APPENDIX 3E DETAILED ANALYSIS ON EFFECT OF ARTIFICIAL AERATION AT MARICULTURE OPERATIONS

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This ***Appendix*** details the assumptions and findings for simulation of the effect of providing artificial aeration as a mean to improve the level of dissolved oxygen at the Project Site.

3E.1 Finding of Modelling Simulation and Implications

Under the modelled baseline scenario, the predicted 10th-percentile depth-averaged dissolved oxygen levels were predicted to be at 4.0 mg/L within the proposed FCZ of Wong Chuk Kok Hoi (also referred as Project Site), which are lower than the WQO criterion of 5 mg/L adopted for assessment. The other water quality parameters at Project Site were predicted to be in compliance to the corresponding WQO criteria.

Mariculturists typically are familiar with low dissolved oxygen conditions and would be aware of such conditions via observing behavioural change of the fish stock and / or by onsite water quality monitoring devices. Also, AFCD is expected to install real time water quality monitoring device at Project Site and inform mariculturists regarding notable water quality deterioration detected. As such, it is anticipated that mariculturists would apply suitable management / control for their own business interest.

One typical response for low dissolved oxygen for mariculture is aeration. Aeration allows oxygen to enter the water column and improve the anoxic conditions. For this Study, the project scenario took into account the change in dissolved oxygen level when aeration is applied at the fish farm of the Project Site by mariculturists.

It should also be highlighted that the observed 10th-percentile depth-averaged dissolved oxygen level at the existing Wong Wan FCZ (shown in ***Figure 3.2 of this EIA Report***) by AFCD was 5.4 mg/L from 2015-2021, which matches pretty well with the model prediction of 5.2 mg/L under the baseline scenario. Given the both the existing Wong Wan FCZ and Project Site are located within the Wong Chuk Kok Hoi embayment, the notable difference in dissolved oxygen levels under the baseline scenario is contributed to the notably higher water depth in Project Site (i.e. inclusion of larger portion of deeper water column resulting in lower depth-averaged dissolved oxygen). In fact, the predicted level of dissolved oxygen on the surface layer, where most of the maricultural activities take place, would be much better than the mid-depth and bottom layer (refer to time series provided in ***Appendix 3C***). This means the actual effect of low dissolved oxygen level on the fish stock at Project Site would likely be less significant than the corresponding figure presented based on the assessment criteria in WQO apparently indicates.

3E.2 Model Settings

For evaluation of the effectiveness for providing aeration at mariculture operation, the 10th-percentile depth-averaged dissolved oxygen would be adopted as the major criterion as that is the only criterion that does not comply to the assessment criteria at Project Site. Note that the assumed aeration method for this exercise was designed to evaluate against WQO compliance. Mariculturists may adopt different aeration regime based on their professional judgment to suit their need.

All the model settings adopted for the project scenario were identical to the baseline scenario, except for the pollution load from the proposed mariculture operation at the Project Site, the nearby proposed new FCZs at Site B and Site C, as well as provision of oxygen loading within Project Site. Please refer to ***Appendix 3A*** for model assumptions and other settings.

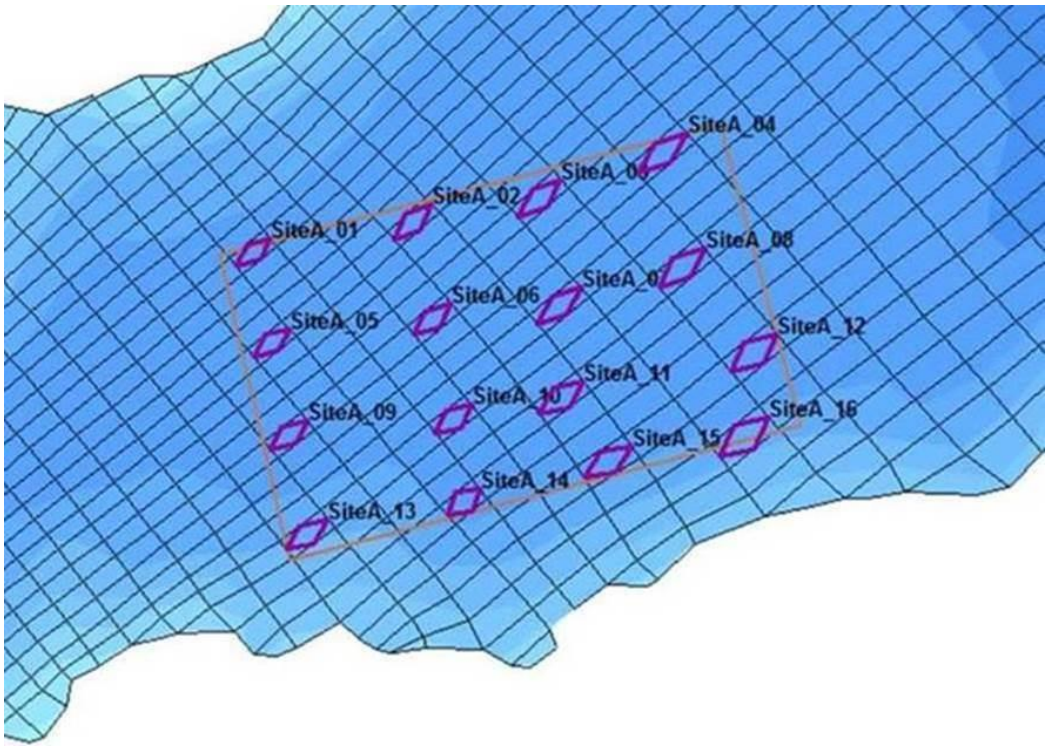
In terms of modelling of aeration, it is assumed air will be pumped and released at the lower end of the water column of mariculture operations in Site A at fixed rate for the three months with lowest dissolved oxygen levels predicted under the baseline scenario. It is assumed the released gas will be in form of fine bubbles to allow effective retention and gaseous exchange with the entire water column. The modelled scenarios were summarized below in ***Table 3E1.1***.

