

**Agreement No. DP 04/2012
Post-Construction Ecological Monitoring
of Drainage Improvement Works in Southern Lantau
Implemented under 4128CD in Contract DC/2006/11**

Final EM&A Review Report

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Pursuant to Condition 4.4 of Environmental Permit No. EP-237/2005/B (amended by EP-237/2005/C), this Final EM&A Review Report for post-construction ecological monitoring and ecological water monitoring has been certified by the Environmental Team Leader (ETL) and verified by the Independent Environmental Checker (IEC)

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EXECUTIVE SUMMARY

This is the Final EM&A Review Report of ecological monitoring and audit exercise for “Drainage Improvement in Southern Lantau” conducted by AECOM Asia Company Limited. The four-year ecological monitoring and audit exercise had been completed in accordance with the EM&A Manual and Environmental Permit requirement in September 2016.

This report summarises the post-construction phase ecological monitoring and audit requirement for the activities undertaken under Agreement No. DP 04/2012, from October 2012 to September 2016. The aim of this monitoring programme is to provide data on the re-establishment of aquatic/riparian communities in the Pak Ngan Heung River (PNH) and Luk Tei Tong River (LTT), marsh habitats at Luk Tei Tong Bypass Channel (LBC) and provide recommendation for the future maintenance activities.

LBC1 was dominated by wetland native species Ferruginous-scale *Fimbristylis* and Leather Fern, which may indicate re-establishment of marsh habitat. LBC2 to LBC5 were dominated by exotic *Wedelia trilobata* which is commonly found in dry land habitat. Limited occurrence of wetland plants at LBC2 to LBC5 may suggest that the water levels/availability within the channel may not be adequate to sustain a marsh habitat.

Significant coverage of exotic Mile-a-minute was observed at PNH3 and PNH4. Overgrown vegetation may hinder the use and movement by fish or freshwater community within the stream. The number of plant species and abundance were low at PNH1, PNH2 and LTT1 to LTT5. Scattered climber or herb species such as *Bidens alba*, Burma-reed and Sea Sword Bean were occasionally recorded at these sites.

During the monitoring programme, no major activities or habitat deterioration were observed. Fauna species, including avifauna, odonate, herpetofauna, freshwater fish and aquatic macroinvertebrate community showed limited fluctuation. The two fish species of conservation importance recorded during the EIA study, Predaceous Chub and Dark-margined Flagtail, were also recorded at PNH and LTT during the monitoring period.

The water quality of the monitored channel sections largely complied with the Water Quality Objectives (WQO) (EPD, 2016), only occasional minor exceedances were recorded. No continuous deteriorating trends or major discharges from nearby village housings were observed. Implementation of specific environmental protection/mitigation measures related to water quality was not required.

1. INTRODUCTION

1.1. Background

1.1.1. The Drainage Services Department (DSD) has implemented Contract No. DC/2006/11 "Drainage Improvement in Southern Lantau and Construction of Mui Wo Village Sewerage Phase 1". The monitoring requirements of the drainage improvement works are subject to the conditions specified in Environmental Permit (EP) No. EP-237/2005/B issued by the Environmental Protection Department (25 January 2006). In response to the latest approval to Variation of an Environmental Permit (VEP) application (VEP-465/2015) regarding Drainage Improvement in Southern Lantau (17 February 2015), the former EP-237/2005/B has been amended to EP-237/2005/C; however, this has not changed the original monitoring requirements. In compliance with the EP, an Environmental Monitoring and Audit (EM&A) programme was established during the construction and post-construction phases of the project. The operation of the project is subject to the conditions in EP No. EP-434/2012. In response to the latest approval to VEP application (VEP-464/2015), the former EP-434/2012 has been amended to EP-434/2012/A.

1.1.2. The post-construction ecological monitoring and audit of drainage improvement works in Southern Lantau under Agreement No. DP 04/2012, commenced in January 2012. AECOM Asia Company Limited was appointed by DSD as the Environmental Team (ET) to conduct the above captioned monitoring project from October 2012 to September 2016. The project proponent has also appointed Ramboll Environ Hong Kong Limited as the Independent Environmental Checker (IEC) for the Project.

1.1.3. A synopsis of project organization for the Project are shown in **Appendix 1** respectively.

1.2. Project Description

1.2.1. Under Contract No. DC/2006/11, the improvement works were undertaken at Pak Ngan Heung River (PNH), Luk Tei Tong River (LTT) and Tai Tei Tong River in Southern Lantau, west of Mui Wo. The works for which the post-construction ecological monitoring required by EP No. EP-237/2005/B (later amended to EP-237/2005/C) included:

- the drainage channel and a three-cell box culvert at PNH;
- the drainage channel at LTT; and
- the bypass channel at LTT.

1.2.2. No ecological monitoring and ecological water monitoring was required following the drainage improvement works at Tai Tei Tong River and village sewerage works in Mui Wo.

1.2.3. Both PNH and LTT are part of the Mui Wo River (also named as Silver River) in Lantau Island. These two tributaries of Mui Wo River, together with Tai Tei Tong River, then joined and connected to Silver Mine Bay next to Mui Wo.

1.3. Report Objectives

1.3.1. This is the Final EM&A Review Report prepared for the Project, pursuant to the Final EM&A Manual. This report summarised the monitoring results over the four-year ecological monitoring exercise conducted from October 2012 to September 2016.

