MAI PO NATURE RESERVE HABITAT MANAGEMENT, MONITORING AND RESEARCH PLAN 2013-2018

VOLUME I
HABITAT MANAGEMENT

October 2013

WWF Hong Kong
15/F Manhattan Centre
8 Kwai Cheong Road
Kwai Chung
New Territories
Tel: [852] 2526 1011
Fax: [852] 2845 2764
e-mail: maipo@wwf.org.hk
website: www.wwf.org.hk

CONTENTS

Appendices

Tables

Figures

Citation:
WWF-HK 2013. **Mai Po Nature Reserve Habitat Management, Monitoring and Research and Plan : 2013 - 2018**. The World Wide Fund for Nature Hong Kong, Hong Kong.

Author:
Volume I : Bena Smith, WWF Hong Kong.

[Cover photo: © Bena Smith, WWF Hong Kong]

ACKNOWLEDGEMENTS

WWF Hong Kong would like to thank a number of people for volunteering their time, knowledge and experience in the production of this Plan.

- All members of the 2004 - 2013 Mai Po Management Committee for their support to WWF-HK and its work at the Mai Po Nature Reserve; Dr. Steve CHEUNG, Ms. Sunny CHOW, Prof. David DUDGEON, Mr. Paul LEADER, Prof. QIAN Pei-yuan, Dr. Paul SHIN, Prof. Nora F.Y. TAM, Mr. Yat Tung YU, and Mr. Nelson YUNG. Also ex-members who served during the last 9 years; Mr. Geoff CAREY, Mr. K.S. CHEUNG, Mr. Mike KILBURN, Dr. Winnie KWOK, Dr. Michael LAU, Dr. Michael LEVEN and Mr. Graham REELS.

- Members of the 2013 - 2018 Mai Po Habitat Management, Research and Monitoring Plan Working Group; Ms. Sunny CHOW, Mr. Paul LEADER, Dr. Paul SHIN, and Prof. Nora F.Y. TAM.

- Dr. Roger KENDRICK, Ms. Carrie MA and Dr. Lew YOUNG for providing updated information.

- WWF-HK Mai Po staff for your valuable comments and ideas.

And finally, welcome to your fourth decade Mai Po Nature Reserve!

PREAMBLE

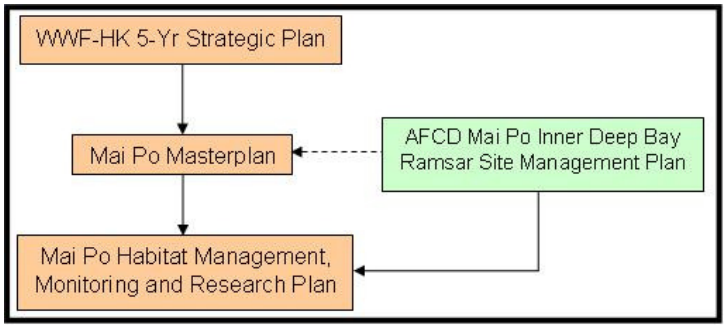
This is the fourth site plan drafted for the Mai Po Nature Reserve (MPNR) by WWF-HK. The Plan lays out the major habitat management, monitoring and research activities to be undertaken at the Reserve in the five-year period commencing 01 November 2013.

It is the first Plan to bring together and synchronize major work components of WWF-HK's Mai Po Reserve Team; management of habitats and species, ecological monitoring and surveys, and research to inform management decisions. It does not address site infrastructure management, a component to consider for inclusion in the next site plan and one that should be driven primarily by the needs of public visitors and school education groups.

Similar to previous plans, a Mai Po Management Committee will be set up to advise WWF-HK on its reserve-based operations and implementation of the Plan. Members comprise local academics, wetland managers, researchers, local NGO's and a Government representative. The committee's term commences in November 2013 and coincides with the lifespan of the Plan.

The content of this Plan is based upon the recommendations of the management plan for the larger Mai Po Inner Deep Bay Ramsar Site (Anon 2011), advice from a range of experts, the experience that WWF-HK has gained since 1983 when they first became involved in the site's management and the direction given in two recent WWF documents; WWF-HK Five-year Strategic Plan (WWF-HK 2010), and Mai Po Master Plan (WWF-HK 2012b).

The Ramsar Site Plan and Mai Po Master Plan collectively set the overall context for the 2013 – 2018 Plan. Guiding statements from these plans and the relationship between them are as follows.



AFCD Mai Po Inner Deep Bay Ramsar Site Management Plan

'The purpose of the Biodiversity Management Zone is to provide a refuge for waterfowl (including a high tide roost) and a focus for biodiversity conservation, education and training in a relatively intensively managed environment.' (Note, the Ramsar Site Biodiversity Management Zone includes all *gei wai* and rain-fed ponds inside the MPNR)

Mai Po Master Plan

Vision - Mai Po Nature Reserve is established as a regional wetland centre of excellence that contributes to the integrity of the East Asian-Australasian Flyway through managing the site as a sanctuary for migratory waterbirds and other wildlife, maturing in both its hardware and software to become a regional training centre and a hub for education by 2017

Goal 1 **-** The Mai Po Nature Reserve is a model waterbird network site within the East Asian-Australasian Flyway and as such significantly supports wetland biodiversity, particularly waterbirds, within the Mai Po Inner Deep Bay Ramsar Site.

A review of the 2006 Mai Po Management Plan (WWF-HK 2012c) was conducted to evaluate the successes and shortcomings of that Plan and highlight issues / challenges facing the Reserve. Several critical issues / challenges identified in the Review are outside the remit of the 2013 – 2018 Plan and require action at the Government level. For example, the reduction of pollution loads in Deep Bay waters; mudflat accretion inside the Mai Po Inner Deep Bay Ramsar Site; exotic species in the Bay, particularly the mangrove tree *Sonneratia* spp. Two issues for WWF-HK to resolve that fall outside the capability of this Plan are 1) finding an off-site disposal solution for the large volume of de-silted *gei wai* material currently stored inside the

Reserve, and 2) meeting rising costs to manage the Reserve (Government funding currently covers ~27% of the overall operational costs of the Reserve). These issues are high priority and require attention in the coming years.

The 2006 Plan was the first plan to employ management targets as a means to assess the effectiveness of WWF's management of the MPNR. The chosen targets were bird species or bird groups for which the Reserve is important and major habitats types. Generally the targets provided a useful framework to gain an overall sense of the condition of the Reserve and to quantify the provision the Reserve offers to those bird species / groups. However, several problems were encountered using the selected targets, hence a new set has been carefully drawn up for the 2013 – 2018 Plan. To save resources, the new targets (and indicators) intentionally overlap with those currently being used in service contracts between AFCD and WWF to manage the Reserve.

The Review recommended greater habitat management effort be given to: -

1. the maintenance of reedbeds in BMZ 2 (i.e. *Gei wai* #8b, #10 and #11b);
2. clearance of climbers from internal bunds and *gei wai* mangrove stands;
3. more frequent desilting of *gei wai* channels and floors; and
4. the management of trees.

The Review recommended several important research studies and monitoring activities to fill information gaps and generate data to inform management decisions: -

1. a study to compare the ecological value of mangal in *gei wai* and inter-tidal areas;
2. a study to investigate the ecological value of the managed area of inter-tidal mudflat;
3. comprehensive water quality monitoring in *gei wai* and freshwater ponds inside MPNR;
4. focal studies on important fauna; and
5. investigation into the impact of different flushing regimes upon water quality and *gei wai* ecology.

