



**Independent Environmental Checker for
Contract No. YL/2009/01 – Hang Hau Tsuen Channel at
Lau Fau Shan**

Post Construction Mangrove Monitoring

Final Report

Prepared for:
Civil Engineering and Development Department

Prepared by:
ENVIRON Hong Kong Limited

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Final Report

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1.0 INTRODUCTION

1.1 Project Background

- 1.1.1 Hang Hau Tsuen is situated at the southern part of Lau Fau Shan bordering the Hang Hau Tsuen stream. A channel improvement project under an Environmental Permit (EP no: EP-343/2009) has been carried out to alleviate flooding occurred in the catchment by converting the existing Hang Hau Tsuen stream between Deep Bay and Deep Bay Road to an engineered channel that will meet the required flood protection standards. Habitat restoration will be performed after finishing the construction work in the channel. In accordance with Clause 2.16 of the EP and Section 6.4 of the Environmental Monitoring and Audit (EM&A) Manual (the EM&A Manual) under the EP, to mitigate the loss of 0.07 ha of mangrove patches, a total of 0.07 ha (1:1 ratio) area at tidal zone on northern side of the constructed channel will be planted with various mangrove species. Monitoring was required to assess the growing condition of planted mangrove plants during the Operation Phase of the Project in accordance with Section 6.4 of the EM&A Manual.
- 1.1.2 The proposal and schedules for Operational Phase monitoring of compensatory mangrove planting had been submitted to AFCD on 14 May 2012. Comments on the proposal had been received from AFCD on 5 June 2012, and the revised proposal and schedules had been submitted to AFCD on 14 November 2012. No comment has been received from AFCD on 19 November 2012.
- 1.1.3 China-Hong Kong Ecology Consultants Co. (CHEC) has been appointed by ENVIRON Hong Kong Limited as ecologist to undertake the post construction mangrove monitoring starting from June 2013 for 2 years.
- 1.1.4 Monitoring should be conducted once every quarter for two years after completion of the mangrove planting in accordance with Section 6.4 of the EM&A Manual.
- 1.1.5 This is the final report summarizing the monitoring results over the entire operational monitoring period and its findings. The report contains the following information:
- Summary of major issues
 - Monitoring methodology
 - Monitoring results
 - Summary and comments

2.0 SUMMARY OF MAJOR ISSUES

2.1 A total of eight post construction quarterly mangrove monitoring surveys were carried out from June 2013 to March 2015.

2.2 Most of the selected plants were recorded as “Fair” health condition during two years monitoring period except some plants were found dead in Quadrate 1 and 2. However, the affected area was small compare to the whole compensatory site, and a total of 0.07 (1:1 ratio) compensation area is still complied as regeneration in other area was observed. Thus the loss of small proportion of trees is minor.

2.3 The mean diameter and height of the selected plants have slightly increased in every monitoring survey except one survey conducted in June 2014, in which the decrease of mean diameter and height of the selected plants was due to death of the highest plants. Most mangrove trees were recorded in positive growth. Overall survival rate of each mangrove species is higher than 75%, thus no replanting shall be implemented.

2.4 Two invasive species including *Sonneratia caseolaris* and *Derris trifoliata* were found in the mangrove compensatory area, but they were removed out immediately to avoid further spreading.

2.5 Post construction quarterly mangrove monitoring has been completed in accordance with Section 6.4 of the EM&A Manual and no further monitoring is recommended.

3.0 MANGROVE MONITORING METHODOLOGY

3.1 Monitoring Equipment

3.1.1 Monitoring was involved physical measurement and photo record. Thus, tape/metallic ruler, vernier caliper and camera were used for the monitoring.

3.2 Quadrate

3.2.1 Locations of five quadrates of 5m x 5m in size were chosen at representative plantation area. The locations of quadrates were selected based on tidal level, species and ground characteristics as well as accessibility by foot. The location for each quadrate was marked by setting up bamboo or similar material at each corner of quadrates. The species and number of mangrove individual were counted within each quadrate. The location of mangrove zone and quadrates within the channel was shown in **Annex A**.

3.3 Measurement

3.3.1 In order to collect data consistent and comparable in temporal scale, for each planted plant species, 5 selected plants in each quadrat were marked by color rope or ribbon. Color rope or ribbon was tied on tree branch for marking only. No damage or any adverse effect was anticipated on the growth of mangrove trees. There was a maximum of 25 plants for each species will be selected for measurements if the species presented in all 5 quadrats. Every planted species was selected for monitoring. It is expected that at least two mangrove species was planted in the planting area. Maximum height of the selected individual plant was measured to a nearest centimeter based on growing form of plant.

3.3.2 Stem diameter for 5 selected plants of each species in each quadrat was measured by vernier caliper. A mark such as rope/ribbon was made on stem where diameter measurement will be carried out. Same orientation for the vernier caliper will be maintained for each measurement. Measurement will be taken to the nearest millimeter.

3.3.3 The overall health condition was assessed for each species within quadrat. The assessment in some inaccessible location was aided by binocular. The following was the health scheme for the assessment. The rate of survival of the mangroves after planting was estimated by visual observation.