2. ECOLOGICAL MONITORING AND AUDIT REQUIREMENTS

2.1. Ecological Monitoring

2.1.1. According to the Final EM&A Manual of the EIA report, a specific ecological monitoring programme of the improved section of PNH, LTT, LTT Bypass Channel (LBC) and its Reference Site (RS) is recommended. Details of the monitoring parameters and survey methodology of each site are described below.

Pak Ngan Heung River and Luk Tei Tong River

2.1.2. The ecological survey for these two rivers was divided into nine 50 m sections and comprised the following:

- Two sections for downstream of PNH (PNH1 and PNH 2), two sections for upstream of PNH (PNH3 and PNH4); and
- Five sections for LTT (LTT1 to LTT5).

2.1.3. The location plan of ecological monitoring at PNH and LTT is shown in **Figure 1** in **Appendix 2**. The survey methodology and monitoring parameters at PNH and LTT are described in **Table 1** below.

Table 1 Survey Methodology and Monitoring Parameters at PNH and LTT

Vegetation Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Aquatic, emergent and riparian vegetation community was recorded by walk-through survey <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Species composition • Relative abundance
Avifauna Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Bird species in each 50 m section were surveyed quantitatively using transect count method <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Species • Abundance
Odonate Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Adult odonate community in each 50 m section were surveyed quantitatively by transect count method <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Species • Abundance
Fish and Aquatic Macroinvertebrate Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Sampling methods included active searching, direct observation, hand netting and kick sampling <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Diversity • Relative abundance

Luk Tei Tong Bypass Channel

2.1.4. The ecological survey for the Luk Tei Tong Bypass Channel (LBC) and its Reference Sites (RS) were carried out in every 50 m section and comprised the following:

- Five sections for LBC (LBC1 to LBC5);

- Five sections for RS (RS1 to RS5).

2.1.5. The location plan of ecological monitoring is shown in **Figure 1** in **Appendix 2**. The survey methodology and monitoring parameters at LBC and RS are described in **Table 2** below.

Table 2 Survey Methodology and Monitoring Parameters at LBC and RS

Vegetation Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Relative plant cover of aquatic, emergent and riparian vegetation were determined by line-intercept method • One line transect of 10 m was set perpendicular to the stream channel at each section, and five 1 m x 1 m quadrats were placed along the transect. Relative coverage and plant species intercepting the transect line was recorded • Percentage cover of each species within the quadrat was recorded to the nearest 10% (except "1" = present but insignificant cover, normally 1 to 2 individuals, and 5% = up to 5%) and their conditions were described <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Relative coverage • Species
Avifauna Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Bird species in each 50 m section were surveyed quantitatively using transect count method <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Species • Abundance
Odonate Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Adult odonate community in each 50 m section were surveyed quantitatively by transect count method <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Species • Abundance
Herpetofauna Survey	<p><u>Survey Methodology</u></p> <ul style="list-style-type: none"> • Any potential habitats of herpetofauna community within LBC and RS by active searching • Amphibians were identified by their calls and the number of calling males in each section was recorded <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Species • Abundance
	<p><u>Survey Methodology</u></p>

Fish and Aquatic Macroinvertebrate Survey	<ul style="list-style-type: none"> • Sampling methods included active searching, direct observation, hand netting and kick sampling <p><u>Monitoring Parameters</u></p> <ul style="list-style-type: none"> • Diversity • Relative abundance
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2.1.6. For all surveys, identification of plant species and distribution status in Hong Kong were made with reference to Corlett *et al.* (2000), Hu *et al.* (2003), Hong Kong Herbarium (2012), and Hong Kong Herbarium and South China Botanical Gardens (2007; 2008; 2009; 2011).

2.1.7. In terms of assessing geographical distribution, published references specializing in the distribution of specific faunal groups in Hong Kong have been utilised. For general status, these have included Fellowes *et al.* (2002) and the Hong Kong Biodiversity Database (AFCD, 2015), and for specific faunal groups, these have included: Avifauna – Carey *et al.* (2001), Viney *et al.* (2005); Dragonflies – Tam *et al.* (2011); Butterflies – Lo (2005); and Chan *et al.* (2011); Amphibians – Chan *et al.* (2005); Reptiles – Chan *et al.* (2006), Chan *et al.* (2009), and Karsen *et al.* (1998); Terrestrial Mammals – Shek (2006); Freshwater Fish – Lee *et al.* (2004); and Freshwater Community – Dudgeon (2003). The status and rarity of vascular plants has been based on Hu *et al.* (2003) and Corlett *et al.* (2000).

2.2. Ecological Water Quality Monitoring

2.2.1. Ecological water quality monitoring along PNH, LTT, LBC, and RS was carried out. Ten locations were selected and comprised the following:

- Three locations for existing PNH (WE1 to WE3);
- Three locations for existing LTT (WE4 to WE6);
- Two locations for RS (WE7 to WE8);
- Two locations for existing LBC (WE9 to WE10).

2.2.2. The location plan for ecological water quality monitoring is shown in **Figure 2** in **Appendix 2**. Water quality monitoring along PNH, LTT, LBC and RS included the monitoring parameters shown below:

- | | |
|--|---|
| <ul style="list-style-type: none"> • Biochemical Oxygen Demand (BOD₅) • Nitrate • Ammonia • Reactive Phosphorus • Total Suspended Solids (SS) • Temperature | <ul style="list-style-type: none"> • Dissolved Oxygen (DO) • Water Depth* and Water Flow Rate • Conductivity • pH • Salinity • Sediment Characteristics |
|--|---|

Note:

*As referred to in the Final EM&A Manual, water depth is required only for LBC.