The first study is particularly important because mangal is now a major habitat type at the Reserve and the lack of information concerning its ecological value is hampering management decisions at the Reserve. The study is seen as a first step towards the drafting of a mangal management strategy for the Reserve.

The above nine recommendations have been given due consideration during the process to draft the 2013 – 2018 Plan.

An adaptive management approach proved successful during the implementation of the previous Management Plan and will be continued. Among the benefits it ensures new research findings are incorporated into management decisions, and adds flexibility to management should there be a need to react quickly to an emerging challenge / issue. Therefore the 2013 – 2018 Habitat Management, Monitoring and Research Plan should not be regarded as a rigid document, but instead as one that through regular reviews and assessment by the management committee is sensitive to, and in-tune with, the needs of the Reserve.

The Objectives of the 2013 – 2018 Plan are: -

Habitat/Species Management

1. to safeguard all threatened habitats and species occurring on the Reserve;

2. maintain and manage the major habitats and vegetation types (reedbed, mangal, rain-fed and brackish habitats) for the benefit of native biodiversity particularly for species of conservation importance;

Research/Monitoring

3. to monitor habitats, site conditions and species on the Reserve to inform site management decisions; and

4. to facilitate and promote research into wetland habitats, species and site management techniques in order to better understand and conserve wetlands in Hong Kong and the region.

1. INTRODUCTION

1.1 SITE STATUS

The Mai Po Nature Reserve (MPNR) is an area of brackish coastal wetland set up and managed by the World Wide Fund for Nature Hong Kong (WWF-HK). The Reserve and surrounding wetlands (collectively referred to as the Inner Deep Bay area) is designated as a Wetland of International Importance under the Ramsar Convention, an Important Bird Area by Birdlife International, a Flyway Network Site by the Partnership for the East Asian-Australasian Flyway and are identified as one of 16 critical inter-tidal areas in Asia for migratory waterbirds by the International Union for the Conservation of Nature (Mackinnon *et al.* 2012). The Reserve is also a Site of Special Scientific Interest.

1.2 POLICY STATEMENT

WWF's Mission Statement:
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by:

1. conserving the world's biological diversity;
2. ensuring that the use of renewable natural resources is sustainable; and
3. promoting the reduction of pollution and wasteful consumption.

Goal 1 of the Mai Po Master Plan:
'The Mai Po Nature Reserve is a model waterbird network site within the East Asian-Australasian Flyway and as such significantly supports wetland biodiversity, particularly waterbirds, within the Mai Po Inner Deep Bay Ramsar Site'

1.3 ADMINISTRATIVE DETAILS

1.3.1 Plan Management Details

This Plan is for the planning period 01 November 2013 to 31 October 2018. Responsibilities for the implementation of the Plan are identified below:

Managing Organization
The World Wide Fund for Nature Hong Kong
15/F Manhattan Building
Kwai Hing
New Territories
Hong Kong
Tel: 2656 1272
Fax: 2845 2764
Email: wwf@wwf.org.hk
Website: http://www.wwf.org.hk

Manager, Habitat Management and Monitoring
Peter Scott Field Studies Centre
Mai Po Nature Reserve
San Tin
Yuen Long
New Territories
Hong Kong
Tel: 2471 6212
Fax: 2482 0369
Email: maipo@wwf.org.hk

WWF-HK set up the Reserve in 1983 and has managed it for the past 30 years. However overall responsibility for the MPNR (and wider Ramsar Site) lies with the Agriculture, Fisheries and Conservation Department (AFCD) of the Hong Kong S.A.R. Government.

The AFCD is responsible for law enforcement in the Ramsar Site and administrative works including providing financial assistance to the WWF-HK in the form of an annual subvention and service contracts for habitat management. As such, WWF-HK is managing the Reserve on behalf of the Hong Kong S.A.R. Government.

Agriculture, Fisheries and Conservation Department
5/F, Cheung Sha Wan Government Offices
303 Cheung Sha Wan Road
Kowloon
Hong Kong
Fax: 2311 3731
Email: mailbox@afcd.gov.hk ; Website: http://www.afcd.gov.hk

1.3.2 Location

Site Name: Mai Po Nature Reserve (and Education Centre)
Country: The People's Republic of China (Hong Kong Special Administrative Region)
Region: New Territories
District: Yuen Long
Coordinates: 22.490716° (lat), 114.038016° (long) [mid-point]

The Reserve lies in the north-western New Territories of the Hong Kong S.A.R on the eastern shore of Deep Bay (Appendix 1). On the opposite side of the Bay is the Shenzhen Special Economic Zone, Guangdong Province, People's Republic of China (P.R.C). Deep Bay is an eastern branch of the Pearl River estuary.

The MPNR is defined as the northern portion of the Mai Po Marshes SSSI i.e. the land north of the Fairview Park drainage channel leading to Shan Pui River (Appendix 1).

1.3.3 Access

Vehicular access: From Castle Peak Road, which runs from Sheung Shui to Yuen Long, turn west at Mai Po village and continue along the Tam Kon Chau road through the villages of Mai Po San Tseun and Mai Po Lo Wai.

Main pedestrian access is via the road from Pak Hok Chau Border Police post and then through Pak Hok Chau village.

Other access: There are two helicopter landing pads for police and emergency use; one at Pak Hok Chau, and another at the south end of the Reserve adjacent to *Gei wai* #22.

The Mai Po Marshes SSSI (in which the MPNR is located) is a Restricted Area and all visitors must hold a valid Mai Po Marshes Entry Permit. Similarly, a valid Frontier Closed Area (FCA) permit is required to enter the seaward side of the MPNR within the FCA (refer to Section 2.2.2.5.2).

The AFCD controls access to the Reserve, and an AFCD Nature Warden is stationed at the entrance to the Reserve at Pak Hok Chau whom enforces this restriction. All persons entering the Restricted Area must present their permit to the Nature Warden before entering. An exception is the residents of several households within the Restricted Area, whom do not require permits to enter the Reserve. According to the Cap. 170, the entry permit requirement shall not apply to a person ordinarily residing in the Restricted Area.

1.4 SUMMARY DESCRIPTION

Conservation status:
- Mai Po Marshes Site of Special Scientific Interest (1976);
- Mai Po and Inner Deep Bay Ramsar Site (1995) [Site code: 750];
- Inner Deep Bay and Shenzhen River Catchment Area Important Bird Area (2004) [Site code: HK001]; and
- Mai Po – Inner Deep Bay Flyway Network Site (2008) [Site code: EAAF003]

Area: 377.0 ha
Altitude: 5 - 15m above mean sea-level
Aspect: Northwest
Geology: Lok Ma Chau formation

The Reserve is of interest for its high ecological diversity and, as an integral component of the Mai Po Inner Deep Bay Ramsar Site, its ecological and functional contribution to the Ramsar Site. Internationally important numbers of waterbirds are present during the winter non-breeding period and peak migrations periods in spring and autumn. Thirty-eight fauna species of global conservation concern (including vagrants) have been recorded on the Reserve (Section 1.6.2.4).

