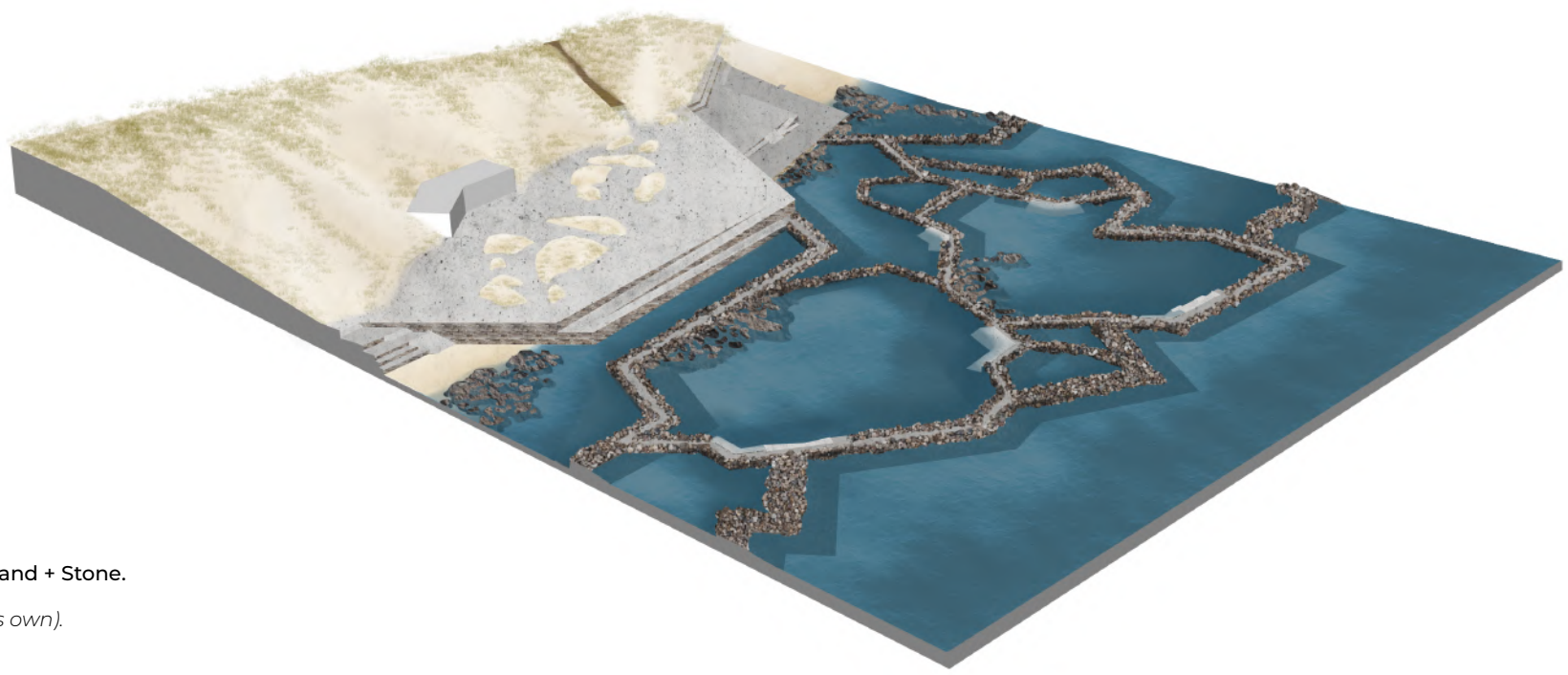
Coastal landscapes are cosmic spaces (Norberg-Schulz, 1980), so to pay respect to their nature the large platforms have a minimalistic approach where the levelling creates seating and the views are uncompromised. The platforms then taper off into the pools initiating a human scaled engagement with the ocean.The human-scale is further explored through miniature dunes that pierce the platform creating play spaces and lending to the idea of this as an explorative landscape of water, sand and stone.