2.2.3. The DO, water depth and water flow rate, conductivity, pH, temperature, salinity and sediment characteristics were measured *in-situ* while the other water samples were analysed in a HOKLAS accredited laboratory and the analyses followed the standard methods according to APHA Standard Methods for the Examination of Water and Wastewater, 20th Edition, or equivalent. The limit of reporting for the laboratory analysis is summarised in **Table 3**.

Table 3 Limit of Reporting for Water Quality Parameters

Parameters	Limit of Reporting (mg/L)
Total Suspended Solids	2
Biochemical Oxygen Demand (BOD ₅)	2
Nitrate	0.01
Ammonia	0.01
Reactive Phosphorus	0.01

2.2.4. The instrument for *in-situ* measurement of pH, temperature, DO, salinity and conductivity is a certified portable and weather proof Multifunctional Meter complete with cable and uses a DC power source. The instruments are capable of measuring:

- pH in the range of 0 to 14
- Temperature of -5 to +65°C
- DO in the range of 0 to 20 mg/L and 0 to 200% saturation
- Salinity in the range of 0-80ppt
- Conductivity in the range of 0 to 4999 µS/cm

2.2.5. According to the requirement of the Final EM&A Manual, two consecutive measurements for parameters of DO concentration, and DO saturation are required to be taken at each monitoring location. When the difference in value between the first and second reading of DO is more than 25%, the reading was discarded and a further reading taken.

2.3. Objectives of Monitoring Programme

2.3.1. The aim of this monitoring programme is to provide data on the re-establishment of aquatic/riparian communities in the PNH and LTT, and allow an assessment of the relative success of the mitigation measures to be made. In addition, monitoring of the LBC will assess whether the proposed channel design has provided suitable compensation for the impacts to the Luk Tei Tong Marsh.

3. MONITORING RESULTS

3.1. Ecological Monitoring Findings

3.1.1. During the four-year ecological monitoring programme, no major activities or habitat deterioration were found at/in the vicinity of the monitoring sites. No complaints, non-compliances, or major comments from IEC on the ecological criterion were received. The summary of vegetation and fauna surveys is presented below.

Vegetation

3.1.2. Vegetation monitoring including species composition and abundance were conducted at PNH, LTT, LBC and RS during the four-year monitoring period. Representative photographs of the monitoring sites are presented in **Appendix 3**. The number of plant species and abundance were low at monitoring locations PNH1, PNH2 and LTT1 to LTT5. Scattered climber or herb species such as *Bidens alba*, Burma-reed (*Neyraudia reynaudiana*), Sea Sword Bean (*Canavalia maritima*) were occasionally recorded at these sites.

3.1.3. Mangrove stands of Spiny Bears Breech (*Acanthus ilicifolius*) and *Kandelia obovata* were observed inside the river channel at LTT2 and LTT3. Several *Kandelia obovata* seedlings were also observed at LTT1, LTT2, LTT3, and LTT5, indicating a natural re-colonization of mangrove at those sites.

- 3.1.4. Significant coverage of exotic Mile-a-minute (*Mikania micrantha*) was commonly observed at the banks of a pool at PNH3 as well as the fish ladder and gabion at PNH4. Although water can still flow freely along the stream, the presence of vegetation on the fish ladder can hinder the use and movement of fish or freshwater community along the sections at PNH3 and PNH4.
- 3.1.5. When compared with the species diversity and abundance at LBC with RS, re-establishment of wetland species was observed at LBC1. LBC1 is different from the remaining LBC sections with a more brackish habitat in nature. It adjoined LTT5 and may be subject to tidal influence during high tide. A pool of open water of approximate area 60 m² was recorded at the eastern tip of LBC1. LBC1 was dominated by wetland native species Ferruginous-scale Fimbristylis (*Fimbristylis sieboldii*) and Leather Fern (*Acrostichum aureum*), which also indicated the re-establishment of marsh habitat at LBC1. Moreover, several *Kandelia obovata* saplings was recorded since August 2015.
- 3.1.6. The dominant species at LBC2 to LBC5 was *Wedelia trilobata* which is an exotic species commonly found in dry land habitat. Species commonly found in freshwater marsh including Hairy Knotweed (*Polygonum barbatum*), Spiny Knotweed (*Polygonum perfoliatum*), Taro (*Colocasia esculenta*) and Ginger Lily (*Hedychium coronarium*) were occasionally recorded. However, their limited occurrence may suggest that the current water levels/availability within the channel may not be adequate to sustain a sizable marsh habitat.

