Drainage Services Department

Agreement No. DP 04/2012

Post-Construction Ecological Monitoring

of Drainage Improvement Works in Southern Lantau

Implemented under 4128CD in Contract DC/2006/11

Monthly EM&A Report – June 2013

July 2013

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Pursuant to Condition 4.3 of Environmental Permit No. EP-237/2005/B, this monthly EM&A Report for post-construction ecological monitoring and ecological water monitoring during June 2013 has been certified by the Environmental Team Leader (ETL) and verified by the Independent Environmental Checker (IEC)

Certified by:

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EXECUTIVE SUMMARY

This is the fifth bi-monthly post-construction ecological monitoring and audit exercise for “Drainage Improvement in Southern Lantau” conducted by AECOM. This report concludes the post-construction phase ecological monitoring and audit requirement for the activities undertaken during the period of 1 June 2013 to 30 June 2013.

Ecological water quality monitoring and ecological monitoring were performed on 7 June 2013 and 18 June 2013, respectively. Results obtained are presented in this report.

The Environmental Team (ET) will continue to implement the environmental monitoring & audit (EM&A) programme in accordance with the EM&A Manual and Environmental Permit requirement. The report is available for public inspection and will be uploaded to the dedicated project website (http://www.envproject.com/sldiwema.htm).

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 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.

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 Co. Ltd. was appointed by DSD as the Environmental Team (ET) to conduct the above captioned monitoring project from October 2012 onwards. This is the fifth bi-monthly post-construction ecological monitoring and audit report under that appointment.

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 (TTT) in Southern Lantau, west of Mui Wo. The works for which the post-construction ecological monitoring required by EP No. EP-237/2005/B covered 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 TTT 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

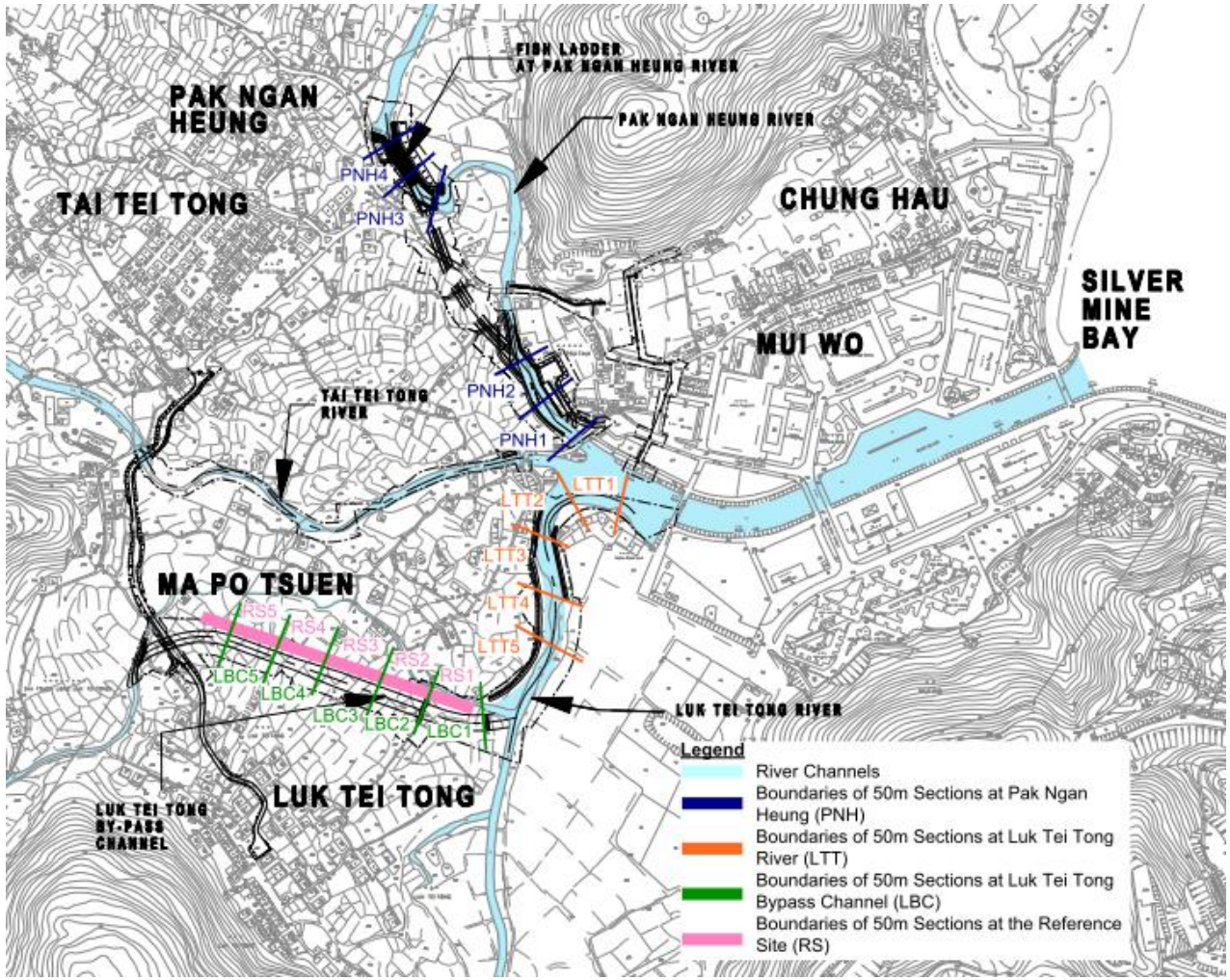
1.3.1. This report presents the findings of the ecological monitoring and the ecological water monitoring conducted in June 2013.

2. ECOLOGICAL MONITORING PARAMETERS

2.1. Ecological Surveys

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

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



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 2), two sections for upstream of PNH (PNH3 and 4);
- Five sections for LTT (LTT1 to 5).

2.1.3. The location plan is shown in **Figure 1** for reference.

2.1.4. The monitoring parameters and survey methodology for each section are described below:

(a) Bird species in each 50 m section were surveyed quantitatively using transect count method. Birds within the river channel and on the riverbank were identified to species and their abundance was recorded. Birds that flew over/across the river channel without landing were not considered to be utilising the area and thus excluded from the records. This does not apply to species which rarely land and is known to associate with the habtiat such as Barn Swallow.

(b) Surveys on aquatic macroinvertebrate focused on determination of the diversity and abundance. Sampling methods included active searching, direct observation, hand netting and kick sampling. In each section, the macroinvertebrate species composition was identified and their relative abundance was recorded.

(c) Surveys on fish focused on determination of the diversity and abundance of fish communities. Sampling methods included active searching, direct observation, and hand netting, and were determined in accordance with site conditions. In each section, the fish species composition was identified and their relative abundance was recorded.

(d) Adult odonate community in each 50 m section were surveyed quantitatively by transect count method. Adult odonate within the river channel and on the riverbank were identified to species and their abundance was recorded. Species requiring close examination were netted.

(e) Aquatic, emergent and riparian vegetation community was recorded by walk-through survey. Plant species composition and their relative abundance were recorded.

Luk Tei Tong Bypass Channel

2.1.5. 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 5);
- Five sections for RS (RS1 to 5).

2.1.6. The location plan is shown in **Figure 1** for reference.

2.1.7. The monitoring parameters and survey methodology are described below:

(a) Bird species in each 50 m section were surveyed quantitatively using transect count method. Birds within the river channel and on the riverbank were identified to species and their abundance was recorded. Birds that flew over/across the river channel without landing were not considered to be utilising the area and thus excluded from the records. This does not apply to species which rarely land and is known to associate with the habtiat such as Barn Swallow.

(b) Where/when water was present, surveys of aquatic macroinvertebrate focused on determination of their diversity and abundance of stream aquatic communities. Sampling

methods included active searching, direct observation, hand netting and kick sampling. In each section, macroinvertebrate species composition was identified and their relative abundance was recorded.

(c) Where/when water was present, surveys of fish focused on determination of their diversity and abundance. Sampling methods included active searching, direct observation, and hand netting, were determined in accordance with site conditions. In each section, fish species composition was identified and their relative abundance was recorded.

(d) Adult odonate community in each 50 m section were surveyed quantitatively by transect count method. Adult dragonflies within the river channel and on the riverbank were identified to species and their abundance was recorded. Species requiring close examination were netted.

(e) Line-intercept method was adopted to determine the relative plant cover of aquatic, emergent and riparian vegetation. 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%). The conditions of vegetation were described.

(f) Herpetofauna community within LBC and RS were surveyed by active searching in potential habitats. Reptiles were identified and their abundance was recorded. Amphibians were identified by their calls and the number of calling males in each section was recorded.

2.1.8. 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).

2.1.9. In terms of assessing geographical distribution, published references specializing in the distribution of specific faunal groups in Hong Kong have been utilized. For general status, these have included Fellowes *et al*. (2002) and the Hong Kong Biodiversity Database (AFCD, 2013), and for specific faunal groups, these have included: Avifauna – Carey *et al.* (2001), Viney *et al.* (2006); 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 3);
- Three locations for existing LTT (WE4 to 6);
- Two locations for RS (WE7 to 8);
- Two locations for existing LBC (WE9 to 10).

