Attachment R

DHI Long Term Landfall Site Erosion Modeling

CWW Landfall Study

Historical analysis of the stability of Dowses Beach

Report
Project No 11829265

23.06.2023

Prepared for Avangrid Renewables

The expert in **WATER ENVIRONMENTS**

CWW Landfall Study

Historical analysis of the stability of Dowses Beach

Report
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No appendices

1 Executive Summary

The present study has been performed upon request from the Avangrid group to establish the historical background of the morphological stability of Dowses Beach, MA.

The present report documents the outcome of the following analysis:

A data inspection and analysis of shoreline and vegetation lines (resembling dune lines) for two decades – 2002-2023 and for years before and after Hurricane Sandy 2011 and 2013-14 – with the aim of determining the planar stability of the area historically to assess the future stability including any erosional tipping points in the future.

The analysis led to the following findings:

Long-term stability

Analyses of selected satellite images for the period 2002-2023 as well as LIDAR based beach topographies for the period 2010 to 2013-2014 show that Dowses beach has been dynamically stable with a tendency to return to an equilibrium shoreline state and with a tendency for a build-up of stabilising vegetation zones.

2 Introduction

The location of Dowses Beach shown in Figure 2-1 is a part of the barrier system of the west-coast of the Centerville Harbour bay. In /1/ the coastline of the inner parts of the bay were studied and found to be very stable and the present study can be seen as an extension of that work to cover also Dowses Beach.

The beach itself is approximately 650 m long (alongshore) and around 200 m across. It has an inclination toward south-east and is shaped by a stabilising structure in each end. It is in general characterised by having a certain alongshore variability of sandy formations where dunes are seen in the southern as well as in the middle and northern part interrupted by a low lying area without dunes. In the most southern part the beach is stabilised by a groyne structure and in the northern part by a stabilizing navigational structure at the opening into the basin area behind the barrier.

Figure 2-1 Top and bottom: The area of Cape Cod and the location of landfall area Dowses Beach (marked with red in bottom figure)

The present report presents an important input to the overall feasibility assessment of adopting Dowses Beach as windmill cable landfall area for three sea cables as seen in the landfall layout in Figure 2-2.

To assess the overall feasibility of the area to function as a stable landfall area with low risks of cables being exposed, etc., an assessment of the area's erosional stability is needed. The present report supports this by assessing the historical trends as can be observed from satellite images over two decades and LIDAR data pre (2011) and post (2013-14) Hurricane Sandy.

