Cove Sailing Club Marina Development, Whitepoint, Cobh, Co. Cork

Hydrodynamic Study

Date: *January 2010*

Job No: *C/293*

Client: *Cove Sailing Club*

Cronin Millar
Consulting Engineers
Civil • Marine • Structural • Environmental

Report Contents

Revision Control Table & Document History Record

Rev.	Date	Description & Reason for Issue	Orig.	Chkd.	App.
1	*26/04/2010*	*For Pre Planning Meeting*	*SMC*	*AC*	*AC*
2	*12/07/2010*	*Issued for Planning*	*SMC*	*AC*	*AC*
1	*05/01/2011*	*Issued for Foreshore*	*CC*	*SMC*	*AC*

1.0 Introduction

1.1 Background to Study

Cove Sailing Club intends to install a 74 berth marina with associated infrastructure at Whitepoint, Cobh, Co. Cork. The purpose of this report is to provide suitable hydrodynamic information to aid in the design and subsequently the Planning Permission and Foreshore Lease/Licence for the marina development. A planning application for the proposed marina was granted on 14 December 2010 (Planning Reg. No: 10/52015). The information in this report is now being submitted as part of Cove Sailing Club's Foreshore Lease/Licence application.

1.2 Modelling Process

Locally generated wind waves are the most critical at this site. An analysis of wind and wave characteristics at the proposed marina site was carried out using the recommendations of the British Yacht Harbour Association, HR Wallingford and BS6399-1:1996 (Loading for Buildings) amongst other recommended texts.

The magnitudes of wind generated waves can be estimated by empirical methods. The method to be used in this case is the Airy (Linear) Wave Theory. The results of this method were compared with results using the Donelan/JONSWAP method and the appropriate design wave was established. The design wave was then factored by various wave transformation coefficients to obtain site specific wave data.

1.3 Site Description

The proposed marina location is at Whitepoint, Cobh on the south shore of the Great Island, Cork Harbour (see Appendix 1). The site is located adjacent to the main navigation channel in Cork Harbour.

Offshore waves propagating through the mouth of Cork Harbour have a negligible effect at Whitepoint. The site is exposed to wind generated waves from an easterly direction. Wind waves generated from the prevailing south and west directions are relatively small in magnitude due to the shelter provided by Whitepoint, Haulbowline Island, and Spike Island.

Current movements in the Cork Harbour are complex and variable and predominantly influenced by tide. Fresh water inputs from the River Lee also have an effect on currents. A considerable tidal current is experienced at Whitepoint. This generally occurs in the centre of the main navigation channel during the middle of the tidal cycle, and is experienced to a lesser extent at the site of the proposed marina.

1.4 Proposed Marina Development

The proposed works will comprise the installation of a 74 berth marina with associated infrastructure. The marina berths will be protected by an array of floating concrete breakwaters. All marina components will be anchored using a chain and anchor system. Land side access to the marina will be via a fixed platform and aluminium gangway from the quay wall at the 'Five Foot Way'. See Appendix 2 for the proposed marina layout.

2.0 Field Data

2.1 Bathymetric Survey

A bathymetric survey was carried out by Hydrographic Surveys Ltd. in September 2010. This survey was used to determine maximum and minimum water depths at various tidal stages at critical points of the marina. This survey was carried out to local Chart Datum (CD) and to Ordnance Datum Malin.

2.2 Tide Levels

Tide level information for Cork Harbour is as follows:

Tide Datum	HAT	MHWS	MHWN	MLWN	MLWS	LAT
Tide Level (CD)	+4.5m	+4.1	+3.2	+1.3	+0.4	-0.1

Table 1: Cork Harbour Tide Level Information (Adapted from Admiralty Tide Tables)

2.3 Tidal Flows

Tidal flows at Whitepoint are caused by the water level differences in Cork Harbour during the different tidal phases. Fresh water inputs from the River Lee also have a small effect on current velocities.

