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Our reference: PA1042-100-100\_gwb300315-wave attenuator.docx  
Date: 8 April 2015

**Subject: CATTLE BAY MARINA – RESPONSE TO SUBMISSIONS ON EIS  
SUPPLEMENTARY STATEMENT ON WAVE ATTENUATOR AND  
POTENTIAL IMPACTS**

Dear Andrew

A number of submissions raised the issue of the proposed wave attenuator, including its final alignment, its potential impacts on adjacent shorelines, particularly Cocora Beach, and its potential impacts on the commercial mussel farm south and west of Cocora Point.

The following sections address the above matters.

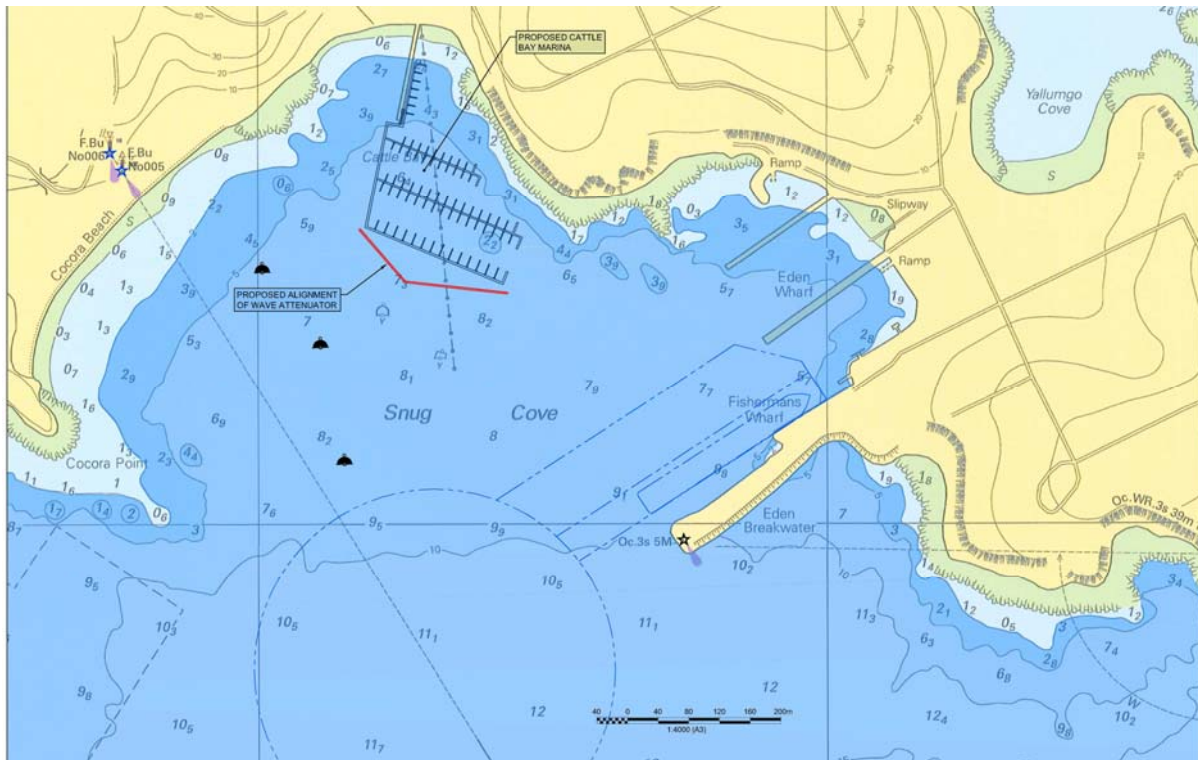
## **1 FINAL ALIGNMENT OF WAVE ATTENUATOR**

The proposed final alignment of the attenuator is 'cranked' rather than straight. The cranked alignment is shown in **Figure 1** and is the alignment modelled in the Cardno report 'Cattle Bay Marina, Eden – Wave Modelling' (Cardno, 28 July 2014). Accordingly, the modelling results in Cardno (2014) pertain to the wave attenuator proposed. It is not proposed or considered necessary to modify the alignment further<sup>1</sup>.

The cranked alignment has been adopted to avoid adverse impacts on Cocora Beach, as discussed further below. It is noted that a cranked alignment is preferred by Council for this reason (Council letter to Eden Resort Hotel, 18 February 2015).

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<sup>1</sup> A number of the Figures in the EIS showed a wave attenuator with a straight alignment. The design evolved through the EIS process to ultimately comprise the cranked alignment now proposed.



**Figure 1** Proposed Alignment of Wave Attenuator

## 2 POTENTIAL IMPACTS OF WAVE ATTENUATOR

### 2.1 General

The primary purpose of the wave attenuator is to moderate the local wind waves (seas) generated across Twofold Bay by strong winds from the south/south-south-west in order that the wave climate at the floating marina satisfies acceptable wave climate criteria in Australia Standard AS 3962-2001 'Guidelines for Design of Marinas'.

An attenuator designed principally to achieve the required reduction in the local seas will also, to an extent, attenuate the swell wave climate from the ocean. In addition, the attenuator will reflect some of the swell wave energy to other adjacent areas. The effects of these reflections must also be considered.

