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16 March 2005

cc Amin Ebrahim
Bill Roberts

Director of Environmental Protection
28/F Southorn Centre
130 Hennessy Road
Wan Chai, Hong Kong
(Attn.: Mr. Elvis Au)

Dear Mr. Au,

Permanent Aviation Fuel Facility
Selection of a Bubble Jacket to Attenuate Noise from Underwater Percussive Piling

I refer to the paper submitted by the Airport Authority copied to you reporting the results of the bubble jacket noise attenuation trial and test to the EIA Subcommittee in accordance with the condition specified by the Advisory Council on the Environment when endorsing the EIA report on Permanent Aviation Fuel Facility at its meeting held on 29 July 2002. Please be informed that the EIA Subcommittee endorsed the recommendations of the report by circulation and the Council noted the views of the Subcommittee on the report at its full Council meeting held on 14 March 2005.

Yours sincerely,

(Ms Josephine Cheung)
for Secretary,
Advisory Council on the Environment

c.c. Airport Authority (Attn. Mr. Martin R. Putnam) By Fax: 2183 3186

(ACE-EIA Sub-Committee Paper /2005)
For information

Permanent Aviation Fuel Facility
Selection of a Bubble Jacket to Attenuate Noise from Underwater Percussive Piling

Purpose

1. The purpose of the paper is to report on the bubble jacket trial undertaken in March 2004 and to recommend the most effective bubble jacket to be used in reducing underwater noise during percussive piling for the construction of the jetty for the Permanent Aviation Fuel Facility (PAFF) near Tuen Mun Area 38.

Background

2. The PAFF, to be located in Tuen Mun Area 38, will provide a secure long-term supply of aviation fuel to the airport.

3. As part of the PAFF, a two berth jetty will be constructed in waters about 17 metres deep approximately 200m off the existing sea wall (Figure 1). A total of 106 piles will be required for the construction of the jetty with percussive pile driving required over a period of approximately 6 weeks.

4. The PAFF Environmental Permit (EP-139/2002/A) (EP) requires that, in order to mitigate potential noise impacts on the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) from pile driving, an overall reduction of 3dB or more from unmitigated noise levels be achieved with the bubble jacket in place. Mitigated noise targets were also stipulated in the EP for different distances from the piling activity as follows:

Mitigated Noise Level

Distance from Piling Work (m)	Noise Level (dB)
250	162
500	152
1000	145

5. To achieve the mitigated noise levels, several types of bubble

jacket were tested in a trial conducted at the actual jetty location near Tuen Mun Area 38. The objectives of this trials were to select the one (i) best able to achieve the target noise attenuation; (ii) most effective in reducing potential noise impact on dolphins; and (iii) most practical to use during construction.

Sound and Sound Measurement

6. Sound and its measurement are technical subjects. Some key terms and concepts are described below in order to help give an understanding of how the results are reported and what they mean.

7. Sound originates as a wave motion by a vibrating source and requires for its transmission an elastic medium such as air, water or a solid. The frequency (f) or the pitch of the sound is the number of cycles, or pressure fluctuations, produced per second. Frequency is expressed in units of Hertz (Hz) or cycles per second. The wavelength (λ) is the distance between successive waveform repetitions. A low frequency sound has a long wavelength, whereas a high frequency sound has a short wavelength (higher frequencies result in high-pitched sounds). Sounds in this trial were recorded from 100 Hz to about 25 KHz (defined for the purposes of this paper as the Broadband range), which equates approximately to the human hearing range and slightly higher frequencies.

8. Use of a logarithmic decibel (dB) scale compresses the vast range of numbers required to describe the wide range of sound pressures. The sound pressure level, in general, is the decibel level of a sound relative to the ambient sound pressure in Pascals. The decibel is a relative, not an absolute, unit and to be meaningful must have a reference value.

9. In air, sound sources are conventionally described either in terms of the sound pressure level referenced to 20 microPascals (ie 20×10^{-6} Pa) at a specified distance (usually 1m). Whereas in water, sound sources are described in terms of the sound pressure level reference to 1 microPascal (ie 1×10^{-6} Pa) at a specified distance (usually 1m).

10. In this trial the median underwater sound pressure density spectrum values were integrated into one-octave band frequency widths of 100 Hz to 25.6 kHz. For each mitigation method, the attenuation was calculated as the ratio of mitigated noise for each octave divided by the corresponding octave

for unmitigated noise at that position.

Proposed Bubble Jacket Design

11. In view of the greater depth of the water (approximately 17m) and stronger currents at the jetty near Tuen Mun Area 38 than at Sha Chau, it was anticipated in the PAFF Environmental Impact Assessment report (EIA) that a 'bubble jacket' may be more effective at attenuating noise, than the 'bubble curtain' deployed during the piling at the Aviation Fuel Receiving Facility (AFRF) at Sha Chau. This was because a jacket may more effectively maintain the bubbles around the pile throughout the entire water column. Several general design types were tested.

Canadian Bubble Jacket

12. The Canadian Bubble Jacket (so named because this bubble jacket variation was firs developed in Canada) consists of three steel rings suspended at various depths around the driven pile below the water surface. The steel rings comprise 50mm inside-diameter air distribution manifolds with 1.5mm diameter air release holes located every 180mm (Figure 2).

