

APPLICATION OF A DREDGED TRENCH TO INFLUENCE SHORELINE LONGSHORE SEDIMENT TRANSPORT

Mariana Oliveira, CWP Engineering, mariana.oliveira@cwpeengineering.com
 Donna Habib, CWP Engineering, donna.habib@cwpeengineering.com
 James Walker, CWP Engineering, james.walker@cwpeengineering.com
 Francesco Ciardulli, CWP Engineering, francesco.ciardulli@cwpeengineering.com

INTRODUCTION

Traditional coastal engineering methods to influence or modify coastal processes and shoreline position include: shore normal groynes, detached shore parallel breakwaters, beach nourishment and beach dewatering systems. An alternative system is investigated herein, whereby the nearshore wave conditions are modified by dredging of an offshore trench. Such a system could potentially enhance the beach amenity compared to traditional coastal engineering solutions.

The effectiveness of dredging offshore to promote beach stability is not yet comprehensively understood (Riedel, 2003). The existing literature is mainly focused on the effects of wave propagation due to dredged navigational channels (Riedel, 1982).

This numerical study seeks to provide insight into the effectiveness of dredging of an offshore trench to modify the equilibrium beach alignment and potentially reduce shoreline recession/erosion.

CASE STUDY

The numerical investigations are based on an actual case study of a beach in the United Arab Emirates within the Arabian Gulf. A major feature of the shoreline is the amenity associated with a long, open, uninterrupted beach exposed to waves with minimal engineering structures. The beach is subject to a net longshore littoral transport from the South to the North. Coastal engineering structures (littoral drift barriers) have been constructed both updrift and downdrift of the beach, resulting in the shoreline responding by rotating in an anti-clockwise direction.

The consequences are a narrowing of the beach crest width at the Southern end, resulting in a loss of beach amenity and creating a greater risk to land based infrastructure and utilities. Currently, beach nourishment and maintenance dredging of the shoreline is undertaken on an annual basis by shifting sand from the Northern end of the beach to the Southern end of the beach. The Client wishes to reduce maintenance dredging requirements, while not significantly increasing the width of the beach at the Northern end and by considering a solution that does not require the construction of groynes. As an alternate solution, the effectiveness of an offshore dredged trench is investigated.

DATA AND METHODS

A wave transformation study was implemented using the SWAN numerical model (Delft, 2006) to define the typical nearshore climatic (annual) wave conditions along the beach. The nearshore wave climate was used as an input to the shoreline evolution studies. The shoreline response has been modelled with LITPACK (DHI, 2016). The bathymetric data and wave climate extraction locations for the existing conditions are shown in Figure 1.

The nearshore wave climate is strongly influenced by offshore developments, with the most frequent waves from the North-Westerly sector.

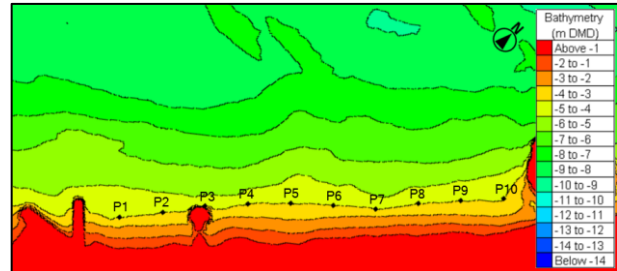


Figure 1 - Bathymetry and wave extraction points along the coastal stretch (Existing scenario)

The dredged trench was modelled for a seabed depth of -15m DMD (Dubai Municipality Datum). The tested configuration has a minimum width of 20m, a maximum width of 180m and a total length of approximately 1km. Bathymetry data including the dredged trench and wave climate extraction locations are shown in Figure 2. The location of the dredged trench is beyond the depth of closure.

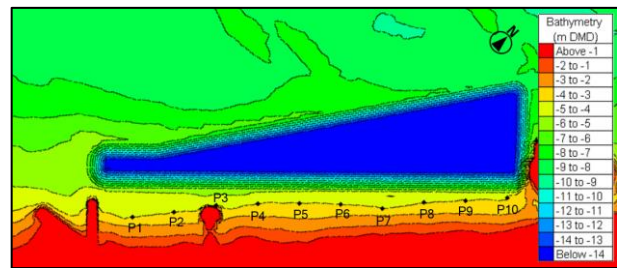


Figure 2 - Bathymetry and wave extraction points along the coastal stretch including the dredged trench

RESULTS

The morphological wave characteristics for locations P2, P6 and P9 for the existing conditions are summarized in Table 1. The morphological wave direction along the beach is not uniform, showing an anti-clockwise rotation of 7 degrees.

