CONTRACT HY/2011/09
Hong Kong-Zhuhai-Macao Bridge
Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill
Proposal for Land-based Dolphin Behaviour and Movement Monitoring

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1. INTRODUCTION

The Hong Kong Link Road (HKLR) comprises a 9.4 km long viaduct section from the HKSAR boundary to Scenic Hill on the Airport Island; a 1-km tunnel section to the reclamation formed along the east coast of the Airport Island, and a 1.6-km long at-grade road section on the reclamation connecting to the Hong Kong Boundary Crossing Facilities (HKBCF). Dragages – China Harbour – VSL JV (hereinafter called the "Contractor") was awarded as the main contractor of "Contract No. HY/2011/09 – Hong Kong-Zhuhai-Macao Bridge Hong Kong Link Road – Section between HKSAR Boundary and Scenic Hill".

According to the HKLR EM&A Manual, a number of environmental monitoring and audit works related to Chinese white dolphins (a.k.a Indo-Pacific humpback dolphins, *Sousa chinensis*) shall be conducted during baseline, construction and post-construction phases, including land-based dolphin behaviour and movement monitoring. Such monitoring shall be undertaken by qualified dolphin specialist, who have sufficient (at least 5-10 years) relevant post-graduate experience and publication in the respective aspects. Approval on the specialist responsible for land-based dolphin behaviour and movement monitoring shall be sought from AFCD and EPD.

This land-based dolphin behaviour and movement monitoring proposal will detail the methodology as well as personnel arrangement/qualification to meet the requirement in the particular specification and EM&A Manual. It is prepared and submitted for approval of the baseline and construction monitoring works. Post-construction phase monitoring will be further proposed and arranged by the Permit Holder. It should also be noted that the land-based theodolite monitoring will not be carried out concurrently with the underwater noise monitoring and acoustic behaviour monitoring for both baseline and construction phase monitoring.

2. LAND-BASED DOLPHIN BEHAVIOUR AND MOVEMENT MONITORING PROGRAMME

2.1. Requirements under the EM&A Manual

Under the HKLR EM&A Manual, the land-based dolphin behaviour and movement monitoring in relation to bored piling activities is required with several clauses:

- *Clause 10.3.5:* Land-based theodolite tracking to study dolphin behaviour near bored piling work site, and examine their north-south movement across the bridge alignment before, during and after bridge construction.
- *Clause 10.4.3:* Land-based dolphin movement and behaviour monitoring – The behaviour near the bored piling sites and north-south movement across the bridge alignment of Chinese white dolphins should be monitored in the waters to the west of Airport.
- *Clause 10.6.3:* Dolphin behaviour in response to bored piling and movement near the bored piling sites will be monitored at the three pier sites for 30 days from the start of bored piling activities in the waters to the west of Airport.

Supplementary information of such land-based dolphin behaviour and movement monitoring in relation to bored piling activities was also provided in the Tuen Mun-Chek Lap Kok Link (TMCLKL) EM&A Manual, which can also be used as reference for the present monitoring programme:

- *Clause 6.4.5.7:* The objective of the land-based theodolite tracking of dolphins is to monitor their movements and behaviour near the bored piling works site before, during and after the works and record and note any changes in response to the bored piling noise. The details of the land-based dolphin tracking methodology and frequency will be defined in a specification prepared during detailed design phase. However, as a minimum the monitoring is likely to comprise 30 days before, 30 days during and 30 days after bored piling works

2.2. Monitoring Location – Shum Wat Station

To conduct the land-based monitoring on dolphin behaviour and movement, HKCRP research team has set up a theodolite-tracking station at Shum Wat in April 2011 with the assistance of Professor Bernd Würsig (Hung 2012; Piwetz et al. 2012).