Fauna

- 3.1.7. A summary of fauna survey results, including avifauna, odonate, herpetofauna, aquatic macroinvertebrate and fish, at PNH, LTT, LBC and RS during the four-year ecological monitoring exercise are summarised in **Table 4**.
- 3.1.8. As the four-year ecological monitoring exercise was undertaken from October 2012 to September 2016, which had only covered the last two months in 2012 (i.e. October 2012 to December 2012) and the first nine months in 2016 (i.e. January 2016 to September 2016). The limited data in 2012 and 2016 may result in a relatively lower species diversity than that in 2013 to 2015.
- 3.1.9. When compared among the four-year data, the number of avifauna species including wetland dependent species utilised PNH, LTT and LBC was found to be relatively stable. Waterbirds and wetland dependent species were commonly observed foraging at the watercourses; while some generalists were recorded roosting at the trees or shrubs along the river channels and RS. No habitat deterioration along the river channels was observed during the monitoring period.
- 3.1.10. Most of odonate species recorded at PNH, LTT and LBC were in low abundance; while no odonate were recorded at RS. Among the above sites, a minor drop in odonate species and abundance was observed during the regular vegetation clearance at PNH and LBC for the purpose of flood prevention. Herpetofauna was only occasionally recorded along the gabion of LBC in low abundance.
- 3.1.11. Fish and aquatic macroinvertebrates, including crustacean, amphipod, bivalves, snails, worms and insects, were recorded at PNH, LTT and LBC1. Some commonly recorded aquatic macroinvertebrates included Chironomidae, *Clithon* sp. and Sea slater (*Ligia exotica*). One aquatic macroinvertebrates species of conservation importance, *Uca crassipes*, was recorded at LTT2 during the monitoring.
- 3.1.12. Two fish species of conservation importance, namely Predaceous Chub (*Parazacco spilurus*) and Dark-margined Flagtail (*Kuhlia marginata*), were also recorded at PNH and LTT during the monitoring period. These two species were also recorded during the EIA study. Predaceous Chub was commonly recorded in LTT and PNH from 2012 to 2016, while Dark-margined Flagtail was recorded only twice at PNH in 2015.

Table 4 Summary of Fauna Survey Results at PNH, LTT, LBC and RS from October 2012 to September 2016

	PNH					LTT					LBC [^]					RS [^]				
	2012*	2013	2014	2015	2016*	2012*	2013	2014	2015	2016*	2012*	2013	2014	2015	2016*	2012*	2013	2014	2015	2016*
Avifauna																				
Total no. of species recorded	18	19	25	27	16	21	27	17	15	9	4	17	19	17	11	10	17	16	14	12
Total no. of wetland dependent species recorded	5	5	6	6	3	7	5	6	3	4	0	1	4	2	0	0	0	1	0	0
Total no. of species of conservation importance recorded	2	1	4	5	3	4	3	4	3	1	0	2	2	1	0	0	1	2	1	0
Odonate																				
Total no. of species recorded	2	11	13	14	10	1	6	2	4	5	1	6	2	4	9	0	0	0	0	0
Total no. of species of conservation importance recorded	1	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Herpetofauna																				
Total no. of species recorded	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Total no. of species of conservation importance recorded	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aquatic Macroinvertebrate and Fish																				
Total no. of species recorded	9	31	43	31	24	19	44	48	42	26	5	20	26	21	14	/				
Total no. of species of conservation importance recorded	1	1	1	2	1	1	2	2	0	0	0	0	0	0						

Note:

*The four-year ecological monitoring exercise was undertaken in the last two months in 2012 (i.e. October 2012 to December 2012) and the first nine months in 2016 (i.e. January 2016 to September 2016).

[^]No water was present at LBC2 to LBC5 and RS at the time of ecological survey, therefore aquatic fauna surveys were not undertaken at these locations.

3.2. Ecological Water Quality Monitoring (EWQM)

- 3.2.1. The Environmental Protection Department (EPD) analyses and presents data from its annual water monitoring programme to express the level of compliance with the statutory Water Quality Objectives (WQOs) including pH, Suspended Solids (SS), 5-day Biochemical Oxygen Demand (BOD₅), and Dissolved Oxygen (DO). These WQOs specify the long-term water quality goals that the Government is to achieve and maintain for individual rivers in Hong Kong. The WQOs of Mui Wo River (i.e. MW1, MW2 and MW4), have been referenced and used in this four-year monitoring exercise.
- 3.2.2. A total of ten water quality monitoring stations was monitored during the post-construction phase EWQM. The EWQM was conducted at WE1 to WE6 from October 2012 to September 2016. As no water was present at WE7 to WE10 at the time of surveys, no water quality monitoring was undertaken at these water quality monitoring stations. Representative photographs of water quality monitoring stations are presented in **Appendix 4**. A total of 18 events of full compliance out of 24 monitoring events.
- 3.2.3. Minor exceedances in pH, DO and/or BOD₅ when compared to WQOs (EPD, 2016) were recorded from PNH and/or LTT during six monitoring events, except the BOD₅ record in June 2015. A summary of the exceedance events is presented in **Appendix 5**. The events were occasional which may be related to weather fluctuation (e.g. seasonal variations, climatic conditions and/or the influence of tidal status at the time of survey). No continuous deteriorating trends or major discharges from nearby village housings were observed during the four-year monitoring exercise. Implementation of specific environmental protection/mitigation measures was therefore not required.