The Reserve supports regionally significant dwarf mangal and reedbed communities. When considered with similar vegetation types in the Deep Bay area, the mangal is the largest in the Pearl River catchment, and reedbed largest in South China.

Culturally, the site is important because it contains one of the last remaining traditionally operated shrimp rearing *gei wai* in Asia.

1.5 GENERAL INFORMATION

Throughout this Plan, the term '*gei wai*' and 'pond' are used to refer to the different impounded waterbodies inside the MPNR. *Gei wai* (plural *gei wai*) is a Chinese term and is synonymous with the rearing of shrimp. A direct translation of *gei wai* is earth bunded pond. *Gei wai* is the official name used in all land licence documentation, but for the purposes of this Plan, '*gei wai*' refers to any brackish water pond which has an operational sluice gate, and 'pond' refers to rain-fed ponds (or former ponds now managed as rain-fed habitat) that do not have a sluice gate, or the sluice gate is blocked and is non-functional.

1.5.1 Land Tenure

This is not a legal document. Please refer to the original tenure documents before taking any decision or action which may have legal implications.

Owner: Hong Kong S.A.R. Government
Type of holding: Licence
Total area licenced to WWF-HK: Approx. 211.7 ha (i.e. 56.2% of the MPNR), consisting of *Gei wai* #3, #4, #6-#24 and land beneath the floating boardwalks and hides located in the inter-tidal zone of the Ramsar Site (Table 1 & Appendix 3). WWF-HK's first licence - dated 02 September 1983 (superseded in 1989) - was for a portion of land next to Pond #15b to erect a small visitor information centre.
Length of licence: Annually renewable to WWF-HK
Cost of licence: Nominal HK$ 1 per year to WWF-HK
Conditions/terms of licence: Each *gei wai* is under either a separate or group Special Licence.

Table 1. Land licence details.

Gei wai no. / land area	Date of licence/control	Approx. area (ha) ^
#3 [a]	1994	10.21
#4 [a]	1994	8.05
#6 [b]	1992	8.77
#7 [b]	1992	10.38
#8 [c]	1988	19.06
#9 [c]	1987	0.93
#10 [c]	1989	10.65
#11 [c]	1987	10.73
#12 [a]	1994	10.97
#13 [a]	1994	11.56
#14 [c]	1985	10.23
#15 [c]	1989	5.94
#16 [c]	1983	10.58
#17 [d]	1985	22.97
#18 [d]	1985	
#19 [c]	1987	11.57
#20 [a]	1995	8.26
#21 [a]	1995	8.47
#22 [a]	1995	8.00
#23 [a]	1995	11.72
#24 [a]	1995	12.39
FCA boardwalks and hides	1985	*0.3

a - Given to WWF-HK by Government for management

b - Donated to WWF-HK by Wharf Holdings

c - Acquired using funds raised from the Big Bird Race

d - Donated to WWF-HK by the Hong Kong Jockey Club

^ - As shown in the land licence

* - Estimated

The Special Licences stipulate a number of conditions (Section 2.2.2.6) and prior written approval is required from the District Lands Office - Yuen Long for a number of management activities. The land directly beneath the wooden boardwalks and four floating bird hides located with the FCA area is licensed to WWF-HK and has its own Special Licence. WWF's management operations extend beyond the boundary of the MPNR e.g. a small portion of inter-tidal mudflat close to the floating bird hides and vegetation clearance along *gei wai* water inlet channels.

District Lands Office
Yuen Long
9/F to 11/F
Yuen Long Government Offices
2 Kiu Lok Square
Yuen Long
New Territories
Tel: 2443 3573; Fax: 2473 3134
Email: landsd@landsd.gov.hk; Website: http://www.landsd.gov.hk

1.5.2 Management Infrastructure

1.5.2.1 Staff structure

Reserve management responsibility is delegated to the Manager, Habitat Management and Monitoring. Staff structure at the MPNR is outlined in Appendix 6 and the titles and duties of 'Reserve Team' staff are as follows:

1. *Manager, Habitat Management and Monitoring:* Overall management of the outdoor section of the Mai Po Nature Reserve and staff. Reports to the Mai Po Centre Manager.
2. *Administration Officer:* Has a wide range of administrative responsibilities for the smooth running of the Reserve. Reports to the Mai Po Centre Manager.
3. *Reserve Officer:* Has responsibility for the ecological monitoring and research programme being conducted at the Reserve.
4. *Conservation Officer:* Responsible for assisting in the administrative aspects of field work within the Reserve.
5. *Assistant Reserve Officer*: Based at the Education Centre and assists in the administration and implementation of field work and research that is carried out at the Reserve. This Officer supervises the work of the Field Officers. All of the above Officers are based at the Education Centre.
6. *Field Officer:* Responsible for general habitat and infrastructure management work on the Reserve. Oversees two Assistant Field Officers and seven full-time Field Assistants.

Volunteers often assist with a variety of practical management activities. Contractors are employed to do work as required, usually on larger habitat management projects.

1.5.2.2 Site infrastructure

WWF-HK has developed a number of facilities at the Reserve (Appendix 2). These are mentioned below, but their management and maintenance falls outside the scope of this Plan.

The *Wildlife Education Centre*, with a building cost of HK$ 2.9 million donated by the Royal Hong Kong Jockey Club, was opened in October 1986. The building has an exhibition hall with displays concerning the natural and human history of Mai Po designed to suit all levels of visitors, a small research laboratory, toilets, office, workshop and storeroom. The design of this centre incorporates access and facilities for the physically less-abled. There is an outside storage hut used by field staff and several picnic tables and benches for visitors.

Since the completion of the Education Centre, the original Visitor Information Centre built in 1983, has been used as a bird-ringing station and a resting point for visitors.

The two-storey Peter *Scott Field Studies Centre* located at Pak Hok Chau, cost HK$ 4.9 million to build and was opened in February 1990. It provides accommodation and study facilities for staff, visiting scientists, researchers, conservationists and members of the public. The Centre has increased the potential of Mai Po as a regional wetland research and management training station. Regular Wetland Management Training Courses are run for wetland reserve staff and Government officials from East Asia, particularly Mainland China. A 'Visitor Centre', upgraded in 2005, where visitors on guided tours report on arrival, is situated in the Centre. The Field Studies Centre also provides a paved area for visitors to park their cars.

Eleven main *bird observation hides* (three of which are suitable for the physically less-abled; Tower Hide, Hide #1 and Hide #8) and two observation screens have been constructed. The three-storey Tower Hide (lower floor accessible to wheelchair users) at Pond #8a provides a commanding view over the northern part of the Reserve. A wooden boardwalk containing floating and fixed sections

(1,370m), built through the mangal on the seaward side of the Reserve, leads to four Floating Hides on the edge of the inter-tidal mangal facing the Deep Bay mudflats with the city of Shenzhen in the distance.

Other facilities include a network of concrete footpaths to a length of 4km constructed around the Reserve. A Nature Trail has been established which loops around the Education Centre. There are a number of educational notice boards along this route, which also includes a rain shelter and a piled boardwalk (200m) at the landward end of *Gei wai* #19. A *Gei wai* Museum has been built beside the sluice gate of *Gei wai* #12, to demonstrate traditional methods of *gei wai* shrimp farming at Mai Po, and the way of life of *gei wai* fishermen in the past. A second rain shelter is situated near the entrance to the floating boardwalk. There are two wooden platforms at Pond #16b designed for education groups to safely collect water samples from.