Fixed Steel Bubble Jacket

13. A steel pipe of 1200mm diameter, 17 metre length and with wall thickness of 8mm was suspended from the construction barge. A 50mm inside diameter airline was fixed inside the base of the jacket with 1.5mm diameter air release holes located every 180mm. To prevent the steel tube touching the side of the pile and transmitting noise into surrounding water, neoprene spacers were fixed on the internal wall of the tube. Piles were driven inside the steel tube whilst air was injected to create the bubble jacket (Figure 3).

Bubble Curtain

14. The bubble curtain arrangement comprised a large diameter steel air distribution manifold weighed down on the seabed (Figure 4). During the trial, deployment of the large diameter manifold proved very difficult due to strong tidal currents combined with the deep water location resulting in the steel manifold buckling when attempts were made to lower it into place. Noise attenuation testing of this option was therefore not possible and it was

concluded that this bubble curtain arrangement was not a practical method for this location. It was not therefore considered further.

15. As a result, the Fixed Steel Bubble Jacket and the Canadian Bubble Jacket were tested along with a number of variations as detailed in Table 1. One of the variants incorporated an air bubble curtain at one metre below the sea surface immediately around the piling barge in an attempt to further attenuate noise levels. In another variant, the air pressure to the air lines injecting air into the steel bubble jacket was raised and lowered above and below a standard pressure level adopted for the field trials, in order to determine whether different air pressures had any effect on noise attenuation.

Percussive Piling

16. The percussive piling method used in the bubble jacket trial and proposed for use in the construction of the PAFF is largely the same as that used previously in the construction of the AFRF at Sha Chau. The percussive piling technique involves the use of a hammer and anvil system that is lowered onto the top of the pile by steel wires from the derrick of the construction barge (Figure 5). The hammer slides up and down inside the hanging frame, driving the pile into the seabed. Notable differences between the piling method used at the AFRF at Sha Chau and the arrangements for the PAFF trial are that the piles are significantly heavier and the length of pile in the water column is much greater than at the AFRF. In addition, the hammer and anvil system for the PAFF trial is only attached to the barge by steel cables.

Requirements of Environmental Permit during Piling

17. All dolphin mitigation measures stipulated for piling activity under the EP such as dolphin monitoring were put in place for the duration of the trials. Representatives from EPD, AFCD and CEDD attended the trials on two of the three trial days.

Methodology

18. Noise measurements were taken at three distances from the piling barge as well as at a further two locations, also 250 m from the barge, during the trials (Figure 1). Sound measurements were taken at positions 1 and 2 as well as position 3 in order to attempt to determine whether direction from the piling

barge had any influence on underwater noise measurements. Positions 3, 4 and 5 were chosen to match the distances specified in the EP of 250m, 500m and 1km away from the piling.

Ambient Noise Measurement

19. Ambient noise levels were measured every day at each position prior to the commencement of piling and bubble curtain noise measurements, during which all sources of noise on the survey boat were turned off, except for a quiet generator to run essential equipment, which was itself acoustically developed by seating it on anti-vibration mountings.

Percussive Piling Noise Measurement

20. For measuring noise from percussive piling activities, the survey vessel was anchored at each position to allow recordings of noise levels from a consecutive set of hammer blows. At each position, the first set of noise measurements were taken without any mitigation measures in place and then checked to ensure suitability. After suitability of measurements was confirmed, noise measurements were then recorded for the variations of the bubble jacket as shown in Table 1.

Results – Noise Measurements

21. Since the main focus of the bubble jackets being tested was to minimise noise impacts on dolphins, the results of the bubble jacket trial have been analysed in terms of both a "Broadband" Range and a "Dolphin Sensitive" Range, which was identified in the PAFF-EIA..

22. The results of the noise measurements for all the options of the bubble jackets tested in the trial in terms of individual frequencies are presented in the Annex. The results for noise within the Broadband Range (100 Hz to 25.6 kHz) and within the EIA Dolphin Sensitive Range (400 Hz to 12.6 kHz) are presented in Tables 2 and 3 respectively.

<u>The Broadband Range and Results</u>

23. As stated previously, the Broadband Range has been taken as 100 Hz to 25.6 kHz, which is the same range measured during use of the AFRF

bubble curtain. Hence the results of the two studies are directly comparable.

24. Although significant mitigation was achieved at different locations for many of the options tested, no option appeared to meet all of the EP noise attenuation requirements at all distances in the Broadband Range. Broadband Range noise measurements for all bubble jacket options are presented in Table 2.

The EIA Dolphin Sensitive Range and Results

25. A review of relevant literature was undertaken as part of the PAFF EIA. This determined that although a precise audiogram for the Indo-Pacific Humpback Dolphin (*Sousa chinensis*) was not available, Bottlenose Dolphins, with comparable internal ear morphology, have been shown to be sensitive from 1 kHz to 10 kHz where they conduct the majority of their low frequency whistling. The PAFF EIA identified that dolphins in general have acute hearing above 500 Hz, but have also been found to communicate within the 400 to 800 Hz range. It was thus considered that analysis over a Dolphin Sensitive Range of 400 Hz to 12.6 kHz would allow a more relevant assessment of the potential for percussive piling works to impact dolphins.