4. RECOMMENDATIONS AND CONCLUSION

- 4.1. Key observations made during the four-year ecological monitoring programme in relation to the implemented mitigation measures are presented in **Table 5**. Where applicable, recommendations for improving the performance of the mitigation measures have been made for DSD's consideration.
- 4.2. LBC1 was dominated by wetland native species Ferruginous-scale Fimbristylis and Leather Fern, which showed the re-establishment of marsh habitat in LBC1. Moreover, several *Kandelia obovata* saplings was recorded since August 2015. Therefore, it is recommended caution should be taken on the established marsh species in future vegetation management work at LBC1 in order to protect the re-established marsh habitat.
- 4.3. The dominant species at LBC2 to LBC5 was the exotic *Wedelia trilobata* which is commonly found in dry land habitat. Limited occurrence of wetland plants may suggest that the water levels/availability within the channel may not be adequate to sustain a marsh habitat.
- 4.4. Significant coverage of exotic Mile-a-minute was observed at the pool in PNH3, fish ladder and the gabion in the PNH4. Regular weed removal is recommended to keep the fish ladder free from vegetation. During the weed removal work, retention of native species at the gabion is recommended, in order to minimize the re-colonization of exotic species.
- 4.5. As any vegetation clearance at areas adjacent to the fish ladder and pools at PNH3 and PNH4 has the potential to result in water quality impacts downstream (e.g. leakage of diesel from trimming machine), hand removal of vegetation is recommended at areas adjacent to the fish ladder and pools. In addition, the debris should be disposed of timely and properly.
- 4.6. Some of the planting pits incorporated into the PNH3 and PNH4 gabion banks were not in use. Planting of riparian vegetation, preferably with native species as suggested in the EIA report **Section 7.8.17** and **Table 2.6** (e.g. *Albizia lebbbeck*, *Sterculia lanceolata*, *Cinnamomum*

camphora, *Polyspora axillaris*, and *Rhaphiolepis indica*), should be implemented where practicable.

Table 5 Key Observations/Comments and Recommendations Arising from the Four-year Ecological Monitoring Period

Location	Mitigation Measure	Implementation Status of Mitigation Measure	Observations/Comments	Recommendations
PNH and LTT	Construction of a small fish ladder at the upstream end of the PNH	Completed	Mile-a-minute (<i>Mikania micrantha</i>) is the dominant plant species at PNH3 and PNH4. Although vegetation growth was observed on both sides of the fish ladder, free water flow was still maintained.	On-going regular weed management is recommended to maintain the open nature of the fish ladder. Hand removal of vegetation is recommended at areas adjacent to the fish ladder and pools. Retention of native species at the gabion activities is recommended. Planting of native riparian vegetation, at planting pits of gabion banks is recommended.
			The fish ladder does not meet the lip of the weir at the up-stream end of PNH4 due to a drop of approximately 30 cm. This could limit the overall function of the fish ladder for fish passage/movement up and downstream.	The gap from the top of the fish ladder and the bottom of the weir presenting an obstacle to fish passage. Improvement may be achieved by stacking additional boulders resembling that in PNH4 to form pools at the top of the fish ladder, which could facilitate fish movement.
	Re-establishment of aquatic/riparian communities	Completed	Two fish species of conservation importance, Predaceous Chub and Dark-margined Flagtail that recorded during the EIA stage, were also recorded at PNH and LTT during the current ecological monitoring programme.	Continuous monitoring on the re-establishment of the aquatic/riparian communities could be considered.
LBC	Re-establishment of marsh habitat	Completed	Marsh vegetation was observed at LBC1 including native species Ferruginous-scale Fimbristylis and Leather Fern, which showed re-establishment of marsh habitat.	Caution should be taken on the established marsh species in future vegetation management at LBC1 to protect and maintain the marsh habitat.

Drainage Services Department

Location	Mitigation Measure	Implementation Status of Mitigation Measure	Observations/Comments	Recommendations
			<p>Only limited marsh species were recorded along LBC2 to LBC5.</p> <p>The limited occurrence of typical marsh plant species suggests that the water levels/availability within the channel may not be adequate to sustain a marsh habitat.</p>	<p>Retention of native marsh species in and removal of exotic invasive species from LBC2 to LBC5 is recommended to maintain the existing habitat and minimize the colonisation of exotic species.</p> <p>The limitations of the bypass channel to maintain adequate water levels/availability and support wetland species should be taken into account for any future projects including such mitigation features.</p>

5. REFERENCES

AFCD (2015). Hong Kong Biodiversity Database. Available at <http://www.afcd.gov.hk/english/conservation/hkbiodiversity/database/resultlist.asp?lang=en> Accessed on 12 November 2016.

Carey, G. J., Chalmers, M. L., Diskin, D. A., Kennerley, P. R., Leader, P. J., Leven, M. R., Lewthwaite, R. W., Melville, D. S., Turnbull, M. and Young, L. (2001). *The Avifauna of Hong Kong*. Hong Kong Bird Watching Society, Hong Kong.

Chan, A., Cheung, J., Sze, P., Wong, A., Wong, E. and Yau, E. (2011). A Review of the Local Restrictedness of Hong Kong Butterflies. *Hong Kong Biodiversity Newsletter* 21: 1-6. Agriculture, Fisheries and Conservation Department, Hong Kong Special Administrative Region.

Chan, K. K. B. and Caley, K. J. (2003). *Hong Kong Field Guides – Sandy Shores*. The Department of Ecology and Biodiversity, The University of Hong Kong.

Chan, S. K. F., Cheung, K. S., Ho, C. Y., Lam, F. N., Tang, W. S., Lau, M. W. N. and Bogadek, A. (2005). *A Field Guide to the Amphibians of Hong Kong*. Agriculture, Fisheries and Conservation Department, Friends of the Country Parks and Cosmos Books Ltd.

Chan, S. K. F., Cheung, K. S., Ho, C. Y., Lam, F. N., Tang, W. S. and Tse, M. L. (2006). *A Field Guide to the Venomous Land Snakes of Hong Kong*. Agriculture, Fisheries and Conservation Department, Friends of the Country Parks and Cosmos Books Ltd.