2.2.2. The location plan for ecological water quality monitoring is shown in **Figure 2** for reference.

2.2.3. Water Quality Monitoring along PNH, LTT, LBC and RS included the monitoring parameters shown below:

- Biochemical Oxygen Demand (BOD_5)
- Nitrate
- Ammonia
- Reactive Phosphorus
- Total Suspended Solids (SS)
- Temperature
- 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.

2.2.4. 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 analyzed 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 summarized in **Table 2.1**.

Table 2.1 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

2.2.5. The instrument for in-situ measurement of temperature, DO, salinity and conductivity is a portable and weather proof multi-meter complete with cable and uses a DC power source (YSI 85), whereas Orion 230A+ is used as for pH measurement. Calibration certificates are attached in **Appendix 1**. The instruments are capable of measuring:

- pH in the range of 0 to 14
- Temperature of -5 to $+65^0$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

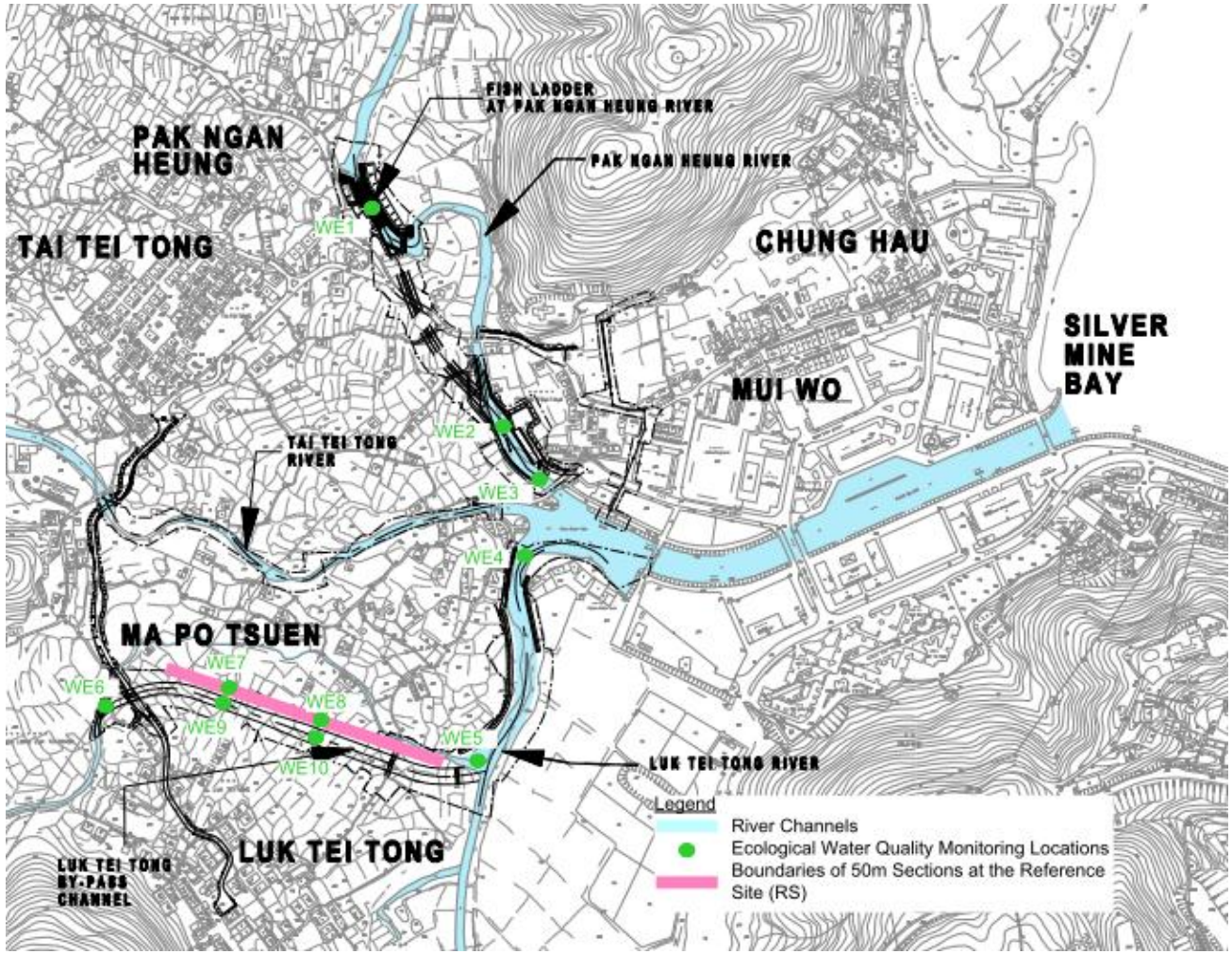
2.2.6. According to the requirement of the Final EM&A Manual, two consecutive measurements for parameters of DO concentration, and DO saturation are required to be taken at each monitoring location. When the difference in value between the first and second reading of DO is more than 25%, the reading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

2.3. Limitations

2.3.1. No water was present at LBC2 to LBC5 at the time of survey, therefore aquatic fauna surveys were not undertaken in these locations.

2.3.2. No water was present at WE7 - WE10 at the time of survey, therefore water quality monitoring was not undertaken at these locations.

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**



3. MONITORING RESULTS

3.1. Ecological Survey Findings

Pak Ngan Heung River (PNH)

3.1.1. The lower stream of PNH (PNH1 and PNH2) is subject to tidal influence from Silver Mine Bay. Vertical concrete retaining wall formed the banks of the river channel. The two sections were located at the mouth of the PNH. PNH1 and PNH2 were adjacent to each other. The bridge formed the southern boundary of PNH1 whereas the box-culvert formed the northern boundary of PNH2. Small boulders and sandy substrate formed the main component of the streambed.

3.1.2. Rock-filled gabion formed the eastern bank and the gabion and a vertical concrete retaining wall formed the western bank of the upper stream (PNH3 and PNH4). PNH3 and PNH4 are adjacent to each other. PNH4 comprised a man-made cascade, including a fish ladder, while PNH3 comprised a pool below the cascade and was bounded by a bridge at its downstream end. Small boulders and sandy substrate were the main component in the middle streambed which allowed water flow and pool formation, whereas big boulders were scattered on both sides of the streambed and had an absence of water. The width of the fish ladder at PNH4 is approximately 7 m.

3.1.3. The cascade/fish ladder at PNH4 was open and free of vegetation, exposing the feature and allowing free water flow and pool formation.

Vegetation

3.1.4. At PNH3 and PNH4, a total of 14 plant species were recorded. The vegetation was dominated by exotic species such as Mile-a-minute (*Mikania micrantha*) and *Bidens alba* at both PNH3 and PNH4. Vegetation coverage increased compared with the last reporting period two months ago though the water flow was not hindered. The vegetation predominantly grew on the banks of PNH3 pool and outer edges of the PNH4 cascade. Species such as *Polygonum* sp. and *Commelina diffusa* were scattered within the flowing water of the PNH4 cascade.

3.1.5. At PNH1 and PNH2, no plant species were recorded within the river channel. The vegetation recorded on the vertical wall has not changed significantly since the last monitoring period, which includes a record of *Bidens alba* and seedlings of Opposite-leaved Fig (*Ficus hispida*).

3.1.6. The list of plant species is presented in **Appendix 2a**.

Terrestrial Fauna

3.1.7. Nine avifauna species were recorded at PNH, all of which are common and abundant in Hong Kong (**Table 3.1**). Four avifauna species were recorded at lower PNH (PNH1 and PNH2). White-throated Kingfisher is the only wetland dependent species recorded, which perched on the railing near PNH1. During the monitoring, the water level at lower PNH was approximately 30 cm.

3.1.8. Seven avifauna species were recorded at PNH3 and PNH4. The birds at upper PNH3 and PNH4 were mostly observed along the banks of the river channel, including the Hong Kong resident species such as Yellow-bellied Prinia (*Prinia flaviventris*) and spring migrant or summer visitor species such as Barn Swallow (*Hirundo rustica*). The dominant species were Red-whiskered Bulbul (*Pycnonotus jocosus*), Crested Myna (*Acridotheres cristatellus*) and Black-collared Starling (*Gracupica nigricollis*). All are of them are common and abundant in Hong Kong (AFCD, 2013).

3.1.9. Two species of dragonfly were recorded at PNH, both of which are abundant in Hong Kong (**Table 3.2**). One individual of Indigo Dropwing (*Trithemis festiva*) was recorded at lower PNH2 while Wandering Glider (*Pantala flavescens*), was recorded at upper PNH3 and PNH4.

3.1.10. No herpetofauna was recorded at PNH.

Aquatic Macroinvertebrate and Fish

3.1.11. Four fish species, two crab species and seven species of other aquatic invertebrates were recorded at PNH (PNH1 to PNH4) (**Table 3.3**). No species of conservation importance were recorded. The snail, Lymnaeidae and Amphipoda, were found in all sections of PNH.

3.1.12. At lower PNH (PNH1 and PNH2), three fish species, two crab species and six other aquatic invertebrate species (such as the Sea Slater, *Ligia exotica*) were recorded at both PNH1 and PNH2. Common Mudskipper (*Periophthalmus cantonensis)* was recorded on the muddy shore. Barcheek Goby (*Rhinogobius giurinus*) and Mozambique Tilapia (*Oreochromis mossambicus*) were found foraging in PNH2.