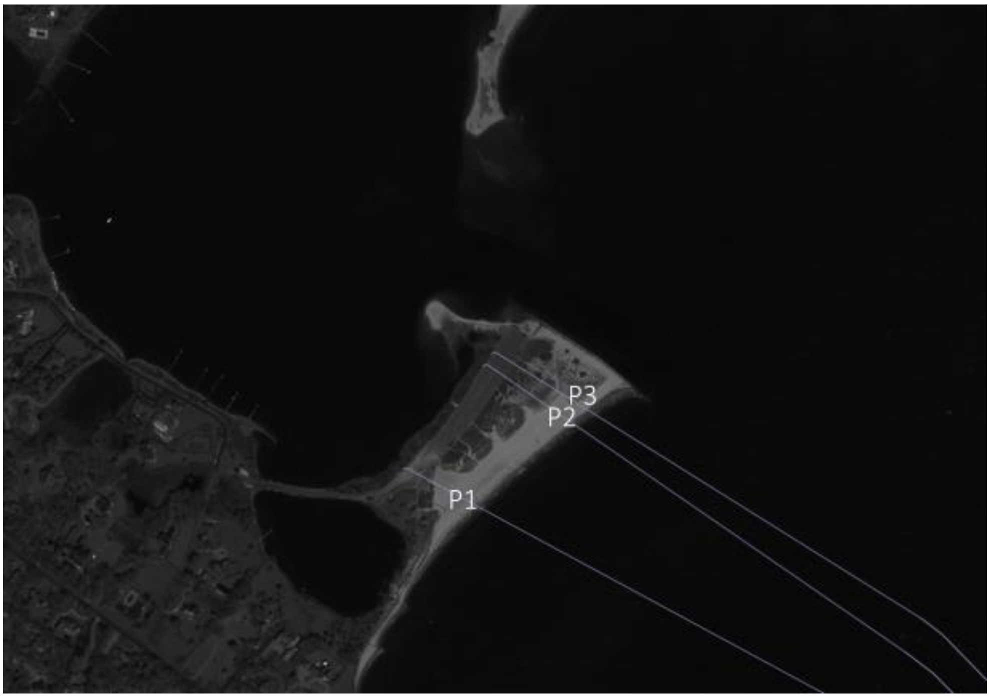

Figure 2-2 Three landfall cable transects – in the present report labelled P1, P2 and P3

Under this task, assessment of the long-term historical (planform) shoreline stability will be made by interpreting the historical shoreline evolution. This assessment will reveal long term historical tendencies of longshore shoreline position which gives further indications of the beach's ability to recover after erosion in the profile. The results from the historical analysis form a fundamental basis for understanding and assessing future conditions of the beach area.

3 Aim and methodology

3.1 Aim

The aim of this study is to estimate the historical erosional conditions of Dowses Beach for the last 2 decades.

3.2 Methodology

The following task has been performed and the outcome is presented in the present report:

Extraction and interpretations of long term (decadal) trends in shoreline and vegetation line (dune foot) – analysis based on analyses of areal satellite images.

3.3 Datum

Two relevant datums will be referred to in the report namely MSL (Mean Sea Level) and NAVD88 (North American Vertical Datum of 1988). The difference between the two is less than 20 cm in the area (see e.g. /4/). MSL will refer to the mean sea level today.

4 Analysis of long-term trends in shoreline and vegetation line

4.1 Satellite images

Satellite images were collected to cover the period 2002 – 2013.

Below in Figure 4-1 and Figure 4-2 these images are depicted.

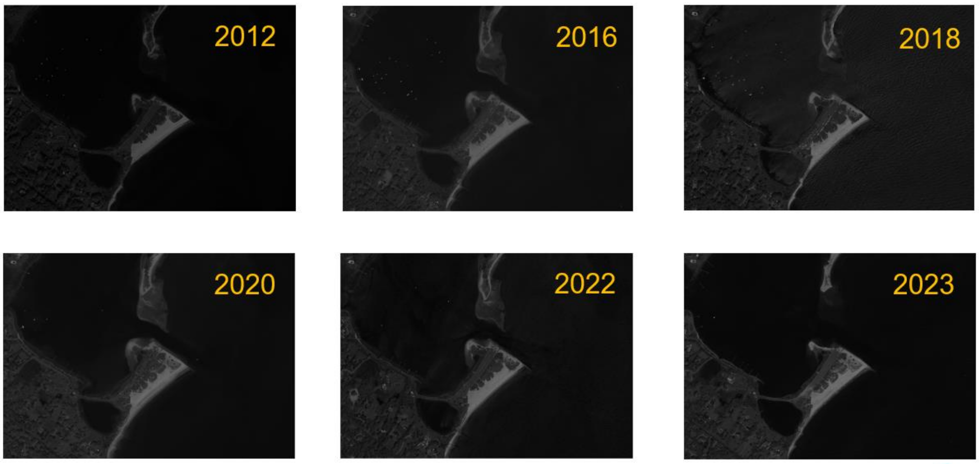

Figure 4-1 Satellite images 2012 – 2023 (data source: Airbus Pléiades)