The maximum charted tidal flow (current) in the vicinity of the marina is 1.0m/s (2kt) for both the ebbing and flooding tide. *(Ref British Admiralty Chart 1777).* This is the maximum charted tidal flow within the centre of the channel and is expected to be lower at the site of the marina. This is due to side friction experienced at the side of channels and the shelter provided in the lee of Whitepoint. The maximum expected tidal flow at the site of the marina would be in the order of 0.5 – 0.75m/s (1-1.5kt). These current velocities will not have a negative impact on navigation within the marina basin, even for inexperienced users.

The proposed marina development will have a negligible effect on the cross section area of the channel at Whitepoint, therefore effects on current velocities will be negligible. The chain and anchor system will be designed such as to resist the anticipated flow. No solid structure (such as a sea wall) will be constructed for these works, and dredging will not be carried out. This means that there will be no change to the cross section and no impact to the sediment regime.

2.4 Wind Data

Design wind speeds were obtained from BS6399-1:1996 (as recommended by HR Wallingford when site specific data is unavailable).

The following wind speed data has been obtained for Cork Harbour site for a maximum wind speed averaged over 15 minutes:

Return Period (years)	1	5	10	20	50	100
Wind Direction	**Wind Speed (m/s)**					
0^{0} North	12.65	15.67	16.61	17.55	18.88	*19.82*
15^{0}	12.24	15.17	16.08	16.99	18.27	*19.18*
30^{0}	11.84	14.66	15.55	16.43	17.67	*18.55*
45^{0}	11.84	14.66	15.55	16.43	17.67	*18.55*
60^{0}	11.84	14.66	15.55	16.43	17.67	*18.55*
75^{0}	11.92	14.76	15.65	16.54	17.79	*18.68*
90^{0} East	12.00	14.86	15.76	16.65	17.91	*18.80*
105	11.92	14.76	15.65	16.54	17.79	*18.68*
120^{0}	11.84	14.66	15.55	16.43	17.67	*18.55*
135^{0}	12.40	15.37	16.29	17.22	18.51	*19.44*
150^{0}	12.97	16.07	17.04	18.00	19.36	*20.33*
165^{0}	13.38	16.57	17.57	18.57	19.96	*20.96*
180^{0} South	13.78	17.07	18.10	19.13	20.57	*21.60*
195^{0}	14.43	17.88	18.95	20.03	21.54	*22.61*
210^{0}	15.08	18.68	19.81	20.93	22.51	*23.63*
225^{0}	15.65	19.38	20.55	21.72	23.35	*24.52*
240^{0}	16.21	20.09	21.30	22.51	24.20	*25.41*
255^{0}	16.13	19.99	21.19	22.39	24.08	*25.28*
270^{0} West	16.05	19.89	21.08	22.28	23.96	*25.16*
285^{0}	15.40	19.08	20.23	21.38	22.99	*24.14*
300^{0}	14.75	18.28	19.38	20.48	22.02	*23.12*
315^{0}	14.03	17.37	18.42	19.47	20.93	*21.98*
330^{0}	13.30	16.47	17.46	18.45	19.84	*20.84*
345^{0}	12.97	16.07	17.04	18.00	19.36	*20.33*

Table 2: Design Wind Speeds (Adapted from BS6399-1:1996)

3.0 Offshore Wave Propagation

Offshore waves (or swell) are waves of long periods and wavelengths. They are generated long distances away from a site and eventually arrive at a site in an orderly wave train because the energy in individual waves is dissipated by internal friction. They generally have smaller wave heights than locally generated waves and occur on coastal sites.

Offshore waves incident at the Mouth of Cork Harbour are generated in the North Atlantic and Celtic Sea. These waves can result in a 'confused' sea state at the Harbour's Mouth where the energy is dissipated. Offshore waves generally do not propagate north of Dognose point (near Carlisle Fort).

The site of the proposed Cove Sailing Club Marina is extremely well protected from offshore waves. It is located approximately 7km from the Mouth of Cork Harbour. The wave energy is dissipated at the mouth of the harbour and the large distance to the marina site means that any residual wave energy is extremely unlikely.

