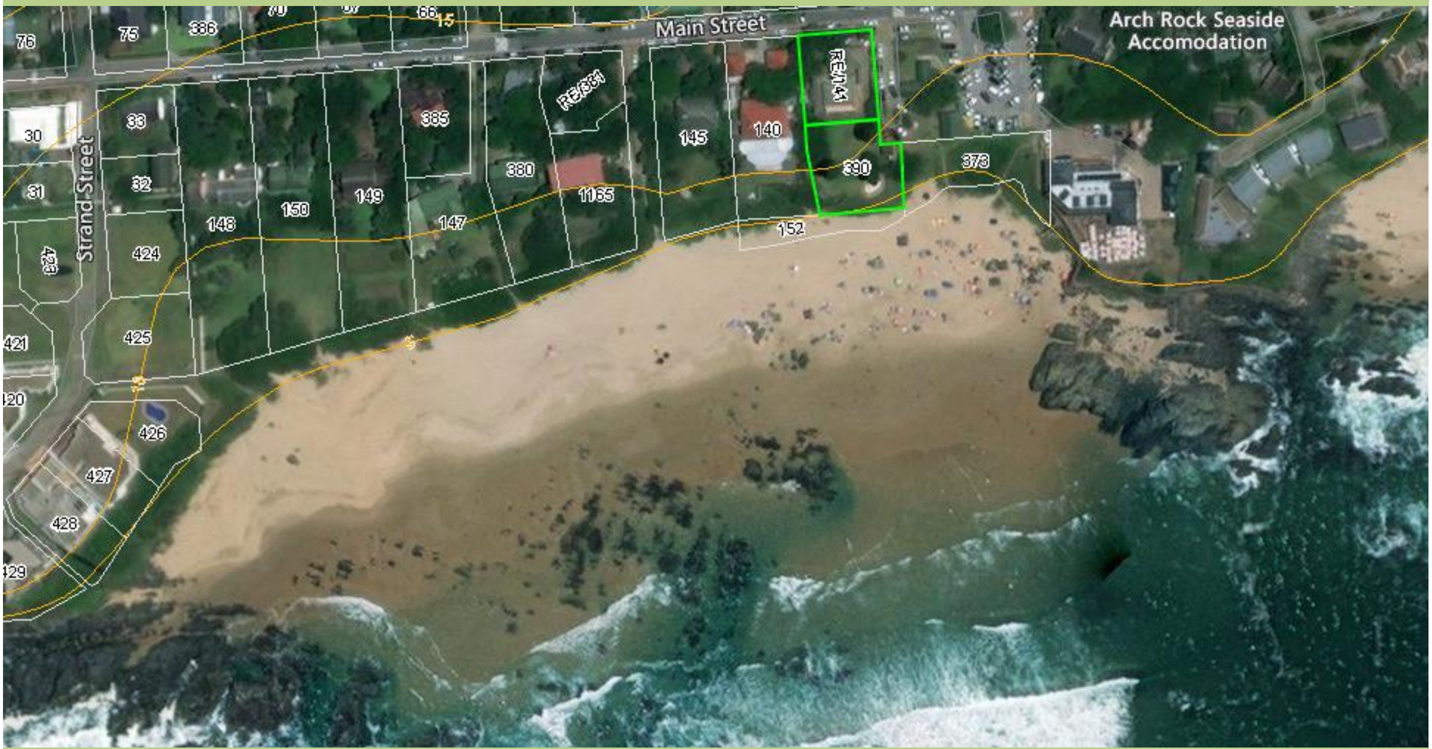
"House Maritz"

Erf 390 & Rem 141 Keurboomstrand



Coastal Engineer's Report

Prepared for

Cava Mola Mining (Pty) Ltd

Prepared by

WML Coast Pty (Ltd)

August 2021

Quality Management

Project number: 210518

Issue **DRAFT**

Date **16 July 2021**

Prepared by	**Checked by**	**Authorised by**
Robyn Owen	Enrique Julyan	Manfred Kloos

Issue **1**

Date **12 August 2021**

Prepared by	**Checked by**	**Authorised by**
Robyn Owen	Enrique Julyan	Manfred Kloos
		

Issue **2**

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Prepared by	**Checked by**	**Authorised by**
Robyn Owen	Enrique Julyan	Manfred Kloos
		

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1 Introduction

1.1 Background

WML Coast was appointed to prepare a coastal engineer's assessment for the remainder of Erf 141 and Erf 390 (Main Street, Keurboomstrand). The applicant is proposing the consolidation of these two erven back into their original erf, breaking down the existing dwelling and building a new dwelling. Figures 1 and 2 below show the location and Figure 3 shows the current and future layout plans.

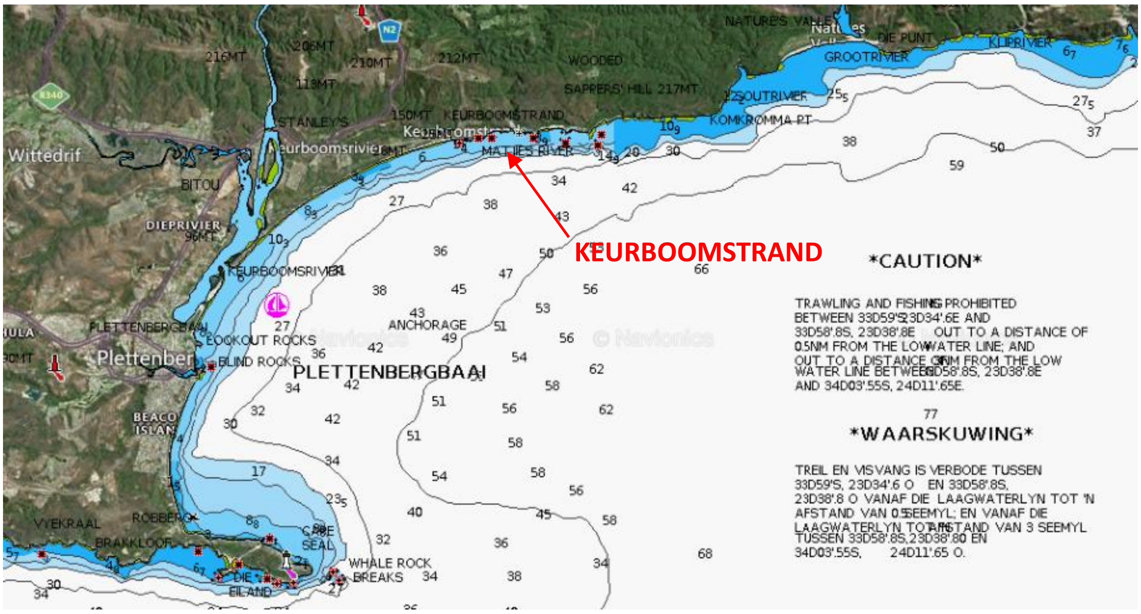


Figure 1: Location of Keurboomstrand to the east of Plettenberg Bay on the Naval Chart (Navionics, 2021)