### 2.2 Wave Modelling

#### 2.2.1 General

An assessment of the potential impacts of the cranked wave attenuator has been undertaken utilising modelling techniques. The modelling was undertaken by Cardno on behalf of Royal HaskoningDHV. The results are set out in Cardno (2014) which was included as Appendix 16 of the EIS.

Cardno applied their calibrated SWAN wave model system of the region for much of the modelling, but also applied the MIKE-21 Boussinesq Wave (BW) system for verification. These wave modelling systems represent latest technology and best practice, and are briefly described below. The calibration and verification procedures adopted provide certainty for the modelling results.

It is also noted that the calibrated SWAN model adopted in this study was that developed by Cardno for Bega Valley Shire Council and the then Lands and Property Management Authority (LPMA), now NSW Trade & Investment Crown Lands, for the Eden Harbour Wave Modelling study undertaken in 2011 (Cardno, 2011).

### 2.2.2 SWAN Model

SWAN was developed at the Delft Technical University in The Netherlands 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. It also includes a nested grid capacity to facilitate computation by having fine grids at inshore locations where bathymetric and structure details vary significantly and coarser offshore grids where a larger model extent is required, but seabed bathymetric changes are generally smaller. This procedure allows efficient modelling to be undertaken without sacrificing resolution where it is needed.

Cardno have verified the SWAN model system for local sea conditions in Eden Harbour (as noted above), as well as for Botany Bay and Port Jackson. Swell calibration has been undertaken in Botany Bay, Port Kembla and Port Hedland, for example.

### 2.2.3 MIKE-21 Boussinesq Wave Model

The MIKE21 Boussinesq Wave (BW) is a state of the art numerical wave model developed by the Danish Hydraulics Institute (DHI), and generally used for the modelling of wave disturbance in ports, harbours and coastal areas. MIKE21 BW is based on the numerical solution of the time domain formulations of Boussinesq type equations, Madsen et al (1991, 1992, 1997a, b), Sorensen and Sorensen (2001) and Sorensen et al (2004).

MIKE21 BW is capable of reproducing the combined effects of all important wave phenomena of interest in ports, harbours and coastal engineering, including, shoaling, refraction, diffraction, wave breaking, bottom dissipation, moving shoreline, partial reflection, wave transmission, non-linear wave-wave interactions, frequency spreading and directional spreading,

The two dimensional wave model solves the Boussinesq type equations using a flux-formulation with improved frequency dispersion characteristics. The enhanced Boussinesq type equations make the models suitable for the simulation of the propagation of non-linear directional waves from deep to shallow water.

The MIKE21 BW model was used to conduct a more detailed investigation of swell wave propagation into Cattle Bay and Cocora Beaches and to validate the SWAN swell wave modelling.

## 2.3 Cocora Beach

Cocora Beach is situated to the west of Cattle Bay. It is approximately 460m long, faces south-east, and is exposed to a low energy swell. The beach is backed by a foreshore reserve and car park. It is a very popular recreational area for the local community.

The alignment of Cocora Beach is controlled, or driven, by the approach direction of swell waves from the ocean. The low energy of the swell contributes to the beach being a safe area for swimming. It is very important that the proposed wave attenuator for Cattle Bay Marina does not impact adversely on Cocora Beach by possibly reflecting swell waves towards the beach which could affect swell wave direction along the beach (thus beach alignment) and/or swell wave energy along the beach.

The modelling by Cardno confirmed that the wave attenuator would not cause significant changes to the swell wave direction and energy along Cocora Beach since:

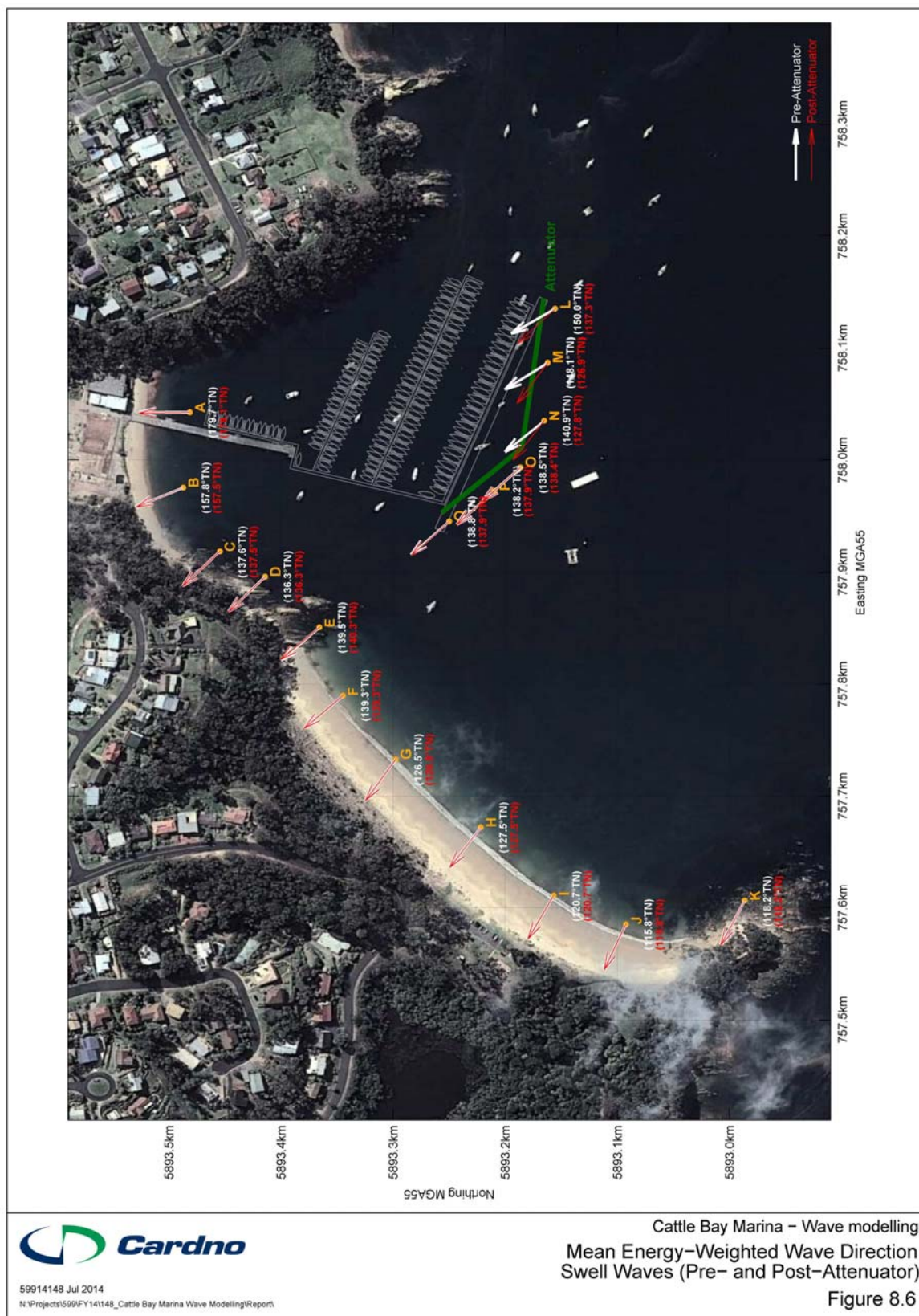
- the eastern section of the attenuator is aligned such that reflected swell wave energy is directed south of Cocora Beach<sup>2</sup>;
- the western section of the attenuator is well aligned with the incoming swell direction and does not cause reflection of swell waves.

**Figure 2** is a copy of Figure 8.6 from Cardno (2014) and shows the mean energy-weighted wave direction for swell waves along Cocora Beach pre and post the wave attenuator. The alignment of the wave attenuator is shown in green. **Table 1** summarises the mean energy-weighted swell wave directions along Cocora Beach pre and post the attenuator. It is apparent that there is no predicted change to swell wave direction as a result of the proposed wave attenuator.

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<sup>2</sup> The potential for this reflected swell to impact on the commercial mussel farm south and west of Cocora Point is discussed in **Section 2.5**.





**Figure 2** Mean Energy – Weighted Wave Direction Swell Waves

**Table 1** Mean Energy-weighted Wave Direction for Swell Waves Pre and Post the Attenuator for Cocora Beach

Location	Mean energy-weighted swell wave direction	
	Pre-attenuator	Post-attenuator
F	139.3° TN	139.3° TN
G	126.5° TN	126.5° TN
H	127.5° TN	127.5° TN
I	120.7° TN	120.7° TN
J	115.8° TN	115.8° TN

**Figures 3 and 4** are copies of Figures 9.6 and 9.7 from Cardno (2014) and show the wave energy at two locations along Cocora Beach (Location G and Location I) pre and post the wave attenuator for two swell wave periods  $T_p$  ( $T_p = 10$  seconds and  $T_p = 15$  seconds).

**Figures 3 and 4** show there is minimal change to swell wave energy along Cocora Beach as a result of the proposed wave attenuator.

## 2.4 Cattle Bay Beach

Cattle Bay Beach is the name which has been given for reporting purposes to the sandy beach at Cattle Bay in front of the old cannery site. It is situated in the lee of the proposed wave attenuator.