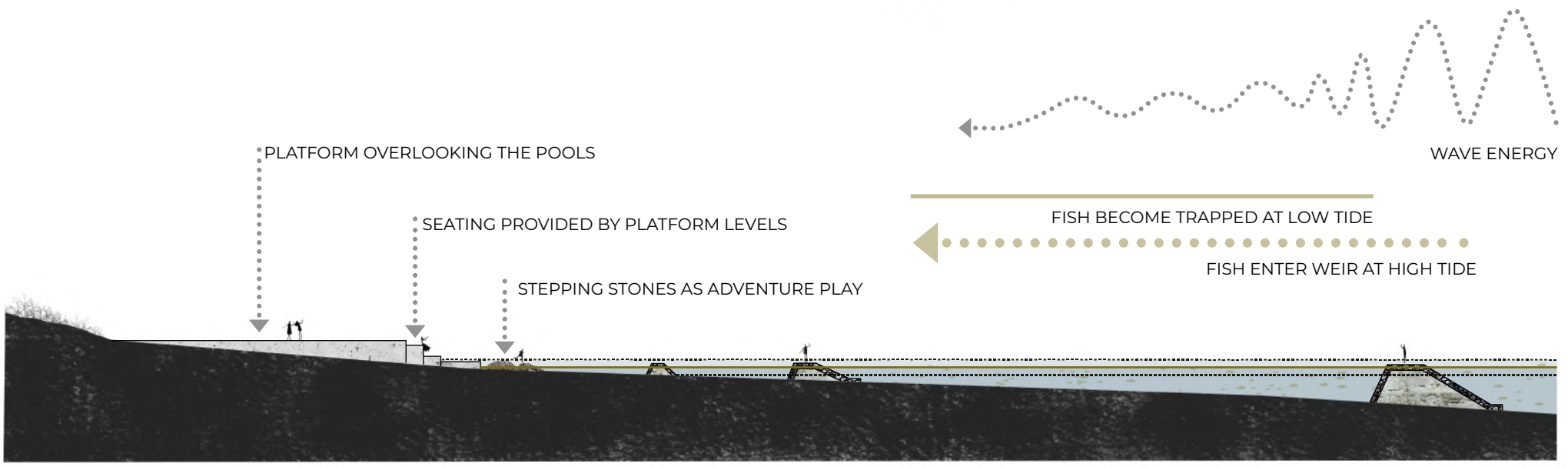
Ablutions and space for further development as the landscape grows is thought of through the building and the large open platform overlooking the pools. This platforms has the capacity to act as a plaza space during tourist season.

The concept is to provide a resource and space for the marginalised local Cape Malay community, whilst not excluding and acknowledging the seasonal influx of holiday makers.