The location of Spike Island, Haulbowline Island and the Spit Bank offer further protection to the proposed marina site. Offshore waves would have to refract and diffract nearly 90 degrees in order to propagate in the direction of the site. This refraction and diffraction cannot occur here due to the large water depths in the harbour.

Irish Hydrodata Ltd. carried out wave measurements between December 2004 and April 2008 on behalf of Ascon Ltd. for a proposed marina development east of Cobh town. The data collected showed that wave swell wave heights at the site are negligible. Over this period, the highest wave height found was 0.7m with an associated wave period of 3.14 seconds. The short period indicates that this was a wind generated wave.

This information has been verified through consultation with local boat users and the Port of Cork who state that swell waves do not occur at the proposed site.

Terminology:

Wave Refraction: *Occurs where a wave propagates to shallower water. The part of the wave advancing in shallower water moves more slowly than that part still advancing in deeper water, causing the wave crest to bend towards alignment with the underwater contours and to cause a change in wave height.*

Wave Diffraction: *Occurs where a wave train is interrupted by a barrier such as a rubble mound breakwater. Waves propagate into the lee of the breakwater in circular arcs radiating from the head of the breakwater. Wave heights in the lee are significantly less than the incident wave height.*

4.0 Wind Wave Modelling

4.1 Methodology

Wind generated waves are of many different wave heights and periods and generally propagate more or less in the wind direction. Wind generated waves are the most significant waves to be considered at this site. The characteristics of these waves are predominantly dependant on fetch length (length of water over which a given wind has blown) and design wind speed (from table 2). These variables are then applied to the applicable wave equations. In this case, the Airy Wave Theory method and the Donelan/JONSWAP method were used.

This study allows for the determination of wave characteristics at a given point in the marina. As this is a complex process, 'worst case scenario' points in the marina were selected.

4.2 Fetch Length

The maximum fetches relevant to the site of the proposed marina are indicated on the fetch layout drawing (see appendix 3). The most critical fetches are Fetch 10 (6400m), Fetch 11 (8225m) and Fetch 12 (5910m), all to the East, from where the site is most exposed. The fetch lengths to the North, West and South are quite low and therefore the site is quite sheltered from these winds.

4.3 Adjusted Wind Speed

The marina shall be designed for a 50 year wind event. The design wind speeds for the appropriate fetches were interpolated from table 2 and then increased by an 'over-water speed-up factor' as recommended by McConnell (1998). This factor is dependant on the fetch length and 'accounts for the effect of reduced friction over water'.

Adjusted Wind Speed					
Fetch No	**Fetch Distance (m)**	**Orientation (deg)**	**V (m/s)**	**Sw**	**U_a (m/s)**
1	1410	225	24.1	1.118	26.9
9	5270	105	18.4	1.264	23.2
10	6400	90	18.5	1.283	23.7
11	8225	81	18.4	1.301	23.9
12	5910	75	18.3	1.278	23.4

Where V = *Design Wind Speed (from table 2)*
Sw = *Over-water speed-up factor (from McConnell (1998))*
U_a = *Adjusted wind speed*

Table 3: Adjusted Wind Speeds (Top 5 fetches only)

4.4 Determination of Wave Characteristics Using the Linear Wave Theory (Airy Wave Theory)

The Linear Wave Theory (Airy Wave Theory) is a simplified empirical approach used to determine wave characteristics.

The significant wave height (H_s) and the mean wave period (T_m) were calculated using this approach. The time taken to develop these wave characteristics (t) was also calculated. Table 4 summarises the critical wave characteristics for the site using Linear Wave Theory.