The Shum Wat station is located along the northwest coast of Lantau Island (GPS position:

$22^{o}16.10'$ N and $113^{o}52.32'$ E; Figure 1). The station was selected based on its height above sea level (minimum requirement of over 20 metres; Würsig et al. 1991), close proximity to shore, and relatively unobstructed views of the HKLR alignment to the west of the airport extending toward the HKSAR Boundary (see panoramic view from the station in Figure 2). The height of Shum Wat station established by HKCRP team is 55.70 m high at mean low water, 66 m from shore, and only a few hundred metres to the closest point of the HKLR alignment, which will be ideal for the purpose of the present behavioural and movement monitoring in relation to the HKLR bored piling works. Moreover, the distances between the Shum Wat Station and the first few bored piling sites are 2100m (P47) and 2260m (P49) respectively, which are well within the acceptable range for effective tracking of dolphin movement and behaviour near these sites (Figure 1). It is also ideal to overlook the entire bridge alignment to examine the north-south movements of Chinese White Dolphins.

2.3. Monitoring Frequency

According to the EM&A Manual, dolphin behaviour in response to bored piling works and movement near the bored piling sites should be monitored at the first three pier sites for 30 days from the start of bored piling activities in the waters to the west of Airport. However, the number of monitoring days is not well specified for the baseline period. Therefore, reference to the requirements in the TMCLKL EM&A Manual was made, in which 30 days of theodolite tracking before and 30 days of theodolite tracking from the start of bored piling activities will be conducted under the present study in order to maintain overall consistency of EM&A programs for the HZMB development.

Tentatively, 30 consecutive days (with 5-6 hours on each survey day) of monitoring will be planned for the baseline and construction phases respectively. However, when the adverse weather condition (e.g. with heavy rain, poor visibility, monsoon) is forecasted, the monitoring survey will be postponed, and the 30 consecutive days of survey works will be extended. It should be noted that every attempt will be made to conduct the 30 days of baseline monitoring and 30 days of construction phase monitoring in favourable weather conditions (Beaufort Sea State 3 or below; good visibility of 3 km or above). However, due to the fluctuating weather condition area during different times of the day in the winter and spring seasons, the HKCRP team will aim to collect at least 80% of the total survey effort in favourable conditions in order to generate adequate amount of data for various analyses.

Moreover, an additional 64 days of monitoring (twice per month, with 5-6 hours on each survey day) will be conducted throughout the construction period to examine the impact of bridge construction on north-south movement of Chinese White Dolphins across the bridge alignment. Such monitoring will commence after the 30 days of construction phase monitoring in relation to bored piling impact assessment is completed.

2.4. Monitoring Methodology

The methodology of the present monitoring programme generally follows the one established under the Piwetz et al. 2012 study, which is also part of the AFCD long-term marine mammal monitoring programme (Hung 2012). On each survey day, observers will search continuously for Chinese white dolphins using the unaided eye and handheld binoculars (7 x 50) from the Shum Wat Station, overlooking the bridge alignment along the west coast of Lantau Island. A theodolite tracking session will be initiated when an individual dolphin or group of dolphins is located, and focal follow methods will be used to track the dolphins.

Within a group, a focal individual will be selected for the purposes of tracking the behaviour and movement of the group, based on its distinctive feature such as colouration or severe injury mark. The focal individual will then be tracked continuously via the theodolite, with positions recorded whenever the dolphin surfaces. If an individual cannot be positively distinguished from other members, the group will be tracked by recording positions based on a central point within the group when the dolphins surface.

Tracking will continue until animals are lost from view, move beyond the range of reliable visibility (> 5 km), or when environmental conditions obstruct visibility (e.g. intense haze). Behavioural state data (Table 1) will also be recorded every 5 minutes for the focal individual or group. This interval is long enough to allow for determination of the behavioural state, and short enough to capture behavioural responses to the bored piling activities. Moreover, when multiple groups or individuals are present in the study area, attempts will be made to record the behaviours of all groups/individuals every 10 minutes, with spotters assisting in determining behaviour of the dolphins.

Positions of dolphins, boats and construction activities will be measured using a Sokkisha DT5 digital theodolite with ± 5-sec precision and 30-power magnification connected to a laptop computer running the program *Pythagoras* Version 1.2 (Gailey and Ortega-Ortiz 2002). This program calculates a real-time conversion of horizontal and vertical angles collected by the theodolite into geographic positions of latitude and longitude each time a fix is initiated.

Pythagoras also displays positions, movements, and distances in real-time. When possible, the position of the focal dolphin will be recorded at every surfacing with use of *Pythagoras*. The position, type, and activity of all vessels within 5 km of the focal dolphin will also be recorded. An effort will be made to obtain at least several positions for each vessel, and additional positions will be acquired when vessels change course or speed.