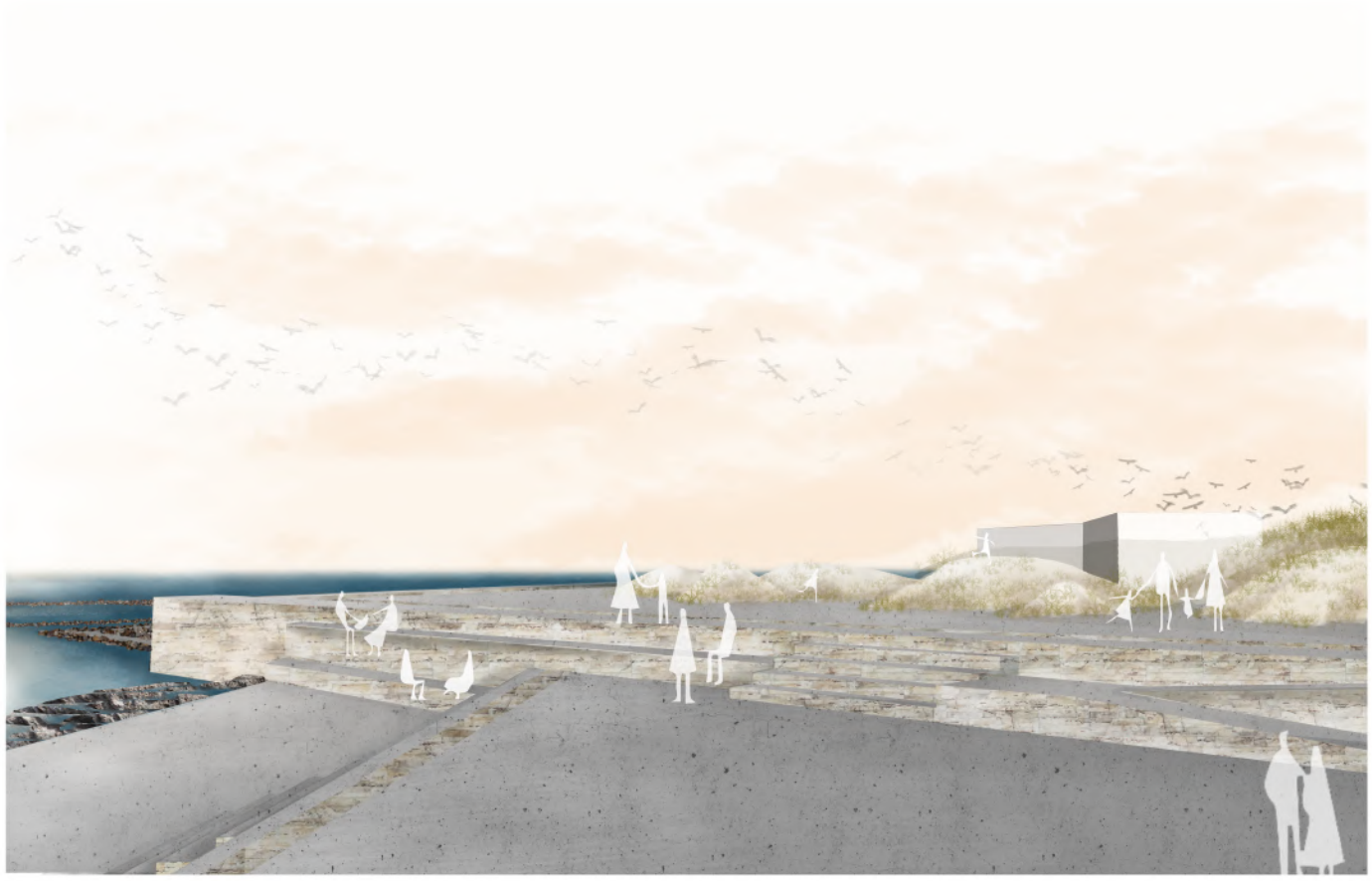


Water, Sand + Stone.

(author's own).



SECTION A-A: Vis-Vywers as Tidal Pools
1:200 @ A1.



Perspective A: Platform enveloped by dune.

Perspective B: A stroll along the weir + a skip across the stone.

Perspective C: Views from above.

BECOMING THE OLD |

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Lastly, as a demonstration of the continual morphing and evolution of the system, we see Voël Eiland coalescing with Skaap Eiland forming a large bird breeding island and Vis Eiland joins the mainland and creates an accessible, sensitive and meaningful space, revealing the memory of the site which protects Langebaan f rom being submerged.

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ETHICS APPLICATION FORM

Please Note:
Any person planning to undertake research in the Faculty of Engineering and the Built Environment (EBE) at the University of Cape Town is required to complete this form **before** collecting or analysing data. The objective of submitting this application *prior* to embarking on research is to ensure that the highest ethical standards in research, conducted under the auspices of the EBE Faculty, are met. Please ensure that you have read, and understood the **EBE Ethics in Research Handbook** (available from the UCT EBE, Research Ethics website) prior to completing this application form: http://www.ebe.uct.ac.za/ebe/research/ethics1

APPLICANT'S DETAILS		
Name of principal researcher, student or external applicant		Abigail Victoria Sendall
Department		Landscape Architecture
Preferred email address of applicant.		abi.sendall@gmail.com
If Student	Your Degree: e.g., MSc, PhD, etc.	MLA
	Credit Value of Research: e.g., 60/120/180/360 etc.	120
	Name of Supervisor (if supervised):	Christine Price
If this is a researchcontract, indicate the source of funding/sponsorship		
Project Title		Ecology & Palimpsest: Uncovering the Miniature and Panoramic Design of Coastal Biogeophysics

I hereby undertake to carry out my research in such a way that:

- there is no apparent legal objection to the nature or the method of research; and
- the research will not compromise staff or students or the other responsibilities of the University;
- the stated objective will be achieved, and the findings will have a high degree of validity;
- limitations and alternative interpretations will be considered;
- the findings could be subject to peer review and publicly available, and
- I will comply with the conventions of copyright and avoid any practice that would constitute plagiarism.

APPLICATION BY	Full name	Signature	Date
Principal Researcher/ Student/External applicant	Abigail Victoria Sendall	Signed by candidate	21/05/2020
SUPPORTED BY	Full name	Signature	Date
Supervisor (where applicable)	Christine Price	Signature Removed	21/05/2020

APPROVED BY	Full name	Signature	Date
HOD (or delegated nominee) Final authority for all applicants who have answered NO to all questions in Section 1; and for all Undergraduate research (Including Honours).	Simone le Grange	Signature Removed	15 June 2020
Chair: Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the questions in Section 1			