Table 1 - Morphological waves (existing conditions)

Location	H_{m0} (m)	T_p (s)	θ_p (°N)
P2	0.5	5.8	307
P6	0.6	5.9	303
P9	0.6	5.9	300

Shoreline evolution over a 43-year time period is shown in Figure 3. The long-term equilibrium shoreline alignment demonstrates an anti-clockwise rotation, resulting in approximately 18m of accretion at the Northern end of the beach and approximately 22m of recession at the Southern end of the beach.

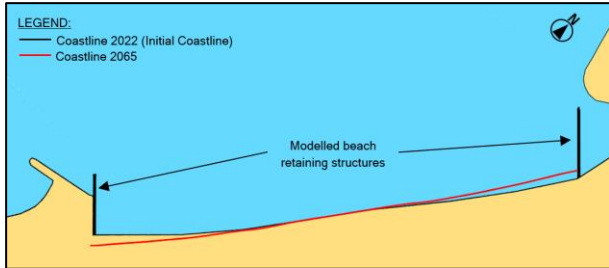


Figure 3 - Equilibrium shoreline alignment (existing conditions)

The morphological wave characteristics for locations P2, P6 and P9 with the inclusion of the dredged trench are summarized in Table 2. The anti-clockwise rotation of the morphological wave direction is reduced to 2 degrees. Negligible changes in morphological wave height and wave period occur.

Table 2 - Morphological wave (dredged trench)

Location	H_{m0} (m)	T_p (s)	θ_p ($^{\circ}$ N)
P2	0.5	5.7	307
P6	0.6	5.8	306
P9	0.5	5.9	305

Shoreline evolution with the inclusion of the dredged trench over a 43-year time period is shown in Figure 4. The shoreline response shows a reduced anti-clockwise rotation due to the influence of the dredged trench. Recession at Southern end of the beach is reduced to 6m.

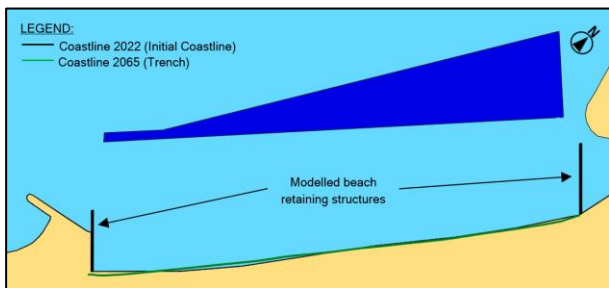


Figure 4 - Equilibrium shoreline alignment (dredged trench)

The average littoral drift after 1 year (2023) for the existing conditions and including the dredged trench is shown in Figure 5. Positive littoral transport represents transport to the North and negative littoral transport represents transport to the South.

For the existing conditions, the maximum average drift for the first year is approximately 6,000m³.

With the inclusion of the dredged trench, the maximum average drift for the first year is reduced to less than 1,900m³. The lower average littoral drift for the first year is reflected by the smaller difference between the existing shoreline orientation and the long-term equilibrium alignment.

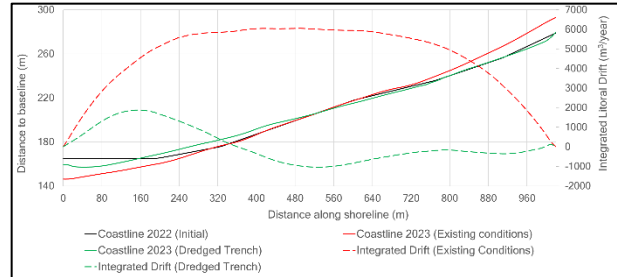


Figure 5 - Average littoral drift for the first year and shoreline evolution for the existing conditions and the dredged trench

DISCUSSION & CONCLUSIONS

Numerical modeling was undertaken to assess the effectiveness of dredging an offshore trench to modify the equilibrium shoreline alignment. Initial findings demonstrate that the tested configuration influences the littoral drift and the long-term shoreline alignment. Shoreline recession at the Southern end of the beach is reduced significantly. Further investigations will explore different configurations, depths and dimensions for the dredged trench. Additional numerical models such as BOUSS2D and Artemis will be used to test the sensitivity of the results. To further validate the numerical models, physical model tests are proposed.

REFERENCES

- Delft (2006): SWAN - Scientific and Technical Documentation, Delft University of Technology.
- DHI (2016): Littoral Processes FM - Scientific Documentation, Danish Hydraulic Institute, Denmark.
- Riedel, Peter and Byrne (1982): Dredging to minimize wave penetration into a harbour, Proceedings 18th International Conference on Coastal Engineering, Cape Town, ASCE, pp. 1514-1521.
- Riedel, O'Brien and Smith (2003): Configuration Dredging - An Alternative to Groynes & Offshore Breakwaters, Soft Shore Protection An Environmental Innovation in Coastal Engineering, SPRINGER, pp. 127-136.