While the primary source of human disturbance to dolphins of interest in this study is bored piling works for the Hong Kong Link Road Project, the presence of vessels may also have an effect on the behaviour and movement patterns of dolphins. Prior to the construction phase (i.e. baseline phase), the simultaneous tracking of dolphins and boats over time will provide information on the speed and orientation of dolphins, as well as their movements in relation to vessel activities. This data will be used as a baseline for comparison once construction begins. Other construction activities in relation to the bored piling works will be recorded during the construction phase monitoring, and the same theodolite tracking and behavioural procedures will be followed as during the baseline phase.

2.5. Data Analysis

2.5.1. Assessment on potential impacts from bored piling activities

2.5.1.1. Movement patterns

To evaluate if dolphin behaviour or movement patterns vary in the presence of vessels in the baseline phase, it is necessary to determine how many vessels are present with the focal group at any time. A vessel will be considered to be present with the focal dolphin when the two are within 500 metres of each other. Data recorded in *Pythagoras* will be used to calculate dolphin and vessel positions in latitude and longitude for this comparison. If two consecutive fixes in a track for one dolphin are more than 300 seconds apart, the track will be split at this point, which will be analysed separately. Dolphin and vessel positions will be interpolated every 150 seconds, assuming linear travel at a constant speed between subsequent positions. Distance between the focal individual/group and each vessel will be calculated to determine how many vessels are within 500 metres of the group at each point.

Tracks will be split into 10-minute segments and the maximum number and type of vessels present calculated for each segment, as well as bored piling activity state during the construction phase. Several response variables, including mean leg speed, mean inter-breath interval, reorientation rate and linearity, will be calculated for each segment for both baseline and construction phases of monitoring. These response variables have been commonly used by many researchers, including the dolphin specialists of the present project (Lunquist et al. 2012a; Lundquist 2012; Lunquist and Markowitz 2009). Leg speed (km/hr) is the displacement between two successive points divided by the time interval. Inter-breath interval (s) is the length of time between successive surfacings. Reorientation rate (˚/min) is a measure of how much the group changed course over time. It is calculated as the sum of the absolute values of heading changes (defined as 0 to 180 degrees relative to the current bearing) divided by the duration of the track in minutes. Linearity is a dimensionless index ranging from 0 (no net movement) to 1 (straight line). It is calculated by dividing net distance from the first to last fix of a track by the sum of all the distances for each leg.

Multiple segments within a track cannot be considered statistically independent, thus analysis of each as a single sample results in pseudoreplication. The time interval required between two segments from the same track for them to no longer show autocorrelation will be calculated in a preliminary analysis using linear mixed-effect modelling in *R*. Segments will be filtered based upon the results of the autocorrelation analysis.

Generalised additive models will be fitted using package mgcv in *R* to describe heterogeneity in dolphin responses to vessels and bored piling activities. This package uses thin-plate regression splines to fit smooth terms for the explanatory variables. It includes a penalty for excessive flexibility, which is determined by the number of knots used to model the smoothed relationship for each model term. Smoothing is automated for all model terms simultaneously, with the multiple generalised cross-validation (GCV) score used within a maximum likelihood framework to evaluate fit of the model. Simultaneous evaluation (rather than one-by-one) avoids problems inherent to many step-wise procedures.

To aid model convergence, the number of knots in each spline will be left at the default of 10 (9 degrees of freedom). Histograms will be evaluated for each response variable to determine the appropriate distribution and link function to use. The fully saturated model is:

$$y \sim s(NumberOfBoats) + TypeOfBoats + ConstructionActivity$$

The procedure for dropping terms from the model is based on rules specified by Wood (2001). Smooth terms will be dropped if three conditions are met:

1. The estimated degrees of freedom (e.d.f.) is close to 1
2. The confidence interval for the term includes zero everywhere

3. The GCV score drops and deviance explained increases when the term is removed

If the first condition is met but not the other two, the smooth term will be replaced with a linear term for that variable. Linear terms will be dropped if:

1. The parameter coefficient is close to 0
2. The significance of the term is near to 1
3. The GCV score drops and deviance explained increases when the term is removed

In summary, the abovementioned analytical technique (based on a previous study by Bain et al. 2006) utilizes a model which includes all factors of interest in which the dolphin movement might be affected (hence called "fully saturated model", which includes all factors). A statistical technique (i.e. generalized addictive modeling) is then used to fit the data to the model and determine which factors that actually help predict differences in dolphin movement and describe the heterogeneity in the response. From these results, it can be determined whether human activities have influenced dolphin movements.