Chan, S. K. F., Chan, A. S. W., Cheung, K. S., Ho, C. Y., Ng, C. K. Y. and Tang, W. S. (2009). *The Skinks of Hong Kong*. *Hong Kong Biodiversity Newsletter*: Issue 17.

Corlett, R., Xing, W. F., Ng, C. S., Chau, K. C. L. and Wong, M. Y. L. (2000). *Hong Kong Vascular Plants: Distribution and Status*. *Memoirs of the Hong Kong Natural History Society*, 23, 1-157.

Drainage Services Department. 2005. Agreement No. CE 49/2002(DS) – Drainage Improvements in Southern Lantau: Final Environmental Assessment Report. Prepared by Maunsell Consultants Asia Ltd. The Government of the Hong Kong Special Administrative Region.

Dudgeon (2003). *Hong Kong Field Guides – Hillstreams*. The Department of Ecology and Biodiversity, The University of Hong Kong.

Environmental Protection Department (2005). *Wetland Restoration in Country Parks*. Advisory Council on the Environment Nature Conservation Subcommittee. Committee Paper NCSC 2/05.

Environmental Protection Department (2016). *River Water Quality in Hong Kong in 2015*. The Government of the Hong Kong Special Administrative Region.

Fellowes, J. R., Lau, M. W., Dudgeon, D., Reels, G. T., Ades, G. W. and Carey, G. J. (2002). *Wild Animals to Watch: Terrestrial and Freshwater Fauna of Conservation Concern in Hong Kong*. *Memoirs of the Hong Kong Natural History Society*, 25, 123-159.

Hong Kong Herbarium and South China Botanical Garden (2007). Flora of Hong Kong. Volume 1. Agriculture, Fisheries and Conservation Department, Government of Hong Kong Special Administrative Region.

Hong Kong Herbarium and South China Botanical Garden (2008). Flora of Hong Kong. Volume 2. Agriculture, Fisheries and Conservation Department, Government of Hong Kong Special Administrative Region.

Hong Kong Herbarium and South China Botanical Garden (2009). Flora of Hong Kong. Volume 3. Agriculture, Fisheries and Conservation Department, Government of Hong Kong Special Administrative Region.

Hong Kong Herbarium and South China Botanical Garden (2011). Flora of Hong Kong. Volume 4. Agriculture, Fisheries and Conservation Department, Government of Hong Kong Special Administrative Region.

Hong Kong Herbarium (2012). Check List of Hong Kong Plants 2012. Agriculture, Fisheries and Conservation Department, HKSAR Government.

Hu, Q. M., Wu, T. L., Xia, N. H., Xing, F. W., Lai, P. C. C. and Yip, K. W. (2003). Rare and Precious Plants of Hong Kong. Agriculture, Fisheries and Conservation Department, Hong Kong Special Administrative Government.

IUCN (2016). IUCN Red List of Threatened Species. Version 2016-2. Available at www.iucnredlist.org. Accessed on 12 November 2016.

Lee, V. L. F., Lam, S. K. S., Ng, F. K. Y., Chan, T. K. T. and Young, M. L. C. (2004). Field Guide to the Freshwater Fish of Hong Kong. Agriculture, Fisheries and Conservation Department, Friends of the Country Parks and Cosmos Books Ltd. Hong Kong.

Lo, P. Y. F. (2005). Hong Kong Butterflies, 2nd edition. Agriculture, Fisheries and Conservation Department.

Karsen, S. J., Lau, M. W. N. and Bogadek, A. (1998). Hong Kong Amphibians and Reptiles. Urban Council, Hong Kong.

Shek, C. T. (2006). A Field Guide to the Terrestrial Mammals of Hong Kong. Agriculture, Fisheries and Conservation Department, Hong Kong.

Tam, T. W., Leung, K. K., Kwan, B. S. P., Wu, K. K. Y., Tang, S. S. H., So, I. W. Y., Cheng, J. C. Y., Yuen, E. F. M., Tsang, Y. M. and Hui, W. L. (2011). The Hong Kong Dragonflies. AFCD, Friends of Country Park and Cosmos Books Ltd. Hong Kong.

Tam, N. F. Y. and Wong, Y. S. (2000). Hong Kong Mangroves. Agriculture, Fisheries and Conservation Department. City University of Hong Kong Press.