26. In the more relevant Dolphin Sensitive range, results show that the Option 7 bubble jacket arrangement, which combined the Fixed Steel Bubble Jacket with the lower ring of the Canadian Bubble Jacket (see Table 1), successfully met all mitigated noise levels specified in the EP at all distances. This is illustrated in Figure 6.

27. Results show that noise attenuation of –3 dB or more was not achieved at Position 2 (250 m). However, it should be noted that the unmitigated noise level at this location recorded at 159.7dB, was already below the EP noise target for this distance of 162 dB. This reduced further, to 158.0dB, when the bubble jacket was switched on. Results from the three 250m locations show that although there are variations with direction, these are small compared with attenuation levels achieved with the mitigation techniques. As three sets of measurements were taken at this distance, average measurements from all three have been used in determining the 250 metre attenuated noise level. Dolphin Sensitive range noise measurements for all bubble jacket options are presented in Table 3.

Conclusions

28. A comparison of these trials with results from the percussive piling noise measurements taken during construction of the AFRF at Sha Chau shows that the noise levels recorded in the AFRF study were lower than those in this study. This may be due to factors such as use of a smaller hammer and smaller diameter piles which passed through a much shallower water column at the AFRF. In addition, higher natural noise attenuation was achieved at the AFRF through the absorption and multiple scattering effect of the sea bed/sea surface in the shallow waters at Sha Chau.

29. The trial identified that none of the bubble jacket options tested can completely meet all of the EP noise attenuation targets for the Broadband noise spectrum (100Hz to 25.6Hz), although consistent and significant attenuation is achieved with bubble jackets in place.

30. However, the primary objective of the bubble jacket trials was to determine the most effective means of mitigating potential adverse noise impacts, during marine percussive piling at the PAFF, on the local population of the Indo-Pacific Humpback Dolphin (*Sousa chinensis*). It was thus considered more relevant to focus analysis on the EIA Dolphin Sensitive frequency range (400 Hz to 12.6 kHz).

31. Results in the EIA Dolphin Sensitive range show that the Fixed Steel Bubble Jacket combined with the lower ring of the Canadian Bubble Jacket (Option 7, Table 1) successfully meets the mitigated noise levels specified in the EP. Results also indicate that adding air bubbles around the hull of the barge is likely to further attenuate piling noise. Therefore, this arrangement would also be deployed during piling activity.

32. Reducing and increasing air pressure, although not conclusive, indicates that varying the air pressure in the air hose supply line may affect the efficacy of the mitigation. As it is simple to adjust the pressure on the barge, further tests will be undertaken during the construction noise measurement period.

33. Deployment of Option 7 during percussive piling activities would mitigate against adverse underwater pressure pulses such that

EP-139/2002/A Conditions 3.2 and *3.24* are met and that underwater noises, in the frequency range that dolphins are most likely to be affected, are minimized.

Recommendations

34. It is recommended that the Fixed Steel Bubble Jacket combined with the lowest ring of the Canadian Bubble Jacket (Option 7) plus the air bubble curtain at 1 metre below the sea surface around the barge should be taken forward as the proposed piling noise mitigation method for PAFF jetty piling works. Further testing to determine the optimum air supply pressure during the construction noise monitoring period should also be undertaken.

Table 1 - Variations of the Bubble Jackets

Options	Bubble Jacket System
1	Canadian Bubble Jacket with 3 Rings
2	Canadian Bubble Jacket with 3 Rings plus bubble curtain around barge
3	Canadian Bubble Jacket with 4 Rings
4	Canadian Bubble Jacket with 4 Rings plus bubble curtain around barge
5	Fixed Steel Bubble Jacket
6	Fixed Steel Bubble Jacket plus bubble curtain around barge
7	Fixed Steel Bubble Jacket plus lowest ring of Canadian Bubble Jacket

Table 2 Broadband Noise Levels and Noise Attenuation within the Broadband Range 100 Hz to 25.6 kHz

Position	EP Criteria (dB)	Ambient Levels (dB)	Unmitigated Noise Levels (dB)	Mitigated Noise Levels (dB)							Attenuation in Noise Levels (dB)						
				Option							Option						
				1	2	3	4	5	6	7	1	2	3	4	5	6	7
1 (250m)	162	135.2	167.3	162.6	162.1	165.8	164.9	161.8	162.0	161.7	4.7	5.2	1.5	2.4	5.5	5.3	5.6
2 (250m)	162	133.6	163.2	161.8	161.8	162.3	163.0	162.2	161.8	161.5	1.4	1.4	0.9	0.1	1.0	1.4	1.7
3 (250m)	162	134.8	168.4	168.1	168.2	165.8	165.9	163.2	163.1	163.4	0.3	0.1	2.6	2.5	5.2	5.3	5.0
4 (500m)	152	132.8	162.1	159.7	160.2	160.0	160.4	158.8	156.4	156.8	2.4	1.9	2.1	1.7	3.3	5.6	5.2
5(1,000m)	145	133.7	157.5	153.5	151.2	154.1	153.7	150.7	151.2	150.6	4.0	6.4	3.4	3.8	6.8	6.3	7.0

Note: Shaded Cells indicate Mitigation Measure meets EP Requirements

Table 3 Broadband Noise Levels and Noise Attenuation within the EIA Dolphin Sensitive Range 400 Hz to 12.8 kHz