There are a number of huts in the Reserve (*Gei wai* #3, #6, #13, #14, #16, #17, #18, #19, #20a, and #20b, #21). These are used for the storage of equipment and materials, however #3, #6, #20b, and #21 also function as bird observation hides.

Approval from the Town Planning Board and District Lands Office - Yuen Long is required for most structures. Permission renewal dates are shown in Table 2.

Table 2. Permission renewal dates for site infrastructure.

Description	Ref.	Renewal date
Wooden boardwalk extension at *Gei wai* #8	A/YL-MP/28	N.A.
Wooden platform at Pond #15c	A/YL-MP/58	N.A.
Wooden boardwalk (Round Table boardwalk)	A/YL-MP/84	N.A.
Extension to the existing FCA wooden boardwalk	A/YL-MP/152	N.A.
	(139) in DLOYL 78/YPG/60B	N.A.
Wooden platforms at Pond #16b	A/YL-MP/192	08 May 2014
	(14) in DLOYL 92/YAT/2011	
Fixed wooden boardwalk and ringing hut (*Gei wai* #7 and #8)	A/YL-MP/195	21 Oct 2015
	(38) in DLOYL 63/YAT/2008	N.A.
Wooden buffalo shelter at Pond #17b	A/YL-MP/198	N.A
	(6) in DLOYL 59/YAT/2012	20 Apr 2016

1.6 ENVIRONMENTAL INFORMATION

1.6.1 Physical

1.6.1.1 Climate

Hong Kong has a typically wet, sub-tropical climate tending towards temperate for nearly half the year. Data from the nearby Lau Fau Shan (HKO 2012) automated weather station during the period 1981 – 2012 shows the monthly mean air temperature ranges from 15.2°C in January (coldest month) to 28.3°C in July (hottest month), and the mean annual rainfall is 1,505.3 mm. The annual rainfall is low compared with the rest of Hong Kong (2,398.5 mm/year) because the MPNR is situated in the rain shadow of the Tai Mo Shan massif. June, July and August are the wettest months.

The lowest temperature recorded at the Hong Kong Observatory is 0°C although sub-zero temperatures and ground frost occur at times on high ground and in the New Territories, including Deep Bay.

Tropical cyclones occur from June to October (although gales may occur any time between May and November). Heavy rain from tropical cyclones may last for a few days, and subsequent flooding may cause more damage than the winds.

Long-term data collected at the Hong Kong Observatory meteorological station in Kowloon shows that Hong Kong is becoming warmer and wetter; the average annual temperature increase is 0.22°C per decade since 1983; the annual rainfall increase is 29mm per decade since the 1940s.

1.6.1.2 Hydrology

The MPNR is situated on the eastern shore of Deep Bay which has a total catchment area of 112 km². The Bay is nowhere deeper than 6m and has an average depth of 2.9m. With a maximum tidal range of some 2.8m (mean of 1.4m), extensive mudflats are exposed at low tide. The average flushing time of waters in Deep Bay decreases from 25.7 days in the inner part to 5.1 days in the outer part (Lee and Qian 2003).

Deep Bay is part of the Pearl River estuary - the largest river in southern China - and drains an area of some 450,000 km². The estimated annual flow is 308 billion cubic metres. The river is characterized by a heavy sediment load as well as various organic and inorganic loadings.

The Pearl River has a significant effect on water quality in Deep Bay, as well as on the general hydrology of Hong Kong's western marine waters. During the summer wet season it creates a transition from estuarine to oceanic conditions in a northwest to southeast direction (Morton & Wong 1975). The seasonal occurrence of extremely low salinities in Deep Bay can be attributed to this river discharge (Morton & Wong 1975). Major rivers and tributaries flowing into Deep Bay include:

1. the Shenzhen River, which has the Ng Tung River and Ping Yuen River as major tributaries from Hong Kong, and the rivers Buji and Shawan as major tributaries arising from the Shenzhen Special Economic Zone, P.R.C.;
2. the Yuen Long River (Shan Pui River) and the associated Kam Tin River which join to form a common tidal creek (Yuen Long Creek) before entering Deep Bay, 3km to the south of the Shenzhen River; and
3. the Dasha River, located in north-western Deep Bay about 10 km west of the Shenzhen River.

1.6.1.3 Geology

The MPNR lies in the Yuen Long Basin where sediment was first deposited 300 million years ago during the Carboniferous era. It was then compressed into rock and then further "cooked" by high geological pressures and temperatures converting it into marble during the Jurassic era (150 million years ago). It is described as metamorphosed, sedimentary rock belonging to the Lok Ma Chau formation.

This Lok Ma Chau Formation is widespread between Lo Wu and Tuen Mun, and can be divided on lithology into the Mai Po Member and the Tai Shek Member. The former is older, and mainly consists of metamorphosed siltstone, fine-grained sandstone and carbonaceous siltstone, while the latter is composed of metamorphosed sandstone and conglomerate.

Recent microfossil evidence suggests that the Lok Ma Chau Formation is of a Tournaissian or Namurian-Westphalian age, formed when the area was a neritic swamp. Lower layers are composed of silts, fine sand and carbonaceous horizons, probably deposited in a deltaic floodplain. As the delta built up, the sediment-type gradually changed to medium sand, coarse sand and pebbles (Landford *et al.* 1989).

Colluvium (>15,000 yrs ago)
During the last ice age, sea level was about 120m below today's level. Erosion of the hillsides resulted in the deposition of colluvium, a sandy rocky soil at the bottom of the slopes.

Alluvial Deposits (> 8,000 years ago)
Polar ice caps began to melt and sea level rose. The Yuen Long Basin was transformed into a broad alluvial plain. As the force of the rivers increased, sand and clay alluvium was deposited here. Sand is coarser grained than clay so it is dropped first.

Marine Deposits (8,000 - 6,000 years ago)
Sea levels continued to rise until about 6,000 years ago. At this time sea level was probably up to 4m above that of today. A thick layer of clayey marine deposits was laid down. Evidence of this are the fragile "window pane" oysters (*Placuna placenta*) which can be seen in the marsh soils today.

1.6.1.4 Geomorphology

The Deep Bay landscape at the end of the last Ice Age, (about 15,000 years ago), was very different from that of today. Sea level was then as much as 120 metres lower than at present, and the area

around MPNR was a considerable distance inland (Irving and Morton 1988). The rocks which underlie this area, comprising metamorphosed limestones and shales of the Lok Ma Chau formation, were exposed at the surface. Eroded by fast flowing streams, the land was formed into a series of valleys which ran into the major river course along the line of present Deep Bay.

After the Ice Age, sea level rose rapidly as the ice melted and retreated. About 4,000 years ago the sea reached its present level and the coastline of Hong Kong assumed its characteristic "drowned" appearance. In other words, former mountain peaks became islands, and river valleys flooded to become rias. This happened in Deep Bay too, where the shore probably reached the line of the present Castle Peak Road. Many hill summits and ridges dividing the former river valleys became isolated islands, breaking the surface of the estuarine waters. The present day names of these rocky outcrops often include the suffix "chau" meaning island.