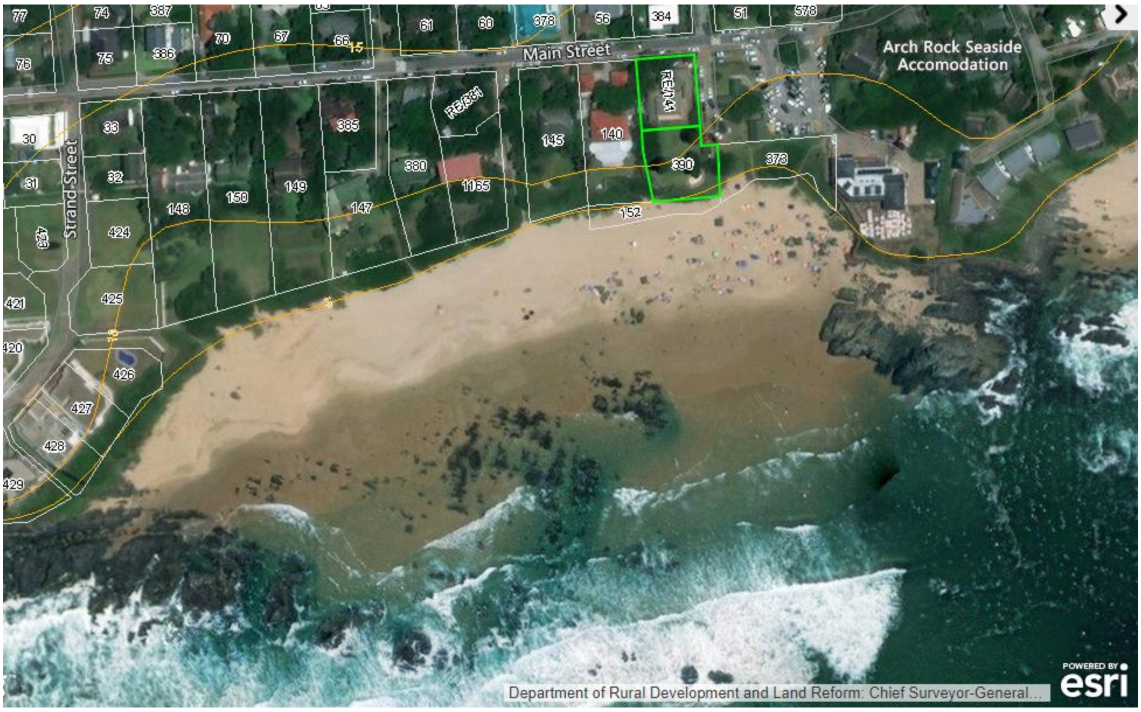


Figure 2: Location of Rem Erf 141 and Erf 390 in Keurboomstrand (CFM, 2021)

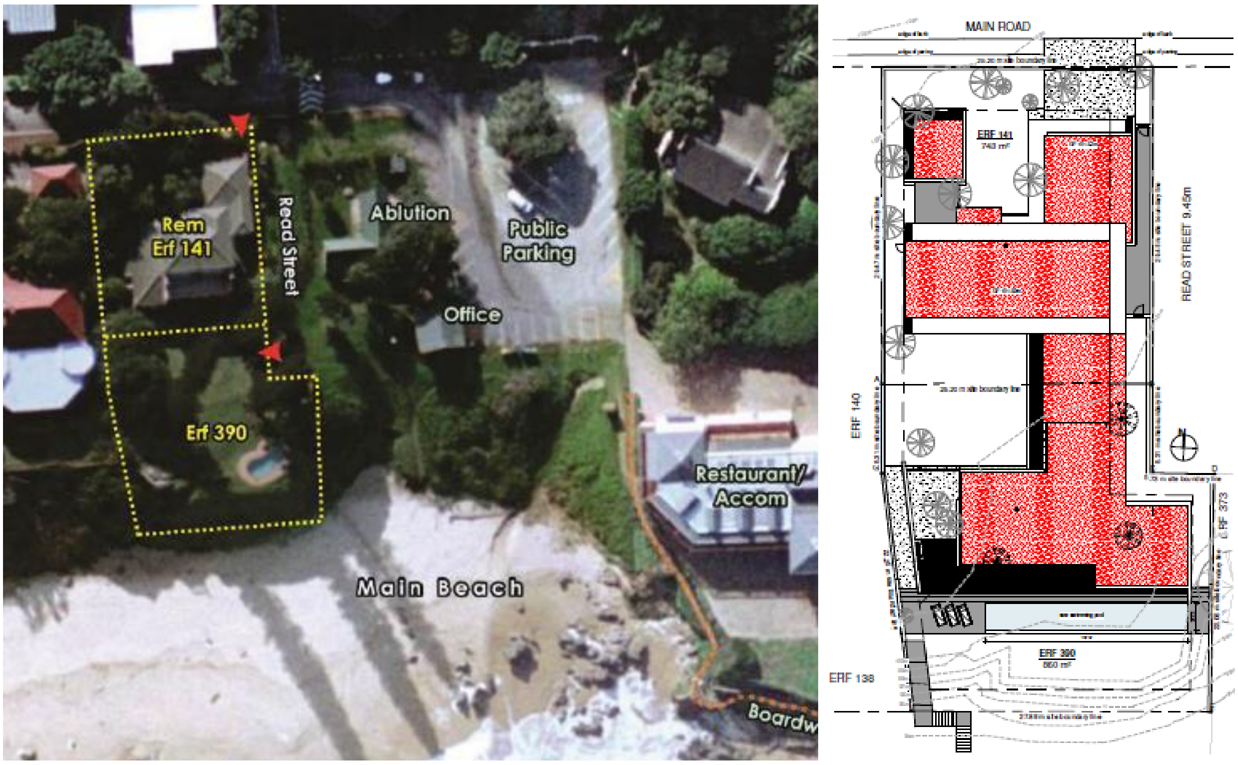


Figure 3: Setting and current layout of Rem Erf 141 and Erf 390 (left, Perception Planning) and new dwelling site plan (right, CLD Architects)

1.2 Scope of work

The Coastal Engineer's investigation for this site involved:

- an analysis of historical images in order to determine the dominant coastal processes at play and possible implications for the property
- a review of the extreme run-up levels expected for the site considering waves, winds, storm surges and sea level rise
- suggestion of risk mitigation measures considered appropriate for the site and the proposed development
- presentation of the findings in the form of a technical report

1.3 Limitations

The findings of this study are based on a purely desktop study of information obtained from the surveyor, published literature and engineering assumptions made which are deemed representative of the local site conditions. They are intended to provide a high level assessment of the coastal risks and potential solutions. All solutions proposed require expert detailed design prior to implementation.