Position	EP Criteria (dB)	Ambient Levels (dB)	Unmitigated Noise Levels (dB)	Mitigated Noise Levels (dB)							Attenuation in Noise Levels (dB)						
				Option							Option						
				1	2	3	4	5	6	7	1	2	3	4	5	6	7
1 (250m)	162	133.1	163.9	158.8	158.6	161.7	159.7	158.3	157.9	157.8	2.2	5.3	2.2	4.3	5.6	6.1	6.1
2 (250m)	162	132.0	159.7	158.9	157.9	156.5	156.8	159.4	159.3	158.0	0.8	1.8	3.2	2.9	0.3	0.4	1.7
3 (250m)	162	133.0	165.1	164.2	165.1	163.8	162.8	159.3	159.3	159.3	0.9	-0.1	1.3	2.3	5.7	5.7	5.7
4 (500m)	152	131.8	156.2	155.8	157.0	154.4	154.3	153.2	151.7	152.0	0.4	-0.9	1.8	1.8	3.0	4.5	4.2
5 (1,000m)	145	131.8	152.5	149.0	145.5	146.1	145.4	143.8	147.0	143.5	3.5	7.0	6.3	7.1	8.7	5.4	9.0

Note: Shaded Cells indicates Mitigation Measure meets EP Requirements

Figure 1 PAFF Jetty Location and Noise Monitoring Points