Fetch No.	Fetch Length (m)	Hs (m)	Tm (sec)	t (minutes)
1	1410	0.516	2.095	22.5
9	5270	0.859	3.094	56.9
10	6400	0.968	3.325	64.3
11	8225	1.108	3.627	75.8
12	5910	0.920	3.226	61.2

Table 4: Critical Wave Characteristics (Linear/Airy Wave Theory)

4.5 Determination of Wave Characteristics Using the Donelan/JONSWAP Method

The Donelan/JONSWAP Method to calculate wave characteristics was applied in order to verify the characteristics calculated in section 3.4. The peak wave period (Tp) was also calculated. Table 5 summarises the critical wave characteristics for the site using the Donelan/JONSWAP method:

Fetch No.	Fetch Length (m)	Hs (m)	Tp (sec)	Tm (sec)
1	1410	0.573	2.338	1.917
9	5270	0.955	3.272	2.683
10	6400	1.076	3.498	2.868
11	8225	1.232	3.787	3.105
12	5910	1.023	3.401	2.783

Table 5: Critical Wave Characteristics (Donelan/JONSWAP Method)

4.6 Comparison of Results

The maximum significant wave height and mean wave period occurred for the Fetch 11 scenario. Using the Airy Wave theory, these values were 1.108m and 3.62sec respectively and using the Donelan/JONSWAP method, these values were 1.232m and 3.79sec respectively.

McConnell (1998) states: *'It has been indicated that this method'* (i.e. Donelan/JONSWAP method) *'produces a slight over-estimation of wave height, resulting in a generally conservative design. It is however also noted that this method tends to give rather short wave periods.'* With this consideration in mind, the results of the Airy Wave Theory Method have been assumed.

4.7 Deepwater Wave Characteristics

Linear Wave Theory was applied to determine a deepwater wave length (L_o) of 20.46m with a wave celerity (C_o) of 5.65m/s. This is based on the worst case Fetch 11 scenario. These values can then be used to determine wave shoaling and refraction coefficients.

4.8 Shoaling and Refraction

Both wave shoaling and wave refraction occurs when a decrease in water depth causes an increase in wave height. The water depth at all stages of the tide at this site is large when compared to the wavelength, therefore the effects of shoaling and refraction are assumed negligible.

4.9 Wave Diffraction
Wave diffraction was ignored for the purposes of this design as there are no significant barriers to cause diffraction on site.

5.0 Wave Attenuation

It is generally agreed that the maximum wave height in a marina should be 0.3-0.4m to allow for safe navigation and berthing in the marina and for the comfort of marina users.
The marina is designed with a 50 year design life. Therefore a significant wave height of 1.1m with a period of 3.63 seconds may occur in the design life of the marina and is thus taken as the incident wave characteristics.

A breakwater will be necessary around the perimeter of the marina in order to reduce the wave height of the waves in the marina to suitable levels. A Marinetek Type 4300k is proposed in order to accomplish this. This breakwater unit is 4.0m wide (excluding fenders), 1.8m high and has a draught of 1.25m. A typical concrete breakwater is shown in Image 1 below.

This type of breakwater can attenuate wave heights by up to 65% thus resulting in a 1 in 50 year transmitted wave within the marina basin of 0.385m. The 1 in 10 year transmitted wave height within the marina will be 0.341m. This transmitted wave height is within the acceptable maximum wave height of 0.300m to 0.400m.

Image 1: Floating Concrete Breakwater

6.0 Conclusions & Recommendations

The following conclusions and recommendations can be made regarding the study.

a) It is envisaged that the proposed marina development will not impact on the flow regime in Cork Harbour or at the site of the proposed marina.

b) The proposed marina site is very sheltered from offshore wave conditions (swell). It is anticipated that offshore swell will have negligible (if any) affect on the development.

c) The marina will be subject to locally generated wind waves. Highest waves are generated by winds blowing from the East. A design incident wave height of 1.1m with a corresponding wave period of 3.63sec was calculated for the site. It was estimated that wave transformations (diffraction, refraction and shoaling) will be negligible.

d) A floating concrete breakwater is proposed as wave protection to the marina. The wave characteristics for the marina have been calculated for a 1 in 50 year wind event. The design significant wave (1.1m height) is attenuated by the breakwater resulting in a transmitted wave height of 0.385m. This wave height satisfies the recommended upper limit of 0.300 to 0.400m wave height in a marina.

e) Dredging will not be required for this marina development, therefore there will not be any impact on the natural sediments regimes.