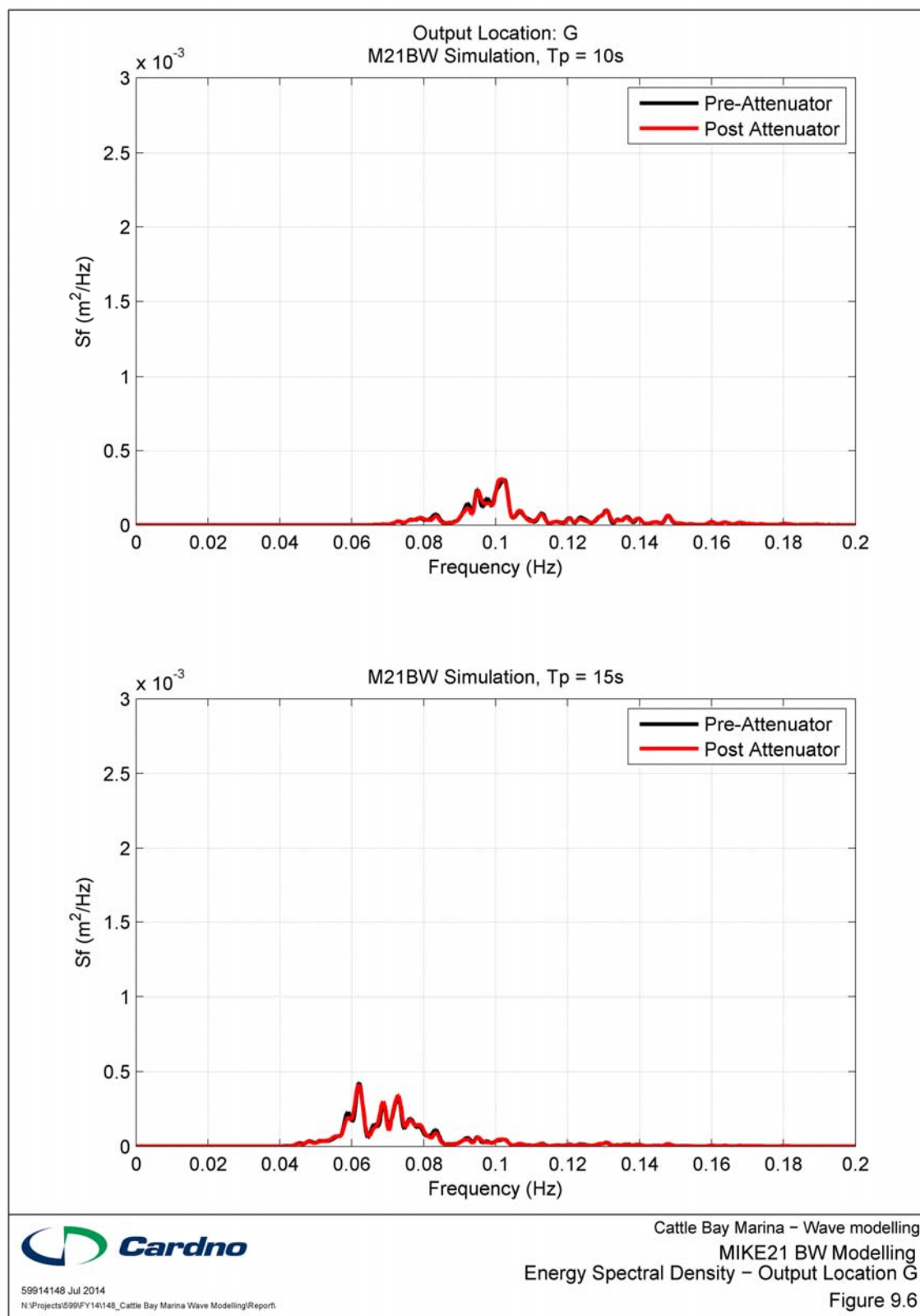
The alignment of Cattle Bay Beach is driven by both swell and local sea waves. For these reasons and given it is situated in the lee of the proposed wave attenuator, it can be expected that the alignment of the beach and the wave energy conditions along it would be affected by the wave attenuator.

In terms of wave energy, the beach will become more sheltered and fluctuate less in response to ocean storms and episodes of strong wind waves from the south/south-south-west. This is not viewed as necessarily an adverse impact.

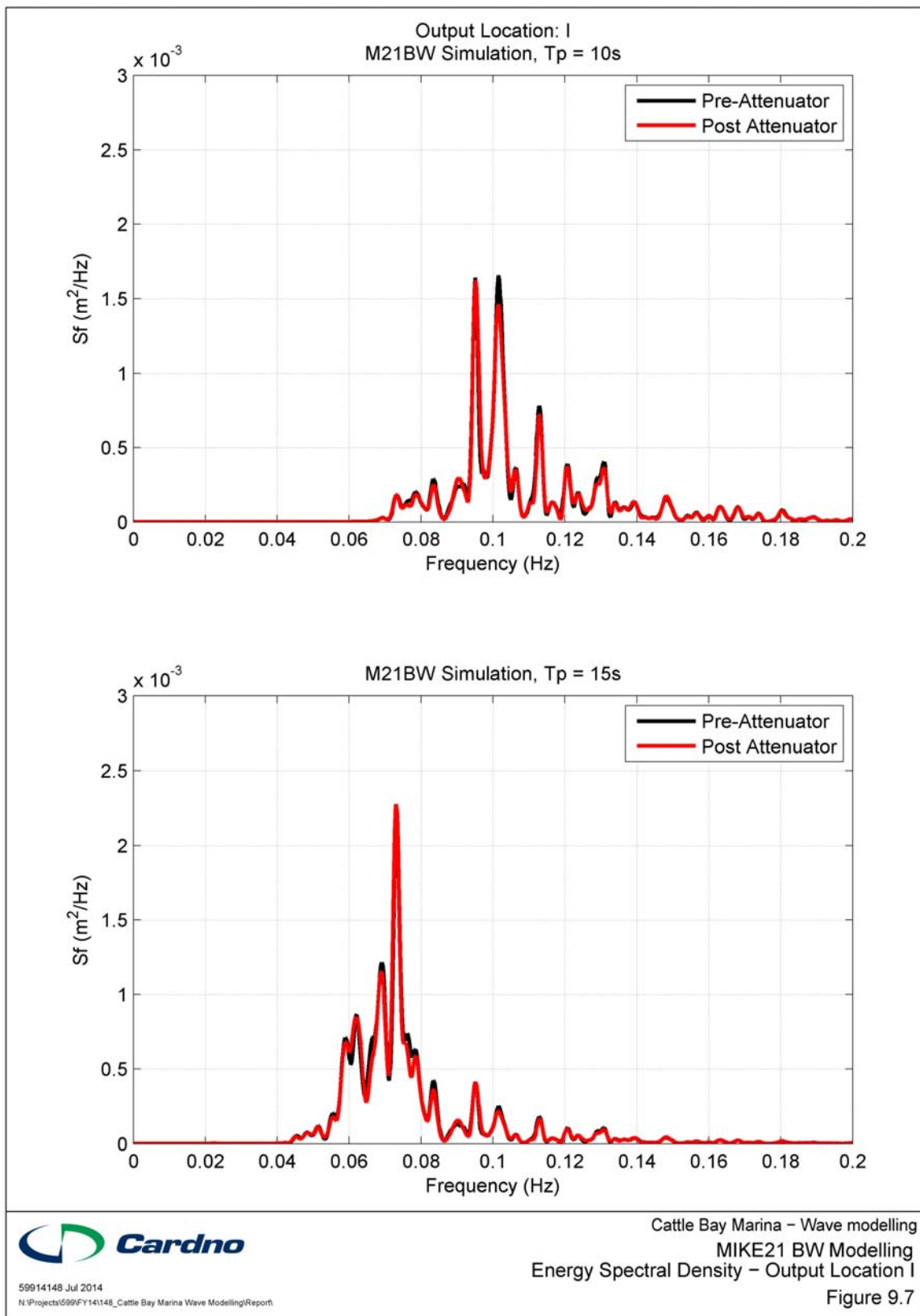
In terms of beach alignment, **Figure 5** (a copy of Figure 8.9 from Cardno, 2014) shows the predicted change in alignment as a result of the wave attenuator. It is expected that over time the beach would rotate in a clockwise direction, with a 8.5m landward movement at the western end and a 7m seaward movement at the eastern end, ie. a sandy beach would be retained (not lost) but it would be narrower at the western end and wider at the eastern end.