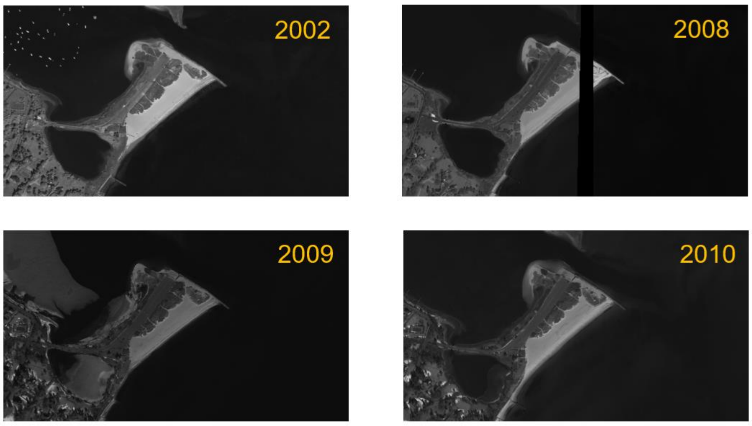

Figure 4-2 Satellite images 2002 – 2010

4.2 Analysis

From the period 2002-2023 an image from 2008 was discarded due to quality / bias issues, leaving the following years relevant for the analysis:

- 2002
- 2010
- 2012
- 2016
- 2018
- 2020
- 2023

The images were analysed with respect to:

1. The line between wet and dry beach (resembling the shoreline)
2. The line between sand and vegetation (resembling the dune foot line).

Note that we implicitly assume that erosional changes in beach morphology is mainly linked to extreme events – hence that seasonal variation plays a minor role compared to the effects of extreme events (hurricanes) as well as long term effects (SLR and changes in hurricane patterns). This assumption is supported by previous work /1/.

Shoreline variability

In Figure 4-3 the shoreline variability in the period is shown. The following phenomena are noted:

- The shoreline development reveals that the beach does not gain or lose sediments, i.e., the shoreline is dynamically stable in the period.
- The shoreline fluctuates rotationally around a centre point approximately located at 1/3 of the sandy beach stretch south-west of the stabilising groyne in north.
- Shoreline excursions in 2012 are seen to be the most extreme - Maximum retreat / protrusion are seen to be in the order 50m as observed from 2010 to 2012 the shoreline retreats in the southern part and tends to protrude close to the northern control structure in the same order of magnitude. This observation correlates with the passing of Hurricane Sandy (Oct. 2012) causing the shifting the shoreline due to cross-shore profile changes and alongshore movement of sand.

Figure 4-3 Shoreline variability 2002-2023. Orange line: 2002, Green line: 2010, Yellow dashed line: 2012, Red line: 2023

Vegetation line variability

In Figure 4-4 the vegetation line variability in the period is shown. The following phenomena are noted:

- A general tendency for a migration of the vegetation line in the seaward direction.
- The migration seems to be a consequence of a process where 1) sand is eroded from the dune front and deposited in the area close to the dune front 2) vegetation is established over a number of years with mild conditions after the erosional event has happened.
- The migration of the vegetation line is hence only weakly correlated with shoreline changes.