3.3.4 Health scheme:

Good: Low mortality rate. Green foliage color. Dense foliage. No damage from floating rubbish or high water flow.

Fair: Low to medium mortality rate. Less dense foliage. Some yellowish foliage color recorded. Some leave or branches were damaged by floating rubbish, water flow or insect.

Poor: High mortality rate. Highly sparse crown and most foliage were drying up. The plant may be seriously damaged.

3.4 Photo Record

3.4.1 Photos of overall view for mangrove compensation area and each quadrat was taken. For consistence, same photo location and angle for each measurement will try to be maintained but it may need adjustment due to site and plant change. Other site conditions and observations should also be recorded.

4.0 MONITORING RESULTS

4.1 Visual Inspection

- 4.1.1 The species and the total number of mangrove tree were counted within each quadrat. Two native species (*Acanthus ilicifolius*, *Kandelia obovata*) were planted on the compensatory mangrove planting area.
- 4.1.2 The overall health condition of each species within each quadrat during two years monitoring period was assessed and shown in **Table 1 to Table 1**.
- 4.1.3 The overall health conditions of the selected individuals were assessed as “Fair” condition during two years monitoring period except some individuals were dead in Quadrat 1 and 2 respectively. Individuals in Quadrat 1 were observed in high mortality rate since the inspection conducted in December 2013. As that side of Quadrat 1 was nearest to an outfall, it was believed that eastern side of Quadrat 1 was immersed by the discharge from outfall, which leads to the death of mangrove tree on that area. However, the affected area was small compare to the whole compensatory site, and a total of 0.07 (1:1 ratio) compensation area is still complied as regeneration in other area was observed. Thus the loss of small proportion of trees is minor.
- 4.1.4 One of the selected *Kandelia obovata* was found dead in Quadrat 2 during the last inspection. As the rest of trees in the same quadrat were observed in positive growth without significant change, it was believed that the tree was dead naturally and reason of the death is not related to any impacts raised from the compensatory site.
- 4.1.5 Except Quadrates 1, the survival rate of the rest of Quadrates was not varied significantly during monitoring period. The overall survival rate of each mangrove species is higher than 75% on the compensatory mangrove planting area, thus no replanting shall be implemented. The total number, density and survival rate of mangrove tree within each quadrat were shown in **Table 9**.
- 4.1.6 *Sonneratia caseolaris* and *Derris trifoliata* were found in some parts of the mangrove compensatory area, which are invasive species that their existence would possibly affect the original plants in the channel due to their rapid growth characteristic. However, they were removed immediately to avoid further spreading and threatening the original planted plants.

4.2 Measurement of selected plant individual

- 4.2.1 Maximum height and stem diameter of maximum 5 selected individual of each species in each quadrat was measured during the monitoring survey. Result of the measurement was shown in **Table 1 to Table 8**.
- 4.2.2 Mean height & diameter of *Acanthus ilicifolius* and *Kandelia obovata* was

calculated and shown in **Tables 10 & 11**. The change of measurement parameters since June 2013 was shown in **Figures 1 & 2**.

- 4.2.3 A positive growth in mean height and diameter of selected individuals were constantly recorded in every quarterly monitoring except one monitoring conducted in June 2014, in which reduction in mean height and diameter was observed due to the death of the highest plants. Reselected shorter and smaller plant resulted in a reduction in mean height and diameter.

Table 1 Mangrove plant growth and health monitoring for each planted species for June 2013

Date: 4 June 2013 Temperature: ~29°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
<i>Acanthus ilicifolius</i>	75	12.46	110	14.61							Good
<i>Kandelia obovata</i>	55	13.11	49	13.64	53	12.58	59	21.1	41	12.32	Poor to Fair
<i>Sonneratia caseolaria</i>	133	11.54	149	9.95	108	8.7	85	8.22	134	11.83	Poor to Fair
Quadrat 2	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)
<i>Acanthus ilicifolius</i>	60	6.61	108	9.11	86	10.2	124	10.82	98	9.21	Fair
<i>Kandelia obovata</i>	59	12.53	73	14.37	56	15.42	67	15.6	40	13.3	Fair
Quadrat 3	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)
<i>Acanthus ilicifolius</i>	95	12.72	90	12.82	122	11.04	92	12.03	86	9.56	Fair
<i>Kandelia obovata</i>	110	12.62	96	16.46	113	13.88	144	16.39	102	10.81	Poor to Fair
<i>Sonneratia caseolaria</i>	103	11.28	125	10.04	158	12.84	65	7.57			Poor to Fair
Quadrat 4	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)
<i>Acanthus ilicifolius</i>	105	11.74	96	10.31	93	10.95	76	10.45	84	96.6	Fair
Quadrat 5	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)
<i>Acanthus ilicifolius</i>	113	13.48	74	11.5	63	8.99	99	13.84			Fair
<i>Kandelia obovata</i>	71	16.46	111	17.57	42	10.54	109	13.6	51	12.88	Poor to Fair

Table 2 Mangrove plant growth and health monitoring for each planted species for September 2013