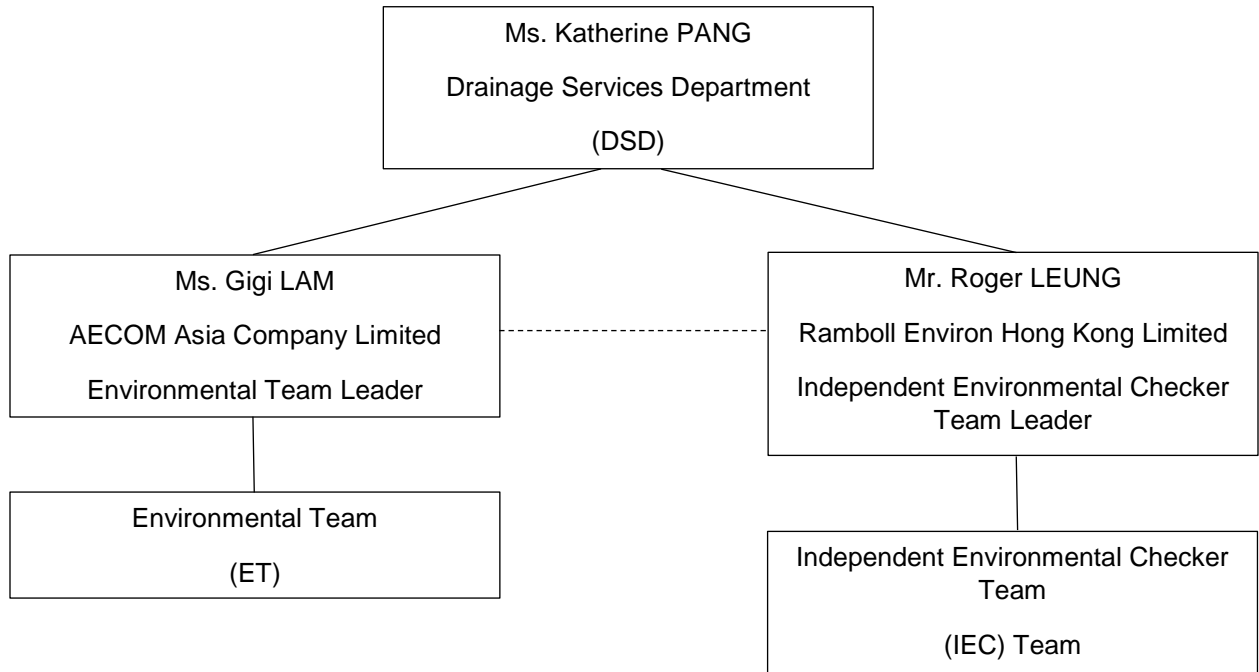
Viney, C., Phillips, K. and Ying, L. C. (2005). The birds of Hong Kong. Information Service Department.

Wang, L. M., Mu, M. R., Li, X. F., Lin, P. and Wang, W. Q. (2010). Differentiation between true mangroves and mangrove associates based on leaf traits and salt contents. *Journal of Plant Ecology*, pp.1-10.

Williams, G. A. (2003). *Hong Kong Field Guides: Rocky Shore*. The Department of Ecology and Biodiversity, The Hong Kong University of Hong Kong, Hong Kong.

Zheng, G. M. and Wang, Q. S. (1998). *China Red Data Book of Endangered Animals: Aves*. Science Press, Beijing.

Appendix 1 Synopsis of Project Organization



Appendix 2 Locations of Ecological Monitoring and Ecological Water Quality Monitoring

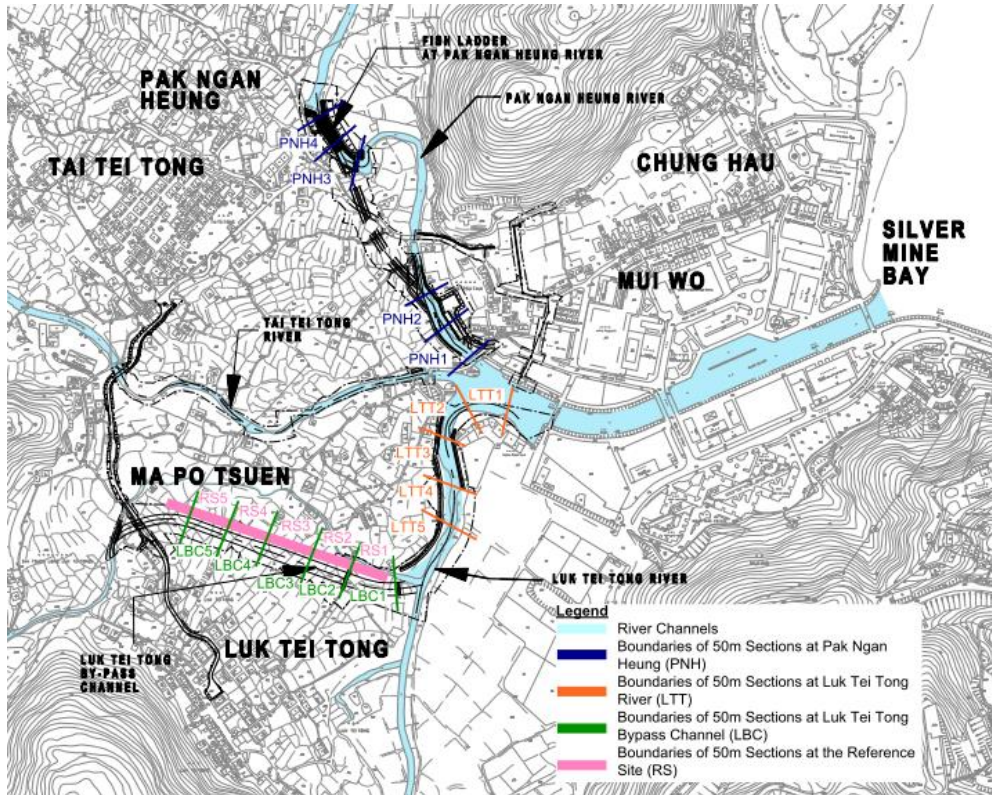


Figure 1 Ecological Monitoring Locations at Pak Ngan Heung River, Luk Tei Tong River, Luk Tei Tong Bypass Channel and the Reference Site