2 Site characteristics

2.1 Topographical levels and description

The contour levels on the seaward side of Erf 390 on the mean sea level (MSL) datum are shown in Figure 4 (extracted from the surveyors drawing provided). 0 m MSL appears to be at approximately 90 m on the arbitrary architect's datum (AD) used for the SDP layout (CLD Architects). There is currently an interlocking concrete block retaining wall at a slope of 4:3 (vertical: horizontal) on the beachfront side of Erf 390. A gabion wall, mostly outside of the Erf boundary, protects the toe of the retaining wall. Both the gabions and the interlocking concrete blocks have been in place since 2004 (the earliest date of Google Earth historical imagery) and potentially much longer than that. The gabion wall was apparently managed as part of the property by the previous owner. Photographs in Figures 5 and 6 show details of the retaining wall. Approximate levels are as follows:

Beach level in front of gabions	~ 4 m MSL	~ 94 m AD
Top of gabions / bottom of interlocking concrete block retaining wall	~ 5 m MSL	~ 95 m AD
Top of retaining wall	~ 9.5 m MSL	~ 99.5 m AD
New dwelling ground floor	~ 10 m MSL	~ 100 m AD

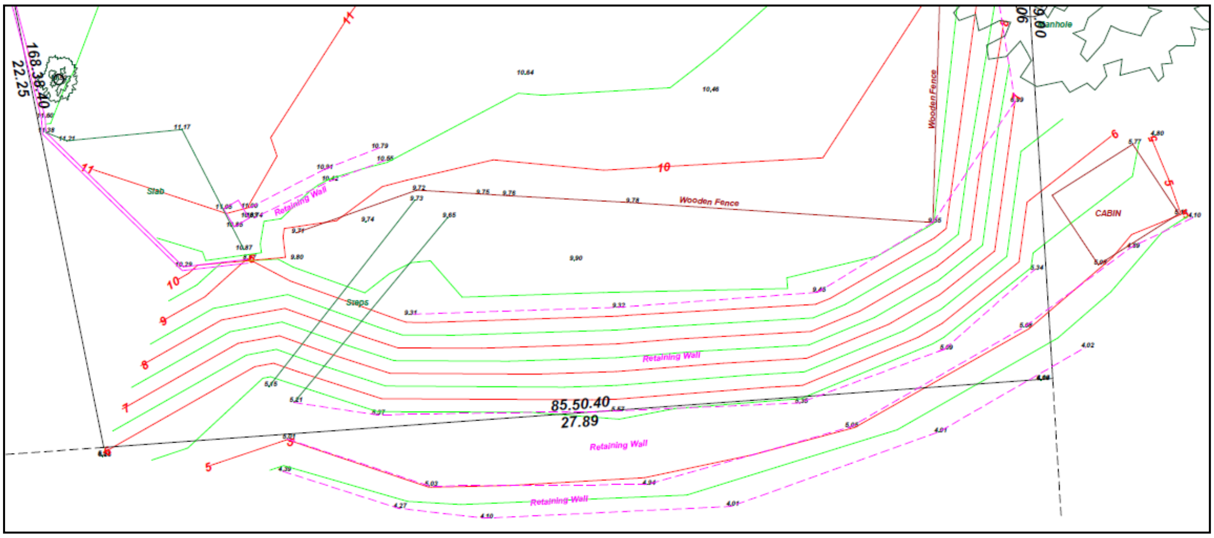


Figure 4: Extract of Detail Plan (Beacon Survey, June 2021) showing topographical levels (above MSL) on the seaward (southern) boundary of Erf 390

Figure 5: Photograph showing the site from the south (Stefan de Kock, Perception Planning)

Figure 6: Photographs showing the interlocking concrete block retaining wall, stairway and upper concrete retaining wall / viewing deck (Melissa Mackay, CapeEAPrac)

2.2 Bathymetry

The nearshore bathymetry is shown in the Figure 7 below. The foreshore here has a moderate slope of about 1:30. Nearshore rocky reefs offer some protection from wave attack. A photograph of the beach in front of Erf 390 at a time of relatively low sand levels is shown in Figure 8.

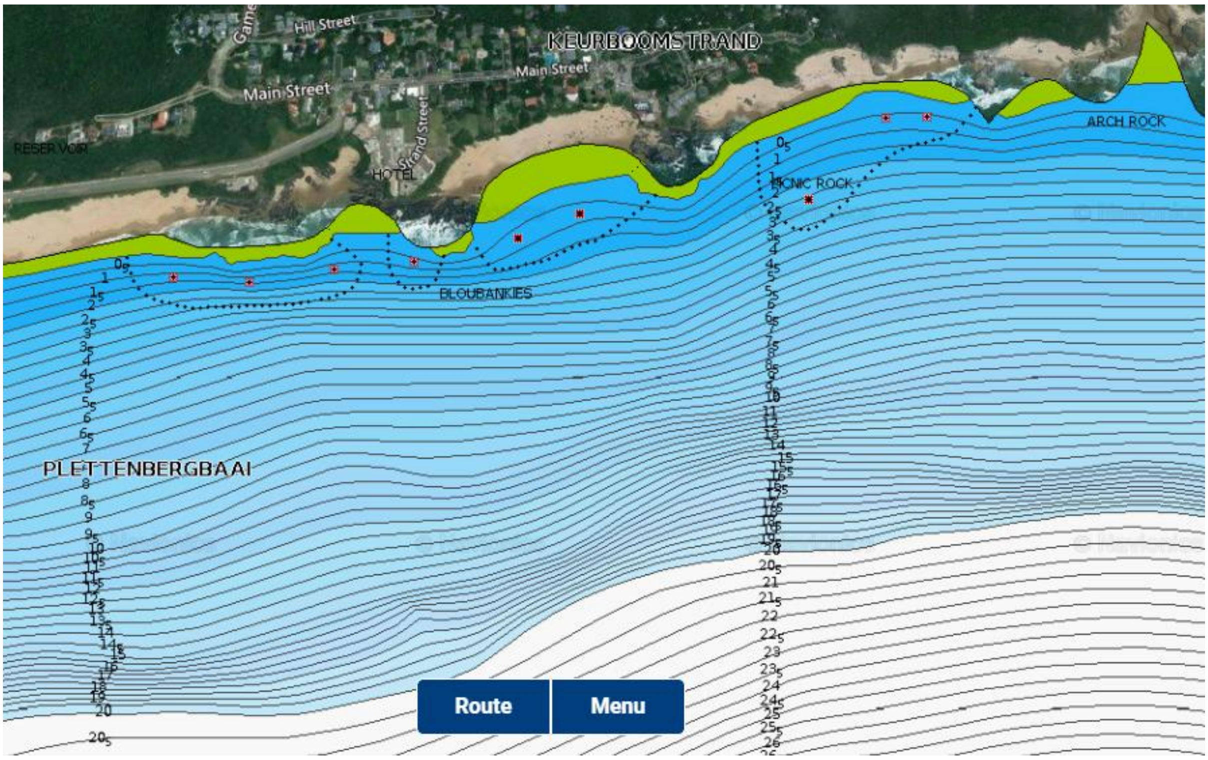


Figure 7: Nearshore bathymetric levels (m below Chart Datum) in front of Keurboomstrand according to Navionics SonarChart^{TM} (Navionics, 2021)