For comparison between baseline and construction phase monitoring data, the analysis of data from the baseline phase will first be performed to determine whether there are influences due to vessel presence in the absence of construction activity. Then the construction phase data will also be added into the model (while keeping the baseline data as well) and recalculated. If the construction activity (i.e. bored piling works) is a significant factor in the best-fitting model, then it is evident that dolphin movements were in fact affected by the construction activity.

2.5.1.2. Behavioural state

Since consecutive behavioural observations are not likely to be statistically independent, they will be analyzed as a series of time-discrete Markov chains. First-order Markov chain analyses will be used to quantify the dependence of each behaviour event on the preceding event in the behavioural sequence. Defining a set of mutually exclusive and wholly inclusive behaviours (Table 1) permits analysis of variation in behaviour of dolphin groups using Markov chains. Notably, the same set of variables for behavioural state (see Table 1) will be collected in both baseline and construction phases of monitoring to maintain consistency. This form of analysis of behavioural impacts of human activity has been widely used in past cetacean studies (Lusseau 2003; Lundquist et al. 2012a, b).

Each 10 min sample will be classified according to the behavioural state and number of vessels present, as well as bored piling activity state during the construction phase. Markov chains will be used to build transition matrices of preceding behaviour (at time 0) versus succeeding behaviour (at time 1) for each transition split by vessel presence/absence and bored piling activity state. A transition will only be included in the "no vessel" chain when no vessels are present for at least 15 min prior to the observation period in order to reduce the likelihood that dolphin behaviour was altered due to a vessel interaction.

In the baseline phase, two chains (behaviour when no vessels are present vs. behaviour when vessels are present) will be compared using log-linear analysis as described below. In the construction phase, two sets of chains (baseline vs. construction with vessels present, and baseline vs. construction with no vessels present) will also be compared. Any differences between these chains will help determine if human activities have a significant effect on behavioural transitions of dolphins, and indicate whether dolphins have behaved differently due to the construction activity. Notably, if no difference is found between the two chains in the baseline phase, all of the baseline data can then be combined for comparison to the data collected in the construction phase. In that case, the comparison during construction phase will simply be between two chains: baseline phase behavioural data vs. construction phase behavioural data (i.e. there will be no need to split the data by vessel presence).

Log-linear analysis (LLA) will be conducted in *R* to test whether the likelihood of dolphins moving from one behavioural state to another is affected by human activities. This will be accomplished by using count data from the transition matrices and testing models in *R* for all combinations of parameters and interactions between parameters: 5 preceding behaviours x 5 succeeding behaviours x 2 vessel conditions x different bored piling activity states. The two vessel conditions would be: 1) no vessels present, and 2) vessels present. The different bored piling activity states will be further defined when different stages of bored piling procedure are confirmed with the engineers before construction commences, but will at least include two activity states: 1) no construction activity being conducted, and 2) construction activity being conducted. Maximum likelihood for the model being tested is approximated by G^2. Comparing the goodness-of-fit for each model to the goodness-of-fit for the fully saturated model (ΔG^2) approximates the effect of the missing variables. Degrees of freedom are the difference in degrees of freedom between the two models being compared. Evaluating the significance of this difference determines which variables are significant. Akaike Information Criteria (AIC) values will be calculated and used to choose the best-fitting model.

Based on the results from the LLA, the transition matrices will be used to calculate the behavioural budget of dolphins in the absence and presence of human activities. The left eigenvector of the dominant eigenvalue of each transition matrix will be used to approximate the behavioural budget of dolphins under the conditions of the matrix. A Z test for proportions will be used to test for differences between behavioural budgets, and 95% confidence intervals will be calculated.