There is little evidence to indicate that sea level 4,000 years ago was actually higher than it is today, or that geomorphic uplift has occurred in the Deep Bay region to cause the subsequent retreat of the shoreline. Rather, the most likely explanation for the increase in land area is that deposition of sediments from the Bay has led to gradual and natural reclamation from the sea i.e. shoreline progration.

Shoreline progration is further assisted by the mangrove trees fringing Deep Bay which bind silt particles around their root systems. The fact that the mangal community is steadily extending seawards, especially in the area near MPNR, is a clear indication that natural processes are playing an active role in the landscape evolution of Deep Bay.

1.6.1.5 Soils/Substrates

The Mai Po soils belong to the Mai Po Association, which is found in the Mai Po, San Tin and Sheung Shui districts, and in pockets of agricultural land along the border from Lok Ma Chau to Lo Wu and Ta Kwu Ling. The Mai Po Association is formed on alluvial and colluvial material derived from rocks of the Lok Ma Chau Formation but affected also by Tai Mo Shan Porphyries. The soils around Mai Po are poorly drained and frequently highly saline, and thus are not important agriculturally.

Sediments in the Inner Deep Bay area are anoxic, and predominantly clay and slit. There is a gradient in the spatial concentrations of inorganic nutrients (total nitrogen, total kjedhal nitrogen, ammonia, total phosphorus and sulphide) from the outer Deep Bay (lowest) to the mudflat and to the *gei wai* (highest).

1.6.2 Biological

1.6.2.1 Habitats

Habitat distribution and areas at the MPNR are shown in Figure 1 and Table 3. The Reserve is composed entirely of brackish and rain-fed habitats. It should be noted that the total area of each *gei wai* calculated by WWF-HK differs slightly from that shown in the land licences (Table 1). The total area of all the MPNR *gei wai* and ponds is calculated by WWF-HK as 213.55ha, 2.15ha more than the land licence i.e. 1.0%.

The salinities of brackish habitats typically range from 2-3 ‰ in summer (lowest in July) to 16-18 ‰ in late winter. The salinities of rain-fed habitats vary greatly between ponds, but range from 2-9 ‰ between summer and late winter. The rain-fed habitats cannot be classified as ‘freshwater’ due to this range. There is a general salinity gradient across the Reserve, decreasing northward towards the Shenzhen River mouth.

1.6.2.1.1 *Rain-fed habitats*

A variety of rain-fed habitats occur, mainly in the southern and eastern portions of the Reserve. They support a range of flora and are particularly important for the Reserve’s Odonata and Amphibian species.

1. Ponds #17b and #24 are buffalo grazed and contain areas of differing water-depths, with stands of Common Reedgrass (*Phragmites australis*) and sedges.
2. Ponds #15 and #20 are predominantly unvegetated deepwater ponds (>1m) managed for ducks. Pond #15 contains four waterbird roosting islands.

3. Ponds #8a and #23 are shallow water ponds with islands for roosting waterbirds. Pond #8a contains a sedgebed, four waterbird roosting islands, and an island planted with Weaver's Bamboo (*Bambusa textilis*), Chinese Hackberry (*Celtis sinensis*) and Chinese Banyan (*Ficus microcarpa*) to establish an egretry. Pond #23 contains four waterbird roosting islands.
4. Pond #16b is dominated by emergent vegetation such as water-lilies and sedges with a waterdepth of around 0.5m.

1.6.2.1.2 *Brackish water habitats*

There are eight brackish *gei wai* being managed to rear fish and shrimp following traditional management practices.

1. *Gei wai* #8b, #10, and #11 are dominated by large areas of reedbed, both 'wet' and 'dry'.
2. *Gei wai* #12, #13, #14, #18 and #19 contain large stands of mangal vegetation, dominated by mature *Kandelia obovata*.

There are seven brackish *gei wai* being managed as habitat for roosting waterbirds through the provision of shallow water areas.

1. *Gei wai* #3, #4, #6 and #7 in the northern portion of the Reserve contain scattered mangal vegetation (mainly *K. obovata*) fringed with *P. australis*.
2. *Gei wai* #16/17 and #21 are largely devoid of internal vegetation. Small islands of sedge occur in shallower areas. *Gei wai* #16/17 is flanked by a thin strip of *P. australis* along one length and a strip of Knot Grass (*Paspalum distichum*) on the other. The islands are dominated by grasses such as *Panicum* spp.
3. *Gei wai* #22 is flanked by *P. australis*, with a few vegetated internal bunds.

1.6.2.1.3 *Reedbed*

The major areas of reedbed are located in *Gei wai* #8b, #10, #11 and #23. Scattered smaller sized stands occur in other *gei wai* /ponds. The reedbed is known to support a high invertebrate diversity and is attractive to a variety of specialised bird species.

Two broad types of reedbed are found; 'dry' and 'wet'. Dry reedbed areas contain mixes of Mangrove Fern (*Acrostichum aureum*), Chinese Feverine (*Paederia scandens*) and small mangrove trees, mainly *K. obovata*. Wet reedbed areas are generally pure stands of *P. australis*. Gradations between the two types are also found.

1.6.2.1.4 *Mangal*

Gei wai #12, #13, #14, #18 and #19 contain the major stands of mangal vegetation. *K. obovata* and *Aegiceras corniculatum* are the dominant canopy species, and Spiny Bears Breech (*Acanthus ilicifolius*) the most common under-story species. Where mangrove trees are less dense, or in canopy gaps, patches of *A. aureum* are found. Other mangal vegetation includes Derris (*Derris trifoliate*), Sea Sword Bean (*Canavalia maritima*) and the planted Cerbera (*Cerbera manghas*).

In drier areas, particularly at the landward end of *gei wai*, extensive areas of the Mile-a-Minute Weed (*Mikania micranthus*) have established on top of the mangrove tree canopy.

The mangal in Hong Kong is close to its northerly limit, and so species diversity is less than that in more tropical areas to the south. The ecological value of the *gei wai* mangal compared to those in inter-tidal areas is not known, nevertheless they provide important sources of litter for benthic organisms. Mangrove trees and *P. australis* are the foundation of the food web in the *gei wai* (Qin *et al.* 2000).

1.6.2.1.5 *Bunds*

Bunds of varying height and width are found throughout the Reserve. Vegetated bunds are dominated by grasses such as *Panicum* spp. and a variety of tree/shrub species such as China-berry (*Melia azedarach*), *Ficus* spp., Elephant's Ear (*Macaranga tanarius*) and *Sapium* spp. Unvegetated bunds are typically found close to recently completed desilting works.

Figure 1. Habitat distribution at the Mai Po Nature Reserve in 2013.

