



# Memorandum

10 February 2016

|         |                         |         |              |
|---------|-------------------------|---------|--------------|
| To      | Advisian                |         |              |
| Copy to | Paul Moses, Lex Nielsen |         |              |
| From    | Alexis Berthot          | Tel     | 02 9239 7240 |
| Subject | Eden Wave Modelling     | Job no. | 21/24795     |

## 1 Introduction

As part of the work on the Eden Wharf Extension project, Advisian requires an understanding of the potential impact the proposed dredge footprint (Figure 1) would have on Cocora Beach. In particular, if there would be a change in wave conditions in the nearshore area, and the nearshore wave climate during extreme wave conditions.

Numerical wave modelling investigations to assess the wave climate in the Eden Port Snug Cove Harbour have previously been undertaken by GHD for Bega Valley Shire Council (BVSC). The detail of the wave models setup, input and validation can be found in GHD 2013 Review of Wave Attenuator and Marina Report and GHD 2013 Channel Operational Conditions Study.

GHD has been commissioned to use its existing wave model of Twofold Bay to undertake the required assessment.



**Figure 1 Proposed dredge footprint (reference: Revised Dredge 160202)**

## **2 Scope**

In order to complete the required assessment, the following tasks were undertaken:

- Transfer 12 years of offshore wave data to five locations along Cocora Beach for both the existing and developed bathymetry (i.e. including the proposed dredging). Preparation of time series at each location and comparison of mean wave angle and effective wave height
- Determination of the 50 year and 100 year wave parameters for Cocora Beach

## **3 Wave Modelling**

### **3.1 Model Setup**

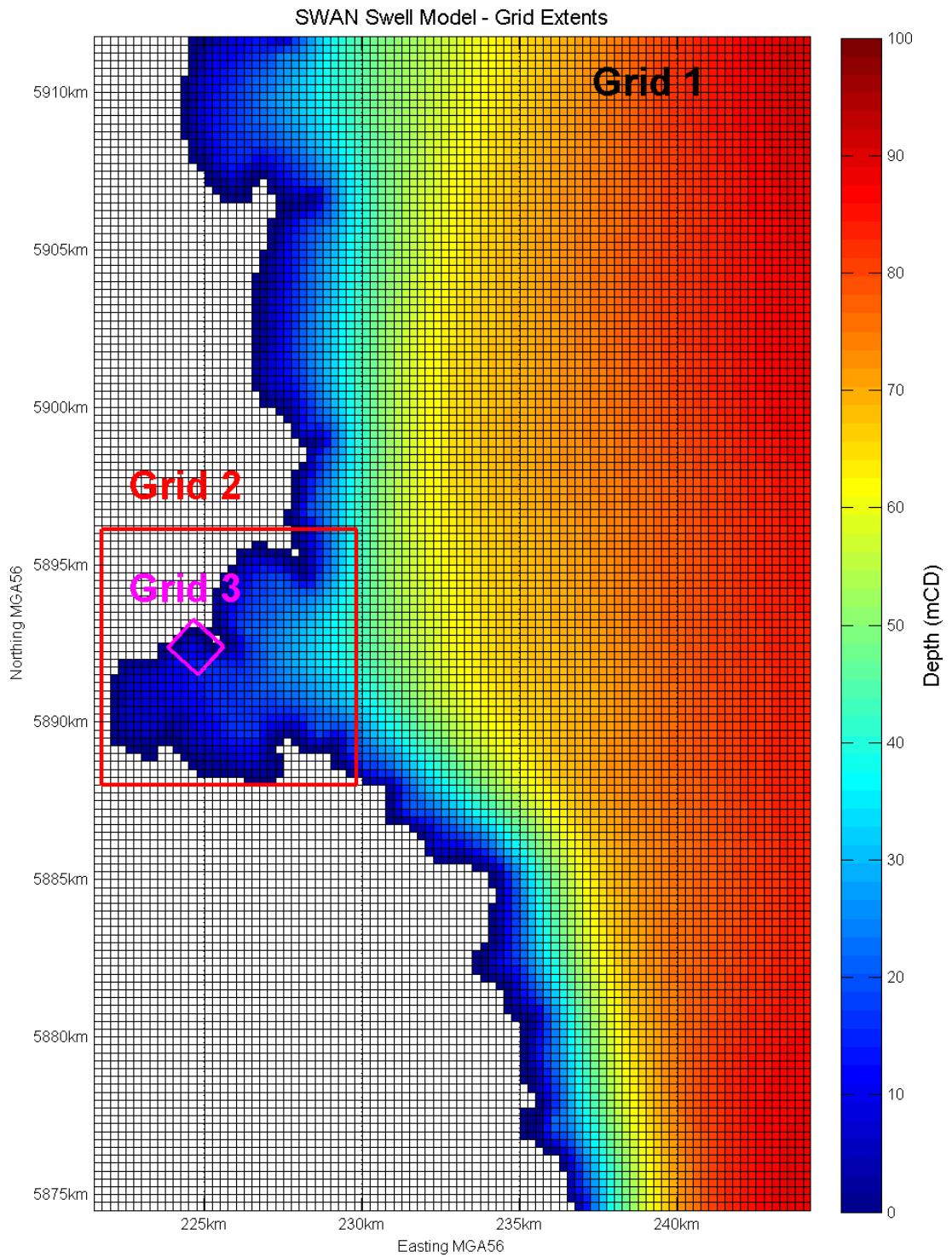
The SWAN wave model was used to investigate the propagation of waves into Twofold Bay / Eden Harbour. This model system was developed at the Delft Technical University and includes wind input (local sea cases), combined sea and swell, offshore wave parameters (swell cases), refraction, shoaling, non-linear wave-wave interaction, a full directional spectral description of wave propagation, bed friction, white capping, currents and wave breaking.