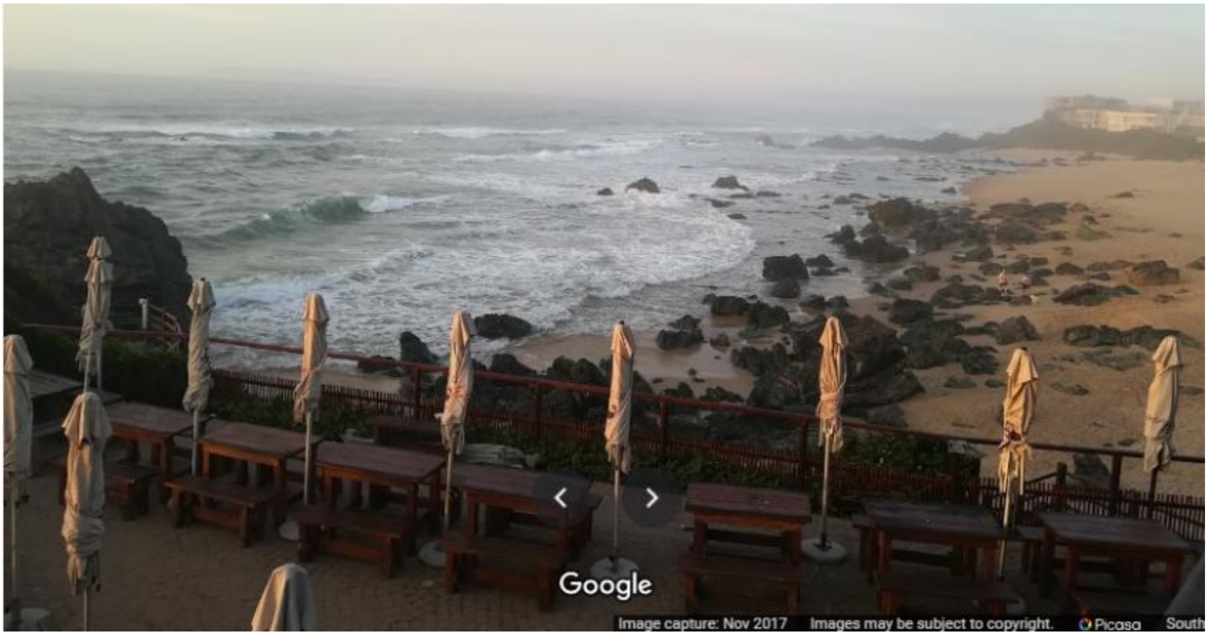


Figure 8: Photograph of the beachfront in front of Erf 390 (Google Maps, Nov 2017). Large boulders/protruding rock provide some protection from wave attack and help to retain sand on the beach.

2.3 Geotechnical conditions

No geotechnical reports for the site have been provided. It is assumed that the site is a retained sand dune with rock below at approximately sea level. The soil and geology description closest to the site from the Environmental Potential Atlas of South Africa (see Figure 9 below) is "grey regic sands and other soils; Aeolian sands and marine terrace gravel and sand, partly calcareous".

Figure 9: Soils & Geology near the site from Environmental Potential Atlas of South Africa (CFM, 2021)

2.4 Historical erosion / deposition trends

The Keurboomstrand Beach sand erodes and accretes intermittently over time and appears to be currently "dynamically stable". Selected historical aerial photographs over the past 17 years are shown in Figure 10. West of Erf 390 thin dune vegetation appears to have grown further seaward over the past decade whereas the vegetation line in front of the public parking to the east shows some erosion (see Figure 11). These minor trends are probably primarily due to pedestrian traffic rather than coastal processes. The effects of climate change (including sea level rise and increased storm intensity) can nonetheless be expected to pose increasing risk to the beachfront properties in this area.

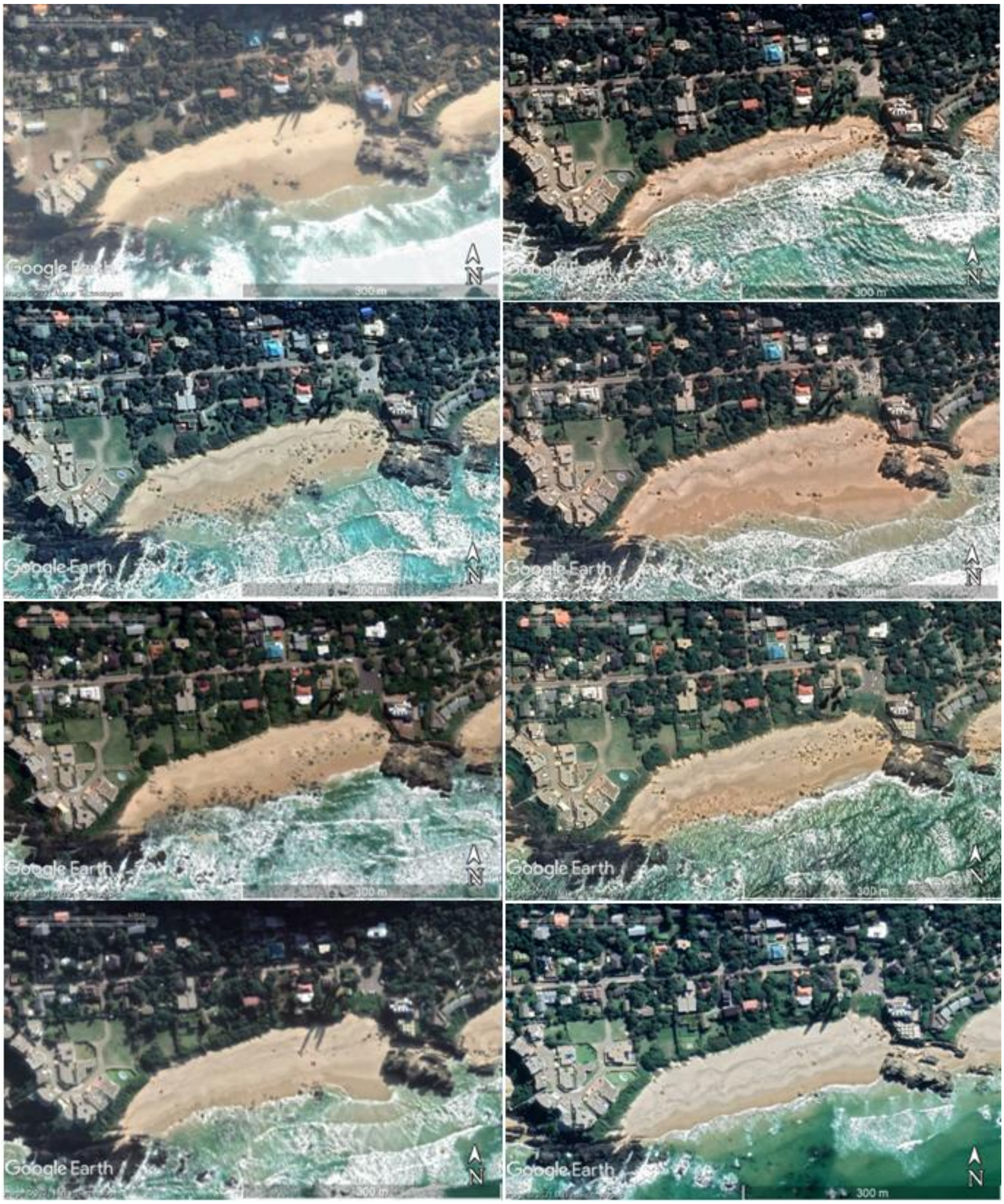


Figure 10: Selected satellite images of Keurboomstrand Beach between 2004 and 2021 (Google Earth)

Figure 11: Satellite images taken 2010 (top) and 2021 (bottom) of Keurboomstrand in front of Erf 390

2.5 Tidal and extreme water levels

The estimated tidal and extreme still water levels relevant to the property are listed in Table 3.