Date: 12 September 2013 Temperature: ~30°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	78	12.62	112	15.3	73	6.21	58	7.14	62	6	Good
	58	14.7	50	13.64	57	12.6	59	21.3	43	12.5	Fair
Kandelia obovata											
Quadrat 2	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	64	7.33	110	9.15	88	10.2	128	10.92	99	9.66	Fair
Kandelia obovata	61	13.37	73	15.95	58	17.14	70	17.6	47	13.5	Fair
Quadrat 3	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	98	14.24	93	12.82	125	11.34	97	12.44	92	9.56	Fair
Kandelia obovata	58	13.38	98	16.7	92	13.88	144	16.39	105	11.33	Poor to Fair
Quadrat 4	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	109	12.94	102	11.91	102	11.6	83	10.48	92	9.81	Fair
Quadrat 5	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	120	13.58	80	11.5	63	9.88	100	14.4	102	12.47	Fair
Kandelia obovata	72	17.51	111	18.42	43	11.69	110	13.9	52	13.72	Fair

Table 3 Mangrove plant growth and health monitoring for each planted species for December 2013

Date: 3 December 2014 Temperature: ~22°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	Dead	Dead	Dead	Dead	73.5	6.59	59	7.34	65	6.44	Poor to Fair
	Dead	Dead	51	13.64	Dead	Dead	62	21.91	46	12.5	Poor to Fair
Kandelia obovata	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	66	7.62	110	9.15	90	10.3	129	10.92	99	9.66	Fair
Kandelia obovata	61	13.37	73	15.95	58	17.14	70	19.8	52	13.5	Fair
Acanthus ilicifolius	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	102	14.24	98	12.82	125	12.19	97	12.44	92	9.64	Fair
Kandelia obovata	58	13.72	96	17.62	51	13.88	37	16.39	60	12.04	Fair
Acanthus ilicifolius	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	112	12.94	108	12.31	106	11.75	83	10.48	92	10.04	Fair
Kandelia obovata	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	
Acanthus ilicifolius	120	13.68	83	11.58	64	9.88	103	14.4	105	12.62	Fair
Kandelia obovata	75	17.61	111	18.42	43	11.73	110	13.9	54	13.94	Fair

Table 4 Mangrove plant growth and health monitoring for each planted species for March 2014

Date: 4 March 2014 Temperature: ~16°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 1 <i>Acanthus ilicifolius</i>	Dead	Dead	Dead	Dead	83	7.5	61	8.2	Dead	Dead	Health (GFF/P)	(Unchange/Better/Poor)
	Dead	Dead	53.5	14	Dead	Dead	62	21.91	48	13.2	Poor to Fair	Unchange
Quadrat 2 <i>Kandelia obovata</i>	Dead	Dead	53.5	14	Dead	Dead	62	21.91	48	13.2	Poor to Fair	Unchange
	Dead	Dead	53.5	14	Dead	Dead	62	21.91	48	13.2	Poor to Fair	Unchange
Quadrat 3 <i>Acanthus ilicifolius</i>	69	7.8	110	9.22	94	10.3	138	10.92	110	9.86	Fair	Unchange
	61	14.51	73	15.85	68	17.14	70	19.8	51	13.6	Fair	Unchange
Quadrat 4 <i>Acanthus ilicifolius</i>	106	14.24	106	12.82	127	13.1	102	12.45	92	10.1	Fair	Unchange
	58	13.8	99	17.62	53	14.21	38	16.39	61	12.5	Fair	Unchange
Quadrat 5 <i>Kandelia obovata</i>	114	12.94	111	12.5	106	11.75	85	10.48	93	10.1	Fair	Unchange
	114	12.94	111	12.5	106	11.75	85	10.48	93	10.1	Fair	Unchange
Quadrat 6 <i>Acanthus ilicifolius</i>	71	12.26	84	11.58	65	9.88	105	14.4	106	12.7	Fair	Unchange
	77	17.62	112	18.61	44	11.73	111	14.12	54	13.94	Fair	Unchange

Table 5 Mangrove plant growth and health monitoring for each planted species for June 2014

Date: 20 June 2014 Temperature: ~31°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 1	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Poor to Fair	Unchange
	Dead	Dead	55	14	90	9.2	70	10.2	50	15.1	Poor to Fair	Unchange
Quadrat 2	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)	(Unchange/Better/Poor)
Acanthus ilicifolius	72	9	110	9.22	94	10.3	138	10.92	110	9.66	Fair	Unchange
	61	14.7	73	15.95	58	17.14	84	22	59	13.6	Fair	Unchange
Quadrat 3	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)	(Unchange/Better/Poor)
Acanthus ilicifolius	112	14.24	110	12.82	135	13.1	102	12.45	92	10.1	Fair	Unchange
	60	14.1	104	21.1	59	20	46	16.39	66	14.9	Fair	Unchange
Quadrat 4	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)	(Unchange/Better/Poor)
Acanthus ilicifolius	5	6.59	111	13	9.5	6.28	85	10.48	93	11.2	Fair	Unchange
	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
Quadrat 5	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	Health (G/F/P)	(Unchange/Better/Poor)
	73	12.26	84	11.58	65	9.88	26	8.5	112	13.2	Fair	Unchange
Kandelia obovata	77	17.62	112	18.61	44	11.73	111	14.4	54	15.3	Fair	Unchange