Model simulations were undertaken at Mean Sea Level (MSL) as this is the most common water level and is considered to be realistic for short and long term shoreline impact studies.

The bathymetry was prepared from the latest detailed bathymetry survey provided by the Port Authority of NSW (2015) as well as offshore bathymetric data from Mike C-MAP. The bathymetry for the developed case was updated based on the dredge footprint provided by Advisian on the 2<sup>nd</sup> March 2016 (Figure 1).

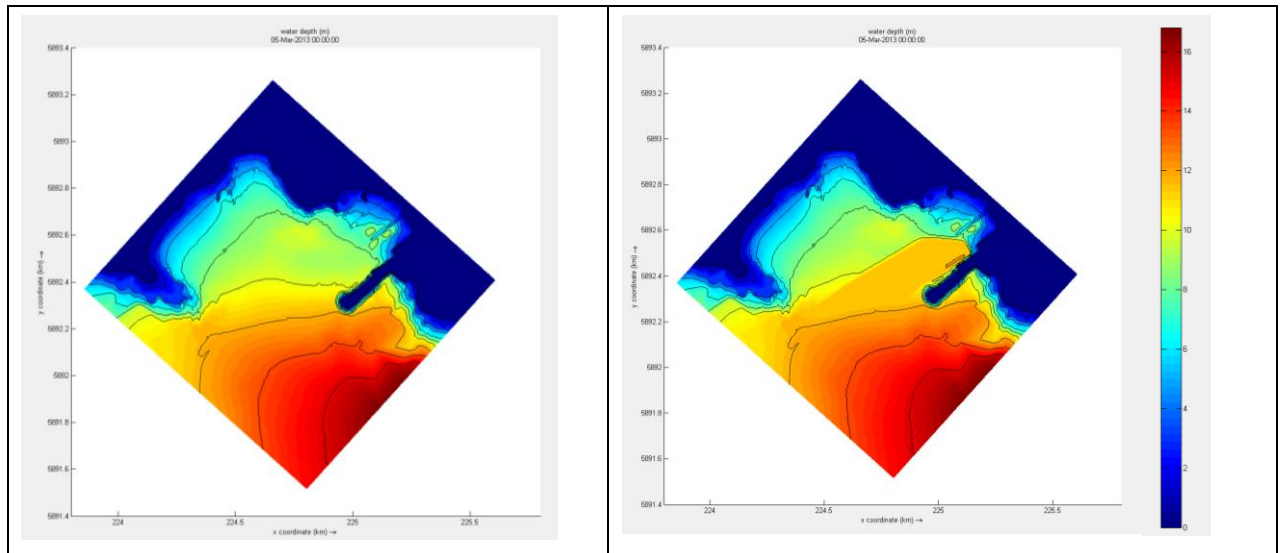
The grid system used for the SWAN modelling of wave conditions incorporated three rectangular grids. The grids progressively increase in spatial resolution with the finest detail being in Twofold Bay having a refined 5 m grid resolution in order to more accurately model the wave climate near the harbour. The three grids are detailed below and are shown in Figure 2.