## 2.5 Commercial Mussel Farm

A submission to Bega Valley Shire Council by the NSW Cultured Mussel Growers Association (February 2015) has noted that too little weight has been given in the EIS to the potential impacts on mussel farm infrastructure of swell waves reflected off the wave attenuator. This infrastructure is located to the west of Cocora Point approximately 470m south-west of the proposed wave attenuator. The point made by the Association is reasonable, accordingly a specific examination has been made of this issue.



**Figure 3** Energy Spectral Density – Output Location G



**Figure 4** Energy Spectral Density – Output Location I





**Figure 5** Beach Alignment Change Cattle Bay Beach

Cardno, on behalf of Royal HaskoningDHV, has extracted and analysed wave modelling results from the modelling undertaken for the EIS but at new locations in the vicinity of the mussel farm. The outcome of this work is included in a Cardno letter dated 16 March 2015, a copy of which is included in **Attachment A**.

The examination of the modelling results by Cardno has shown that the proposed wave attenuator would have only minimal effects on wave heights, wave directions and wave energy at the location of the mussel farm. The reason is that the mussel farm is sufficiently distant from the proposed attenuator (470m) that reflected waves off the attenuator would be able to disperse over the intervening and surrounding waterway area.

## **2.6 Effect of Reflected Waves on Existing Vessels at Swing Moorings**

Roads & Maritime Services (RMS) has raised concerns at the potential impacts of waves reflected from the proposed wave attenuator on existing vessels at swing moorings located offshore from the attenuator (letter to Bega Valley Shire Council 11 December 2014).

The above issue was recognised in the EIS where it was noted that a section of waterway some 50 to 100m wide offshore from the attenuator may be unsuitable for moorings and that provision of swing moorings in the general area should be subject to a trial (refer Section 6.9.1 of EIS).

In more recent discussions with RMS (March 2015) as part of the development of a Swing Mooring Relocation Strategy, RMS has advised that all existing swing moorings located in the reflection zone seaward of the wave attenuator must be relocated. This requirement has been adopted in the preparation of the Swing Mooring Relocation Strategy (refer separate response) hence this issue has been addressed.

## **3 REFERENCES**

Cardno (2014): Cattle Bay Marina, Eden. Report 59914148  
Prepared for Royal HaskoningDHV

Cardno (2011): Eden Harbour Wave Modelling. Report LJ2916/R2685  
Prepared for the Land and Property Management Authority – Crown Lands NSW and Bega Valley Shire Council.

Madsen, P.A., Murray, R and Sorensen, O.R. (1991)  
A new form of the Boussinesq Equations with improved Linear Dispersion Characteristics (Part 1)  
Coastal Eng., 15, 371-388.

Madsen, P.A., Murray, R and Sorensen, O.R. (1992)  
A new form of the Boussinesq Equations with improved Linear Dispersion Characteristics (Part 2)  
Coastal Eng., 18, 183-204.

Madsen, P.A. and Sorensen, O.R. and Schaffer, H.A. (1997a)  
Surf Zone Dynamics Simulated by a Boussinesq type model. Part 1: Model description and cross shore motion of regular waves. Coastal Eng., 32, 255-288.

Madsen, P.A. and Sorensen, O.R. and Schaffer, H.A. (1997b)  
Surf Zone Dynamics Simulated by a Boussinesq type model. Part 2: Surf beat swash zone oscillations for wave groups and irregular waves. Coastal Eng., 32, 289-320.