Table 6 Mangrove plant growth and health monitoring for each planted species for September 2014

Date: 26 September 2014

Temperature: ~31°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 1 <i>Acanthus ilicifolius</i>	Dead	Dead	Dead	Dead	90	9.8	94	11.2	Dead	Dead	Fair	(Un)change/Better/Poor
	Dead	Dead	58	15	Dead	Dead	Dead	Dead	54	17.4	Poor to Fair	
Quadrat 2 <i>Kandelia obovata</i>	Dead	Dead	58	15	Dead	Dead	Dead	Dead	54	17.4	Poor to Fair	Unchange
	Dead	Dead	58	15	Dead	Dead	Dead	Dead	54	17.4	Poor to Fair	
Quadrat 3 <i>Acanthus ilicifolius</i>	80	9.8	95	9.4	100	10.3	138	11	110	9.66	Fair	Unchange
	61	15.4	74	16.3	45	17.4	87	27	71	14.5	Fair	
Quadrat 4 <i>Kandelia obovata</i>	80	9.8	95	9.4	100	10.3	138	11	110	9.66	Fair	Unchange
	61	15.4	74	16.3	45	17.4	87	27	71	14.5	Fair	
Quadrat 5 <i>Acanthus ilicifolius</i>	118	14.8	110	12.82	135	13.8	69	14.5	57	10.1	Fair	Unchange
	66	16	105	23.8	66	23	68	16.39	76	18	Fair	
Quadrat 6 <i>Kandelia obovata</i>	118	14.8	110	12.82	135	13.8	69	14.5	57	10.1	Fair	Unchange
	66	16	105	23.8	66	23	68	16.39	76	18	Fair	
Quadrat 7 <i>Acanthus ilicifolius</i>	40	6.59	115	13.7	30	6.37	94	10.63	101	11.8	Fair	Unchange
	40	6.59	115	13.7	30	6.37	94	10.63	101	11.8	Fair	
Quadrat 8 <i>Acanthus ilicifolius</i>	40	6.59	115	13.7	30	6.37	94	10.63	101	11.8	Fair	Unchange
	40	6.59	115	13.7	30	6.37	94	10.63	101	11.8	Fair	
Quadrat 9 <i>Kandelia obovata</i>	73	12.4	84	11.58	67	10.5	37	9.1	113	13.3	Fair	Unchange
	77	17.62	112	18.61	44	11.8	111	16.5	54	15.5	Fair	

Table 7 Mangrove plant growth and health monitoring for each planted species for December 2014

Date: 23 December 2014

Temperature: ~15°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 1	Dead	Dead	60	16	90	9.9	104	11.5	56	18.6	Fair	Unchange
	Dead	Dead	60	16	Dead	Dead	Dead	Dead	Dead	Dead	Poor to Fair	Unchange
Quadrat 2	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 3	80	9.8	97	10.7	102	12.6	138	12.3	110	11.2	Fair	Unchange
	63	16.5	74	17.8	45	17.4	87	29.4	74	21	Fair	Unchange
Quadrat 4	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 5	118	14.8	118	12.82	135	13.8	70	15.3	57	10.1	Fair	Unchange
	67	17.4	109	24.89	73	24	68	16.72	78	19	Fair	Unchange
Quadrat 6	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 7	41	7.01	120	13.7	30	6.7	94	10.63	101	11.8	Fair	Unchange
	41	7.01	120	13.7	30	6.7	94	10.63	101	11.8	Fair	Unchange
Quadrat 8	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Quadrat 9	73	12.4	84	11.58	67	10.5	39	10.1	113	13.3	Fair	Unchange
	79	19	112	20.6	45	12.5	111	16.9	54	15.5	Fair	Unchange

Table 8 Mangrove plant growth and health monitoring for each planted species for March 2015

Date: 20 March 2015

Temperature: ~25°C

Quadrat	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Acanthus ilicifolius	Dead	Dead	Dead	Dead	91	10.85	107	11.8	Dead	Dead	Fair	Unchange
	Dead	Dead	63	18.1	Dead	Dead	Dead	Dead	59	18.6	Poor to Fair	Unchange
Kandelia obovata	Dead	Dead	63	18.1	Dead	Dead	Dead	Dead	59	18.6	Poor to Fair	Unchange
	Dead	Dead	63	18.1	Dead	Dead	Dead	Dead	59	18.6	Poor to Fair	Unchange
Quadrat 2	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Acanthus ilicifolius	80	10.2	97	10.7	102	13.8	139	13.2	110	11.3	Fair	Unchange
	63	16.5	Dead	Dead	45	17.4	87	29.4	75	21	Fair	Unchange
Kandelia obovata	80	10.2	97	10.7	102	13.8	139	13.2	110	11.3	Fair	Unchange
	63	16.5	Dead	Dead	45	17.4	87	29.4	75	21	Fair	Unchange
Quadrat 3	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Acanthus ilicifolius	118	14.8	127	13	135	13.8	70	15.7	57	10.4	Fair	Unchange
	70	18.6	117	26.4	73	24	68	17	79	19	Fair	Unchange
Kandelia obovata	118	14.8	127	13	135	13.8	70	15.7	57	10.4	Fair	Unchange
	70	18.6	117	26.4	73	24	68	17	79	19	Fair	Unchange
Quadrat 4	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Acanthus ilicifolius	46	8.54	120	13.7	30	6.7	94	10.98	101	12	Fair	Unchange
	46	8.54	120	13.7	30	6.7	94	10.98	101	12	Fair	Unchange
Quadrat 5	Individual 1		Individual 2		Individual 3		Individual 4		Individual 5		Overall health condition	Change of overall health condition
	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)	H (cm)	Dia (mm)		
Acanthus ilicifolius	73	12.4	84	11.58	67	10.5	40	12.5	113	13.3	Fair	Unchange
	80	19.93	112	20.6	50	12.5	111	16.9	54	15.5	Fair	Unchange
Kandelia obovata	73	12.4	84	11.58	67	10.5	40	12.5	113	13.3	Fair	Unchange
	80	19.93	112	20.6	50	12.5	111	16.9	54	15.5	Fair	Unchange