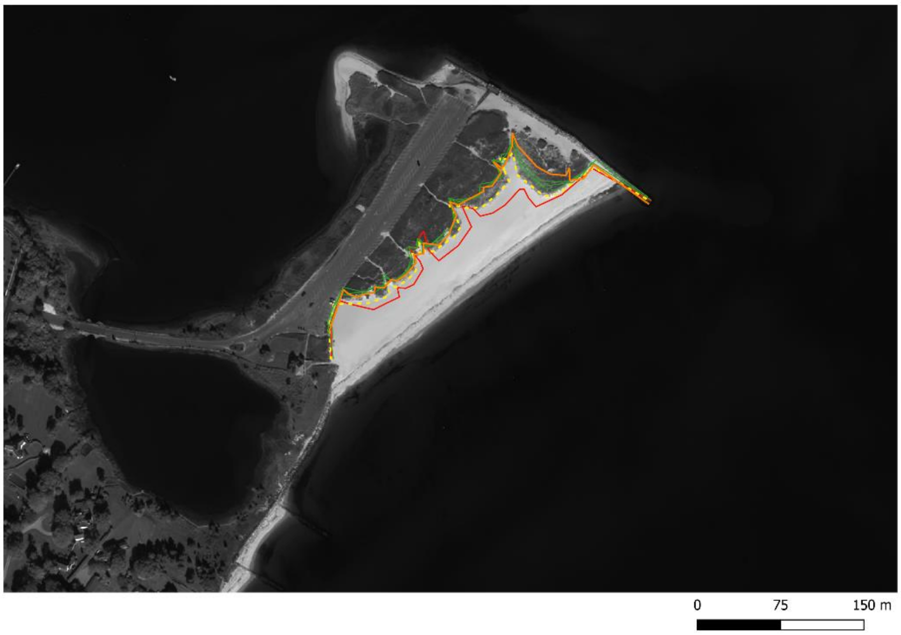

Figure 4-4 Vegetation line variability 2002-2023. Orange line: 2002, Green line: 2010, Yellow dashed line: 2012, Red line: 2023

4.2.1 LIDAR measurements

The client provided a topographical data set generated from LIDAR measurements in the years before and after Hurricane Sandy hit the eastern coast of US. The measurements were collected in the following years:

- 2011
- 2013-2014

This means that effects of Hurricane Sandy on the beach morphology are seen as differences between the data.

Two ways of illustrating the situation are given:

1) Cross-shore profiles along cable transects

2) Alongshore profile

Cross-shore profiles along cable landfall transects

In below figures the profiles along the cable transects are given. Top figures show the location of the profile given in the bottom figures. In the top figures the topographic isolines are given with a spacing of 0.5m (vertical).

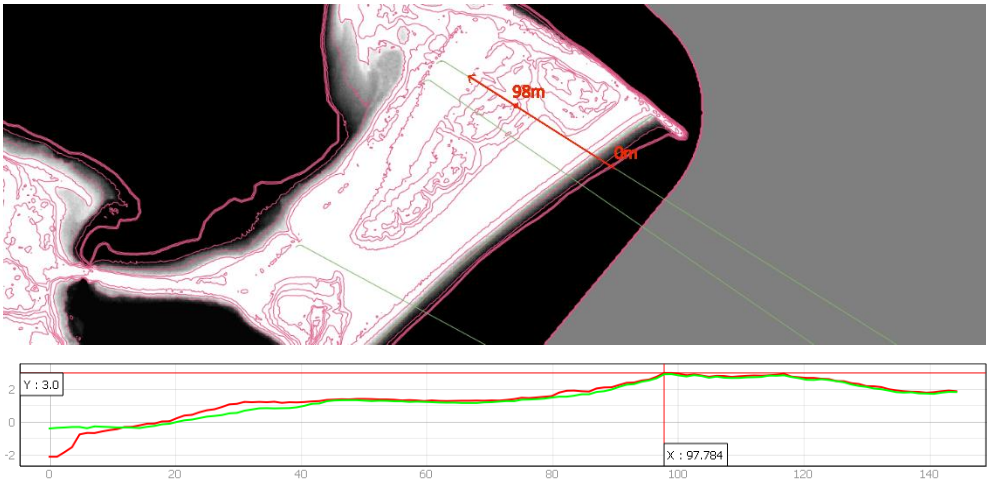

Figure 4-5 Top: location of profile section cable corridor. Bottom: Beach level profiles in m MSL. Green line: 2011. Red line: 2013-2014. Vertical reference NAVD88.