- Grid 1: Spatial grid resolution of 250 m extending about 20 km North, 18 km South and 20 km offshore of Snug Cove;
- Grid 2: Spatial grid resolution of 150 m extending about 3.5 km North, 4.5 km South and 5 km offshore of Snug Cove; and
- Grid 3: Spatial grid resolution of 5 m extending about 1 km offshore of the proposed Snug Cove wave attenuator.



**Figure 2 Grid extent and offshore bathymetry for the SWAN model used for offshore swell conditions**

Figure 3 shows the finer grid and bathymetry for the existing and developed case. This finer grid covers an area from just East of Lookout Point to about 200 m Southwest of Cocora Point.



**Figure 3 Grid extent and model bathymetry for the Eden Harbour SWAN model (existing and developed case)**

### 3.2 Model Results

A hindcast modelling approach which considers all wave directions (i.e. directions at 22.5 degree intervals) was adopted. Waves from 17 directions combined with nine wave periods ( $T_p$ ) from 4.2 to 15.4 seconds were applied. These combinations amount to 153 basic simulation cases, such that all potential cases are considered. In each case offshore wave height was adopted to be 1.5 m.

Application of the 1.5 m offshore wave height to wave propagation processes in equation (1), see below, leads to slightly conservative inshore wave heights. This is because bed friction attenuation would be relatively greater for higher waves, but to the same extent in both the existing and changed seabed cases. This wave height ( $H_s=1.5$  m) is approximately the median offshore significant wave height.

Model application with offshore  $H_s = 1.5$  m provides realistic wave transfer coefficients,  $K_w$ , between offshore and inshore locations.