Table 1: Tidal and extreme still water levels for the Eden District coastline

<table>
<tr><td colspan="3" rowspan="2"></td><td colspan="6">LEVEL</td><td></td></tr>
<tr><td colspan="3">(m Chart Datum)</td><td colspan="3">(m MSL)</td><td>Reference</td></tr>
<tr><td rowspan="7">ASTRONOMICAL TIDAL LEVELS</td><td>Lowest astronomical tide</td><td>LAT</td><td colspan="3">0.00</td><td colspan="3">-0.93</td><td rowspan="7">Predicted (astronomical) tides at Mossel Bay from SANHO Tide Table 2019</td></tr>
<tr><td>Mean low water at springs</td><td>MLWS</td><td colspan="3">0.26</td><td colspan="3">-0.67</td></tr>
<tr><td>Mean low water at neaps</td><td>MLWN</td><td colspan="3">0.88</td><td colspan="3">-0.05</td></tr>
<tr><td>Mean level</td><td>ML</td><td colspan="3">1.17</td><td colspan="3">0.24</td></tr>
<tr><td>Mean high water at neaps</td><td>MHWN</td><td colspan="3">1.46</td><td colspan="3">0.53</td></tr>
<tr><td>Mean high water at springs</td><td>MHWS</td><td colspan="3">2.10</td><td colspan="3">1.17</td></tr>
<tr><td>Highest astronomical tide</td><td>HAT</td><td colspan="3">2.44</td><td colspan="3">1.51</td></tr>
<tr><td rowspan="4">ADDITIONAL ALLOWANCES</td><td rowspan="2">Storm surge</td><td rowspan="2">SS</td><td colspan="2">1:20 yr</td><td colspan="2">1:50 yr</td><td colspan="2">1:100 yr</td><td rowspan="2">RHDHV (2018)</td></tr>
<tr><td colspan="2">+ 0.86</td><td colspan="2">+0.93</td><td colspan="2">+0.97</td></tr>
<tr><td rowspan="2">Sea level rise</td><td rowspan="2">SLR</td><td colspan="2">Short term</td><td colspan="2">Medium term</td><td colspan="2">Long term</td><td rowspan="2">RHDHV (2018)</td></tr>
<tr><td colspan="2">+ 0.20</td><td colspan="2">+0.50</td><td colspan="2">+1.00</td></tr>
<tr><td rowspan="3">EXTREME STILL WATER LEVEL</td><td rowspan="3">Extreme still water level**</td><td>1:20 yr</td><td colspan="3">3.16</td><td colspan="3">2.23</td><td rowspan="3">= MHWS+ SS + SLR**
RHDHV (2018)</td></tr>
<tr><td>1:50 yr</td><td colspan="3">3.53</td><td colspan="3">2.60</td></tr>
<tr><td>1:100 yr</td><td colspan="3">4.07</td><td colspan="3">3.14</td></tr>
<tr><td colspan="10">*In the RHDHV modeling process (see Section 2.6) the 1:20 year run-up levels were calculated assuming an extreme still water level of MHWS tide + 1:20 year storm surge + ~ 20 years sea level rise, with 1:20 year extreme waves. It must be noted however that extreme storm surge and extreme wave heights can occur at any time.</td></tr>
</table>

2.6 Extreme wave run-up and erosion risk lines

A district level coastal process and risk modelling study for the Eden District was performed by Royal Haskoning DHV for the Western Cape Government Department of Environmental Affairs between 2016 and 2018. The wave run-up and erosion risk lines (RHDHV, 2018) at Keurboomstrand are shown in Figure 10. Table 2 provides the deep-water input wave conditions used in the modelling process. The following approximate levels are estimated for extreme wave run-up ($R_{u2\%}$)

- 1:10 year wave run-up level ~ 6.7 m MSL
- 1:20 year wave run-up level ~ 6.8 m MSL
- 1:50 year wave run-up level ~ 7.6 m MSL
- 1:100 year wave run-up level ~ 8.1m MSL

The erosion risk lines were determined by adding an offset (determined using a *geomorphological conceptual model* which describes how different processes act on areas along the coast, such as wind and wave conditions, geology, geomorphology, sediment dynamics and infrastructure interactions) to the respective extreme wave run-up levels.

Table 2: Summary of deep water input wave conditions used in the prediction of wave run-up levels at Keurboomstrand (RoyalHaskoning DHV, 2018)

Time Horizon	Extreme Water Level (m, CD)	Wave Direction - WSW		Wave Direction - SSW		Wave Direction - E	
		Offshore Wave Height (m)	Peak Wave Period (Tp, s)	Offshore Wave Height (m)	Peak Wave Period (Tp, s)	Offshore Wave Height (m)	Peak Wave Period (Tp, s)
10 year	2.10	8.81	13.48	6.56	11.49	6.49	10.94
20 year	3.16	9.26	13.82	7.09	11.95	6.90	11.27
50 year	3.53	9.85	14.25	7.77	12.51	7.49	11.75
100 year	4.07	10.28	14.56	8.27	12.91	7.98	12.13

Figure 12: DEA Eden District wave run-up and erosion risk lines at Keurboomstrand

3 Discussion of coastal risks at Keurboomstrand 390

While no physical inspections were made and no structural details have been reviewed, we consider the retaining wall on the beachfront edge of Keurboomstrand Erf 390 to be at risk from coastal attack. Interlocking concrete block retaining walls are typically highly susceptible to complete failure (via a "domino effect") when undermined and are not suitable as seawalls when the structures behind are reliant on them. The photograph below shows failure of such a seawall in Herolds Bay in 2006.

Figure 13: Failure of an interlocking concrete block wall at Herolds Bay in 2006 (terraforce.com, 2019)

The gabion wall below the toe of the interlocking concrete block wall (see Figure 5) offers some protection from undermining but this is not considered sufficient for extreme wave run-up events, which are expected to occur more and more frequently in the future due to the effects of climate change.

Notwithstanding the risk of retaining wall failure, the risk of coastal flooding and damage to the new dwelling is low. The proposed floor levels are above the predicted 1:100 year wave run-up level (RHDHV, 2018).

4 Coastal Engineer's recommendations

4.1 Acceptance of risk

The landowner (like most coastal landowners in South Africa and around the world) needs to be aware of and accept the increasing risk of property damage due to extreme coastal events. Note that it is never economically feasible to mitigate for all risks in design; and repair and maintenance through the life of the structure(s) may be required.

4.2 Conceptual options for retaining wall at risk

Options to mitigate the risk of failure of the interlocking concrete block retaining wall include (a) replacing / reinforcing the retaining wall or (b) designing the foundations of the new structure to remain stable in the event of retaining wall failure. In the drawings issued with this report we have provided three conceptual options for consideration.

OPTION 01: GABION WALL (Drawing 210518/11)

OPTION 02: SHEETPILE WALL (Drawing 210518/21)

OPTION 03: PILED SUPPORT (Drawing 210518/31)

Gabions (Option 01) are a relatively low cost seawall construction option which can be built to a steep slope. Construction is a labour intensive but relatively simple operation with well established methods and specifications. When covered with top soil vegetation can re-establish with roots between the stones. The integrity of a gabion structure is however completely reliant on the wire mesh cages. A double layer of gabions is therefore considered the minimum possible protection within the wave run-up zone, and inspections and maintenance are required throughout the life of the structure.