2.5.2. Assessment of potential impacts on north-south movements

To investigate whether the north-south movement of Chinese white dolphins between North and West Lantau waters will be affected by the presence of Hong Kong Link Road, in particular the spacing between bridge pile cap piers, two approaches will be adopted to examine the number of dolphins that move across the bridge alignment (either from north to south, or from south to north) before and during the construction of the bridge.

First, the proportion of dolphin tracks per unit of theodolite tracking effort that cross the bridge alignment before and during construction will be compared to determine if there is any significant change, which will be evaluated by parametric (z-test for two proportions) or non-parametric (chi-squared test) statistical procedure as appropriate. The advantage of this approach is to demonstrate directly how dolphin movements occur across the bridge alignment. If a significantly greater percentage of dolphin tracks is recorded crossing the bridge alignment in the baseline phase than in the construction phase, the obstruction of the bridge as a barrier to dolphin movement will become evident.

However, the sample size for the first approach may be insufficient during the 30 days of baseline theodolite tracking works, and there is a possibility that the ability to track dolphins is compromised when the dolphins are at greater distances (i.e. to the north of bridge alignment which is further away from the tracking station). In light of this, a second approach will also be adopted, which is to calculate the proportion of sightings per unit of theodolite tracking effort on each side of the bridge alignment. Such proportion of sightings on both sides of the bridge alignment will be compared (as described above) between the baseline and construction phases to determine whether there is a significant difference before and during construction phases. These analyses with the two approaches will be conducted at the end of the construction period, to allow enough sample sizes of data collected between baseline and construction phase monitoring for meaningful statistical comparisons.

Moreover, as the ranging patterns of many individuals based on photo-identification data indicated in the past that they frequently moved across the area of the proposed bridge alignment before the bridge is constructed (i.e. baseline phase) (Hung 2011, 2012), their range use will be further examined at the end of the construction period to determine whether any shift in range use has occurred in response to the potential obstruction by the bridge structure. For the ranging pattern analysis, location data of individual dolphins with 10 or more re-sightings that were frequently sighted on both sides of the bridge alignment will be obtained from the HKCRP photo-identification catalogue. To deduce home ranges for individual dolphins using the fixed kernel method, the program Animal Movement Analyst Extension (Hooge and Eichenlaub 1997) will be loaded as an extension with ArcView© 3.1 along with another extension Spatial Analyst 2.0. The kernel estimator then calculates and displays the overall ranging area at 95% UD (utilization distribution) level. The ranging patterns of the examined individuals will be compared between baseline (several years before construction) and construction phases, to determine whether any shift in range use has occurred during the construction period, and the results will be used to supplement information for the abovementioned analyses utilizing shore-based theodolite tracking data.

3. KEY PERSONNEL AND QUALIFICATIONS

According to the EM&A requirement, the present land-based dolphin behaviour and movement monitoring should be undertaken by suitably qualified specialist(s) with sufficient (at least 5-10 years) relevant post-graduate experience and publication in the respective aspects (in this case, theodolite-tracking technique). Approval on the specialist(s) responsible for this ecological monitoring survey should be sought from AFCD and EPD.

To satisfy this requirement, HKCRP will employ **Professor Bernd Würsig**, the Senior Research Consultant of HKCRP, and **Dr. David Lundquist**, the Research Consultant of HKCRP, to serve as dolphin specialists for this project. Professor Würsig is a world-renowned marine mammal biologist, and has been studying many cetacean species in the past 30 years. Professor Würsig has pioneered several major research techniques including theodolite tracking and photographic recognition of marine mammals that are widely applied across the marine mammal field of science, and his experience in theodolite tracking on cetaceans is unparalleled in the world. Professor Würsig has published over 140 peer-reviewed journal articles and book chapters, with many on the topic of land-based theodolite tracking works to study the behaviour and movement of cetaceans. In fact, the only two publications on theodolite tracking works on Chinese white dolphins in Hong Kong were authored (Würsig et al. 2000) and supervised/co-authored (Piwetz et al. 2012) by Professor Würsig (both were included in the appendix for reference) . His unique experience in shore-based theodolite tracking and extensive knowledge on Chinese white dolphins and Hong Kong marine environment will greatly enhance the success of the present study. For the presents study, Professor Würsig will be responsible to oversee the entire study, by developing the methodology proposal, supervising the local field works with Dr. Samuel Hung, conducting data analyses with the assistance of Dr. David Lundquist, writing up the baseline report and construction phase report, and answering any queries in relation to the land-based study. His detailed CV is included in the Appendix.