$K_w$  is defined by: -

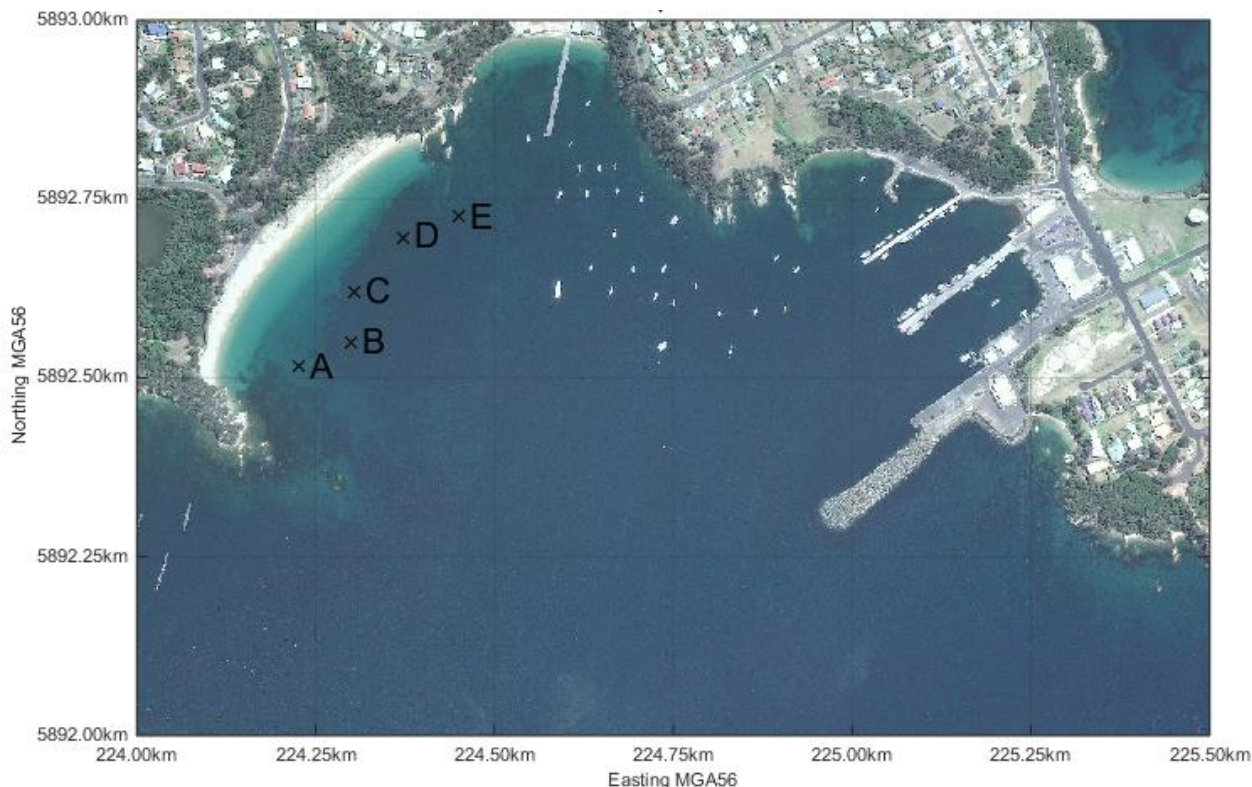
$$H_i = H_o \times K_w \quad (1)$$

where  $H_i$  is inshore wave height

$H_o$  is offshore wave height

$K_w$  depends on offshore wave period and direction and includes the wave transformation processes.

Locations along Cocora Beach were selected for the model output in order to assess the swell wave climate there. Shoreline locations were selected in a depth of about 6 m MSL, typically, see Figure 4.



**Figure 4 SWAN wave model output locations along Cocora Beach**

The results of SWAN modelling of swell wave propagation into Twofold Bay for the existing and developed cases provided 17 x 9 matrices of wave coefficients and weighted average wave directions at the model output locations.

Preparation of a 12 years offshore wave data set was undertaken using the Eden Waverider Buoy (Eden WRB) data, as obtained from Manly Hydraulics Laboratory (MHL), for the period between 2002 and 2013. Wave direction was only available from the Eden WRB from December 2011 to May 2013. Comparison between Eden and Batemans Bay wave data has been undertaken and has showed that the wave direction at Eden WRB had a greater variability with wave direction varying from North to South-West whereas Batemans Bay wave direction was mainly comprised between North-East and South. An inspection of the NOAA wave model data offshore Eden showed better agreement with the measured wave direction at Eden (from Dec 2011 to May 2013) and on this basis, NOAA model wave direction was used for the offshore time series for all records prior to December 2011. It was also considered suitable to use NOAA wave data to fill gaps in the Eden wave rider buoy data including significant wave height, period and wave direction where needed.

The wave coefficients, inshore wave period and directions were then combined with the 12 year offshore time series.. For each record in the dataset, inshore wave conditions (wave height, period and direction)

were calculated using a 3D matrix interpolation based on offshore wave height, offshore wave direction and offshore wave period.

### 3.2.1 Nearshore Comparison

Based on the 12 years inshore wave time series at each selected location near Cocora Beach, the principal parameters,  $H_e$  (effective significant wave height) and weighted mean wave direction  $\phi_m$  were calculated for the periods between each surveys,

These parameters describe the long term characteristics of wave height and direction as they affect sediment transport and are defined as below.

$$H_e = H_{50} e^{\sigma_y^2}$$

where  $H_{50}$  is the median wave-height defined by the log normal distribution =  $(H_{10} \times H_{90})^{1/2}$

$$y = \ln(H)$$

$$\sigma_y = \text{standard deviation of } y = 1/2.563 \ln(H_{10}/H_{90})$$

$$\text{Mean direction} = \frac{\sum H_{si}^2 T_{pi} \text{Dir}_i}{\sum H_{si}^2 T_{pi}}$$

The effective wave height was calculated based on all data records where significant wave height was greater than 0.1 m.