Table 9 Record sheet for mangrove plant density and survival rate monitoring

Date	Parameter	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Overall Survival rate in five Quadrates (%)	
4 Jun 2013	Initial total number of mangrove tree	18	24	31	20	18	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m ²)	0.72	0.96	1.24	0.8	0.72	N.A	
12 Sep 2013	Initial total number of mangrove tree	23	26	27	31	20	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m ²)	0.92	1.04	1.08	1.24	0.8	N.A	
	Survival rate (%)	<i>Acanthus ilicifolius</i>	86%	100%	89%	84%	100%	91.8%
		<i>Kandelia obovata</i>	88%	89%	94%	N.A	93%	91%
03 Dec 2013	Initial total number of mangrove tree	23	26	27	31	20	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m ²)	0.92	1.04	1.08	1.24	0.8	N.A	
	Survival rate (%)	<i>Acanthus ilicifolius</i>	57%	94%	89%	84%	100%	85%
		<i>Kandelia obovata</i>	63%	78%	94%	N.A	93%	82%

Date	Parameter	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Overall Survival rate in five Quadrates (%)	
04 Mar 2014	Initial total number of mangrove tree	23	26	27	31	20	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m ²)	0.92	1.04	1.08	1.24	0.8	N.A	
	Survival rate (%)	<i>Acanthus ilicifolius</i>	55%	94%	89%	84%	100%	85%
		<i>Kandelia obovata</i>	60%	78%	94%	N.A	93%	82%
20 Jun 2014	Initial total number of mangrove tree	23	26	27	31	20	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m ²)	0.92	1.04	1.08	1.24	0.8	N.A	
	Survival rate (%)	<i>Acanthus ilicifolius</i>	55%	94%	89%	84%	100%	85%
		<i>Kandelia obovata</i>	59%	78%	94%	N.A	93%	82%
26 Sept 2014	Initial total number of mangrove tree	23	26	27	31	20	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m ²)	0.92	1.04	1.08	1.24	0.8	N.A	
	Survival rate (%)	55%	94%	89%	84%	100%	85%	

Date	Parameter	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Overall Survival rate in five Quadrates (%)	
23 Dec 2014	<i>Kandelia obovata</i>	59%	78%	94%	N.A	93%	82%	
	Initial total number of mangrove tree	23	26	27	31	20	N.A	
	Initial density of mangrove tree (No. of mangrove tree / m2)	0.92	1.04	1.08	1.24	0.8	N.A	
	Survival rate (%)	<i>Acanthus ilicifolius</i>	55%	94%	89%	84%	100%	85%
		<i>Kandelia obovata</i>	59%	78%	94%	N.A	93%	82%
	20 Mar 2015	Initial total number of mangrove tree	23	25	27	31	20	N.A
Initial density of mangrove tree (No. of mangrove tree / m2)		0.92	1	1.08	1.24	0.8	N.A	
Survival rate (%)		<i>Acanthus ilicifolius</i>	55%	94%	89%	84%	100%	85%
		<i>Kandelia obovata</i>	59%	74%	94%	N.A	93%	80%
Change of survival rate compared with last month (Unchanged/ better/poor)	<i>Acanthus ilicifolius</i>	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	Unchanged	
	<i>Kandelia obovata</i>	Unchanged	Poor	Unchanged	Unchanged	Unchanged	Unchanged	

Table 10 Mean height of *Acanthus ilicifolius* and *Kandelia obovata*

Month	Mean Height (cm)							Change of mean height (Positive growth, negative)	
	Jun 2013	Sept 2013	Dec 2013	Mar 2014	June 2014	Sept 2014	Dec 2014		Mar 2015
<i>Acanthus ilicifolius</i>	92.81	93.2	94.85	97.18	85.54	88.64	90.05	90.95	Positive growth
<i>Kandelia obovata</i>	75.05	73.05	65	65.92	66.525	72.41	73.82	75.38	Positive growth