3.1.13. At upper PNH (PNH3 and PNH4), two fish species and four other aquatic macroinvertebrate species were recorded. Mozambique Tilapia and Nile Tilapia (*Oreochromis niloticus*) were also recorded foraging in PNH3 where no fish was recorded at PNH4. The insect (*Ptilomera tigrina*) and the worm (*Capitella capitata*) were found under boulders in the waterbody at both PNH3 and PNH4.

Table 3.1 Number of Avifauna Recorded at Pak Ngan Heung River (PNH)

Common Name (1)	Scientific Name	Distribution in Hong Kong (2)	Principal Status (3)	Level of Concern (4)	Protection Status in China (5)	China Red Data Book (6)	IUCN Red List (7)	PNH1	PNH2	PNH3	PNH4
White-throated Kingfisher (8)	*Halcyon smyrnensis*	Common	AM,P	(LC)	-	-	-	1			
Red-whiskered Bulbul	*Pycnonotus jocosus*	Abundant	R	-	-	-	-	1		5	
Chinese Bulbul	*Pycnonotus sinensis*	Abundant	R	-	-	-	-				3
Barn Swallow	*Hirundo rustica*	Abundant	SpM,Su	-	-	-	-			2	2
Yellow-bellied Prinia	*Prinia flaviventris*	Common	R	-	-	-	-			1	
Japanese White-eye	*Zosterops japonicus*	Abundant	R,?W	-	-	-	-			2	3
Crested Myna	*Acridotheres cristatellus*	Common	R	-	-	-	-	5		5	2
Black-collared Starling	*Gracupica nigricollis*	Common	R	-	-	-	-			3	5
Eurasian Tree Sparrow	*Passer montanus*	Abundant	R	-	-	-	-	5			

Note:
(1) All wild birds are protected under Wild Animal Protection Ordinance (Cap. 170).
(2) AFCD (2013) Hong Kong Biodiversity Database.
(3) R=resident; Sp=spring; Su=summer; A=autumn; M=migrant; P=present all year, exact composition unknown; ?W=the extent of immigration in winter is unclear.
(4) Fellowes *et al*. (2002); LC=Local Concern; Letters in parentheses indicate that the assessment is on the basis of restrictedness in breeding and/or roosting sites rather than in general occurrence.
(5) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(6) Zheng and Wang (1998).
(7) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.
(8) Wetland-dependent species (including wetland-dependent species and waterbirds).

Table 3.2 Number of Dragonfly Recorded at Pak Ngan Heung River (PNH)

Common Name	Scientific Name	Distribution in Hong Kong (1)	Level of Concern (2)	Protection Status in China (3)	China Red Data Book (4)	IUCN Red List (5)	PNH 1	PNH 2	PNH 3	PNH 4
Wandering Glider	*Pantala flavescens*	Abundant	-	-	-	-			10	5
Indigo Dropwing	*Trithemis festiva*	Abundant	-	-	-			1		

Note:
(1) AFCD (2013). Hong Kong Biodiversity Database.
(2) Fellowes *et al.* (2002).
(3) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(4) Zheng and Wang (1998).
(5) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.

Table 3.3 Relative Abundance of Aquatic Macroinvertebrate and Fish Recorded at Pak Ngan Heung River (PNH)

Fauna Group	Scientific Name	Common Name	Distribution in Hong Kong (1)(2)(3)	Level of Concern (4)	Protection Status in China (5)	China Red Data Book (6)	IUCN Red List (7)	PNH1	PNH2	PNH3	PNH4
Fish	*Periophthalmus cantonensis*	Common Mudskipper	Very common	-	-	-	-	++			
Fish	*Rhinogobius giurinus*	Barcheek Goby	Common	-	-	-	-		+		
Fish	*Oreochromis mossambicus*	Mozambique Tilapia	Common	-	-	-	-		+	++	
Fish	*Oreochromis niloticus*	Nile Tilapia	Common	-	-	-	-			++	
Crab	*Perisesarma bidens*	-	-	-	-	-	-		++		
Crab	*Sesarmops sinensis*	-	-	-	-	-	-	++	++		
Worms	*Capitella capitata*	-	-	-	-	-	-		++	+	++
Tube-worms	*Spirorbis spp.*	-	-	-	-	-	-	+			
Polychaete	*Sigambra hanaokai*	-	-	-	-	-	-		+		
Snail (Lymnaeidae)	Lymnaeidae	-	-	-	-	-	-	+++	+++	++	++
Snail (Amphipoda)	Amphipoda	-	-	-	-	-	-	+++	+++	+++	+++
Insect	*Ligia exotica*	Sea Slater	Common	-	-	-	-	++	++		
Insect	*Ptilomera tigrina*	-	-	-	-	-	-			+	+

Note:
(1) AFCD (2013). Hong Kong Biodiversity Database.
(2) Williams, G. (2003). Hong Kong Field Guides – Rocky Shores
(3) Chan *et al*. (2003). Hong Kong Field Guides – Sandy Shores
(4) Fellowes *et al.* (2002).
(5) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(6) Zheng and Wang (1998).
(7) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1
(8) Relative abundance: + = occasional, less than 5 individuals were found; ++ = common, 5-20 individuals were found; +++ = abundant, more than 20 individuals were found.

Luk Tei Tong River (LTT)

3.1.14. The LTT is subject to tidal influence from Silver Mine Bay and is estuarine in nature. It is a north-south running river. A vertical concrete retaining wall formed the river bank of the LTT1 whereas rock-filled gabion formed the river bank of LTT2 to LTT5. LTT1 was located at the confluence with Pak Ngan Heung River, Tai Tei Tong River and Luk Tei Tong River. Since it is subject to tidal flow, water flowed from south to north during the survey when the tide was going out. LTT1 and LTT2 had sandy substrate whilst LTT3 to LTT5 had muddy substrate. Clusters of boulders occurred at both sides of the river channel. The width of the river channel was approximately 8-10 m.

3.1.15. No evidence of maintenance works (including those relevant to Conditions 2.1 to 2.4 of EP No. EP-434/2012) was observed during the monitoring period.

Vegetation

3.1.16. A total of 10 plant species were recorded in LTT. More than half of the recorded species were exotic. The majority were herbs or climbers scattered along the gabion such as Smooth Crotalaria (*Crotalaria pallid*) and Burma-reed (*Neyraudia reynaudiana*). In addition to the mangrove species (Spiny Bears Breech, *Acanthus ilicifolius*; and *Kandelia obovata*) that colonized inside the river channel at LTT2 and LTT3, several seedlings of *Kandelia obovata* have naturally regenerated in LTT1, LTT2, LTT3 and LTT5. Herbaceous species such as Mile-a-minute was recorded on the gabion in LTT2, LTT4 and LTT5.

3.1.17. The list of plant species is presented in **Appendix 2a**.

Terrestrial Fauna

3.1.18. A total of fourteen avifauna species were recorded at LTT, most of them are common and abundant in Hong Kong (AFCD, 2013) (**Table 3.4**). Waterbird species, including Chinese Pond Heron (*Ardeola bacchus*), Grey Heron (*Ardea cinerea*) and Little Egret (*Egretta garzetta*) were recorded feeding in the main river channel. Other lowland species such as Eurasian Tree Sparrow (*Passer montanus*) and Crested Myna (*Acridotheres cristatellus*) were recorded flying along the river channel. Individuals of Barn Swallow (*Hirundo rustica*) were observed flying over the river channel at all sections of LTT.Chinese Pond Heron, Grey Heron, Greater Coucal and Little Egret are common species of conservation importance recorded at LTT. Chinese Pond Heron, Grey Heron and Little Egret are considered as Potential Regional Concern by Fellow *et al.* (2002). while Greater Coucal is classified as Class II Protected Animal in China and is assessed as vulnerable by China Red Data Book.

3.1.19. A total of four dragonfly species were recorded at LTT, all of them are abundant in Hong Kong (AFCD, 2013). One individual of Common Flangetail (*Ictinogomphus pertinax*), was recorded at LTT1 (**Table 3.5**) whereas Crimson Darter (*Crocothemis servilia servilia*), Russet Percher (*Neurothemis fulvia*), Wandering Glider (*Pantala flavescens*) were recorded at LTT3.

3.1.20. No herpetofauna were recorded at the LTT during the monitoring.

Aquatic Macroinvertebrate and Fish

3.1.21. A total of four fish species, three crab species and eighteen species of other aquatic invertebrates were recorded from the LTT (**Table 3.6**). No species of conservation importance were recorded. The bivalves, Rock Oyster (*Saccostrea cucullata*), and the insect, Sea Slater (*Ligia exotica*), were recorded in all sections of LTT.

3.1.22. All fish species recorded mainly occur in river mouth or estuarine environments in Hong Kong (AFCD, 2013). Grey Mullet (*Mugil cephalus*) were recorded through LTT3 to LTT5 while Mozambique Tilapia (*Oreochromis mossambicus*) was recorded at LTT5. A Goby sp. was recorded at LTT1 while individuals of Jarbua Terapon (*Terapon jarbua*) were recorded at LTT1 and LTT2.