Options 02 and 03 are integrated into the structural design of the building. With these options the existing retaining wall would remain in place and maintenance of the existing gabions just outside the beachfront Erf boundary would be recommended to reduce the risk of undermining. In the event of retaining wall failure the building itself would remain stable but the front terrace / beach access stairway would need to be repaired.

4.3 Preferred solution

After consultation with the client and the architect, replacement of the existing interlocking concrete block retaining wall with a gabion wall (option 1 above) was selected as the preferred risk mitigation solution (see Drawing 210518/11). This solution protects the full embankment and swimming pool as well as the building and also reduces the potential risks to the public property associated with failure of the existing wall. The gabion wall with timber decking and stairs is deemed fitting with the new dwelling design. The exposed gabion wall structure can be fit within the boundary of Erf 390 (set back from the toe of the existing wall). However, a buried toe mattress which extends over the seaward boundary line (to the existing half buried gabions) will be required for scour protection. This may trigger an additional listed activity in terms of Environmental Regulations and will be included in the environmental assessment.

It is acknowledged that the gabion wall structure may require maintenance. Additional long term structural protection in the form of piled supports (option 3 above, see Drawing 210518/31) together with the gabion wall may be considered for peace of mind.

4.4 Notes on stormwater management

No stormwater runoff should be allowed to concentrate onto the gabion wall or the beachfront area in front of the property, where it can contribute to erosion problems. Runoff from the roof of the new building could be fed into an existing formal stormwater drainage system (if present) or directly infiltrate into soft landscaped areas surrounding the building (in such a way that it is not likely to form an erosion channel).

5 References

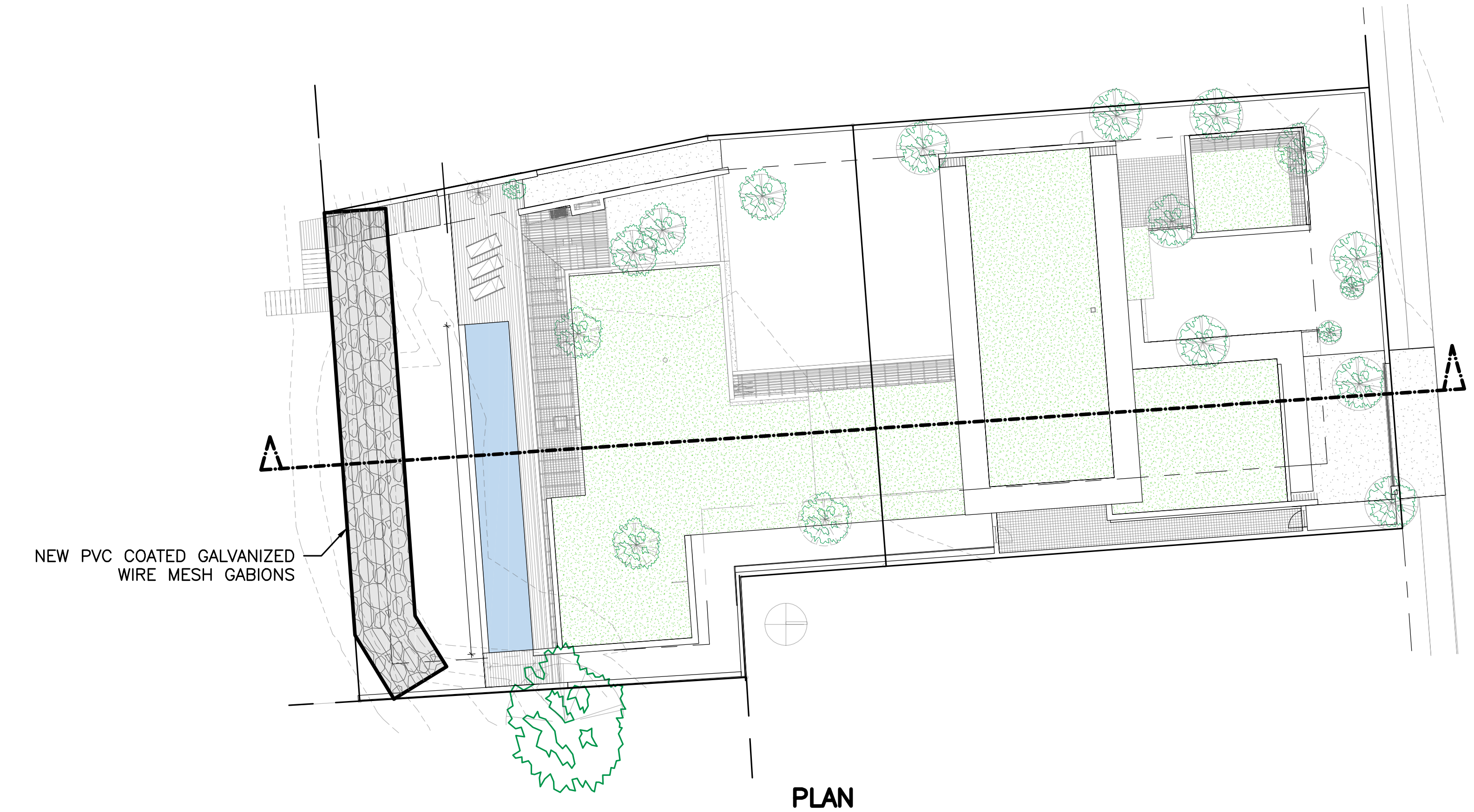
CFM. (2021). *CapeFarmMapper*. Retrieved from Western Cape Department of Agriculture: https://gis.elsenburg.com/apps/cfm/

Navionics. (2021). *Navionics ChartViewer*. Retrieved from https://webapp.navionics.com/?lang=en#boating

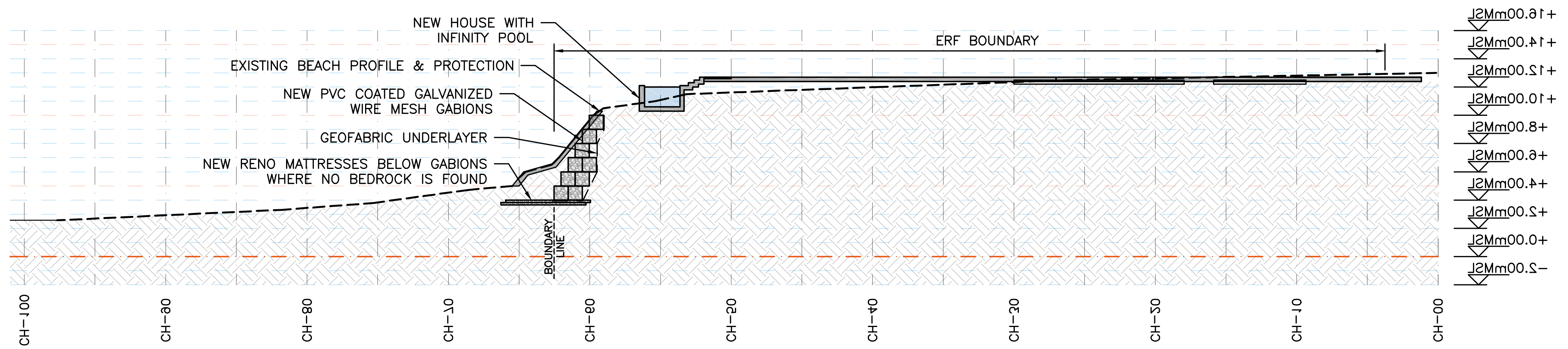
SANHO. (2019). *South African Tide Tables.* Cape Town: South African Naval Hydrographical Office.

terraforce.com. (2019). *Herolds Bay Sea Wall - a restrospective*. Retrieved from Terraforce: https://www.terraforce.com/erosion-control/riverbank-lake-seashore/10-2019-a-retrospective-herolds-bay-sea-wall/

USACE. (2008). *Coastal Engineering Manual.* US Army Corps of Engineers.