Table 11 Mean diameter of *Acanthus ilicifolius* and *Kandelia obovata*

Month	Mean Diameter (mm)							Change of mean height (Positive growth, negative)	
	Jun 2013	Sep 2013	Dec 2013	Mar 2014	June 2014	Sept 2014	Dec 2014		Mar 2015
<i>Acanthus ilicifolius</i>	11.05	10.94	10.83	11.13	10.5312	11.05	11.47	11.90	Positive growth
<i>Kandelia obovata</i>	14.26	14.96	15.39	15.59	16.0145	17.66	19.01	19.46	Positive growth

4.3 Photographic record

- 4.3.1 The overall view of the mangrove compensation area and each quadrat was presented by a number of photos taken at specific location along the channel. The photos are useful to illustrate and compare the mangrove plant condition. The overall view of the mangrove compensation area and each quadrat for both last and current inspection was presented in **Annex B, Photo 1-8** and **Photo 9-18** respectively. The current view of the surveyed area is shown in **Photo 19-20**.
- 4.3.2 By comparing the photographic record for both last and current inspection, more new plants were observed established in the channel and the original planted species have become higher and denser.

5.0 SUMMARY AND COMMENTS

5.1 A total of eight post construction quarterly mangrove monitoring surveys were carried out from June 2013 to March 2015. The species and the total number of mangrove tree were counted within each quadrat. The overall health condition of each species within each quadrat was assessed and shown in **Table 1 to Table 8**. The total number, density and survival rate of mangrove tree within each quadrat were shown in **Table 9**. Overall survival rate of each mangrove species is higher than 75%, thus no replanting shall be implemented.

5.2 Most of the selected plants were recorded as “Fair” health condition during two years monitoring period. Individuals in Quadrat 1 were observed in high mortality rate as that side of Quadrat 1 was immersed by the discharge from nearest outfall. One of the selected individuals was found dead in Quadrat 2 during the last inspection. As the rest of selected plants were observed in regular positive growth in every monitoring survey except one of the survey undertaken in June 2014 because of the death of highest individuals. Nevertheless, a total of 0.07 (1:1 ratio) compensation area is still complied as regeneration in other area was observed.

5.3 Two invasive species including *Sonneratia caseolaris* and *Derris trifoliata* were found in the mangrove compensatory area, but they were removed immediately to avoid further spreading.

5.4 Post construction quarterly mangrove monitoring has been completed in accordance with Section 6.4 of the EM&A Manual and no further monitoring is recommended.

Figures

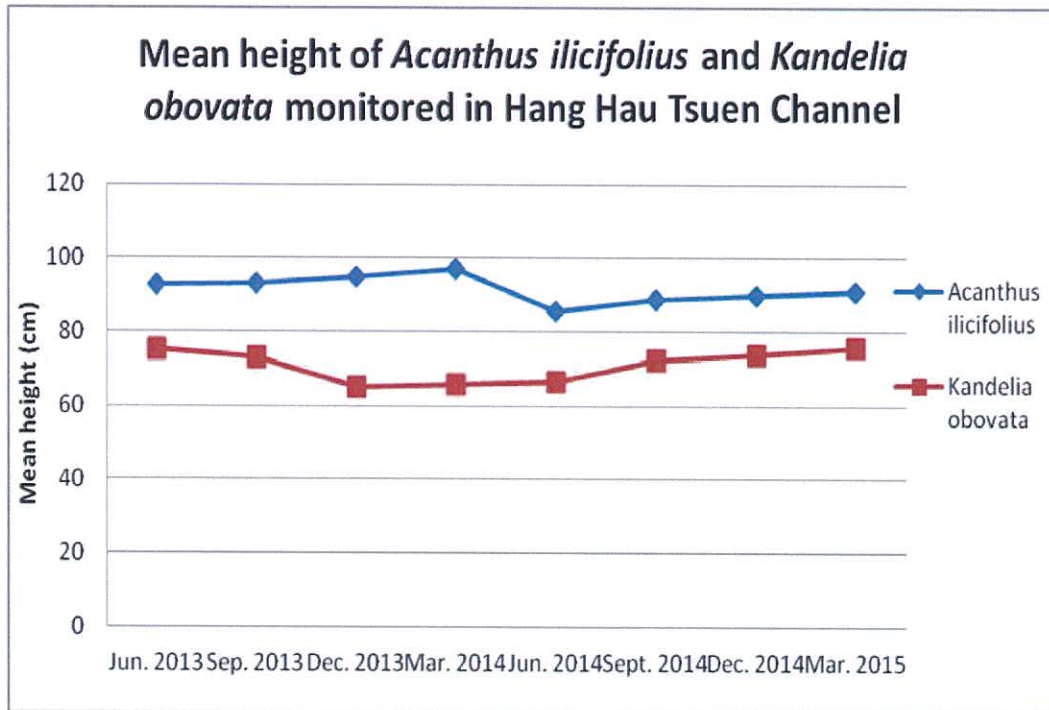


Figure 1 - Mean height (cm) of *Acanthus ilicifolius* and *Kandelia obovata* monitored at Hang Hau Tsuen Channel from June 2013 to March 2015