References:

BS6399-1:1996 (Loading for Buildings)

BS6349-6:1989 (Maritime Structures)

The Yacht Harbour Association Ltd., (2007), 'A Code of practice for the design, construction and operation of coastal and inland marinas and yacht harbours.'

McConnell, (1998), 'Revetment systems against wave attack – a design manual.'

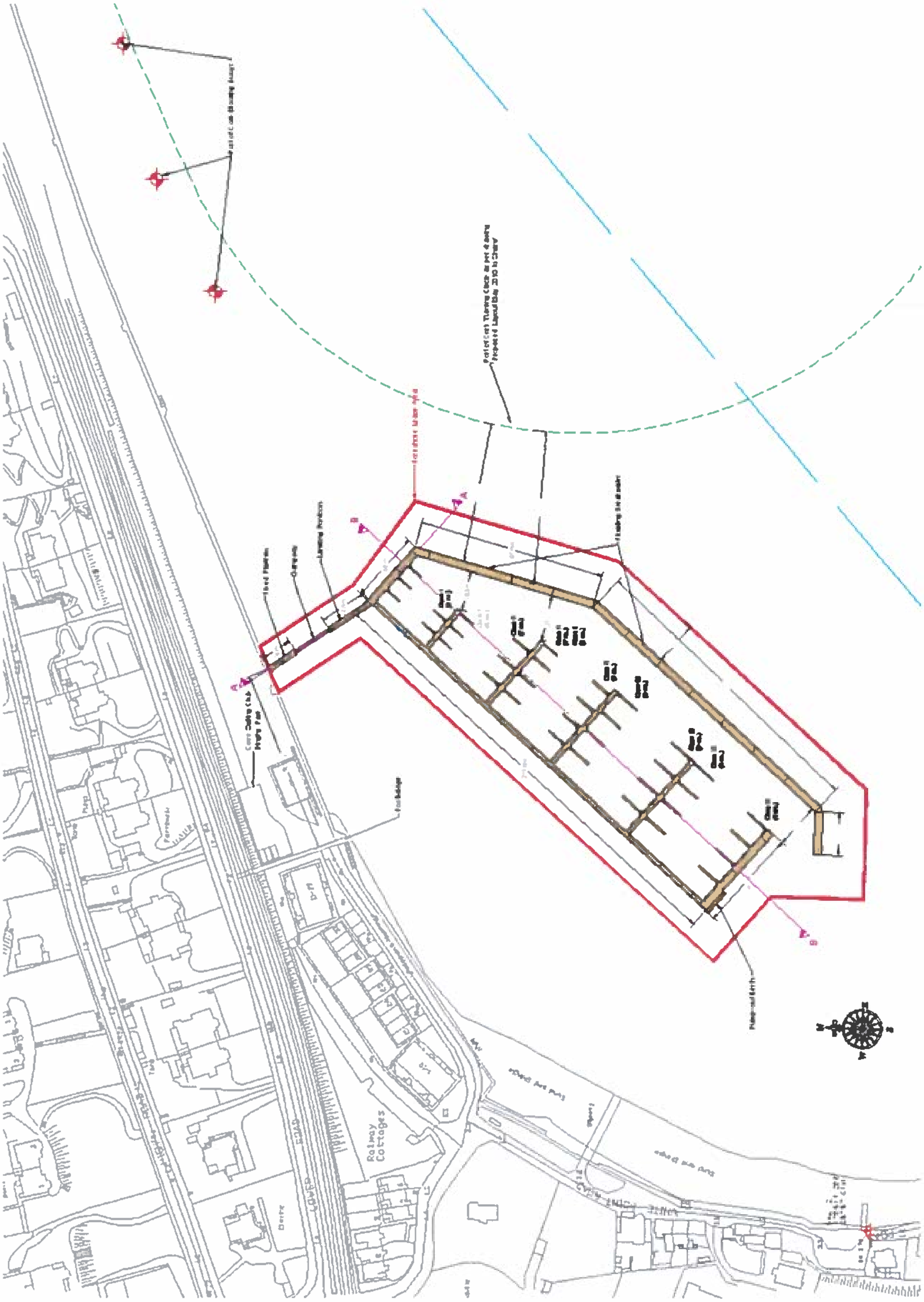
British Admiralty Chart 1777 – Port of Cork lower harbour and approaches