Table 3E1.1 Modelling Scenarios – Consideration for Aeration

ID	Aeration Rate and Duration	Description
Baseline	No aeration	Baseline Scenario – without Project.
Project-	16 L/s at each mariculture operation in July, August and September	Project operation with aeration for three months.

For the aeration scenario, aeration was assumed to occur at each fish farm (1) in the Project Site (indicatively shown in ***Figure 3E.1.1*** below). It is assumed diffused aeration method would be used to allow fine bubbles to be released from the lower end of the water column and passes through the entire water column to maximize gaseous exchanges. For 16 L/s aeration rate, about 4.3571 g/s of oxygen (2) would enter the water column. Assuming roughly 50% oxygen dissolved into the water column (3), about 2.1786 g/s of oxygen would become dissolved oxygen at each fish farm. The dissolved oxygen load was assumed to be evenly distributed in the entire water column.

Figure 3E.1.1 Locations of Loading Input for Project Site



3E.2 Model Findings

A summary of predicted results for dissolved oxygen under baseline and project scenarios are provided in ***Table 3E1.2***. Time series of dissolved oxygen level at surface, mid-depth and bottom levels at Site A under baseline and project scenarios were presented in ***Appendix 3C***. As shown, modelling results

(1) In the model, pollution load from mariculture operation was discharged into the water column at 16 discrete points in the Project Site. For this exercise, these 16 points are considered as individual fish farms. Accordingly, loading of dissolved oxygen were added to the model alongside with other pollution load during the specified period.

(2) Take density of air as 1.184 g/L and oxygen mass percentage of 23%, oxygen flow rate is calculated as:
16 L/s × 1.184 g/L × 23% = 4.3571 g/s

(3) Typical oxygen transfer efficiency for fine bubble diffuser could be up to 2% per foot of diffuser submergence (https://www.webpages.uidaho.edu/ce431/Handouts/Sanitaire%20Diffused%20Air%20Design%20Guide.pdf). For deployment near bed level at Project Site (>10 m or >32.8 ft), oxygen transfer efficiency would be over 50%. Therefore, assuming at 50% oxygen transfer is deemed conservative.

indicated aeration for 3 months at rate of 16 L/s will allow levels of 10th-percentile depth-averaged and bottom dissolved oxygen to remain at levels same as the baseline scenario.

Table 3E1.2 Modelling Results for Dissolved Oxygen for Aeration at Site A

ID	WSR	Scn.	Annual			
			10th-percentile		Mean	
			Depth-averaged	Bottom	Depth-averaged	Bottom
			Dissolved Oxygen (mg/L)			
Fish Culture Zone – Mirs Bay Assessment Criteria			≥5	≥2	N/A	N/A
Project site	Proposed Wong Chuk Kok Hoi FCZ	Baseline	**4.0**	2.9	5.8	5.2
		Project	**4.0**	2.8	5.8	5.1

3E.2 Summary and Conclusion

Water quality modelling simulation has taken into account aeration by mariculturists at Project Site in response to the predicted low dissolved oxygen levels under baseline scenario. Modelling results indicated aeration will result in localized increase of dissolved oxygen at Project Site and negate the effect of increase organic loading from Project operation. Within Project Site, the modelling results indicated aeration provided for the three months with the lowest dissolved oxygen levels at rate of 16 L/s at each mariculture operation will allow 10th-percentile depth-averaged dissolved oxygen levels be at level similar to the baseline condition (i.e. no aggravation of existing condition).

Overall, the modelling results indicated mariculturists will be able to exert control over the dissolved oxygen levels at their mariculture operation in response to low dissolved oxygen condition which typically occur in wet season. Therefore, the predicted reduction in dissolved oxygen at the Project Site could be controlled by adopting aeration as necessary and unacceptable water quality impact is not anticipated for mariculture operation at Project Site after adopting such control measure in case of low dissolved oxygen level.