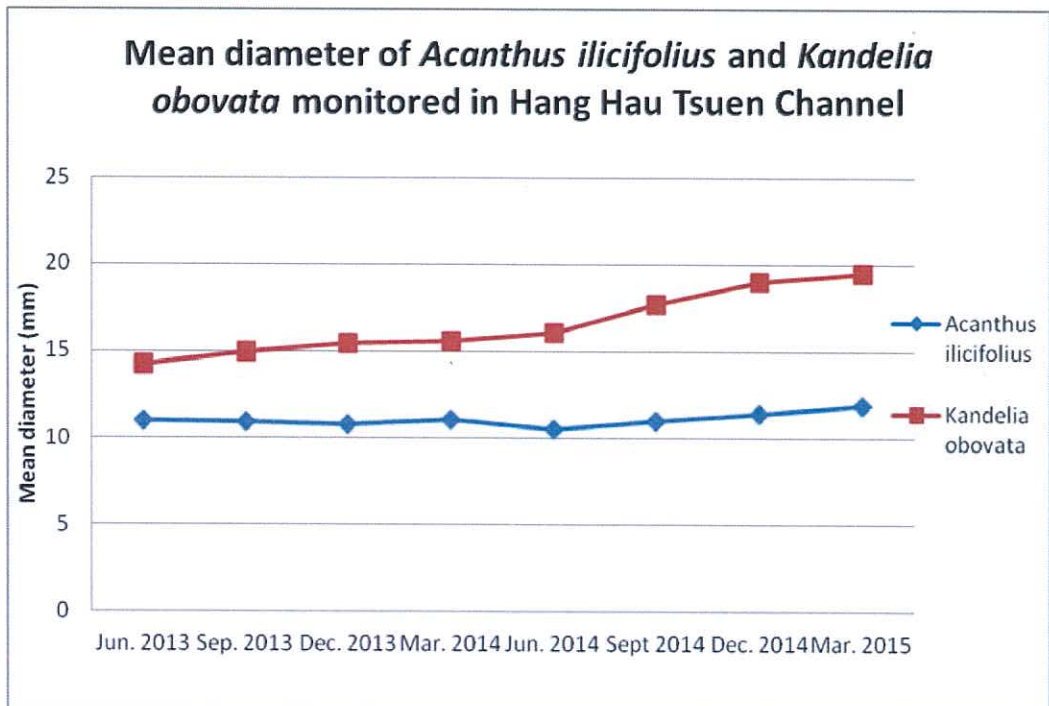
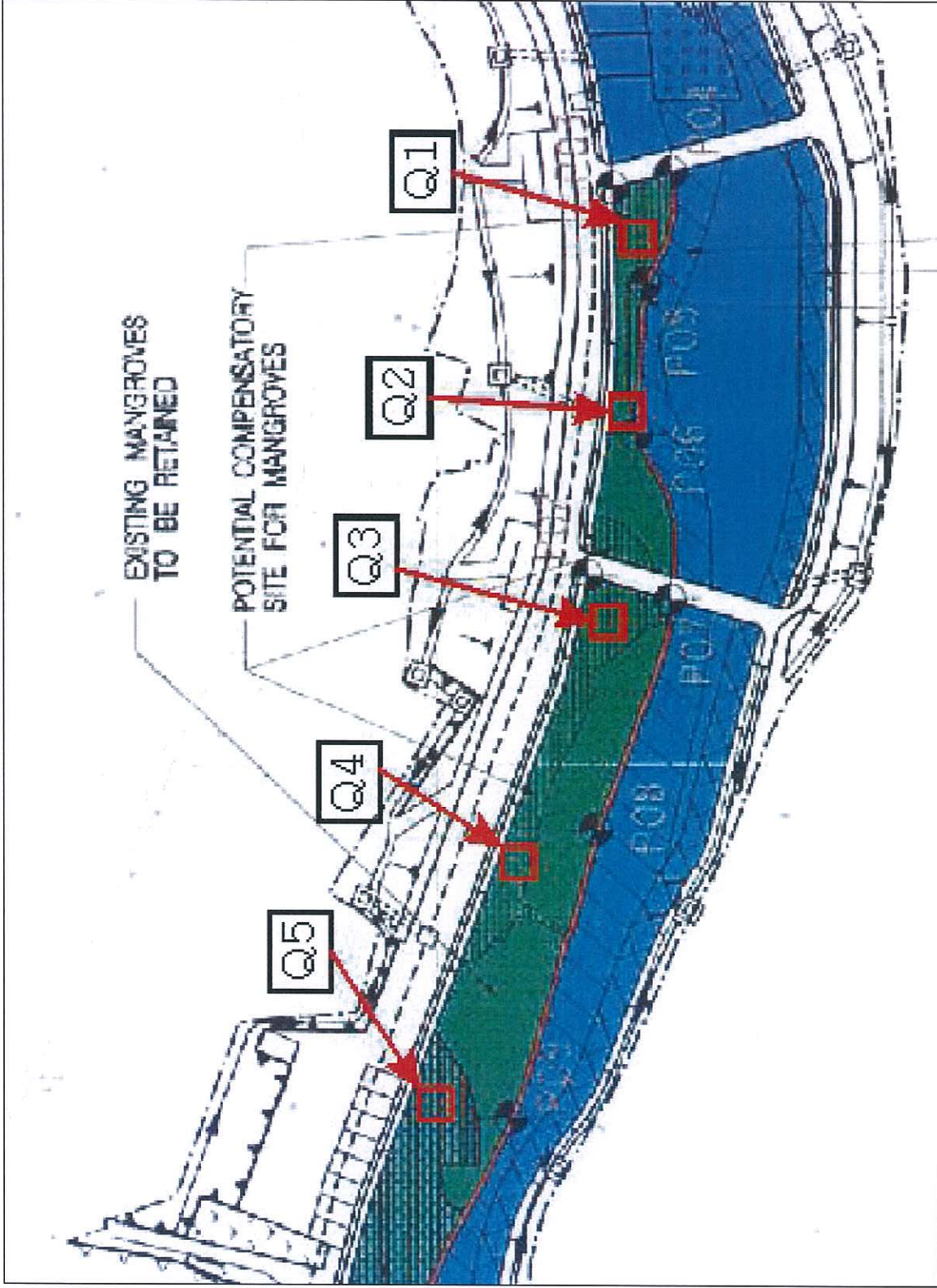