Dr. David Lundquist will serve as another dolphin specialist for the project, and will assist Professor Würsig in various data analyses under the present study. Dr. Lundquist has over five years of theodolite tracking experience, and the topics of his master's thesis and Ph.D. dissertation were on behaviour and movement patterns of southern right whales and dusky dolphins respectively, utilizing land-based theodolite tracking data to examine the effects of ecotourism activities. Dr. Lundquist is very experienced in advanced analysis of theodolite tracking data with many years of experience, and has published several papers on such works, including the movements of Chinese white dolphins in Hong Kong in response to vessel movements (Piwetz et al. 2012). The CV of Dr. Lundquist is included in the Appendix.

For the local field works, Professor Würsig and Dr. Lundquist will supervise the HKCRP research team, led by **Dr. Samuel Hung**, the Director of HKCRP. Since 1997, Dr. Hung has been extensively involved in the multi-disciplinary research on Chinese white dolphins in Hong Kong and nearby regions, and has been widely recognized as the leading marine mammal expert in Hong Kong. He has 16 years of field experience in studying Chinese white dolphins, and has profound knowledge and experience on different cetacean research and monitoring techniques. In 2011, under the close supervision of Professor Würsig, Dr. Hung and his research team have successfully initiated a long-term study on investigating dolphin behaviour and movements using shore-based theodolite tracking technique (Hung 2012). This pioneer study has helped to understand the potential disturbance effects of vessel movements and associated underwater noises on dolphins (Piwetz et al. 2012). The CV of Dr. Hung is included in the Appendix.

The local theodolite tracking team will be composed of three main personnel: one primary theodolite operator, one computer operator, and one dolphin observer (i.e. spotter). The primary theodolite operator would require the most relevant experience, and this important role will be fulfilled by two key staff of HKCRP, **Mr. Vincent Ho** and **Mr. Perry Chan**. Mr. Ho and Mr. Chan were both trained and endorsed by Professor Würsig in April 2011, and their field works have been audited by Professor Würsig again in October and December 2012. Both have nearly two years of theodolite tracking experience in Hong Kong, including all tracking works from Shum Wat Station. They have helped Professor Würsig to set up the theodolite tracking station at Shum Wat in April 2011, and have been extensively involved in the field works of theodolite tracking for AFCD long-term monitoring project since then. Moreover, both have been extensively involved with the recent land-based theodolite tracking works for the EIA study of the Third Runway Expansion Project commissioned by the Airport Authority, under the close supervision of Professor Würsig and Dr. Samuel Hung. Their unique field experience in land-based theodolite tracking on small cetaceans in Hong Kong is unparalleled, and both are uniquely qualified to undertake the specialized field works for the present study. Their CVs are included in the Appendix.

Besides Mr. Ho and Mr. Chan as the primary theodolite operators, the theodolite tracking works will be supported by the strong field team of HKCRP. Several research assistants, with the training and supervision of Dr. Samuel Hung, will be allocated to rotate into the positions of computer operator and dolphin observer. Dr. Hung will supervise the field work team closely, and will audit the field works once per week to ensure the data quality is consistent.

4. REPORTING

According to EM&A Manual, the Environmental Team (ET) Leader shall prepare and submit a Baseline Environmental Monitoring Report within 10 working days of completion of the baseline monitoring. Copies of the Baseline Environmental Monitoring Report shall be submitted to the Contractor, the IEC, the ER and EPD.

The baseline monitoring report will include at least the following information:

- up to half a page executive summary;
- brief project background information;
- drawings showing locations of the baseline monitoring stations;
- monitoring results together with the following information:
    - monitoring methodology;
    - parameters monitored;
    - monitoring locations; and

  - monitoring date, time frequency and duration;
- details of influencing factors, including:
  - major activities, if any, being carried out on the site during the period;
  - weather conditions during the period; and
  - other factors which might affect the monitoring results;
- determination of the Action and Limit Levels for each monitoring parameter and statistical analysis of the baseline data; and
- comments, recommendations and conclusions.