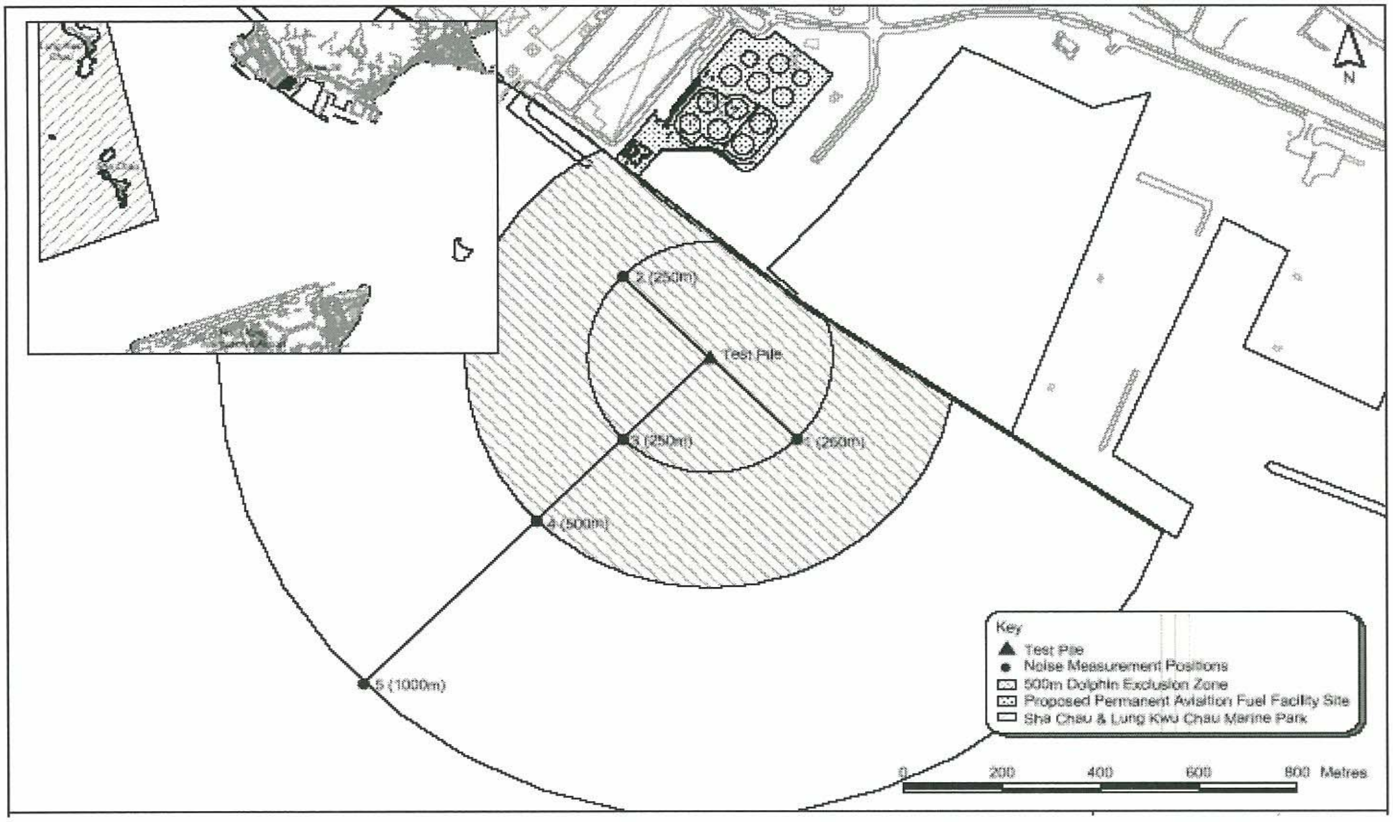


Figure 2 Canadian Bubble Jacket

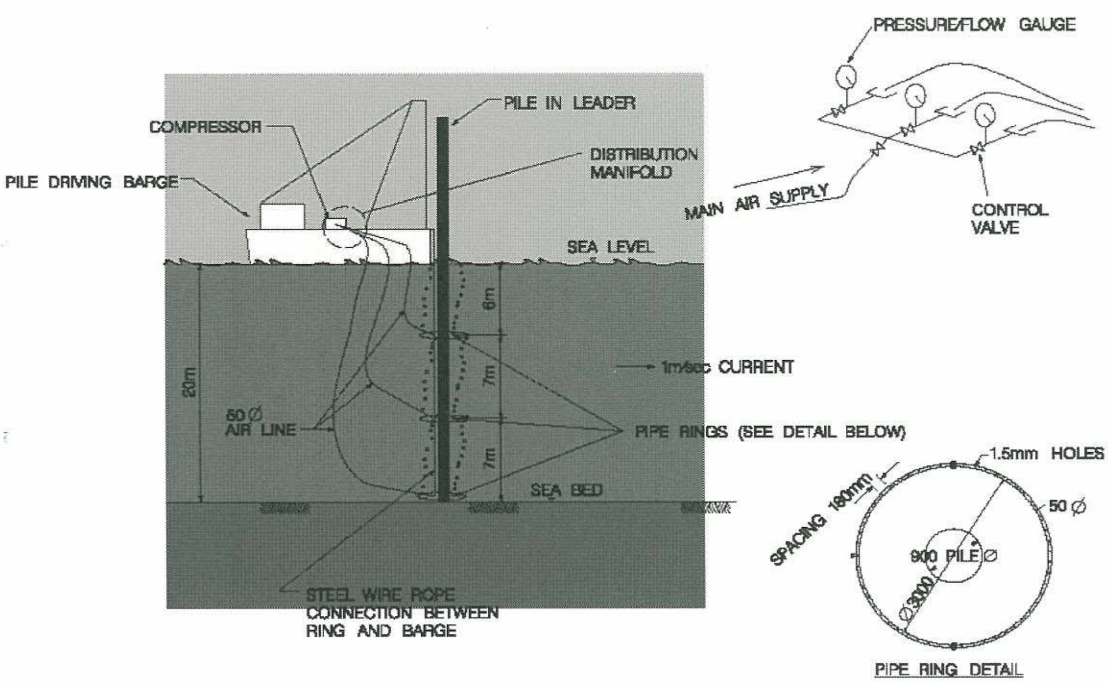


Figure 3 Fixed Steel Bubble Jacket

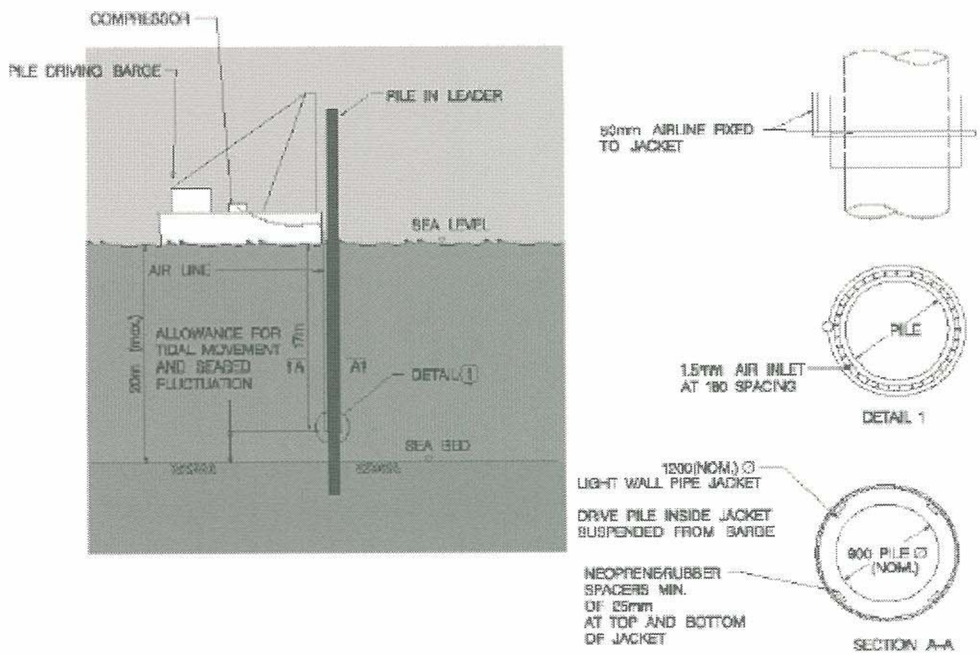


Figure 4 Bubble Curtain

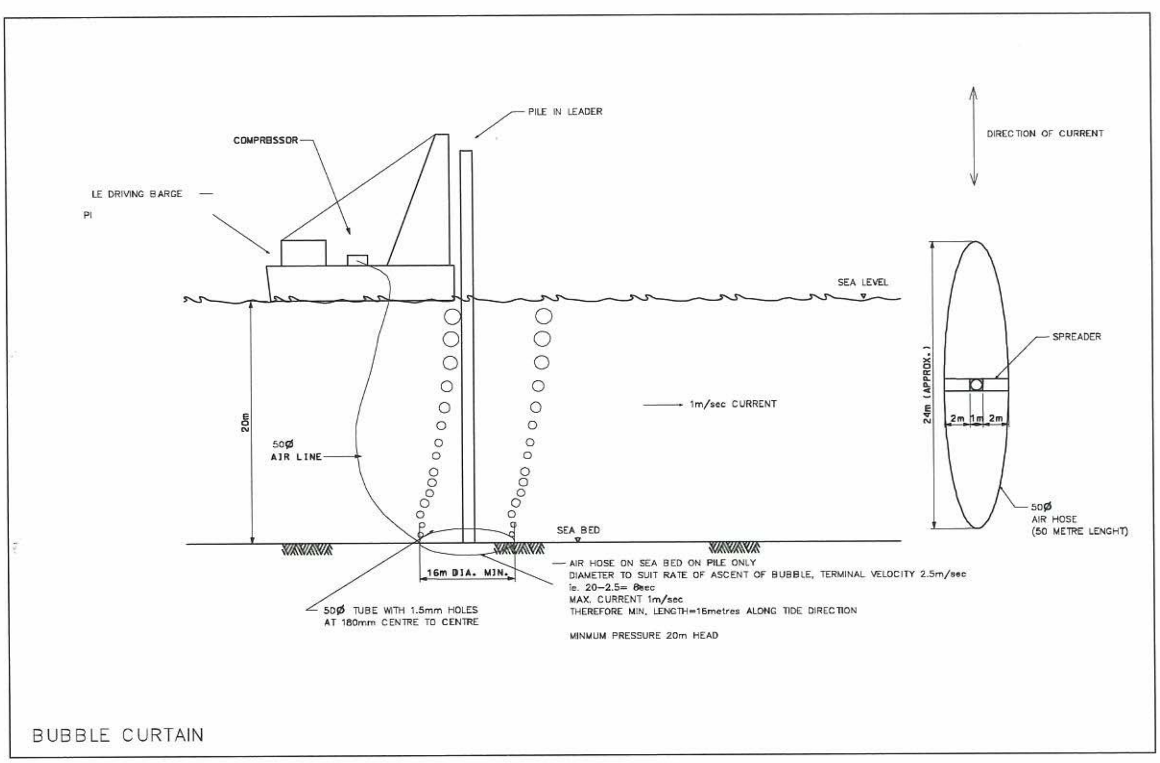


Figure 5 Photo of Construction Barge and Piling Arrangement

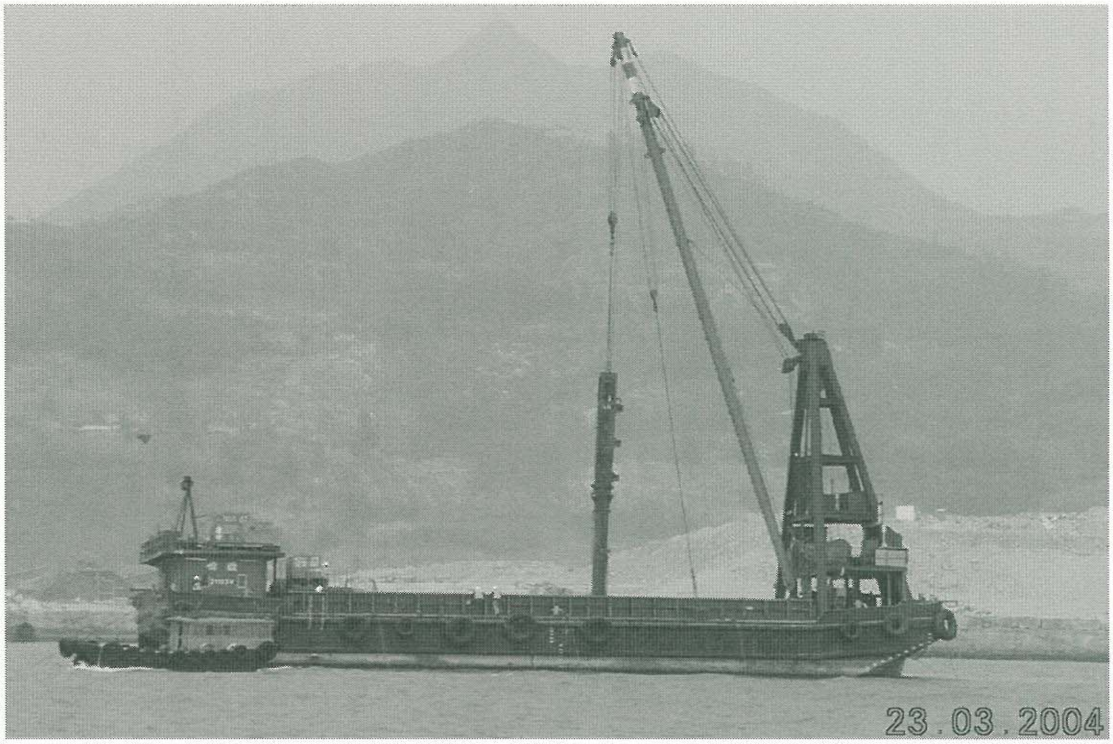
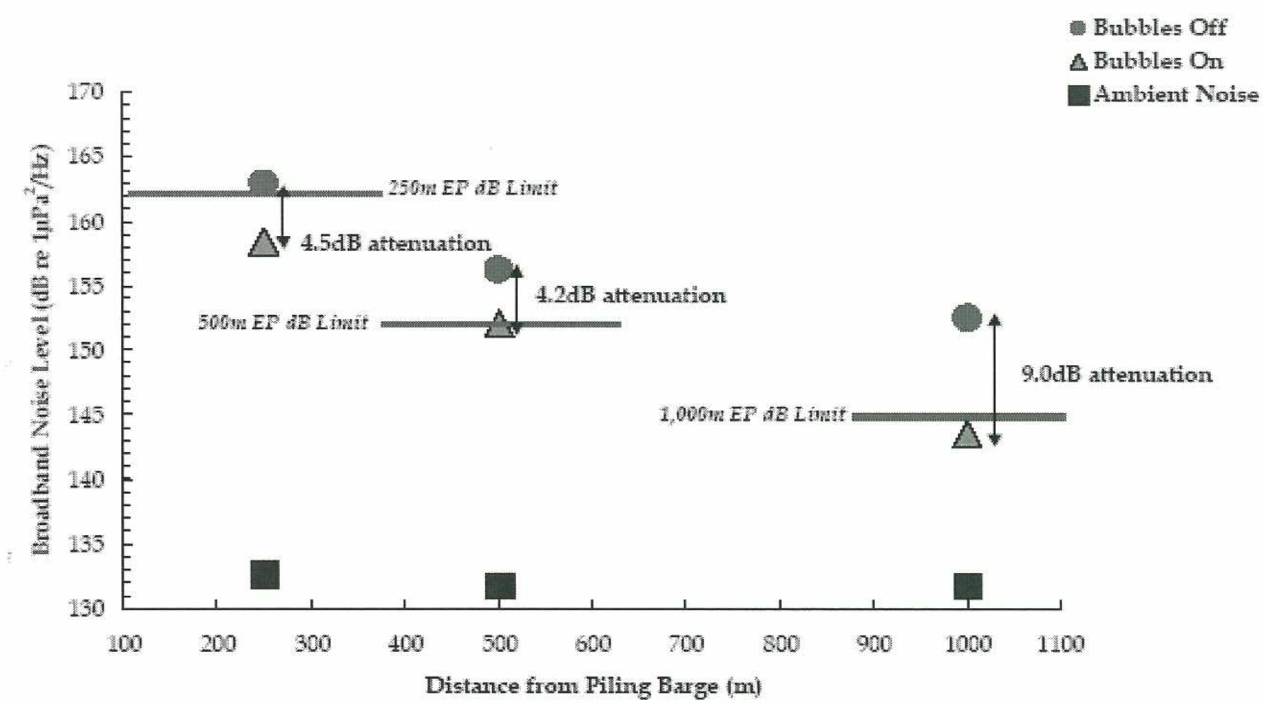