PLAN
OPTION 01: GABION WALL
SCALE 1:400



TYPICAL SECTION
OPTION 01: GABION WALL
SCALE 1:400

1:400 — 8m 0 8 16 24

DRAFT FOR DISCUSSION

REV	DATE	DRN	DES	APP	REVISION DESCRIPTION
.	13/07/21	TP	RO	MK	FIRST ISSUE

CLIENT : HOUSE MARITZ

PROJECT : KEURBOOMSTRAND KB141&390 CER

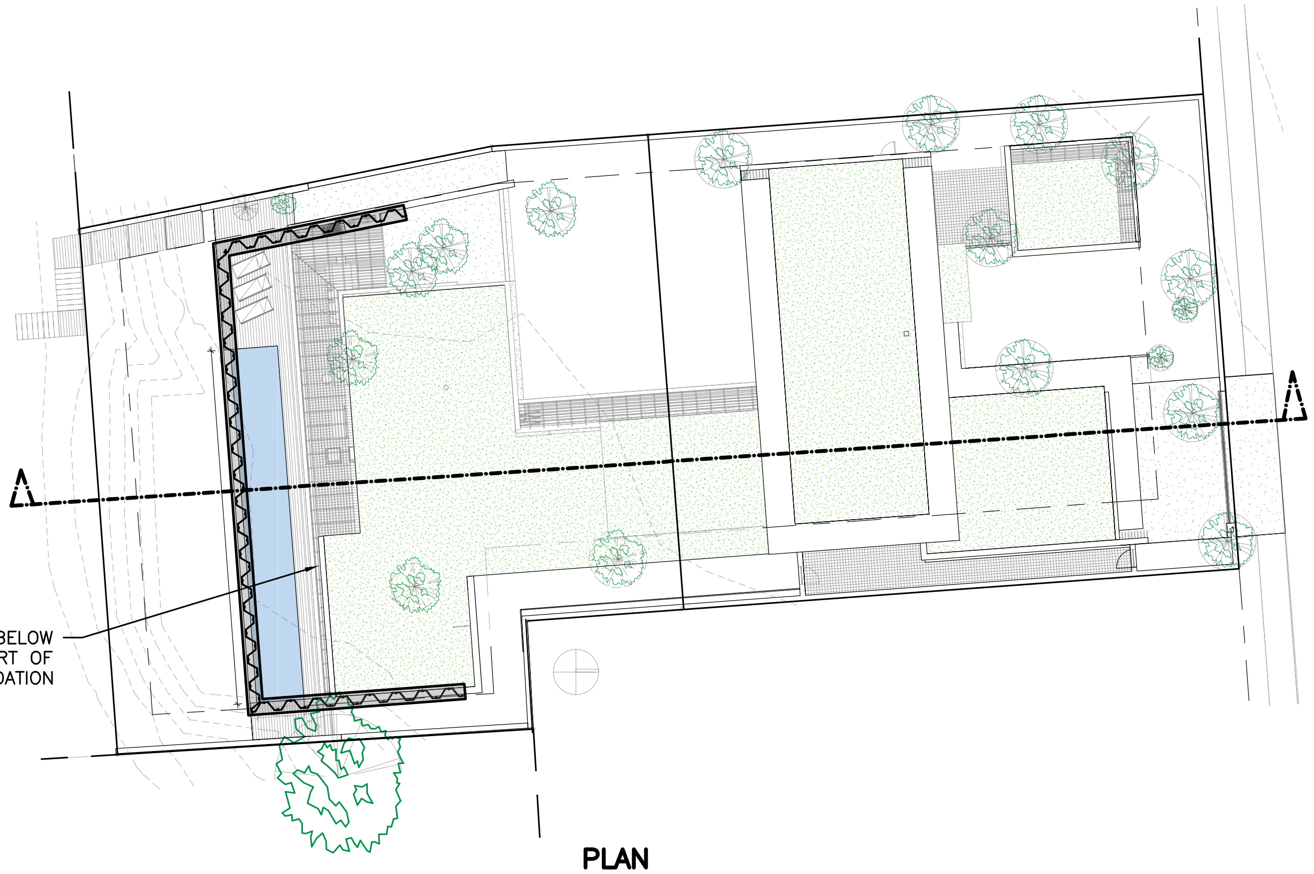
CONSULTANT : WML COAST
WML Coast (Pty) Ltd
35 Church Street | Stellenbosch | 7600
Tel: +27 21 883 8870

DRAWING : PLAN & TYPICAL SECTION OPTION 01: GABION WALL

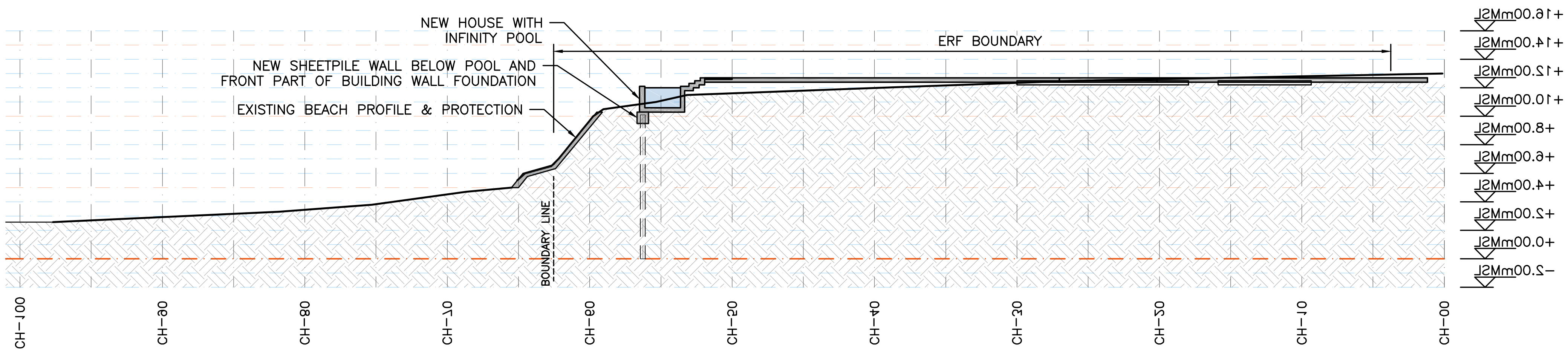
SCALE : AS SHOWN (A3)

DATE : JUL. 2021

DRAWING : 210518/11
REV. .