Sorensen, O.R., Schaffer, H.A. and Sorensen, L.S. (2001).  
Boussinesq type modelling using an unstructured finite element technique.  
In Proc.I 27<sup>th</sup> Coastal Eng Conf. 190-202.

Sorensen, O.R., Schaffer, H.A. and Sorensen, L.S. (2004).  
Boussinesq type modelling using an unstructured finite element technique.  
Coastal Eng., 50, 181-198.

Please contact the undersigned should you require any clarification or additional information.

Yours faithfully  
Haskoning Australia Pty Ltd



G W Britton  
Resident Director

**Attachment A – Cardno letter (16 March 2015)**

Our Ref 59914148/L001: CJB

Contact Chris Beadle



16 March 2015

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Attention: Mr Greg Britton

## **CATTLE BAY MARINA – MUSSELL FARM IMPACT ASSESSMENT**

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Dear Sir,

Web: [www.cardno.com.au](http://www.cardno.com.au)

### **Introduction**

In 2014, Cardno was commissioned by Royal Haskoning DHV (RHDHV) to undertake numerical wave and current modelling for a proposed marina layout at Cattle Bay, situated in northern Twofold Bay, NSW (Cardno, 2014) – see **Figure 1**. The proposed marina layout included a cranked wave attenuator which was designed to reflect some swell wave energy to the south of Cocora Point in order to obviate adverse impacts at Cocora Beach. Cardno (2014) concluded that the cranked wave attenuator successfully achieved this design aim.

RHDHV has advised that the NSW Mussel Growers Association has prepared a submission expressing concern that the proposed wave attenuator will result in increased swell energy at the site of the Twofold Bay mussel farm, which is situated to the south of Cocora Point, and approximately 470 m south-west of the proposed wave attenuator. Consequently there is a need to undertake an assessment of the effects of the wave attenuator on the wave climate in the vicinity of the mussel farm. In March 2015 Cardno was commissioned by RHDHV to undertake this study, utilising the results of wave modelling conducted as part of the previous investigation (Cardno, 2014).

The aim of the study is to assess the wave climate in the vicinity of the mussel farm before and after the installation of the proposed wave attenuator, and highlight any potential changes.



## Methodology

The work was comprised of the following tasks, as outlined below.

### Wave Climate

As part of Cardno (2014), Cardno conducted wave hindcast modelling for both sea and swell waves. As the SWAN model implemented for this task also covered the mussel farm region, results from the previous modelling exercise were extracted and analysed - but at new locations in the vicinity of the Mussel Farm. These locations are depicted in **Figure 1**.

Using these model results, an assessment of the design wave heights and directions for local sea waves, swell waves and a combined sea and swell case were determined in the study area for both pre and post wave attenuator scenarios.



**Figure 1 – Approximate Extent of Mussel Farm (red outline) and most relevant SWAN Model output locations.**

Further details of the SWAN Wave modelling conducted previously can be found in Section 7 of Cardno (2014).

### Wave Spectra

As part of Cardno (2014), MIKE21 Boussinesq Wave (BW) modelling was conducted in order to validate the SWAN swell modelling results, and assess potential changes to swell wave spectra in the study area. Figure 9.1 of Cardno (2014) shows that the MIKE21 BW model set-up doesn't cover the mussel farm in its entirety, with the western and south-western extent of the mussel farm buoys outside the model domain. However, as the eastern and north-eastern extents of the mussel farm are within the model domain, wave spectra can be assessed for these regions. Theoretically, if the results show that the effects of the attenuator in these regions are minimal, then it would be reasonable to assume that the regions outside the model domain would be similarly or less affected.

Further details of the MIKE21 BW modelling conducted previously can be found in Section 9 of Cardno (2014).

## Results

### Wave Climate

The effects of the wave attenuator on design wave criteria were assessed by estimating ARI wave heights from the modelled inshore wave data, for both the pre- and post-attenuator situations. This was achieved by fitting a Weibull distribution to independent peak storm wave heights exceeding the 98th percentile. **Table 1** shows the estimated 1-year ARI and 50-years ARI wave heights at the nominated output locations (see **Figure 1**).

**Table 1 - Design Wave Heights for Local Sea and Swell (Pre- and Post-Attenuator)**

Significant Wave Height, $H_s$ (m)	Local Sea Waves				Swell Waves			
	Pre-Attenuator		Post-Attenuator		Pre-Attenuator		Post-Attenuator	
	1 year ARI	50 years ARI	1 year ARI	50 years ARI	1 year ARI	50 years ARI	1 years ARI	50 years ARI
Output Location								
MF1	0.76	1.07	0.78	1.09	1.75	2.33	1.75	2.33
MF2	0.79	1.10	0.80	1.11	2.20	3.32	2.20	3.32

These results show that the presence of the attenuator has only a minimal impact on the design significant wave heights in the mussel farm region. Design local sea wave heights post-attenuator are slightly higher for both output locations, in the order of 1 to 2%. This is beyond what could reasonably be discerned in the field through observation. The presence of the attenuator has little to no effects on the design swell wave heights, as is shown in **Table 1**.

**Figures 2 to 4** present energy-weighted mean wave directions for swell waves, local sea waves and combined swell/local sea for both the pre- and post-attenuator situation. These figures show that the effect on energy-weighted mean wave directions is minimal, with changes of the order of half a degree, or less.