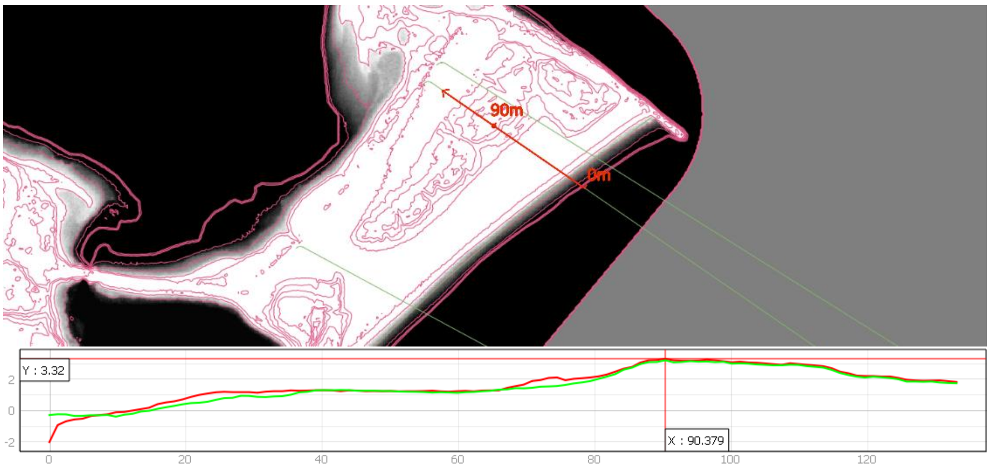

Figure 4-6 Top: location of profile middle section cable corridor. Bottom: Beach level profiles in m MSL. Green line: 2011. Red line: 2013-2014. Vertical reference NAVD88.

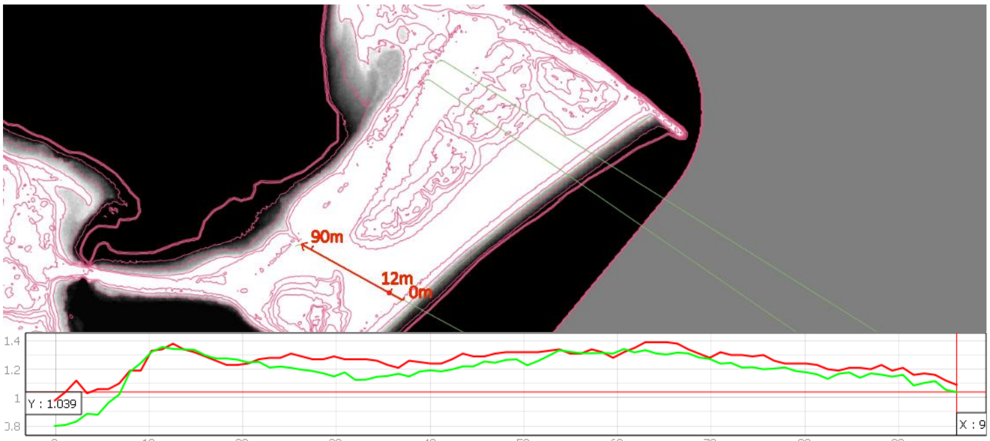

Figure 4-7 Top: location of profile south-west section cable corridor. Bottom: Beach level profiles in m MSL. Green line: 2011. Red line: 2013-2014. Vertical reference NAVD88.

Alongshore transect

Below a figure is shown of the ground levels along an alongshore transect going through the low-lying area to the south (with no dune) and further north-east along the dune area (running approximately through the dune tops).

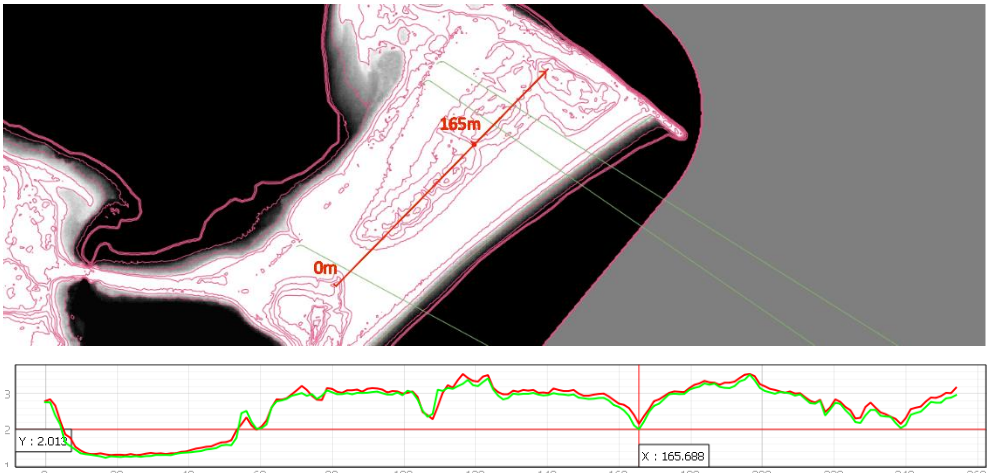

Figure 4-8 Top: location of profile south-west section cable corridor. Bottom: Beach level profiles in m MSL. Green line: 2011. Red line: 2013-2014. Vertical reference NAVD88.