For the reporting schedule, according to Section 16.2 of the EM&A Manual, the results and findings from the baseline period shall be prepared and submitted as a Baseline Environmental Monitoring Report within 10 working days of completion of the baseline monitoring. Moreover, upon the completion of the 30 days of construction phase monitoring on dolphin behaviour and movement in response to bored piling activities, a final report shall be prepared and submitted within 30 days. Copies of the Baseline Environmental Monitoring Report and Construction Phase Monitoring Report on dolphin behaviour and movement in response to bored piling activities shall be submitted to the Contractor, the IEC, the ER and EPD.

According to Section 16.3 of the EM&A Manual, the monthly progress from monitoring on north-south movement of dolphins shall be recorded in the monthly EM&A reports prepared by the ET Leader. The EM&A report shall be prepared and submitted within 10 working days of the end of each reporting month, with the first report due the month after construction commences. The monthly EM&A report shall be submitted to the Contractor, the EIC, the ER and EPD.

4. EVENT AND ACTION PLAN

According to Section 10.8.1 of the EM&A Manual, the Action and Limit Levels and event-action plan for ecology shall be proposed by respective specialists of the Environmental team upon the baseline monitoring data, and agreed by AFCD and EPD. Since the baseline condition has yet to be established, only a preliminary Event and Action Plan is included here based on the response variables for dolphin movement patterns (i.e. mean leg speed, mean inter-breath interval, reorientation rate and linearity) and dolphin behaviours (five different behavioural states), which will be recorded during both baseline and construction phase monitoring works.

If these variables recorded in the construction phase are significantly different from those in the baseline phase (such comparison will be conducted using various data analyses as described in Section 2.5), the Action Level or Limit Level will be triggered, and the corresponding follow-up action will be taken. The actual Action Level (AL) and Limit Level (LL) will be determined upon the examination of baseline data, and the AL and LL along with the corresponding follow-up actions will be proposed in the Baseline Environmental Monitoring Report within 10 working days of completion of the baseline monitoring as described in the reporting schedule.

Preliminary Event and Action Plan

EVENT	ACTION			
	ET Leader	**IEC**	**SO**	**Contractor**
Response variables for dolphin movement patterns including mean leg speed, mean inter-breath interval, reorientation rate and linearity, as well as dolphin behaviour, recorded in the construction phase monitoring are significantly different from those recorded in the baseline monitoring	- Repeat statistical data analysis to confirm findings; - Review historical data to ensure differences are as a result of natural variation or previously observed seasonal differences; - Identify source(s) of impact; - Inform the IEC, SO and Contractor; - Check monitoring data; - Discuss additional dolphin monitoring and any other measures, with the IEC and Contractor.	- Discuss monitoring with the ET and the Contractor; - Review proposals for repeat monitoring and any other measures submitted by the Contractor and advise the ER accordingly.	- Discuss with the IEC the repeat monitoring and any other measures proposed by the ET; - Make agreement on the measures to be implemented.	- Inform the FSR and confirm notification of the non-compliance in writing; - Discuss with the ET and the IEC and propose measures to the IEC and the SO; - Implement the agreed measures.

Abbreviations: ET – Environmental Team, IEC – Independent Environmental Checker, SO – Supervising Officer