PLAN
OPTION 02: SHEETPILE WALL
SCALE 1:400



TYPICAL SECTION
OPTION 02: SHEETPILE WALL
SCALE 1:400

8m 0 8 16 24
1:400

DRAFT FOR DISCUSSION

REV	DATE	DRN	DES	APP	REVISION DESCRIPTION
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CLIENT: HOUSE MARITZ

PROJECT: KEURBOOMSTRAND KB141&390 CER

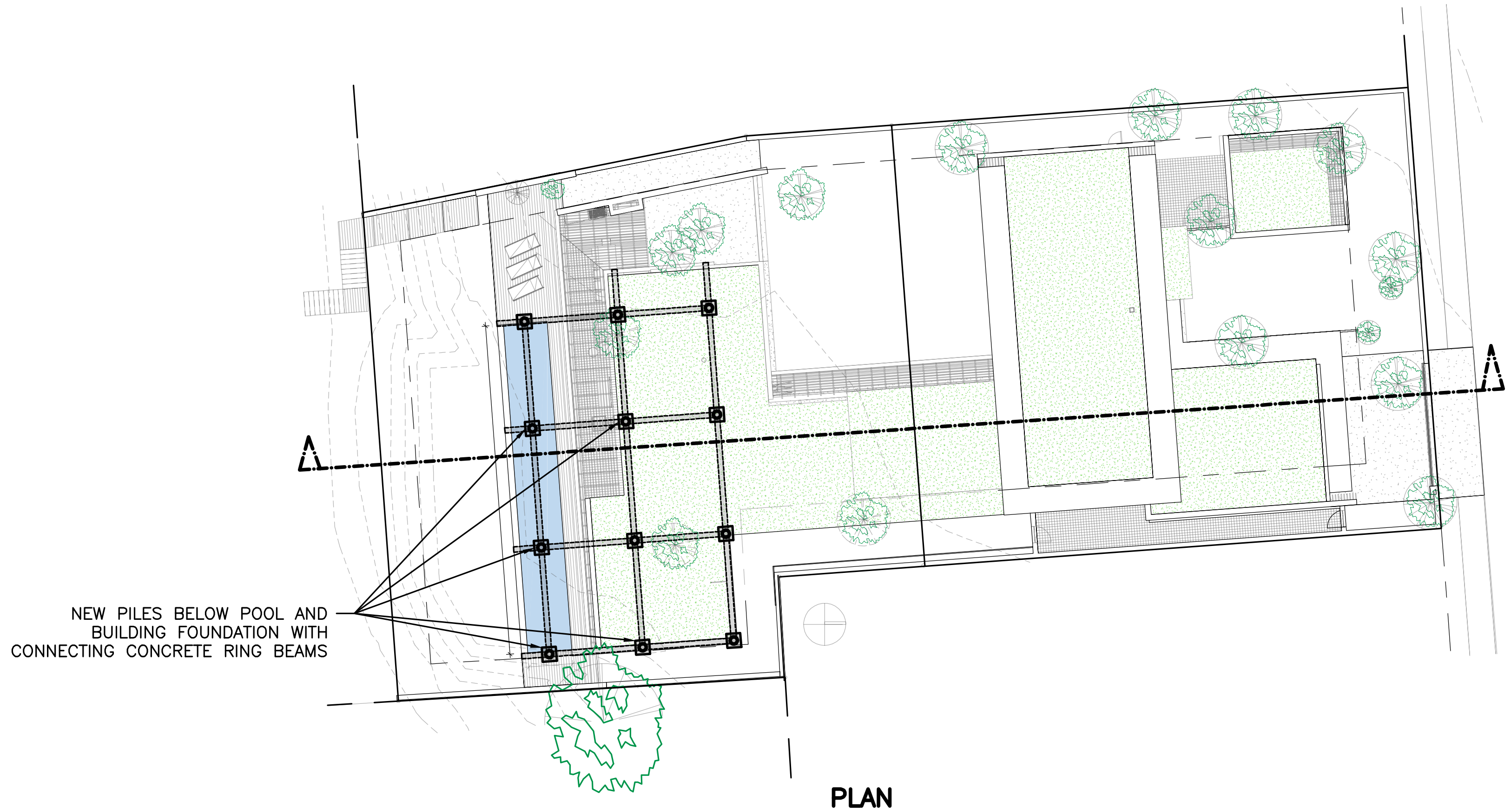
CONSULTANT: WML COAST
WML Coast (Pty) Ltd
35 Church Street | Stellenbosch | 7600
Tel: +27 21 883 8870

DRAWING: PLAN & TYPICAL SECTION OPTION 02: SHEETPILE WALL

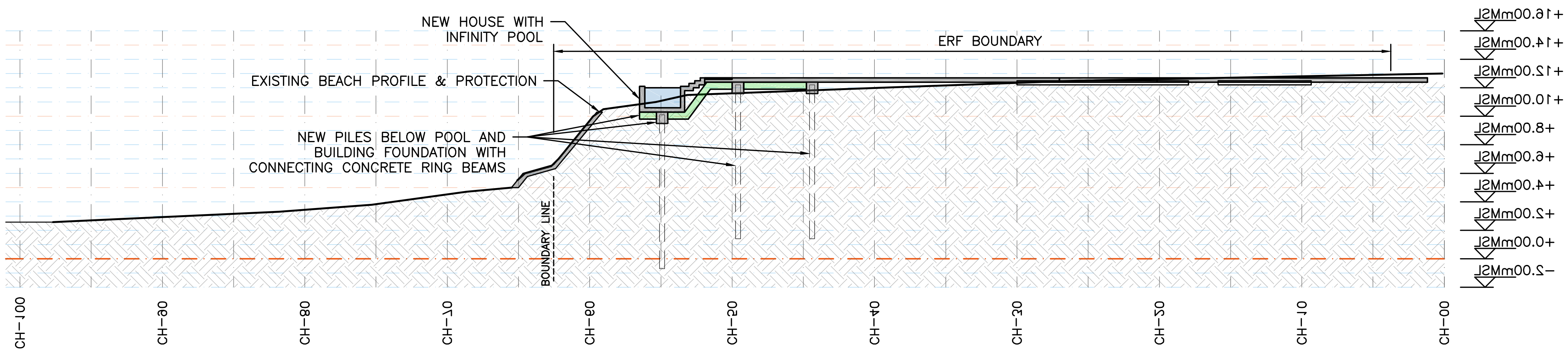
SCALE: AS SHOWN (A3)

DATE: JUL. 2021

DRAWING: 210518/21
REV. .



PLAN
OPTION 03: PILED SUPPORT
SCALE 1:400



TYPICAL SECTION
OPTION 03: PILED SUPPORT
SCALE 1:400

8m 0 8 16 24
1:400

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PROJECT : KEURBOOMSTRAND KB141&390 CER

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WML Coast (Pty) Ltd
35 Church Street | Stellenbosch | 7600
Tel: +27 21 883 8870

DRAWING : PLAN & TYPICAL SECTION OPTION 03: PILED SUPPORT

SCALE : AS SHOWN (A3)

DATE : JUL. 2021

DRAWING : 210518/31
REV. .