Table 3.4 Number of Avifauna Recorded at Luk Tei Tong River (LTT)

Common Name (1)	Scientific Name	Distribution in Hong Kong (2)	Principal Status (3)	Level of Concern (4)	Protection Status in China (5)	China Red Data Book (6)	IUCN Red List (7)	LTT1	LTT2	LTT3	LTT4	LTT5
Chinese Pond Heron (8)	*Ardeola bacchus*	Common	P	PRC	-	-	-	1				
Grey Heron (8)	*Ardea cinerea*	Common	W	PRC	-	-	-	1				
Little Egret (8)	*Egretta garzetta*	Common	P	PRC (RC)	-	-	-	1	2			
Greater Coucal	*Centropus sinensis*	Common	R	-	Class II	Vulnerable	-					1
Chestnut-winged Cuckoo	*Clamator coromandus*	Uncommon	Su	-	-	-	-			1		
Asian Koel	*Eudynamys scolopacea*	Common	Su, R	-	-	-	-			1		
Large-billed Crow	*Corvus macrorhynchos*	Common	R	-	-	-	-	1		2	1	1
Great Tit	*Parus major*	Common	R	-	-	-	-		1			
Barn Swallow	*Hirundo rustica*	Abundant	R	-	-	-	-	5	5	1	1	1
Yellow-bellied Prinia	*Prinia flaviventris*	Common	R	-	-	-	-			1		
Crested Myna	*Acridotheres cristatellus*	Common	R	-	-	-	-	4	2			1
Black-collared Starling	*Gracupica nigricollis*	Common	R	-	-	-	-			2		
Eurasian Tree Sparrow	*Passer montanus*	Abundant	R	-	-	-	-	5	5			
White Wagtail	*Motacilla alba*	Common	W, R	-	-	-	-			1		

Note:
(1) All wild birds are protected under Wild Animal Protection Ordinance (Cap. 170).
(2) AFCD (2013). Hong Kong Biodiversity Database
(3) R=resident; Su=summer; W=winter visitor; P=present all year, exact composition unknown.
(4) Fellowes *et al.* (2002); RC=Regional Concern; PRC=Potential Regional Concern. Letters in parentheses indicate that the assessment is on the basis of restrictedness in breeding and/or roosting sites rather than in general occurrence.
(5) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(6) Zheng and Wang (1998).
(7) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1
(8) Wetland-dependent species (including wetland-dependent species and waterbirds).
(9) Species of conservation importance is noted in bold type face.

Table 3.5 Number of Dragonfly Recorded at Luk Tei Tong River (LTT)

Common Name	Scientific Name	Distribution in Hong Kong (1)	Level of Concern (2)	Protection Status in China (3)	China Red Data Book (4)	IUCN Red List (5)	LTT1	LTT2	LTT3	LTT4	LTT5
Common Flangetail	*Ictinogomphus pertinax*	Abundant	-	-	-	-	1				
Crimson Darter	*Crocothemis servilia servilia*	Abundant	-	-	-	-			1		
Russet Percher	*Neurothemis fulvia*	Abundant	-	-	-	-			1		
Wandering Glider	*Pantala flavescens*	Abundant	-	-	-	-			6		

Note:

(6) AFCD (2013). Hong Kong Biodiversity Database.
(7) Fellowes *et al.* (2002).
(8) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(9) Zheng and Wang (1998).
(10) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.

Table 3.6 Relative Abundance of Aquatic Macroinvertebrate and Fish Recorded at Luk Tei Tong River (LTT)

Fauna Groups	Scientific Name	Common Name	Distribution in Hong Kong [1][2][3]	Level of Concern [4]	Protection Status in China [5]	China Red Data Book [6]	IUCN Red List [7]	LTT1	LTT2	LTT3	LTT4	LTT5
Fish	*Mugil cephalus*	Grey Mullet	Common	-	-	-	-			+++	+++	++
Fish	*Goby* sp.	-	-	-	-	-	-	+				
Fish	*Terapon jarbua*	Jarbua Terapon	Common	-	-	-	-	+++	++			
Fish	*Oreochromis mossambicus*	Mozambique Tilapia	Common	-	-	-	-					++
Crabs	*Perisesarma bidens*	-	-	-	-	-	-	++	++	++	++	
Crabs	*Uca (Deltuca) arcuata*	-	Common	-	-	-	-		++	++		
Crabs	*Sesarmops sinensis*	-	-	-	-	-	-	+++	++	+++	++	
Sea-anemones	*Haliplanella lineata*	-	Common	-	-	-	-		+			
Polychaete	*Sigambra hanaokai*	-	-	-	-	-	-		+			
Amphipod	Amphipoda	-	-	-	-	-	-	+++	+++	+++		
Worms	*Capitella capitata*	-	-	-	-	-	-				++	++
Snail	*Planaxis sulcatus*	-	-	-	-	-	-	+++	++			
Snail	*Clithon* sp.	-	-	-	-	-	-	+++				
Snail (Nerites)	*Nerita* sp.	-	Common	-	-	-	-	+++	+	+		
Snail	*Onchidium* spp.	-	Common	-	-	-	-		++			
Snail	*Cerithidea cingulata*	-	Very common					+++				
Snail	*Cerithidea diadjariensis*	-	Very common					+++				
Bivalves	Lymnaeidae	-	-	-	-	-	-		++			
Bivalves	*Grafrarium pectinatum*	-	Common	-	-	-	-	+				
Bivalves	*Saccostrea cucullata*	Rock Oyster	Very common	-	-	-	-	+	+	+	+	+

Fauna Groups	Scientific Name	Common Name	Distribution in Hong Kong (1)(2)(3)	Level of Concern (4)	Protection Status in China (5)	China Red Data Book (6)	IUCN Red List (7)	LTT1	LTT2	LTT3	LTT4	LTT5
Bivalves	*Septifer virgatus*	Black Mussel	Very common	-	-	-	-		++			
Barnacles	*Balanus amphitrite*	-	Very common	-	-	-	-	++	++			+
Insect	*Ligia exotica*	Sea Slater	Common	-	-	-	-	++	++	++	+	+
Insect	*Ptilomera tigrina*	-	-	-	-	-	-					+
Insect	*Metrocoris sp.*	-	-	-	-	-	-			+	+	+

Note:
(1) AFCD (2013). Hong Kong Biodiversity Database.
(2) Williams, G (2003). Hong Kong Field Guides – Rocky Shores
(3) Chan *et al*. (2003). Hong Kong Field Guides – Sandy Shores
(4) Fellowes *et al*. (2002).
(5) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(6) Zheng and Wang (1998).
(7) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.
(8) Relative abundance: + = occasional, less than 5 individuals were found; ++ = common, 5-20 individuals were found; +++ = abundant, more than 20 individuals were found.

Luk Tei Tong Bypass Channel (LBC) and Reference Site (RS)

3.1.23. The LBC is linked to the end of LTT5 and runs east to west but the connection with LTT5 is blocked by a layer of gabion wall approximately 1 m in height which allows water flow between LBC and LTT when water level is higher than the height of the gabion. It is located in the Luk Tei Tong Marsh to the west of the original LTT. Gabion walls formed both sides of the channel bank. Generally, all sections were heavily vegetated except in LBC1 where a small pool of approximately 60 m^2 in size was located at the western end of LBC1. The pool was separated from the LTT by a weir constructed from a single layer of rock-filled gabion. The substrate comprised soil which was translocated from the marsh area prior to construction of the bypass. The width of the bypass channel was approximately 15 m.

3.1.24. The RS was located parallel to the northern side of the LBC. Next to the RS was village housing. The site was vegetated and did not have any free-standing water at the time of survey.

Vegetation

3.1.25. A total of 33 plant species were recorded in LBC, of which 12 species were found in the quadrats sampled. The list of plant species is presented in **Appendix 2b**. Almost half of the recorded species were exotic. During the survey, only LBC1 included a small patch of open shallow water. Other sections were dry.

3.1.26. The habitat at LBC1 differed from the remaining sections in terms of vegetation type. It may be subject to tidal influence during high tide because of its location immediately next to LTT. The sedge, Ferrugineous-scale Fimbristylis (*Fimbristylis sieboldii*), dominated LBC1 with a pool of open water forming the western part of the section next to LTT.

3.1.27. The plant species recorded in LBC2 to LBC5 were dominated by the exotic species *Wedelia trilobata*. Other herbaceous species commonly encountered along the transects were exotic Mile-a-Minute (*Mikania micrantha*), and native Ciliate Microstegium (*Microstegium ciliatum*). Other species only formed a small proportion of the vegetation. Records of wetland species such as Taro (*Colocasia esculenta*) and Ginger Lily (*Hedychium coronarium*) were occasional.

3.1.28. A total of 39 plant species were recorded in the RS, of which 10 species were found in the quadrats (**Table 3.7**). Seventeen of the 39 species were exotic. All sections were dry and were located next to the village housing. The dominant species was exotic *Wedelia trilobata*. Exotic *Mimosa diplotricha* and Wild Kudzu Vine (*Pueraria phaseoloides*) were commonly recorded across the RS sections. The majority of vegetation recorded at the RS could typically be found in disturbed land. Records of wetland species such as Taro (*Colocasia esculenta*) and Ginger Lily (*Hedychium coronarium*) were occasional.