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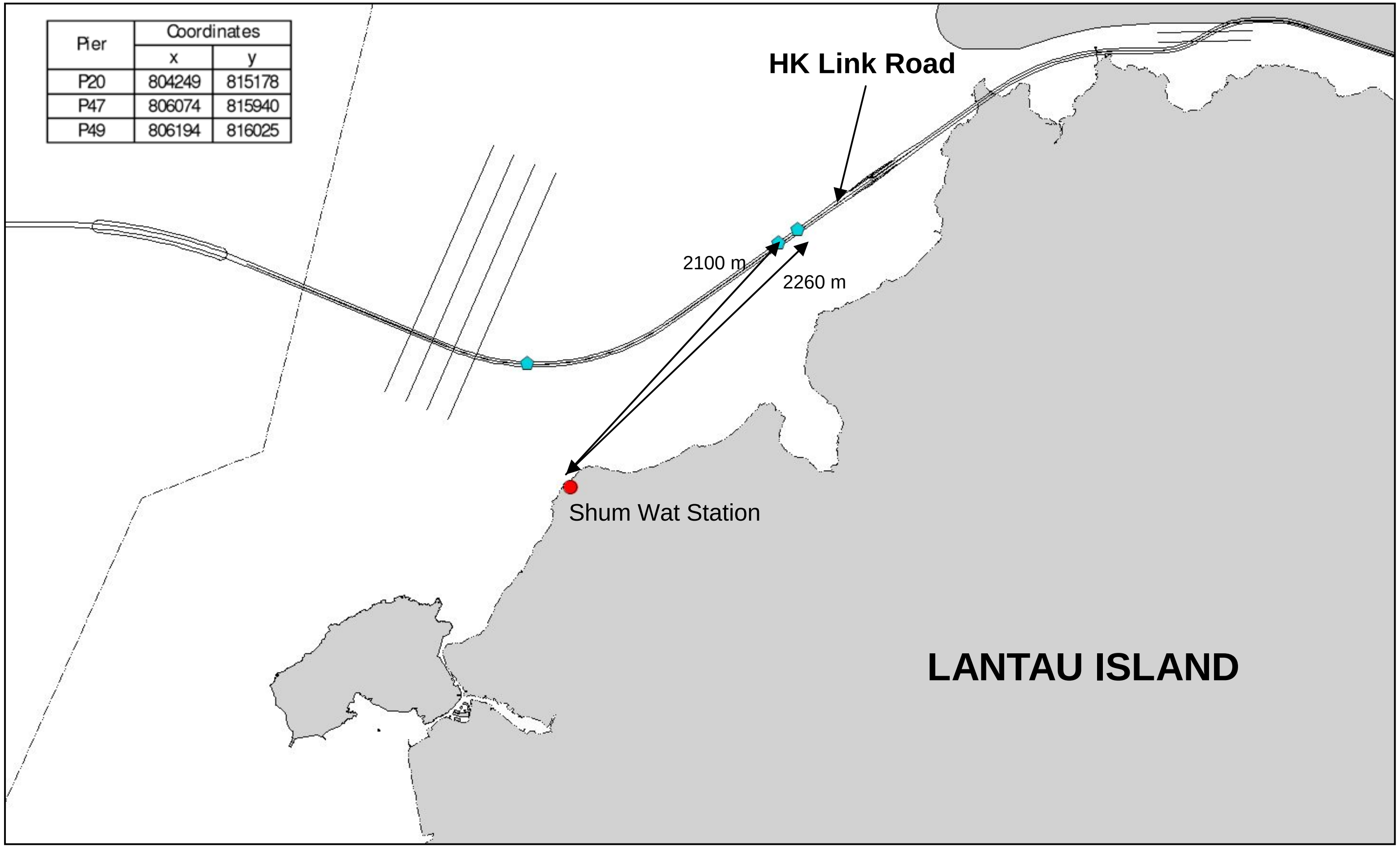
Table 1. Definitions of group behavioural states of dolphins.

State	**Definition**
Resting	Dolphins close to the surface and each other, surfacing at regular intervals and in a coordinated fashion. Movement very slow.
Traveling	All individuals oriented and moving in the same direction. This behavioural state includes all high-speed, directional behaviours (e.g. porpoising).
Milling	Individuals within the group simultaneously moving in different directions, with no overall clear direction of travel.
Socialising	Physical interactions taking place among members of the group, including chasing, high levels of body contact, coordinated clean leaps and noisy leaps.
Feeding	Dolphins observed either capturing or pursuing fish at the surface. High number of non-coordinated re-entry leaps, rapid changes in direction and long dives. Dolphin rostrum or body covered with mud. Associations with operating fishing boats.

Figure 1. Location of Shum Wat in northwestern Lantau with the first three bored piling locations



Pier	Coordinates	
	x	y
P20	804249	815178
P47	806074	815940
P49	806194	816025

Figure 2. Panoramic View from the Shum Wat Theodolite Tracking Station (photos taken on 20/12/2012)