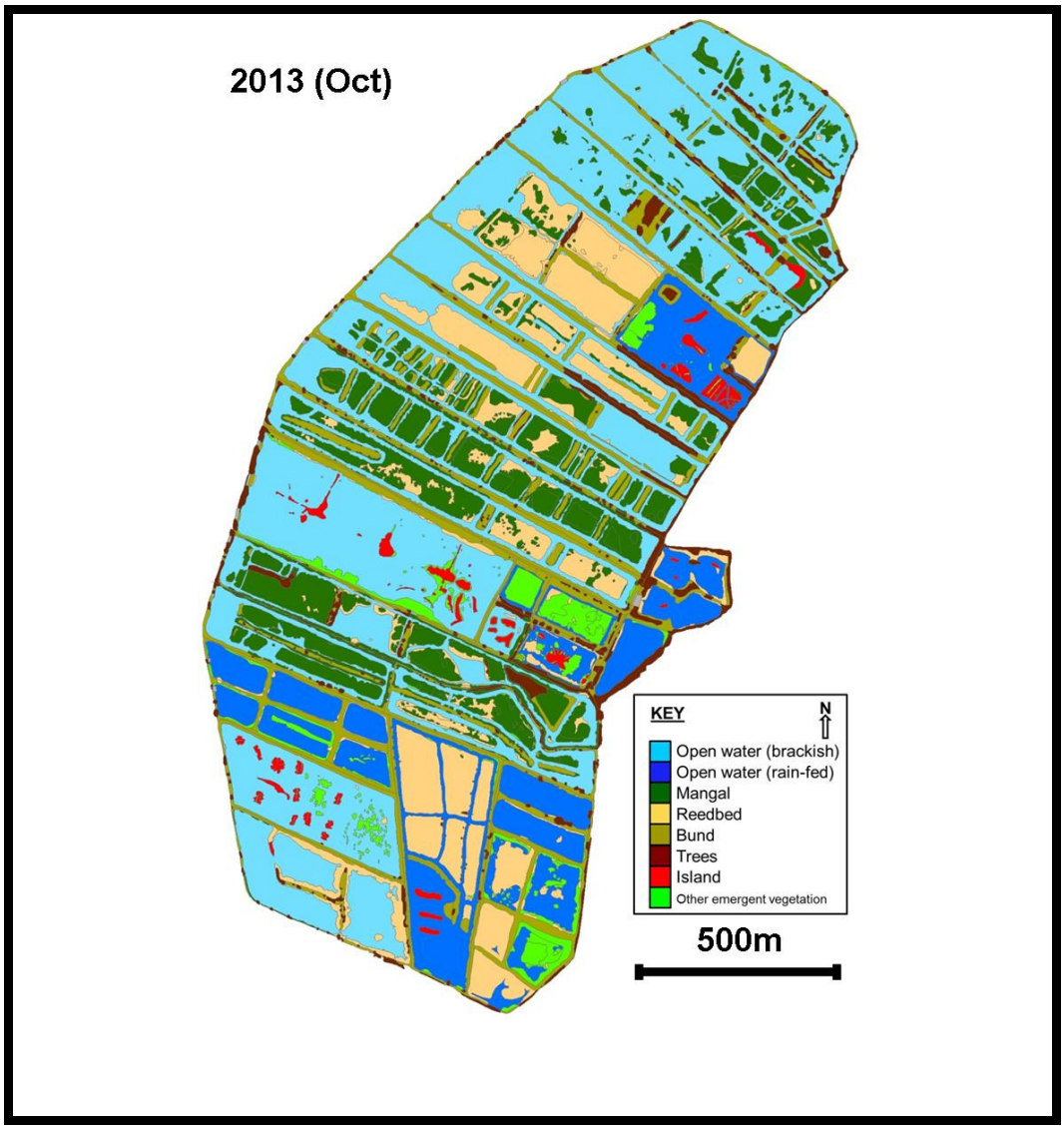


Table 3. Areas of different habitats at the Mai Po Nature Reserve in 2013.

Habitat type	Total area (ha)
Mangal	31.32
Open water (brackish)	83.18
Open water (rain-fed)	24.38
Reedbed[a]	28.90
Bunds (inc. vegetation)	36.36
Islands[b]	2.74
Other emergent vegetation[c]	6.69
TOTAL	**213.57**

[a] – good (pure stands of *P. australis*) and poor (various mixes of *P. australis* / climber / patches of mangal vegetation inc. ferns) quality
[b] – islands (bare and vegetated) [<50cm in height, designed for roosting waterbirds]
[c] – water-lilies, sedges, emergent grasses

1.6.2.2 Flora

A list of vascular plants for MPNR is provided in Appendix 7. No survey has been carried out for fungi. The distribution of fungi and plant species in the Reserve needs to be mapped, and an assessment of their significance on a local, national and international level is required.

Local rarities include Widgeon Grass (*Ruppia maritima*) which used to be found in many *gei wai* (Melville & Chan 1992), but now is only known from *Gei wai* #8b.

Six native and naturally occurring mangrove tree/shrub species can be found inside the Reserve; *A. ilicifolius*, *A. corniculatum*, Black Mangrove (*Avicennia marina*), Many-petaled Mangrove (*Bruguiera gymnorrhiza*), Milky Mangrove (*Excoecaria agallocha*) and *K. obovata*. The Looking-glass Mangrove Tree (*Heritiera littoralis*) is native to Hong Kong but planted at the Reserve in 1986 for educational purposes. A few individuals remain inside *Gei wai* #13.

A full flora survey is needed.

1.6.2.3 Fauna

1.6.2.3.1 *Birds*

Inner Deep Bay area
The Inner Deep Bay wetland has a high avian diversity with nearly 400 species of wild bird recorded representing 80% of the Hong Kong total (Appendix 7).

The wetland is a rich feeding area for waterbirds including migratory waterbirds and wetland dependant species. In recent years the average number of wintering waterbirds in the Bay is 70,000 – 90,000 individuals. The major waterbird groups are ducks and shorebirds.

The wetland regularly supports 20 waterbird species of global conservation concern and an additional five shorebird species of regional conservation concern in the East Asian-Australasian Flyway (EAA Flyway) (Table 4). Fifteen waterbird species are recorded in numbers greater than 1% of their estimated population along the EAA Flyway, and a further 11 species meet the staging criteria of a waterbird Flyway Network Site (0.25% of their estimated population along the EAA Flyway during migration). Therefore, 26 species of waterbird are regarded as being regularly recorded in internationally significant numbers.

MPNR
In winter the Reserve provides habitat to an average 28% (max = 52% in 2006/07) of the waterbirds in the Ramsar Site (based on winter aggregate dataset between winters 1998/99 and 2011/12). The MPNR is also an important roosting area for the majority of the 20,000 – 30,000 shorebirds that pass through Deep Bay annually. On average around 78% of the Ramsar Site population use the Reserve in spring, around 89% in autumn (2006 – 2012 dataset).

The MPNR is important for the globally endangered Black-faced Spoonbill (*Platalea minor*). It supports the largest roost in Hong Kong with up to 423 individuals recorded inside the Reserve (January 2010, AFCD data) and can attract up to 300 foraging individuals on a draining *gei wai* (WWF-HK data).

The Reserve and adjacent area of inter-tidal mangal provide roosting habitat to the globally near-threatened Collared Crow (*Corvus torquatus*). Around 120 individuals roost in summer and around 100 in winter (WWF-HK data). Deep Bay is becoming a regional stronghold for this species.

Thirty-four bird species of global conservation concern (including vagrants) have been recorded at the MPNR (Section 2.1.1).

All wild birds and their nests in Hong Kong are protected under the Wild Animals Protection Ordinance (Cap. 170).

Table 4. Important bird species regularly recorded, and bird species recorded in significant numbers, in the Inner Deep Bay area.