These results confirm that any reflected swell wave energy largely disperses before reaching the mussel farm region so that changes in wave conditions are minimal.



**Figure 2 – Mean Energy-Weighted Wave Direction – Swell Waves**





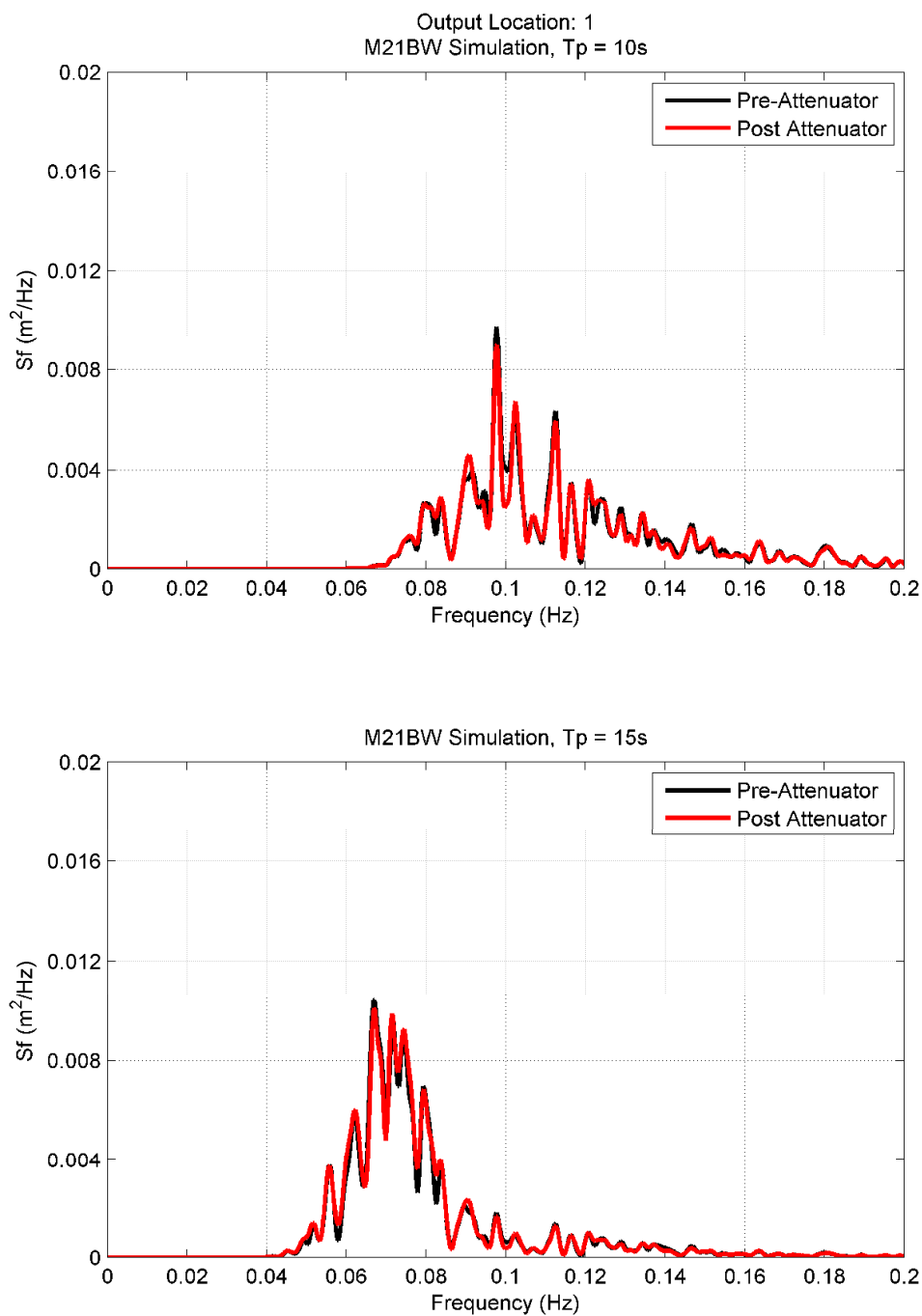
**Figure 3 – Mean Energy-Weighted Wave Direction – Local Sea Waves**