Figure 6 Broadband Noise Mitigation (EIA Dolphin Sensitive Range 400 Hz to 12.8 kHz) Achieved by Option 7 at all Distances from the Test Pile



Annex

Sound Pressure Levels (dB re 1μPa)

POSITION 1 - Distance to Barge 250m

Frequency			Mitigation Method (see Table 1 of ACE Paper for description of reference numbers)						
(Hz)	Ambient	Unmitigated	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
100	126.8	157.9	155.8	154.8	156.9	157.4	155.6	155.5	156.0
200	128.9	163.6	158.5	157.8	162.7	162.1	156.8	157.9	156.8
400	132.0	163.0	158.0	157.7	161.0	159.1	157.2	156.4	156.6
800	124.9	155.5	150.2	150.8	152.7	149.6	150.5	151.5	151.1
1,600	117.3	148.9	141.9	142.5	143.4	142.7	144.9	143.7	143.4
3,200	116.0	144.5	130.5	129.7	136.4	133.4	132.2	133.6	133.6
6,400	113.0	142.2	127.1	128.0	134.0	131.9	129.7	129.4	130.3
12,800	110.1	139.3	124.7	124.9	133.0	131.0	129.4	129.1	130.6
25,600	108.8	138.1	122.9	123.9	132.5	131.1	129.1	129.0	129.7
Broadband Range (100 Hz to 25.6k Hz)	**135.2**	**167.3**	**162.6**	**162.1**	**165.8**	**164.9**	**161.8**	**162.0**	**161.7**
Dolphin Sensitive Range (400 Hz to 12.8k Hz)	**133.1**	**163.9**	**158.8**	**158.6**	**161.7**	**159.7**	**158.3**	**157.9**	**157.8**