It is seen how the beach varies from a dune formation to the south, over the approximately 35m wide low-lying area, followed in the north-eastern direction by the dune system.

The following is noted:

- The southernmost dune formation elevation reaches up to a level in the order 2.8 m.
- The low-lying area is fairly uniform in the alongshore direction with the levels in the order 1.2-1.4 m.

- The northern dune system elevation is up to a maximum of approximately 3.2 m and is interrupted by narrow section with an elevation of approximately 2 m.
- A tendency for the two data set to be shifted in the order 20cm is noted, which is not due to a physical effect, but instead reflects the level of relative uncertainty in the data sets.

4.3 Interpretations and conclusions

General observations

The satellite images, including the analysis of shoreline and vegetation line evolution suggests:

- The beach is in the current conditions dynamically stable, with minimal sand gain or loss.
- The shoreline orientation is seen to vary over the decades 2002-2023 but with no apparent loss of sediment, meaning that sand volumes are shifted forth and back across the profile and along the stretch.

Hurricane Sandy - October 2012

Data shows that in 2012 the shoreline orientation has its largest change in the period. This is interpreted as the effect of hurricane Sandy, which moved sediments from the south-west part of the beach to the north-east part resulting in a clock-wise rotation of the shoreline by a few degrees.

The shoreline orientation is seen to recover the following years.

Vegetation lines

The vegetation lines seem to migrate / translate in the seaward direction over the entire period leaving the impression of a stabilizing mechanism where vegetation is established whenever conditions are right with a tendency to form a larger and larger area of stabilized coverage.

Overall conclusion

The overall impression is that the beach is dynamically stable in the horizontal plane with a large degree of capacity to recover from impacts of storms. A main factor here is that the area seems not to lose (or gain) sediments to the surroundings due to the control structures preventing sand transport in and out of the area.

5 Summary and conclusions

First it is noted that this analysis concludes only on the HDD cable landing and does not evaluate the proposed onshore infrastructure in parking lot, roadways, etc. (joint bays, duct bank, causeway crossing).

Based on the report's analysis of the behaviour and erosional conditions of Dowses Beach over the last 2 decades, the following can be concluded:

- Analyses of 20 years of satellite images as well as LIDAR based data sets for 2011 and 2013-2014 indicates a dynamically stable beach – supported by stabilizing structures preventing sand losses alongshore.
- As long as the beach / dune system in this way remains a dynamically stable morphology as documented being the case for the last two decades, the area will be very well suited as a cable landfall area because erosional envelopes are limited in magnitude and a sufficient burial depth henceforth can be defined.

Comparing the erosional conditions found in the present historical analysis with preliminary HDD burial depths provided by Avangrid - with a minimum depth in the order 20 feet or 6 m (below MLLW) at the transition from the beach to the casted facility and 57 feet or 17 m (below MLLW) along the beach section (to the sea) leads to the following conclusion:

- The suggested burial depths along the beach will be sufficient for erosional conditions at Dowses Beach similar to the historical conditions analysed in the present report.

6 References

/1/ DHI report, Appendix I, project 1826005, Morphodynamic analysis of landfall – Model supported analysis of the littoral zone seabed variability in and around cable landfall area, 3 Sept. 2012, Vineyard Wind LLC

/2/ Sea Level Projection Tool – NASA Sea Level Change Portal, Web portal

/3/ Mangor, K. Drønen, N., Deigaard, R., Kristensen, S, Kaergaard, K., 2017, Shoreline Management Guidelines, DHI ebook

/4/ https://tidesandcurrents.noaa.gov/, Web portal

Appendix A

No appendices