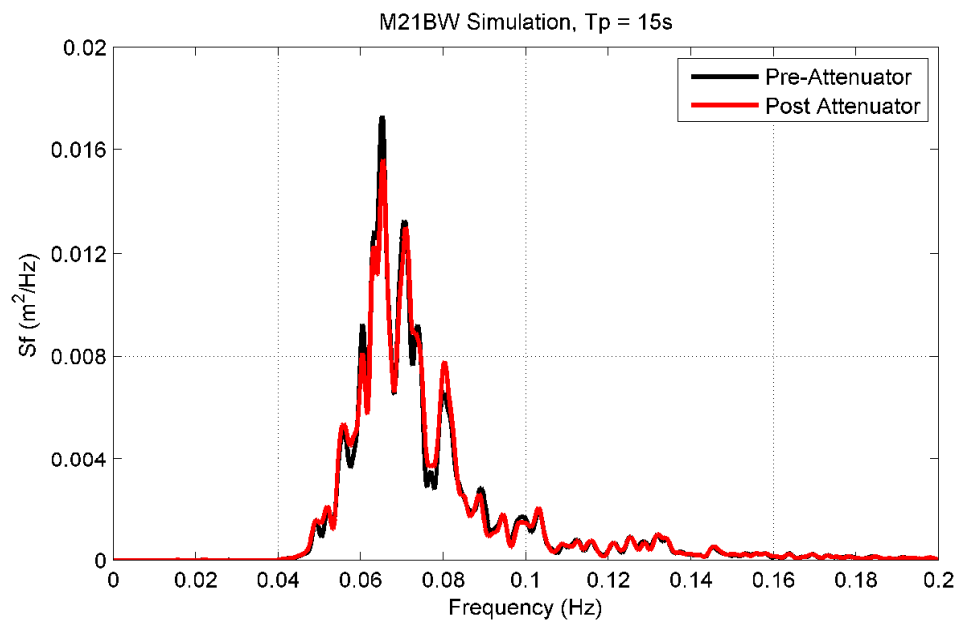
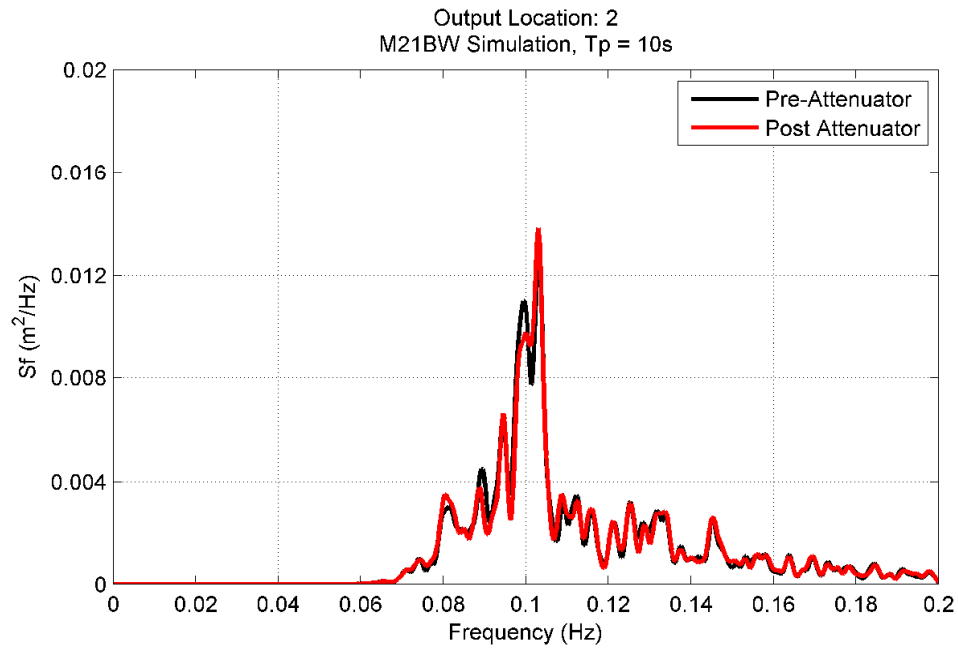
**Figure 4 – Mean Energy-Weighted Wave Direction – Combined Swell and Local Sea Waves**

### Wave Spectra

The results of the previous MIKE21 BW modelling were extracted and the energy spectral density functions were assessed for the output locations depicted in **Figure 1**, for wave periods of both  $T_p = 10s$  and  $T_p = 15s$ . These functions are depicted in **Figures 5** and **6**, and show that there is minimal observed change to the energy spectral densities at these locations. This is consistent with Figures 9.3 and 9.5 of Cardno (2014), which showed that there was only minimal change to wave coefficients for the penetration of Tasman Sea swell. These figures also indicate that only minor changes to swell wave energy in the mussel farm region would be caused by the proposed wave attenuator.



**Figure 5 – Energy Spectral Density - Output Location MF1**



**Figure 6 – Energy Spectral Density - Output Location MF2**



## Discussion Concluding Remarks

The SWAN and MIKE21 BW modelling results showed that the implementation of the wave attenuator would have only minimal effect on wave heights, directions and energy spectral density at the locations depicted in **Figure 1**. It should be noted that one of the output locations is situated outside of the mussel farm region, but *closer* to the attenuator. Consequently, it is then reasonable to purport that other locations within the mussel farm that are either as close, or farther, from the wave attenuator would be either equally or less affected.

The reason that the influence is minimal is likely to be the distance of the mussel farm from the attenuator structure. The northern extent of the mussel farm is over 470 m south-west of the proposed wave attenuator, and it is likely that a significant amount of reflected wave energy is dispersed over this expanse. Generally, wave heights diminish in proportion to the inverse square of distance from a finite-length, reflecting surface.

If you have any questions or comments regarding this project or the content of this letter please do not hesitate to contact Chris Beadle on (02) 9496 7851, or [christopher.beadle@cardno.com.au](mailto:christopher.beadle@cardno.com.au).

Yours faithfully,

A handwritten signature in black ink, appearing to read "Beadle".

Christopher Beadle

Coastal Engineer – Water and Environment

For **Cardno (NSW/ACT) Pty Ltd**

## References:

Cardno (2014). Cattle Bay Marina, Eden – Wave Modelling. *Prepared for Royal HaskoningDHV*