Results for effective wave height are plotted in Figure 5.

Results for mean wave direction are plotted in Figure 6.

Values for each parameter are provided in Table 1.

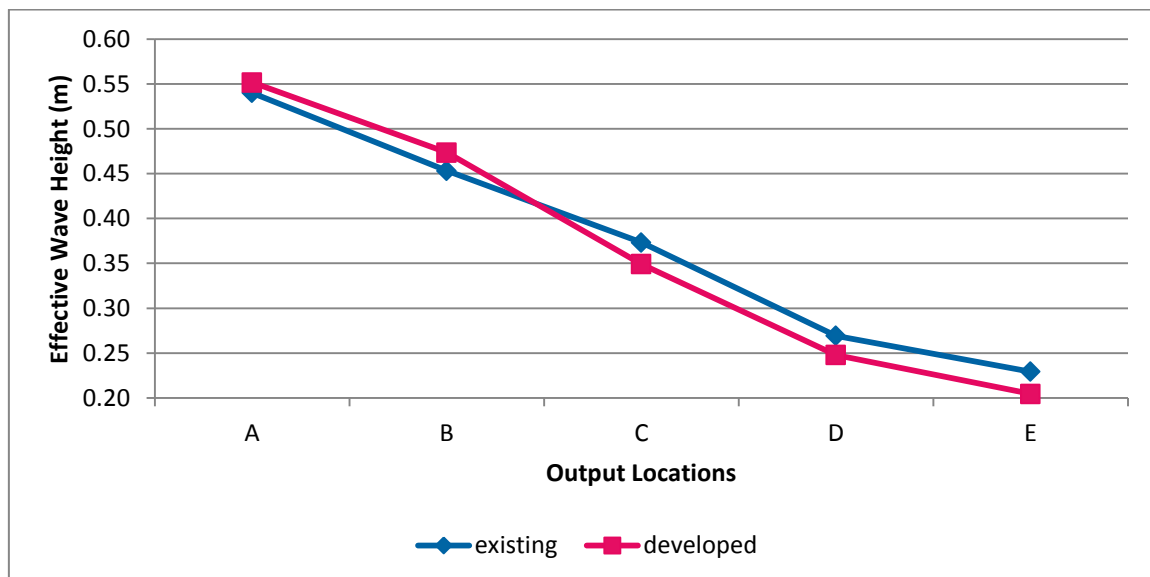


Figure 5 Effective wave height at each output location

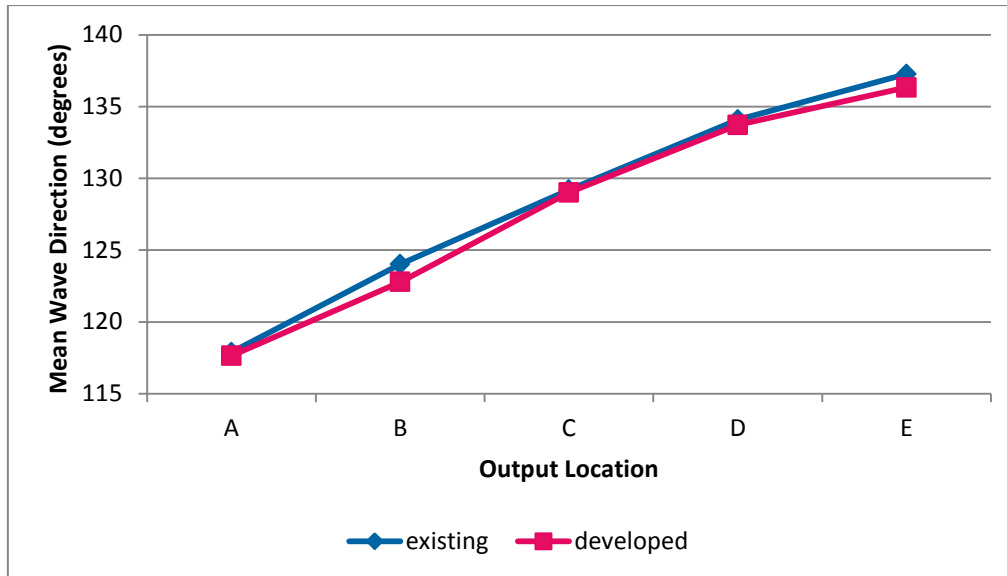


Figure 6 Mean wave direction at each output location

Table 1 Results for effective wave height and mean wave direction

| Output Location | Coordinates (MGA 56) |              | Existing |             | Developed |             |
|-----------------|----------------------|--------------|----------|-------------|-----------|-------------|
|                 | Easting (m)          | Northing (m) | He(m)    | Mean Dir(°) | He(m)     | Mean Dir(°) |
| A               | 224227               | 5892516      | 0.54     | 117.9       | 0.55      | 117.6       |
| B               | 224300               | 5892550      | 0.45     | 124.0       | 0.47      | 122.8       |
| C               | 224305               | 5892620      | 0.37     | 129.2       | 0.35      | 129.0       |
| D               | 224372               | 5892696      | 0.27     | 134.1       | 0.25      | 133.7       |
| E               | 224450               | 5892725      | 0.23     | 137.3       | 0.20      | 136.3       |

### 3.2.2 Extreme Nearshore Waves

The nearshore wave criteria for the modelling investigations have been determined through the analysis of wave data time series at the selected locations. From this analysis, the nearshore significant wave heights for the 100 and 50 year ARI have been determined.

Table 2 and Table 3 present the results of the wave data analysis, based on extreme value analysis on 12 years of data (from transfer of offshore MHL Eden WRB – data from year 2002 to 2013), using peak-over-threshold method and Weibull distribution for 100 year and 50 year average recurrence intervals (ARI).

**Table 2 Extreme Waves – 100 year ARI**

| Output Location | Coordinates (MGA 56) |              | Existing |       | Developed |       |
|-----------------|----------------------|--------------|----------|-------|-----------|-------|
|                 | Easting (m)          | Northing (m) | Hs(m)    | Tp(s) | Hs(m)     | Tp(s) |