Common name	Scientific name	% of flyway population*	Ramsar criteria	Flyway staging criteria	Shorebird regional red list	IUCN red list status
Great Cormorant	*Phalacrocorax carbo*	10.1%	✓			
Black-faced Spoonbill	*Platalea minor*	21.5%	✓			En
Swinhoe's Egret	*Egretta eulophotes*	-				Vu
Northern Shoveler	*Anas clypeata*	2.1%	✓			
Falcated Duck	*Anas falcata*	-				Nt
Tufted Duck	*Aythya fuligula*	1.8%	✓			
Baer's Pochard	*Aythya baeri*	-				Cr
Black-winged Stilt	*Himantopus himantopus*	1.1%	✓			
Pied Avocet	*Recurvirostra avosetta*	13.7%	✓			
Pacific Golden Plover	*Pluvialis fulva*	0.9%		✓		
Grey Plover	*Pluvialis squatarola*	-			Nt	
Little Ringed Plover	*Charadrius dubius*	0.8%		✓		
Kentish Plover	*Charadrius alexandrinus*	2.5%	✓			
Lesser Sand Plover	*Charadrius mongolus (mongolus / stegmanni)*	0.4%		✓	En	
Greater Sand Plover	*Charadrius leschenaultii*	0.8%		✓	Vu	
Asian Dowitcher	*Limnodromus semipalmatus*	0.8%		✓	Nt	Nt
Black-tailed Godwit	*Limosa limosa*	1.7%	✓	✓	Nt	Nt
Bar-tailed Godwit	*Limosa lapponica (baueri / menzbieri)*	-			Vu	
Whimbrel	*Numenius phaeopus*	0.4%		✓	Nt	
Eurasian Curlew	*Numenius arquatus*	1.2%	✓		Nt	Nt
Far Eastern Curlew	*Numenius madagascariensis*	-			Nt	Vu
Spotted Redshank	*Tringa erythropus*	4.1%	✓	✓		
Common Redshank	*Tringa totanus*	2.1%	✓	✓		
Marsh Sandpiper	*Tringa stagnatilis*	0.3%		✓		
Common Greenshank	*Tringa nebularia*	3.6%	✓	✓		
Nordmann's Greenshank	*Tringa guttifer*	6.2%	✓	✓	En	En
Wood Sandpiper	*Tringa glareola*	0.6%		✓		
Grey-tailed Tattler	*Heteroscelus (Tringa) brevipes*	-			Nt	
Terek Sandpiper	*Xenus cinereus*	1.1%	✓	✓		
Ruddy Turnstone	*Arenaria interpres*	-			Nt	
Great Knot	*Calidris tenuirostris*	-			Vu	Vu
Red Knot	*Calidris canutus (rogersii / piersmai)*	-			Vu	
Red-necked Stint	*Calidris ruficollis*	0.6%		✓		
Curlew Sandpiper	*Calidris ferruginea*	5.7%	✓	✓	Vu	
Spoon-billed Sandpiper	*Eurynorhynchus pygmaeus*	0.6%		✓	Cr	Cr
Broad-billed Sandpiper	*Limicola falcinellus*	0.3%		✓		
Saunders's Gull	*Chroicocephalus saundersi*	-				Vu
Relict Gull	*Ichthyaetus relictus*	-				Vu
Gull-billed Tern	*Gelochelidon nilotica*	0.5%		✓		
Greater Spotted Eagle	*Clanga clanga*	-				Vu
Eastern Imperial Eagle	*Aquila heliacal*	-				Vu
Collared Crow	*Corvus torquatus*	-				Nt
Manchurian Reed Warbler	*Acrocephalus tangorum*	-				Vu
Styan's Grasshopper Warbler	*Locustella pleskei*	-				Vu
Yellow-breasted Bunting	*Emberiza aureola*	-				Vu
Japanese Paradise-Flycatcher	*Terpsiphone atrocaudata*	-				Nt

* Based on mean count from 2007-08 to 2011-12 (AFCD data)

Important = IUCN list of threatened species, and/or Shorebird Regional Red List (WWF-HK *in prep [a]*)
Regular = present in at least 2 of the last 3 periods [winters 09/10, 10/11, 11/12; spring or autumn 2010, 2011, 2012]
Significant numbers = mean of the last five maximum annual counts:

- >1% of flyway population (WPE5 data) during any period of the year (qualify as a Ramsar Site and Flyway Network Site)
- >0.25% of flyway population (WPE5 data) during staging period (qualify as a Flyway Network Site)

1.6.2.3.2 Mammals

The MPNR holds 18 (28%) of Hong Kong's native terrestrial mammal species (Appendix 7), 12 are protected (Table 5) under the Wild Animals Protection Ordinance (Cap. 170).

Table 5. Mammal species recorded at the Mai Po Nature Reserve protected under the Wild Animals Protection Ordinance.

Common name	Scientific name
Japanese Pipistrelle	*Pipistrellus abramus*
Noctule Bat	*Nycatalus noctula*
Lesser Yellow House Bat	*Scotophilus khuli*
Lesser Bent-winged Bat	*Miniopterus pusillus*
Short-nosed Fruit Bat	*Cynopterus sphinx*
Leschnault's Rousette Bat	*Rousettus leschnaulti*
Intermediate Horseshoe Bat	*Rhinolophus affinis*
Eurasian Otter	*Lutra lutra chinensis*
Small Asian Mongoose	*Herpestes javanicus*
Chinese Leopard Cat	*Prionailurus bengalensis*
Small Indian Civet	*Viverricula indica*
Rhesus Macaque	*Macaca mulatta*

Eurasian Otter (*Lutra lutra chinensis*) is a globally near-threatened species. The Inner Deep Bay area is thought to be one of the few remaining places for Otter in South China. Fewer than six adults are believed to live in Deep Bay (Anon 2011).

Historical records of the Crab-eating Mongoose (*Herpestes urva*) and Grey Shrew (*Crocidura attenuate*) are doubted (Dr. Michael Lau *pers. comm*) and have been removed from the MPNR species list.

There is a need for further survey and research on all mammal species.

1.6.2.3.3 *Amphibians and reptiles*

Twenty-nine (30%) of Hong Kong's amphibian and reptile species have been recorded from the Reserve (Appendix 7). Burmese Python (*Python molurus*), Reeves' Terrapin (*Chinemys reevesi*), and Chinese Soft-shelled Turtle (*Pelodiscus sinensis*) are protected species in Hong Kong under the Wild Animals Protection Ordinance (Cap. 170). The latter two species are listed as globally endangered and globally vulnerable respectively.

Although not protected under Cap. 170, Bennett's Water Snake (*Enhydris bennettii*) - locally known as Mangrove Water Snake - is of conservation importance because it is a little known species, with a range restricted to the coastal areas of Hainan Island, Guangdong and Fujian Provinces.

1.6.2.3.4 *Fish*

In recent years water pollution has adversely affected fish diversity in the *gei wai*, which is now dominated mainly by Tilapias (*Oreochromis mossambicus* and *Oreochromis niloticus*), Grey Mullet (*Mugil cephalus*), Spotted Snakehead (*Channa maculata*) and Mosquito Fish (*Gambusia affinis*).

A full fish survey is required.

1.6.2.3.5 *Invertebrates/insects*

Nearly 400 species of invertebrates are found in the MPNR reedbeds, with at least four species probably being undescribed previously (Reels 1994).

In 2010 a firefly species new to science was discovered in the Inner Deep Bay area (Ballantyne *et al.* 2011). Initial surveys indicate the Mai Po Bent-winged Firefly (*Pteroptyx maipo*) occurs in inter-tidal mangal areas although a few individuals were recorded just inside the southern boundary of the Reserve in 2012 (WWF-HK data).