3.1.29. The list of plant species is presented in **Appendix 2b**.

Table 3.7 Vegetation Coverage at Luk Tei Tong Bypass Channel (LBC) and Reference Site (RS)

	LBC	RS
No. of species recorded in quadrats	12	10
Total No. of species	33	39
Total No. of exotic species	15	17
Average vegetation coverage	100%	92%
Bare ground coverage	0%	8%

Note:
(1) The transect was not laid along any open water, thus open water coverage was not provided in this table.

Terrestrial Fauna

3.1.30. Ten species of avifauna were recorded at LBC (**Table 3.8**) whereas nine species were recorded at the RS (**Table 3.9**). All recorded species are common or abundant in Hong Kong

(AFCD, 2013). Greater Coucal (*Centropus sinensis*) was recorded at LBC1 and is regarded as species of conservation importance, which is classified as Class II Protected Animal in China and is assessed as vulnerable by China Red Data Book. All other recorded avifauna were lowland species such as Crested Myna (*Acridotheres cristatellus*), Red-whiskered Bulbul (*Pycnonotus jocosus*), Chinese Bulbul (*Pycnonotus sinensis*) and Oriental Magpie Robin (*Copsychus saularis*) and are generalist adapted to disturbed environment.

3.1.31. Two dragonfly species were recorded at LBC (**Table 3.10**), all of them are abundant in Hong Kong (AFCD,2013). Individuals of dragonfly, Blue Percher (*Diplacodes trivialis*) and Wandering Glider (*Pantala flavescens*), were recorded at LBC1.

3.1.32. No herpetofauna were recorded at LBC and RS during the monitoring.

Aquatic Macroinvertebrate and Fish

3.1.33. A total of two fish species and six species of other aquatic invertebrates were recorded from the LBC (**Table 3.11**). The insects such as, *Ptilomera tigrina*, *Rhagovelia sp.* and *Metrocoris sp.* were recorded at LBC1.

3.1.34. Two species of fish were recorded at LBC1 which included Mozambique Tilapia and Nile Tilapia (**Table 3.11**). No species of conservation importance were recorded. All fish species were found foraging.

3.1.35. No aquatic fauna was recorded at the RS or the remaining sections of the LBC as they were dry during the monitoring.

Table 3.8 Number of Avifauna Recorded at Luk Tei Tong Bypass Channel (LBC)

Common Name (1)	Scientific Name	Distribution in Hong Kong (2)	Principal Status (3)	Level of Concern (4)	Protection Status in China (5)	China Red Data Book (6)	IUCN Red List (7)	LBC1	LBC2	LBC3	LBC4	LBC5
Spotted Dove	*Streptopelia chinensis*	Abundant	R	-	-	-	-		1			1
Greater Coucal	*Centropus sinensis*	Common	R	-	Class II	Vulnerable	-	1				
Asian Koel	*Eudynamys scolopacea*	Common	Su, R	-	-	-	-		1			
Eurasian Magpie	*Pica pica*	Common	R	-	-	-	-		1			
Red-whiskered Bulbul	*Pycnonotus jocosus*	Abundant	R	-	-	-	-	2			2	1
Chinese Bulbul	*Pycnonotus sinensis*	Abundant	R	-	-	-	-			2		
Barn Swallow	*Hirundo rustica*	Abundant	SpM, Su	-	-	-	-			1		
Crested Myna	*Acridotheres cristatellus*	Common	R	-	-	-	-	2			3	
Black-collared Starling	*Gracupica nigricollis*	Common	R	-	-	-	-			2		
Oriental Magpie Robin	*Copsychus saularis*	Abundant	R	-	-	-	-		1			

Note:
(1) All wild birds are protected under Wild Animal Protection Ordinance (Cap. 170).
(2) AFCD (2013). Hong Kong Biodiversity Database.
(3) R=resident; Sp=spring; Su=summer; M=migrant.
(4) Fellowes *et al.* (2002).
(5) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(6) Zheng and Wang (1998).
(7) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.
(8) Species of conservation importance is noted in bold type face.

Table 3.9 Number of Avifauna Recorded at Reference Site (RS)

Common Name (1)	Scientific Name	Distribution in Hong Kong (2)	Principal Status (3)	Level of Concern (4)	Protection Status in China (5)	China Red Data Book (6)	IUCN Red List (7)	RS1	RS2	RS3	RS4	RS5
Red-whiskered Bulbul	*Pycnonotus jocosus*	Abundant	R	-	-	-	-		3	1		
Chinese Bulbul	*Pycnonotus sinensis*	Abundant	R	-	-	-	-		1			
Barn Swallow	*Hirundo rustica*	Abundant	SpM, Su	-	-	-	-					1
Yellow-bellied Prinia	*Prinia flaviventris*	Common	R	-	-	-	-			1	2	1
Common Tailorbird	*Orthotomus sutorius*	Common	R	-	-	-	-					1
Japanese White-eye	*Zosterops japonicus*	Common	R	-	-	-	-				2	
Crested Myna	*Acridotheres cristatellus*	Common	R	-	-	-	-	4	2			1
Black-collared Starling	*Gracupica nigricollis*	Common	R	-	-	-	-					2
Oriental Magpie Robin	*Copsychus saularis*	Abundant	R	-	-	-	-	1				

Note:
(1) All wild birds are protected under Wild Animal Protection Ordinance (Cap. 170).
(2) AFCD (2013). Hong Kong Biodiversity Database.
(3) R=resident; Sp=spring; Su=summer; M=migrant.
(4) Fellowes *et al.* (2002).
(5) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(6) Zheng and Wang (1998).
(7) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.

Table 3.10 Number of Dragonfly Recorded at Luk Tei Tong Bypass Channel (LBC)

Common Name	Scientific Name	Distribution in Hong Kong (1)	Level of Concern (2)	Protection Status in China (3)	China Red Data Book (4)	IUCN Red List (5)	LBC1	LBC2	LBC3	LBC4	LBC5
Blue Percher	*Diplacodes trivialis*	Abundant	-	-	-	-	1				
Wandering Glider	*Pantala flavescens*	Abundant	-	-	-	-	1				

Note:
(1) AFCD (2013). Hong Kong Biodiversity Database.
(2) Fellowes *et al.* (2002).
(3) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(4) Zheng and Wang (1998).
(5) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.

Table 3.11 Relative Abundance of Aquatic Macroinvertebrate and Fish Recorded at Luk Tei Tong Bypass Channel (LBC)

Fauna Groups	Scientific Name	Common Name	Distribution in Hong Kong (1)	Level of Concern (2)	Protection Status in China (3)	China Red Data Book (4)	IUCN Red List (5)	LBC1	LBC2	LBC3	LBC4	LBC5
Fish	*Oreochromis mossambicus*	Mozambique Tilapia	Common	-	-	-	-	+++				
Fish	*Oreochromis niloticus*	Nile Tilapia	Common	-	-	-	-	++				
Worms	*Capitella capitata*	-	-	-	-	-	-	+				
Bivalves	Lymnaeidae	-	-	-	-	-	-	+++				
Insect	*Ligia exotica*	Sea Slater	Common	-	-	-	-	++				
Insect	*Ptilomera tigrina*	-	-	-	-	-	-	+				
Insect	*Rhagovelia sp.*	-	-	-	-	-	-	+				
Insect	*Metrocoris sp.*	-	-	-	-	-	-	+				

Note:
(1) AFCD (2013). Hong Kong Biodiversity Database.
(2) Fellowes *et al.* (2002)
(3) List of Wild Animals Under State Protection (promulgated by State Forestry Administration and Ministry of Agriculture on 14 January, 1989).
(4) Zheng and Wang (1998).
(5) IUCN (2013). IUCN Red List of Threatened Species. Version 2013.1.
(6) Relative abundance: + = occasional, less than 5 individuals were found; ++ = common, 5-20 individuals were found; +++ = abundant, more than 20 individuals were found.

3.2. Ecological Water Quality Monitoring (EWQM)

3.2.1. The post-construction phase EWQM was conducted on 7 June 2013. The monitoring results are presented in **Appendix 3** and summarised in **Table 3.10**, which includes reference to the key Water Quality Objectives (WQOs). Baseline surveys were conducted in 2007 prior to the start of the drainage improvement works. The baseline survey results are presented in **Table 3.11**.

3.2.2. The water quality monitoring results are discussed in **Section 5**.

Table 3.10 Summarized Ecological Water Quality Monitoring Results (June 2013)

Parameters	Key Water Quality Objectives (1)	WE1	WE2	WE3	WE4	WE5	WE6
Suspended Solids (mg/L)	<20	<2.0	3.0	3.0	5.0	<2.0	2.0
Nitrogen (Ammonia) (mg/L)	-	0.05	0.02	0.06	0.15	1.39	0.04
Nitrogen (Nitrate) (mg/L)	-	0.61	0.19	0.23	0.56	0.19	0.16
Reactive Phosphorous (mg/L)	-	<0.01	0.03	0.04	0.06	0.16	0.03
5-day Biochemical Oxygen Demand (BOD_5) (mg/L)	<5	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dissolved Oxygen (mg/L)	>4	6.95	7.23	7.28	7.31	6.12	7.23
Temperature (°C)	-	29.3	28.0	28.0	31.7	30.2	26.4
pH	6.5 – 8 5	6.87	6.83	6.73	7.39	6.88	7.03
Salinity (ppt)	-	0.03	0.04	0.05	4.03	0.27	0.04
Conductivity (µs/cm)	-	63.7	68.6	100.4	7,392	560.0	80.8
Water Flow (m/s)	-	1.06	0.47	0.32	0.54	0.13	0.17
Water Depth (cm)	-	45	34	7	9	12	44

Note:
(1) The available key Water Quality Objectives (WQOs) for River Monitoring Stations at Mui Wo River on Lantau Island (EPD, 2011).