| A               | 224227               | 5892516      | 3.11     | 10.4  | 3.21      | 10.4  |
| B               | 224300               | 5892550      | 2.68     | 10.4  | 2.80      | 10.5  |
| C               | 224305               | 5892620      | 2.41     | 11.1  | 2.27      | 11.1  |
| D               | 224372               | 5892696      | 1.83     | 11.3  | 1.68      | 11.3  |
| E               | 224450               | 5892725      | 1.53     | 11.3  | 1.36      | 11.4  |

**Table 3 Extreme Waves – 50 year ARI**

| Output Location | Coordinates (MGA 56) |              | Existing |       | Developed |       |
|-----------------|----------------------|--------------|----------|-------|-----------|-------|
|                 | Easting (m)          | Northing (m) | Hs(m)    | Tp(s) | Hs(m)     | Tp(s) |
| A               | 224227               | 5892516      | 2.95     | 10.1  | 3.04      | 10.2  |
| B               | 224300               | 5892550      | 2.54     | 10.2  | 2.65      | 10.2  |
| C               | 224305               | 5892620      | 2.28     | 10.8  | 2.15      | 10.9  |
| D               | 224372               | 5892696      | 1.73     | 11.0  | 1.59      | 11.1  |
| E               | 224450               | 5892725      | 1.45     | 11.1  | 1.28      | 11.1  |

## 4 Discussion

The results provided in Section 3.2 indicate that the proposed dredge footprint adjacent to the Eden Wharf will alter the wave climate at Cocora Beach. However the magnitude of this change is not expected to be significant.

The effective wave height is expected to decrease across the centre and northern segments of the beach while the southern end is expected to see a slight increase. This is coupled with a slight reduction in mean direction at all output locations. Such results can be explained by the deeper water of the dredge footprint which will encourage propagation of waves into the bay and reduce the potential of wave refraction.

For extreme events, the significant wave height follows a similar trend to that described above for effective wave height. Peak wave periods remain largely unaffected.

Regards

A handwritten signature in black ink, appearing to read 'Berthot', with a long horizontal stroke extending to the right.

**Alexis Berthot**

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