POSITION 2 - Distance to Barge 250m

Frequency			Mitigation Method (see Table 1 of ACE Paper for description of reference numbers)						
(Hz)	Ambient	Unmitigated	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
100	124.8	157.0	155.6	156.6	158.5	158.3	153.0	152.6	153.5
200	126.1	158.1	155.6	156.3	157.5	159.4	157.5	157.0	157.4
400	131.1	158.9	157.8	157.1	156.1	156.3	159.1	159.1	157.5
800	123.9	149.4	150.8	149.1	143.9	145.9	146.6	144.5	147.3
1,600	113.1	145.1	145.4	143.2	138.5	140.0	140.7	139.7	139.5
3,200	110.8	143.4	140.0	137.3	134.4	134.4	134.1	134.4	132.7
6,400	110.4	140.6	137.8	133.8	131.7	131.6	130.6	129.5	129.5
12,800	107.4	139.4	137.0	133.1	132.1	131.3	130.0	127.9	127.9
25,600	106.8	139.0	134.6	131.2	132.2	131.3	128.8	126.9	126.6
Broadband Range (100 Hz to 25.6k Hz)	**133.6**	**163.2**	**161.8**	**161.8**	**162.3**	**163.0**	**162.2**	**161.8**	**161.5**
Dolphin Sensitive Range (400 Hz to 12.8k Hz)	**132.0**	**159.7**	**158.9**	**157.9**	**156.5**	**156.8**	**159.4**	**159.3**	**158.0**

Sound Pressure Levels (dB re 1μPa)

POSITION 3 - Distance to Barge 250m

Frequency (Hz)	Ambient	Unmitigated	Mitigation Method (see Table 1 of ACE Paper for description of reference numbers)						
			Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
100	128.0	160.9	162.5	161.3	155.7	157.3	157.3	156.5	156.6
200	126.2	163.9	163.1	163.2	160.3	161.6	158.3	158.8	159.3
400	132.0	163.8	163.2	164.5	163.1	162.4	157.8	157.9	158.3
800	124.8	157.7	155.8	155.9	154.6	151.1	153.4	153.0	151.7
1,600	116.7	150.9	150.2	146.6	145.7	144.8	144.4	144.8	144.7
3,200	114.1	145.9	144.3	139.9	136.8	134.1	132.1	133.9	132.4
6,400	114.7	143.5	142.5	137.9	133.9	131.3	129.2	129.0	129.1
12,800	109.6	141.9	140.8	135.0	133.5	130.7	127.9	127.4	126.5
25,600	109.9	141.3	139.2	133.5	134.4	132.0	128.5	127.7	127.1
Broadband Range (100 Hz to 25.6k Hz)	**134.8**	**168.4**	**168.1**	**168.2**	**165.8**	**165.9**	**163.2**	**163.1**	**163.4**
Dolphin Sensitive Range (400 Hz to 12.8k Hz)	**133.0**	**165.1**	**164.2**	**165.1**	**163.8**	**162.8**	**159.3**	**159.3**	**159.3**

POSITION 4 - Distance to Barge 500m

Frequency (Hz)	Ambient	Unmitigated	Mitigation Method (see Table 1 of ACE Paper for description of reference numbers)						
			Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
100	119.8	153.8	151.8	151.9	154.0	154.3	151.5	149.4	149.7
200	124.9	159.8	155.9	155.9	156.7	157.5	156.1	153.2	153.6
400	131.0	155.3	155.3	156.6	153.7	153.8	152.8	151.2	151.5
800	122.9	147.3	145.0	145.9	145.2	144.3	142.2	141.5	142.2
1,600	112.1	140.7	137.9	138.5	136.7	136.0	131.0	130.5	129.9
3,200	111.4	136.8	132.3	132.6	130.5	129.8	121.0	120.6	122.6
6,400	112.3	134.8	131.3	129.3	127.6	127.2	122.2	118.6	119.0
12,800	109.7	132.8	129.7	125.4	127.3	126.1	121.1	117.7	118.7
25,600	108.6	132.3	128.0	122.8	127.9	126.5	120.1	116.4	118.1
Broadband Range (100 Hz to 25.6k Hz)	**132.8**	**162.1**	**159.7**	**160.2**	**160.0**	**160.4**	**158.8**	**156.4**	**156.8**
Dolphin Sensitive Range (400 Hz to 12.8k Hz)	**131.8**	**156.2**	**155.8**	**157.0**	**154.4**	**154.3**	**153.2**	**151.7**	**152.0**

Sound Pressure Levels (dB re 1µPa)

POSITION 5 - Distance to Barge 1000m

Frequency (Hz)	Ambient	Unmitigated	Mitigation Method (see Table 1 of ACE Paper for description of reference numbers)						
			Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7
100	123.4	147.7	145.1	145.1	146.8	146.8	145.8	145.1	145.5
200	127.8	155.2	150.5	147.9	152.2	151.9	147.5	147.0	147.5
400	131.0	152.0	148.2	144.4	145.4	144.8	142.6	145.3	141.8
800	122.8	141.2	139.3	137.4	137.4	135.8	136.9	142.0	137.9
1,600	114.0	133.6	133.4	129.0	128.4	127.1	126.4	126.6	127.8
3,200	110.8	130.5	129.2	126.2	122.9	121.1	121.0	117.9	121.7
6,400	111.5	128.4	130.7	130.6	122.0	122.0	120.6	116.5	117.1
12,800	107.6	125.6	127.5	125.6	119.4	120.7	117.8	115.6	116.1
25,600	106.2	124.1	121.7	118.3	117.8	118.9	115.3	114.2	114.5
Broadband Range (100 Hz to 25.6k Hz)	**133.7**	**157.5**	**153.5**	**151.2**	**154.1**	**153.7**	**150.7**	**151.2**	**150.6**
Dolphin Sensitive Range (400 Hz to 12.8k Hz)	**131.8**	**152.5**	**149.0**	**145.5**	**146.1**	**145.4**	**143.8**	**147.0**	**143.5**