Table 3.11 Baseline Results of Ecological Water Quality Monitoring Results (September 2007)

Parameters	WE1	WE2	WE3	WE4	WE5	WE6
Suspended Solids (mg/L)	1.0	2.0	3.0	3.0	<1.0	<1.0
Nitrogen (Ammonia) (mg/L)	0.07	0.12	0.11	0.23	0.03	0.02
Nitrogen (Nitrate) (mg/L)	0.12	0.13	0.13	0.31	0.04	0.05
Reactive Phosphorous (mg/L)	0.04	0.06	0.06	0.09	0.06	0.05
5-day Biochemical Oxygen Demand (BOD_5) (mg/L)	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dissolved Oxygen (mg/L)	6.58	6.82	6.37	7.61	6.87	5.70
pH	6.4	7.1	7.0	6.8	6.6	6.1
Salinity (ppt)	<0.1	0.1	0.3	7.6	0.1	<0.1

4. ECOLOGICAL MONITORING SCHEDULE

4.1. The next ecological surveys monitoring and ecological water quality is tentatively scheduled for mid-August 2013.

5. DISCUSSION AND RECOMMENDATIONS

5.1. The aim of the 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.

5.2. Key observations made during the June 2013 monitoring period in relation to the implemented mitigation measures are presented in **Table 5.1**. Where applicable, recommendations for improving the functionality of the mitigation measures have been made for DSD's consideration.

5.3. Re-establishment of cleared vegetation was observed in PNH and LBC. No further recommendations were made on vegetation re-establishment at PNH since it was not overgrown and blocking water flow; however, this will be monitored.

5.4. The cleared bypass channel is re-establishing with exotic species (mainly *Wedelia trilobata*). Whilst a low abundance marsh species (e.g. Taro, *Colocasia esculenta*; and Ginger Lily, *Hedychium coronarium*) were also observed, the re-establishment of weedy species may outcompete the preferred marsh species. One of the potential underlying issues may lie in the fact that water retention in LBC is not sufficient to support growth of marsh species during dry season. However, more observations have to be made and more data has to be collected during wet season.

5.5. Seedlings of the mangrove species (*Kandalia obovata*) were seen at other sections of LTT in addition to the existing mangrove stand at the junction at LTT2 and LTT3. Several mangrove seedlings were observed at LTT1, which is the confluence of PNH, TTT and LTT, as well as LTT5, which may imply natural re-colonization of mangrove. The natural regeneration of the mangroves will be monitored and re-planting recommended later, if required.

5.6. Whilst some differences between the original 2007 baseline surveys and the April 2013 monitoring surveys are evident, findings from water monitoring could be attributed to a range

of factors including seasonal variations, and climatic conditions and/or the influence of tidal status at the time of survey. Taking this into account, the key Water Quality Objectives (WQOs) for River Monitoring Stations at Mui Wo River (EPD, 2011) have been included to provide a comparison with standard water quality goals applicable to the area (refer to **Table 3.11**).

5.7. The Environmental Protection Department (EPD) analyses and presents data from its annual water monitoring programme to express the level of compliance with the statutory WQOs including pH, Suspended Solids (SS), 5-day Biochemical Oxygen Demand (BOD_5), 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, including the Mui Wo River. As part of the programme five locations are sampled from the Mui Wo River, three of which are associated with the monitoring area for the drainage improvement works (MW1, MW2 and MW4). The objectives related to these sampling locations, have been used in this report. Water quality of of the subject watercourses has met the WQOs during the survey.

5.8. Results of some parameters, such as Ammonia and Nitrate, demonstrated a significant increase from the baseline survey; however, the reason for this and implications for the re-establishment of the aquatic/riparian communities in not currently known. The BOD5 concentration at all locations were still reasonable.

5.9. Concentration of Nitrate, Ammonia and Reactive Phosphorous was generally lower than the last sampling period. In particular, the Nitrate concentration at WE6, which had shown an increase during the April monitoring period, has decreased to 0.16 mg/L during the June monitoring period. However, nitrate concentration at WE1 demonstrated a 3-fold increase compared to the last sampling period, which was also higher than other sampling periods. Ammonia concentration at WE1 was slightly above than the last sampling record. Suspended solid concentration demonstrated a slight decrease at all monitoring stations except WE4 compared to the last sampling record. The cause of the increase was not identified. This phenomenon will be monitored during the future monitoring periods.

5.10. No observable evidence of environmental changes such as odour, or discharge within the surveyed area, were recorded. Frequent precipitation events may contribute to some of the discrepancy of results in the current sampling period because of dilution effect but the precise effect of rainfall is not known.

5.11. The June 2013 monitoring period occurs early in the post-construction monitoring programme and provides only a snap-shot of the water quality conditions. Further monitoring is required to draw conclusions regarding the overall success of the mitigation measures implemented into the project. The assessment will be on-going over the course of the monitoring programme and will be presented in subsequent reports as additional information becomes available.

Table 5.1 Key Observations/Comments and Recommendations Arising from the June 2013 Monitoring Period

Location	Mitigation Measure	Observations/Comments	Recommendations
PNH and LTT	Construction of a small fish ladder at the upstream end of the PNH	Vegetation has re-established in PNH4; however, the fish ladder is not currently overgrown and blocking water flow.	The retention of native species, particularly at the edges of the river channel, during any future maintenance activities is recommended, to maintain existing habitat and minimize the re-colonization of exotic species. Some pits have been incorporated into the gabion banks, but do not appear to have been planted up. Planting of riparian

Location	Mitigation Measure	Observations/Comments	Recommendations
			vegetation, preferably with native species suggested in the EIA report Section 7.8.17 and Table 2.6 (e.g. *Albizia lebbek*, *Sterculia lanceolata, Cinnamomum camphora*, *Polyspora axillaris*, and *Rhaphiolepis indica*) is recommended. On-going weed management is recommended, as required, to maintain the open nature of the fish ladder.
		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.	As per the current design of the fish ladder, the gap from the top of the fish ladder and the bottom of the weir is 30-40cm - presenting an obstacle to fish passage. Some 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	Four fish species (Common Mudskipper, Barcheek Goby, Mozambique Tilapia, Nile Tilapia), which are not of conservation concern, were recorded at upper PNH during this monitoring. The two fish species of conservation importance, Flagtail (*Kuhlia marginata*) and Predaceous Chub (*Parazacco spilurus*) were not recorded. Flagtail was recorded in the 2003-2004 EIA surveys, and Predaceous Chub was recorded in the December 2012 survey of post-construction monitoring.	The presence of species of conservation importance in both PNH3 and PNH4 including relative abundance will continue to be monitored.
LBC	Provision of suitable habitat compensation	Vegetation has re-established, which is dominated by exotic plant species (*Wedelia trilobata*). Only limited marsh species of very low abundance were recorded.	Removal and control of vegetation is recommended to maintain the sub-climatic vegetation community found in marsh habitats. It includes retaining native species (particularly marsh species) within the LBC during any future maintenance activities is recommended, to maintain existing habitat and minimize the re-colonization of exotic species. The regeneration of marsh species in the LBC is to be

Location	Mitigation Measure	Observations/Comments	Recommendations
			monitored. To avoid recolonisation of unwanted species (e.g. *Wedelia trilobata*), replanting of marsh species would be recommended upon confirmation of the water level/availability to support marsh habitat.
		The limited occurrence of typical marsh plant species (although this was also limiting in the RS) suggests that the water levels/availability within the channel may not be adequate to sustain a marsh habitat.	On-going monitoring of water levels and species composition within the channel are required. Further assessment should take into account the timing of the surveys (wet/dry season).

6. REFERENCES

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Appendix 1. Calibration certificate of the instruments (pH meter and multi-meter)

ALS Technichem (HK) Pty Ltd

REPORT OF EQUIPMENT PERFORMANCE CHECK/CALIBRATION

CONTACT:	MR MIKE SHEK	WORK ORDER:	HK1311569
CLIENT:	AECOM ASIA COMPANY LIMITED	LABORATORY:	HONG KONG
ADDRESS:	11/F, TOWER 2, GRAND CENTRAL PLAZA, 138 SHATIN RURAL COMMITTEE ROAD, SHATIN, N.T., HONG KONG.	DATE RECEIVED:	30/04/2013
		DATE OF ISSUE:	09/05/2013
PROJECT:	--		

COMMENTS

It is certified that the item under calibration/checking has been calibrated/checked by corresponding calibrated equipment in the laboratory.
Maximum Tolerance and calibration frequency stated in the report, unless otherwise stated, the internal acceptance criteria of ALS will be followed.

Scope of Test:	Conductivity, Dissolved Oxygen, Salinity and Temperature
Equipment Type:	Multimeter
Brand Name:	YSI
Model No.:	YSI PROFESSIONAL PLUS
Serial No.:	12M100515
Equipment No.:	W.040.01
Date of Calibration:	08 May, 2013

NOTES

This is the Final Report and supersedes any preliminary report with this batch number.
Results apply to sample(s) as submitted. All pages of this report have been checked and approved for release.