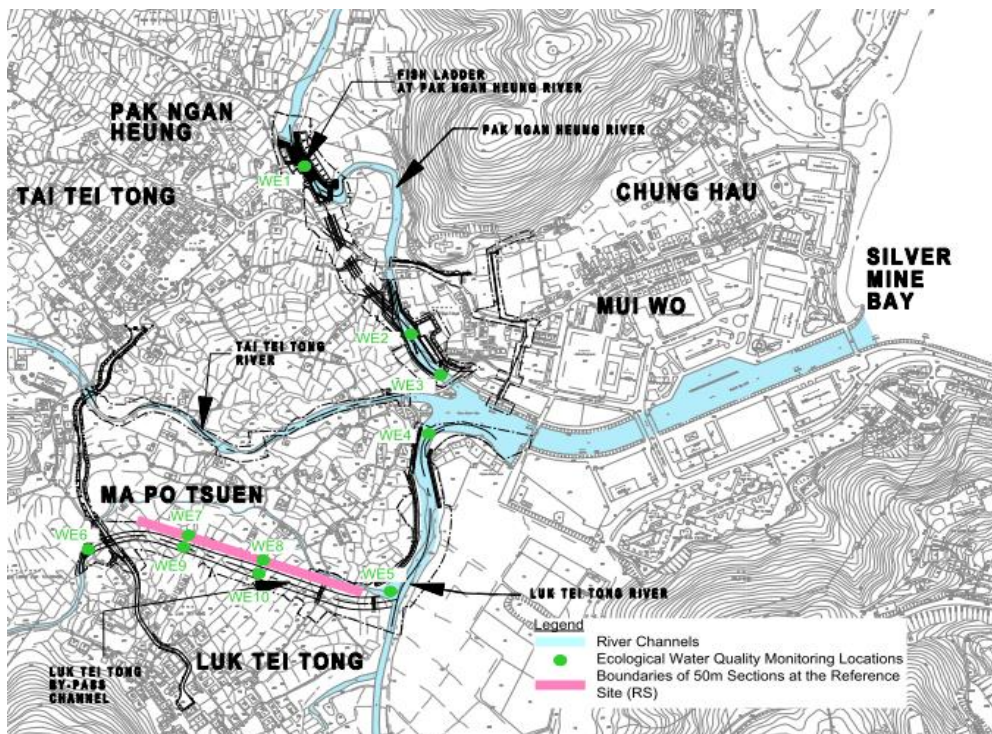


Figure 2 Ecological Water Quality Monitoring Locations at Pak Ngan Heung River, Luk Tei Tong River, Luk Tei Tong Bypass Channel and the Reference Site



PNH1 and PNH2



PNH3 and PNH4



LTT1



LTT2



LTT3 and LTT4



LTT5



LBC1



LBC2 and LBC3

AECOM

Post-Construction Ecological Monitoring
of Drainage Improvement Works in Southern Lantau

Representative Photographs of Ecological Monitoring Locations
(August 2016)

SCALE

N.T.S.

DATE

Nov-16

CHECK

LAMCCG

DRAWN

TSOIWYC

JOB NO.

60278381

DRAWING NO

Appendix 3



LBC4 and LBC5



RS1



RS2



RS3 and RS4



RS5

AECOM

Post-Construction Ecological Monitoring
of Drainage Improvement Works in Southern Lantau

Representative Photographs of Ecological Monitoring Locations
(August 2016)

SCALE

N.T.S.

DATE

Nov-16

CHECK

LAMCCG

DRAWN

TSOIWYC

JOB NO.

60278381

DRAWING NO

Appendix 3



WE1



WE2 and WE3



WE4

AECOM	Post-Construction Ecological Monitoring of Drainage Improvement Works in Southern Lantau	SCALE	N.T.S.	DATE	Nov-16
	Representative Photographs of Water Quality Monitoring Stations (April 2015)	CHECK	LAMCCG	DRAWN	TSOIWYC
		JOB NO.	60278381	DRAWING NO.	Appendix 4



WE5



WE6



WE7 to WE10

AECOM	Post-Construction Ecological Monitoring of Drainage Improvement Works in Southern Lantau	SCALE	N.T.S.	DATE	Nov-16
	Representative Photographs of Water Quality Monitoring Stations (April 2015)	CHECK	LAMCCG	DRAWN	TSOIWYC
		JOB NO.	60278381	DRAWING NO.	Appendix 4

Appendix 5 Summary of Exceedance Events in Ecological Water Quality Monitoring

Monitoring Month	Parameter	Monitoring Site(s)	WQOs*	Exceedance Level
Feb-13	pH	WE6	6.5-8.0	9.8
Apr-13	pH	WE1	6.5-8.0	6.3
Apr-15	pH	WE5	6.5-8.0	9.7
Jun-15	5-day Biochemical Oxygen Demand (BOD ₅)	WE5	<5.0	14.0
	Dissolved Oxygen	WE5	>4.0	3.5
	pH	WE2	6.5-8.0	8.1
Dec-15	5-day Biochemical Oxygen Demand (BOD ₅)	WE1 and WE6	<5.0	WE1 - 5.0 WE6 - 6.0
	pH	WE2 and WE4	6.5-8.0	WE2 - 6.3 WE4 - 6.4
Jun-16	Dissolved Oxygen	WE4	>4.0	3.9

*The available key Water Quality Objectives (WQOs) for River Monitoring Stations at Mui Wo River on Lantau Island (EPD, 2016).