Kamphuis, (2006), 'Introduction to coastal engineering and management'

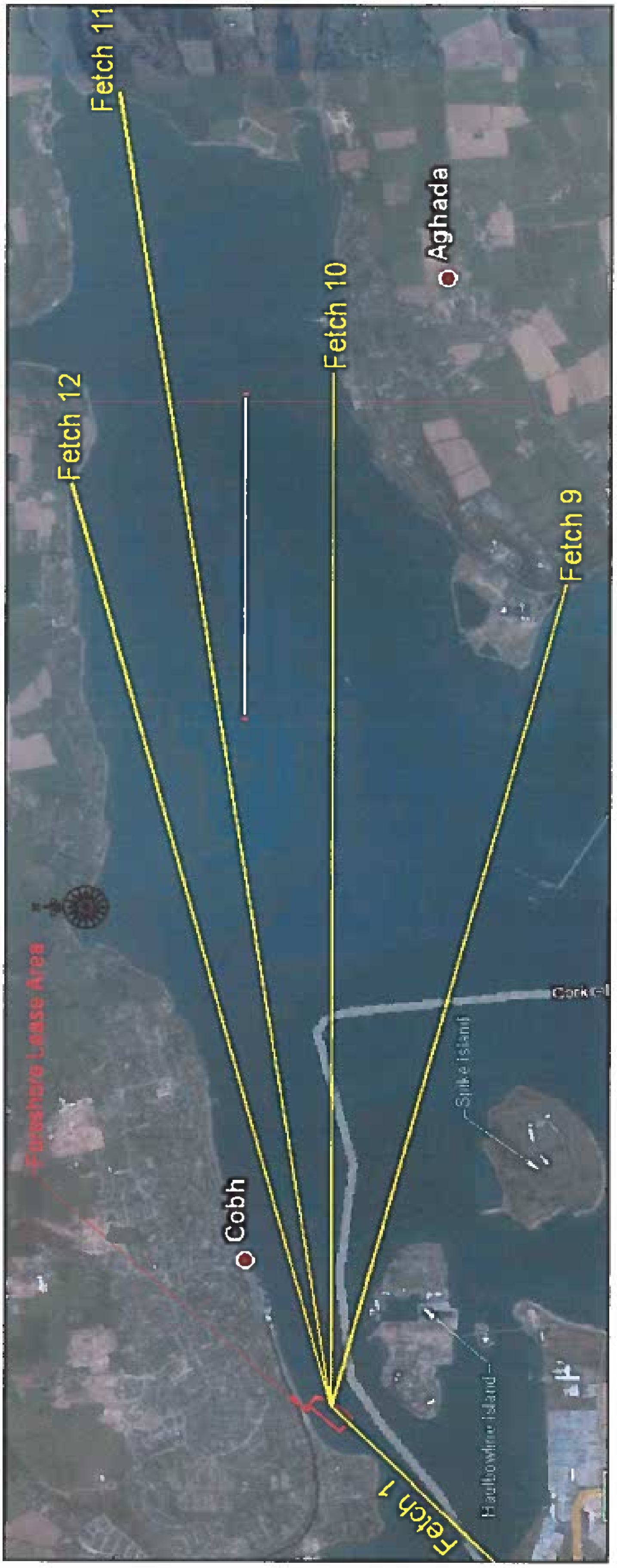
APPENDIX 1


Foreshore Lease Area
C O R K
COBH
(Urban District)
HAULBOWLINE ISLAND
Rocky Island

APPENDIX 2



APPENDIX 3


Fetch 11
Aghada
Fetch 10
Fetch 12
Fetch 9
Foreshore Lease Area
Spike Island
Cobh
Haulbowline Island
Fetch 1