ISSUING LABORATORY: HONG KONG

Address

ALS Technichem (HK) Pty Ltd
11/F Chung Shun Knitting Centre
1-3 Wing Yip Street
Kwai Chung
HONG KONG

Phone: 852-2610 1044
Fax: 852-2610 2021
Email: hongkong@alsglobal.com

Mr. Fung Lim Chee, Richard
General Manager -
Greater China & Hong Kong

ADDRESS 11/F, Chung Shun Knitting Centre, 1-3 Wing Yip Street, Kwai Chung, N.T., Hong Kong | PHONE +852 2610 1044 | FAX +852 2610 2021
ALS TECHNICHEM (HK) PTY LTD An ALS Limited Company

REPORT OF EQUIPMENT PERFORMANCE CHECK/CALIBRATION

Work Order: HK1311569
Date of Issue: 09/05/2013
Client: AECOM ASIA COMPANY LIMITED

Equipment Type: Multimeter
Brand Name: YSI
Model No.: YSI PROFESSIONAL PLUS
Serial No.: 12M100515
Equipment No.: W.040.01
Date of Calibration: 08 May, 2013 Date of next Calibration: 08 August, 2013

Parameters:

Conductivity

Method Ref: APHA (21st edition), 2510B

Expected Reading (uS/cm)	Displayed Reading (uS/cm)	Tolerance (%)
146.9	138.4	-5.8
6667	6190	-7.2
12890	12065	-6.4
58670	56625	-3.5
	Tolerance Limit (±%)	10.0

Dissolved Oxygen

Method Ref: APHA (21st edition), 4500O: G

Expected Reading (mg/L)	Displayed Reading (mg/L)	Tolerance (mg/L)
5.28	5.33	0.05
7.01	7.20	0.19
8.18	8.32	0.14
	Tolerance Limit (±mg/L)	0.20

Salinity

Method Ref: APHA (21st edition), 2520B

Expected Reading (ppt)	Displayed Reading (ppt)	Tolerance (%)
0	0	--
10	10.01	0.1
20	20.23	1.2
30	30.64	2.1
	Tolerance Limit (±%)	10.0

Temperature

Method Ref: Section 6 of International Accreditation New Zealand Technical Guide No. 3 Second edition March 2008: Working Thermometer Calibration Procedure.

Expected Reading (°C)	Displayed Reading (°C)	Tolerance (°C)
10.0	10.6	0.6
22.0	23.0	1.0
42.0	41.8	-0.2
	Tolerance Limit (±°C)	2.0

Remark: "Displayed Reading" presents the figures shown on item under calibration / checking regardless of equipment precision or significant figures.

Mr. Fung Lim Chee, Richard
General Manager
Greater China & Hong Kong

ALS Technichem (HK) Pty Ltd
ALS Environmental

ALS Technichem (HK) Pty Ltd

REPORT OF EQUIPMENT PERFORMANCE CHECK/CALIBRATION

CONTACT:	MR MIKE SHEK	**WORK ORDER:**	HK1308859
CLIENT:	AECOM ASIA COMPANY LIMITED	**LABORATORY:**	HONG KONG
ADDRESS:	11/F, TOWER 2, GRAND CENTRAL PLAZA, 138 SHATIN RURAL COMMITTEE ROAD, SHATIN, N.T., HONG KONG.	**DATE RECEIVED:**	03/04/2013
		DATE OF ISSUE:	17/04/2013
PROJECT:	--		

COMMENTS

It is certified that the item under calibration/checking has been calibrated/checked by corresponding calibrated equipment in the laboratory.
Maximum Tolerance and calibration frequency stated in the report, unless otherwise stated, the internal aceptance criteria of ALS will be followed.

Scope of Test:	pH and Temperature
Equipment Type:	pH Meter
Brand Name:	WTW
Model No.:	pH 3210
Serial No.:	12340605
Equipment No.:	W.039.08
Date of Calibration:	11 April, 2013

NOTES

This is the Final Report and supersedes any preliminary report with this batch number.
Results apply to sample(s) as submitted. All pages of this report have been checked and approved for release.

ISSUING LABORATORY: HONG KONG

Address

ALS Technichem (HK) Pty Ltd
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General Manager
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ALS TECHNICHEM (HK) PTY LTD An ALS Limited Company

REPORT OF EQUIPMENT PERFORMANCE CHECK/CALIBRATION

Work Order: HK1308859
Date of Issue: 17/04/2013
Client: AECOM ASIA COMPANY LIMITED

Equipment Type: pH Meter
Brand Name: WTW
Model No.: pH 3210
Serial No.: 12340605
Equipment No.: W.039.08
Date of Calibration: 11 April, 2013 Date of next Calibration: 11 July, 2013

Parameters:

pH Value

Method Ref: APHA 21st Ed. 4500H:B

Expected Reading (pH Unit)	Displayed Reading (pH Unit)	Tolerance (pH unit)
4.0	3.901	-0.10
7.0	6.931	-0.07
10.0	9.913	-0.09
	Tolerance Limit (±pH unit)	0.20

Temperature

Method Ref: Section 6 of International Accreditation New Zealand Technical Guide No. 3 Second edition March 2008: Working Thermometer Calibration Procedure.

Expected Reading (°C)	Displayed Reading (°C)	Tolerance (°C)
12.0	12.7	0.7
27.0	27.9	0.9
50.0	49.2	-0.8
	Tolerance Limit (±°C)	2.0

Remark: "Displayed Reading" presents the figures shown on item under calibration / checking regardless of equipment precision or significant figures.

Mr. Fung Lim Chee, Richard
General Manager -
Greater China & Hong Kong

Appendix 2a: Plant Species Recorded in Pak Ngan Heung River and Luk Tei Tong River

Scientific Name	Growth Form	Native / Exotic to Hong Kong	Distribution in Hong Kong	PNH1	PNH2	PNH3	PNH4	LTT1	LTT2	LTT3	LTT4	LTT5
Acanthus ilicifolius	shrub	native	common						+	+		
Bidens alba	herb	exotic	very common	+		+	++		+	+	++	
Celtis sinensis	tree	native	common				+					
Colocasia esculenta	herb	native	N/A				+					
Commelina diffusa	herb	native	common			+	++					
Crotalaria pallida	herb	exotic	common								++	
Praxelis clematidea	perennial herb	exotic	very common	+								
Ficus hispida	tree	native	very common	+		+						
Ipomoea cairica	climber	exotic	very common									+
Kandelia obovata	shrub or small tree	native	common					+	+	+		+
Ludwigia octovalvis	perennial herb	native	common			+						
Mallotus paniculatus	tree	native	very common				+					
Microstegium ciliatum	perennial procumbent herb	native	very common			++	+					
Mikania micrantha	climber	exotic	very common			+++	+++		+		++	+
Neyraudia reynaudiana	herb	native	very common							++		
Panicum maximum	herb	exotic	very common				+					+
Polygonum spp.	herb	N/A	N/A				+					
Pueraria spp.	climber	N/A	N/A								+	
Rhus succedanea	tree	native	common				+					
Urena lobata	shrub	native	common				+					
Wedelia trilobata	perennial herb	exotic	common				++					+

Note:
Code for Abundance: +++=abundant; ++=frequent; +=occasional

Appendix 2b: Plant Species Recorded in Luk Tei Tong Bypass Channel and Reference Site

LLT Bypass Channel (LBC)

Scientific Name	Growth Form	Native / Exotic to Hong Kong	Distribution in Hong Kong	LBC1	LBC2	LBC3	LBC4	LBC5	Average
Species recorded in the quadrats along the transects				**Average Percentage Cover**					
Crotalaria pallida	herb	exotic	common	0.00	0.00	0.00	0.15	0.01	0.03
Cyclosorus interruptus	herb	native	common	0.00	0.00	0.11	0.04	0.00	0.03
Praxelis clematidea	perennial herb	exotic	very common	0.00	0.00	0.00	0.13	0.00	0.03
Fimbristylis sieboldii	herb	native	common	0.84	0.00	0.00	0.00	0.00	0.17
Ipomoea cairica	climber	exotic	very common	0.01	0.01	0.01	0.00	0.00	0.00
Microstegium ciliatum	perennial procumbent herb	native	very common	0.00	0.01	0.09	0.02	0.08	0.04
Mikania micrantha	climber	exotic	very common	0.00	0.02	0.23	0.00	0.02	0.05
Mimosa diplotricha	herb	exotic	rare	0.00	0.04	0.00	0.00	0.00	0.01
Paspalum conjugatum	perennial herb	exotic	common	0.00	0.06	0.00	0.00	0.01	0.01
Polygonum perfoliatum	climbing herb	native	common	0.00	0.00	0.00	0.02	0.01	0.01
Ruellia coerulea	herb	exotic	N/A	0.15	0.00	0.00	0.00	0.00	0.03
Wedelia trilobata	perennial herb	exotic	common	0.00	0.85	0.56	0.64	0.86	0.58
Other species recorded during the walk-through survey				**Occurrence of the Species**					
Aster subulatus	herb	exotic	N/A					+	
Bidens alba	herb	exotic	very common		+	+	+	+	
Cassytha filiformis	climber	native	very common					+	
Celosia argentea	herb	native	very common			+		+	
Celtis sinensis	tree	native	common	+					
Colocasia esculenta	herb	native	N/A		+	+	+	+	
Commelina diffusa	herb	native	common			+			
Crotalaria pallida	herb	exotic	common				+	+	
Cyclosorus interruptus	herb	native	common		+	+	+		
Cyperus sp.	herb	N/A	N/A	+					
Cyperus alternifolius subsp. flabelliformis	herb	exotic	N/A	+					
Erechtites hieracifolia	herb	exotic	common				+		
Praxelis clematidea	perennial herb	exotic	very common		+	+	+	+	
Fimbristylis sieboldii	herb	native	common	+					
Hedychium coronarium	shrub	exotic	N/A				+		
Ipomoea cairica	climber	exotic	very common	+	+	+	+	+	
Kandelia obovata	shrub or small tree	native	common	+					
Lophatherum gracile	herb	native	common				+		
Macaranga tanarius	tree	native	common		+				
Microstegium ciliatum	perennial procumbent herb	native	very common	+	+	+	+	+	
Mikania micrantha	climber	exotic	very common		+	+	+	+	
Mimosa diplotricha	herb	exotic	rare	+	+	+	+	+	
Neyraudia reynaudiana	herb	native	very common	+					
Panicum maximum	herb	exotic	very common			+		+	
Paspalum spp.	perennial herb	N/A	N/A	+					