Figure 2 - Mean diameter (mm) of *Acanthus ilicifolius* and *Kandelia obovata* monitored at Hang Hau Tsuen Channel from June 2013 to March 2015

Annex A



Annex A: Location of mangrove zone and quadrates within Hang Hau Tsuen Channel

Annex B



1. First inspection in June 2013



2. Last inspection in March 2015



3. First inspection in June 2013



4. Last inspection in March 2015



5. First inspection in June 2013



6. Last inspection in March 2015



7. First inspection in June 2013



8. Last inspection in March 2015

Post-construction mangrove monitoring – April 2015

Overall view of mangrove compensation area for both last and current inspection

Photo 1 - 8

Date 27th April 2015

Quadrat 1



9. First inspection in June 2013



10. Last inspection in March 2015

Quadrat 2



11. First inspection in June 2013



12. Last inspection in March 2015

Quadrat 3



13. First inspection in June 2013



14. Last inspection in March 2015

Post-construction mangrove monitoring – April 2015

Overall view of Quadrat 1 – 3 for both first and final inspection

Photo 9 - 14

Date 27th April 2015

Quadrat 4



15. First inspection in June 2013



16. Last inspection in March 2015

Quadrat 5



17. First inspection in June 2013



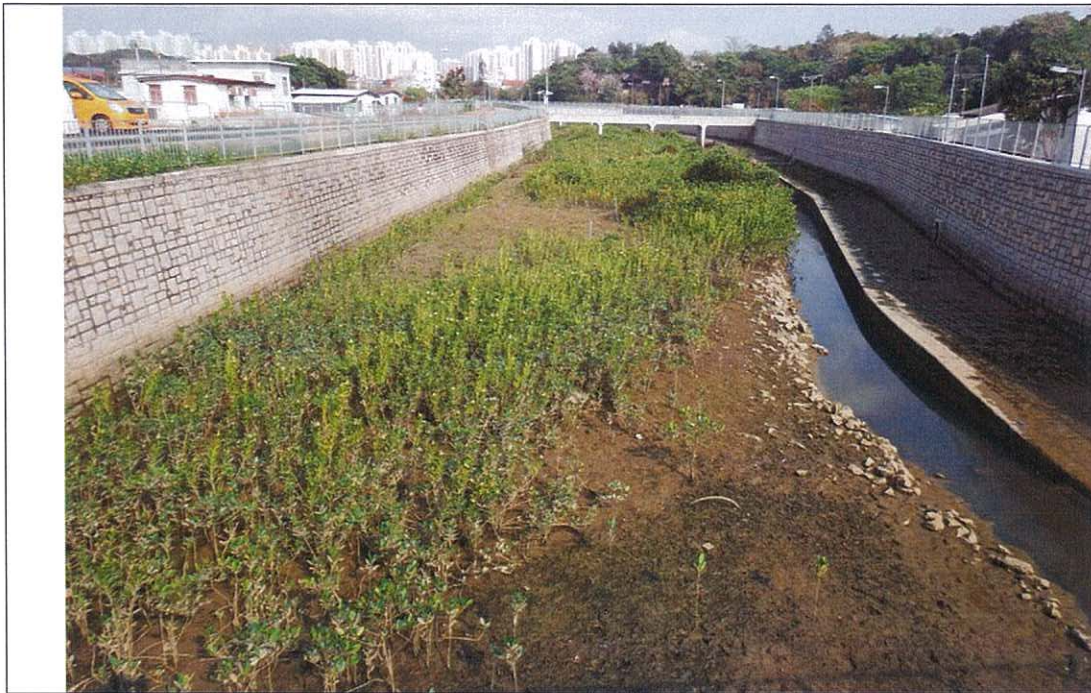
18. Last inspection in March 2015

Post-construction mangrove monitoring – April 2015

Overall view of Quadrat 4-5 for both first and last inspection

Photo 15-18

Date 27th April 2015



19 The current view of the compensatory area



20 The current view of the compensatory area

Post-construction mangrove monitoring – April 2015

The current view of the compensatory area

Photo 19-20

Date 27th April 2015