Note:
Code: +=occurrence of the species

Appendix 2b: Plant Species Recorded in Luk Tei Tong Bypass Channel and Reference Site

LLT Bypass Channel (LBC)

Scientific Name	Growth Form	Native / Exotic to Hong Kong	Distribution in Hong Kong	LBC1	LBC2	LBC3	LBC4	LBC5
Other species recorded during the walk-through survey				**Occurrence of the Species**				
Paspalum conjugatum	perennial herb	exotic	common		+	+		+
Polygonum perfoliatum	climbing herb	native	common			+	+	+
Polygonum spp.	herb	N/A	N/A				+	
Ruellia coerulea	herb	exotic	N/A	+				
Sapium sebiferum	tree	native	common	+	+	+		
Solanum americanum	herb	exotic	very common	+	+	+		
Tarazacum officinale	herb	native	common		+			
Wedelia trilobata	perennial herb	exotic	common	+	+	+	+	+

Note:
Code: +=occurrence of the species

Appendix 2b: Plant Species Recorded in Luk Tei Tong Bypass Channel and Reference Site

Reference Site (RS)

Scientific Name	Growth Form	Native / Exotic to Hong Kong	Distribution in Hong Kong	RS1	RS2	RS3	RS4	RS5	Average
Species recorded in the quadrats along the transects				**Average Percentage Cover**					
Bidens alba	herb	exotic	very common	0.10	0.00	0.00	0.00	0.01	0.02
Colocasia esculenta	herb	native	N/A	0.00	0.00	0.00	0.01	0.00	0.00
Ipomoea cairica	climber	exotic	very common	0.00	0.00	0.00	0.00	0.01	0.00
Microstegium ciliatum	perennial procumbent herb	native	very common	0.00	0.00	0.02	0.01	0.00	0.01
Mikania micrantha	climber	exotic	very common	0.00	0.00	0.00	0.02	0.03	0.01
Mimosa diplotricha	herb	exotic	rare	0.10	0.06	0.01	0.01	0.13	0.06
Paspalum conjugatum	perennial herb	exotic	common	0.04	0.03	0.00	0.00	0.00	0.01
Pueraria phaseoloides	climber	native	very common	0.01	0.00	0.00	0.00	0.16	0.03
Urena lobata	shrub	native	common	0.00	0.02	0.00	0.00	0.03	0.01
Wedelia trilobata	perennial herb	exotic	common	0.67	0.76	0.89	0.88	0.59	0.76
Other species recorded during the walk-through survey				**Occurrence of the Species**					
Acacia auriculiformis	tree	exotic	common		+				
Acacia confusa	tree	exotic	N/A		+		+		
Artemisia japonica	perennial herb	N/A	N/A				+		
Bambusa sp.	bamboo	N/A	common					+	
Bauhinia blakeana	tree	native	common	+					
Bidens alba	herb	exotic	very common	+	+		+	+	
Bidens pilosa	herb	exotic	very common					+	
Calliandra haematocephala	shrub	exotic	common					+	
Canna indica	herb	exotic	N/A				+		
Cassytha filiformis	climber	native	very common					+	
Celtis sinensis	tree	native	common	+	+	+			
Chloris barbata	herb	native	very common		+				
Colocasia esculenta	herb	native	N/A		+	+	+		
Conyza canadensis	herb	exotic	very common		+		+		
Cyperus spp.	herb	N/A	N/A	+					
Praxelis clematidea	perennial herb	exotic	very common		+				
Ficus hispida	tree	native	very common			+	+		
Hedychium coronarium	shrub	exotic	N/A		+	+			
Ipomoea cairica	climber	exotic	very common	+	+			+	
Ipomoea pes-caprae	perennial herb	native	common		+				
Lantana camara	shrub	exotic	very common			+		+	
Leucaena leucocephala	tree	exotic	common				+		
Mallotus paniculatus	tree	native	very common				+		
Melastoma malabathricum L.	herb	native	common			+			
Microstegium ciliatum	perennial procumbent herb	native	very common			+	+		
Mikania micrantha	climber	exotic	very common			+	+	+	
Mimosa diplotricha	herb	exotic	rare	+	+	+	+	+	

Note:
Code: +=occurrence of the species

Appendix 2b: Plant Species Recorded in Luk Tei Tong Bypass Channel and Reference Site

Reference Site (RS)

Scientific Name	Growth Form	Native / Exotic to Hong Kong	Distribution in Hong Kong	RS1	RS2	RS3	RS4	RS5
Other species recorded during the walk-through survey				**Occurrence of the Species**				
Miscanthus floridulus	perennial herb	native	common					+
Neyraudia reynaudiana	herb	native	very common		+			
Oxalis corymbosa	perennial herb	exotic	common					+
Paspalum spp.	perennial herb	N/A	common	+				+
Paspalum conjugatum	perennial herb	exotic	common	+	+	+	+	+
Pueraria phaseoloides	climber	native	very common	+	+			+
Saccharum arundinaceum	herb	native	N/A					+
Sageretia thea	shrub	native	very common	+			+	+
Sapium sebiferum	tree	native	common		+			+
Setaria sp.	herb	N/A	N/A					+
Urena lobata	shrub	native	common	+	+	+	+	+
Wedelia trilobata	perennial herb	exotic	common	+	+	+	+	+

Note:
Code: +=occurrence of the species

Appendix 3: Ecological Water Quality Monitoring Raw Data

(June 2013)

Date of Monitoring: 7 Jun 2013 **Weather : Sunny**

Monitoring Location	Suspended Solids (mg/L)	Nitrogen (Ammonia) (mg/L)	Nitrogen (Nitrate) (mg/L)	Reactive Phosphorous (mg/L)	5-day Biochemical Oxygen Demand (BOD5) (mg/L)	Dissolved Oxygen (mg/L)	
						M1	M2
WE1	<2.0	0.05	0.61	<0.01	<2.0	6.96	6.94
WE2	3.0	0.02	0.19	0.03	<2.0	7.22	7.24
WE3	3.0	0.06	0.23	0.04	<2.0	7.27	7.29
WE4	5.0	0.15	0.56	0.06	<2.0	7.30	7.31
WE5	<2.0	1.39	0.19	0.16	<2.0	6.13	6.11
WE6	2.0	0.04	0.16	0.03	<2.0	7.21	7.24
WE7	No water - Not sampled						
WE8	No water - Not sampled						
WE9	No water - Not sampled						
WE10	No water - Not sampled						

Monitoring Location	Temperature (°C)		pH		Salinity (ppt)		Conductivity (µs/cm)	Water Flow (m/s)	Water Depth (cm)
	M1	M2	M1	M2	M1	M2			
WE1	29.3	29.2	6.86	6.87	0.03	0.02	63.7	1.06	45
WE2	27.9	28.0	6.83	6.82	0.03	0.04	68.6	0.47	34
WE3	28.0	28.0	6.73	6.73	0.05	0.05	100.4	0.32	7
WE4	31.6	31.7	7.39	7.39	4.03	4.03	7392.0	0.54	9
WE5	30.2	30.2	6.87	6.89	0.27	0.27	560.0	0.13	12
WE6	26.3	26.4	7.03	7.03	0.03	0.04	80.8	0.17	44
WE7	No water - Not sampled								
WE8	No water - Not sampled								
WE9	No water - Not sampled								
WE10	No water - Not sampled								

Note:
Where more than one measurement was taken, the data is represented by Measurement M1 and M2.

PNH1 and PNH2

PNH3 and PNH4

LTT1 and LTT2

LTT3 and LTT4

LBC1

LBC2 to LBC5

Reference Site

Working Photo

AECOM	Post-Construction Ecological Monitoring of Drainage Improvement Works in Southern Lantau	SCALE	N.T.S.	DATE	Jul-13
	Representative Photographs taken during the Monitoring	CHECK	McmillanSE	DRAWN	CHIKYY
		JOB NO.	60278381	DRAWING No.	Appendix 4