Some 94 species of butterflies have been recorded at MPNR (Appendix 7), accounting for 25% of Hong Kong's total.

The Reserve holds a number of moth species which are characteristic of mangal and reedbed vegetation communities including *Chasmina candida*, which has only been recorded from seven different locations in Hong Kong, with the MPNR being the stronghold (R. Kendrick, pers. comm.).

MPNR is the type locality for two moth species, *Schrankia bilineata* Galsworthy, 1997 and *Thalassodes maipoensis* Galsworthy, 1997. *S. bilineata* is a species endemic to Hong Kong (most records are from the New Territories), whilst *T. maipoensis* is restricted to Deep Bay. Little is known about either species and both probably qualify as species of global conservation concern (R Kenderick, pers. comm.). *Athetis hongkongensis* Galsworthy, 1997 [Noctuidae, Noctuinae, Caradrenini] is another species found at the MPNR which is endemic to Hong Kong. A full moth survey and an updated species list are both required.

The Reserve supports 51 species of dragonfly and damselfly (Appendix 7), accounting for 45% of Hong Kong's total. Of importance is the presence of the globally near-threatened damselfly Four-spot Midget (*Mortonagrion hirosei*) in the MPNR reedbeds.

Benthic communities inside the *gei wai* and ponds need to be surveyed. A list of the crabs on the Reserve has been drawn up (Lee & Leung 1999) with the mangrove crab *Perisesarma maipoense* being of particular conservation concern because it has so far only known from limited locations in Hong Kong, Futian National Nature Reserve, Macau and a recent record in Vietnam (Ng *et al.* 2010). However it has not been recorded in the Mai Po Inner Deep Bay area since the late 1990s.

1.6.3 Cultural

1.6.3.1 Archaeology/past land use

There are no known archaeological remains on the site. However, a certain amount of information is available on the past land use of the entire Deep Bay area including Mai Po, which has management implications.

The wetlands around Mai Po have been used for a wide range of agricultural and other practices including shrimp farming, fishing, oyster cultivation, algae collection and salt production. The first settlers around Deep Bay were fishermen who reclaimed the marshes for cultivation. The first such project took place some 1,000 years ago near Yuen Long but the most intensive period of reclamation occurred this century, when more than 1,700 ha of former marshland were brought under cultivation. Due to the poorly drained soil which had a high salinity, a salt-tolerant variety of rice known as "red rice" was cultivated. After some years of planting "red rice", areas of former marshland became sufficiently salt-free to allow conversion to freshwater rice cultivation.

After World War II, immigrants from China settled around Deep Bay bringing with them the technique for rearing shrimps using *gei wai*. Around 1940-45, the first *gei wai* at Mai Po were constructed. It was recently discovered that the alignments of the *gei wai* perimeter bunds converge on the peaks (Tai To Yan and Kai Kung Leng) of the nearby mountain in Lam Tseun Country Park. The peaks are assumed to have been used as guidance aids through mangrove trees to help align the *gei wai* bunds during their construction.

In the 1950s, the Agriculture and Fisheries Department began intensive research into improved methods of pond fish culture. As the results were successful, it led to farmers adopting the method in the 1960s and 1970s and converting the *gei wai* and paddy outside of the present Reserve boundary into deepwater ponds for fish farming. Some of the southern *gei wai* inside MPNR were also converted into such deepwater fish ponds in the 1970's. Attempts were made to convert the northern ponds into deepwater ponds in 1979/1980 but failed due to Government withholding permission. However, the sluice gates of these *gei wai* were blocked up so that they could still be used as permanent ponds, and this caused the mangrove trees inside to drown and die. In the 1980's, new operators took over the ponds who reinstated traditional *gei wai* management and unblocked the sluice gates to allow water exchange. When the *gei wai* were drained during water exchange, it provided conditions for *P. australis* to rapidly colonize. Those *gei wai* in the central part of Mai Po were traditionally operated to rear shrimp and fish over this period, and now the Reserve holds the last remaining *gei wai* in Hong Kong.

1.6.3.2 Present land use

All *gei wai* located on the eastern side of the Frontier Closed Area are under the management of WWF-HK. Nearly 90 hectares of tidal *gei wai* are still managed to rear shrimp and fish, the remainder

are managed as roosting habitat for waterbirds.

The MPNR has been used for educational purposes by WWF-HK since the early 1980s in the form of school groups and public awareness tours. Individuals, usually in the form of naturalists, experienced birdwatchers and bird photographers or scientists conducting research in the area may gain access to MPNR and thus the site is used for special interest purposes. Currently around ~1000 such persons hold these permits. In addition, the Hong Kong Bird Watching Society holds a 50 person entry permit and uses it to bring groups of birdwatchers into the Reserve.

1.6.3.3 Past management for nature conservation

The flora of the Inner Deep Bay area was originally dominated by mangal communities. Over the past 70 years however, it has been greatly altered by human influence, e.g. from the creation of *gei wai* and fish ponds which led to the loss of the original mangal, and replacement by other marshland or coastal plants.

The need to conserve the Deep Bay wetland, particularly the Mai Po *gei wai* has been recognized for nearly 50 years. In 1964 Sir Peter Scott, one of the founders of WWF, recommended that a reserve be established and this was echoed by the Government's Provisional Council for the Use and Conservation of the Countryside in 1968.

In 1974 hunting was prohibited in the Mai Po area and a year later access was restricted to permit holders so reducing disturbance to the area.

In 1975, the Government's Wildlife Protection Advisory Sub-committee considered a proposal to establish a nature reserve and waterfowl collection at Mai Po and in 1977, Prof. Geoffrey Matthews of the Wildfowl Trust visited Hong Kong at the invitation of the Hong Kong Government and prepared an outline proposal for a reserve, but no further action was taken at that time.

The Hong Kong Government designated Mai Po Marshes as a Site of Special Scientific Interest (SSSI) in 1976 to control and restrict development in the area.

In 1982, the Hong Kong Government's Executive Council approved in principle WWF-HK's request for permission to develop a nature reserve at Mai Po, and in the autumn of 1983 WWF-HK started to develop and manage the Mai Po Marshes Wildlife Education Centre and Nature Reserve with the following aims:

1. to manage the entire Mai Po Marshes so as to maintain and, if possible increase the diversity of native wildlife in the area;
2. to promote the use of the area for educational purposes both by school pupils and the general public (which includes the provision of special facilities for the disabled);
3. to provide facilities for training of overseas personnel in wetland management and research techniques; and
4. to promote scientific research.

To achieve these objectives, WWF-HK set up a Mai Po Management Committee. Staff were recruited to manage the *gei wai* and other habitats on the Reserve, and to develop educational programmes. An Education Centre and a Field Studies Centre, the latter with accommodation for overseas personnel, were built in 1986 and 1990 respectively (Section 1.5.2.2).

The quantity and number of management activities undertaken for nature conservation gain at the Reserve has increased considerably since the late 1990s. This serves to diversify the habitat types, optimize the ecological value of existing ones, and combat the negative effects of siltation and ecological succession on wetland habitats.

1.6.3.4 Public interest

The MPNR is of considerable interest to a wide variety of people because it is:

1. a tranquil place where the general public can appreciate nature, see large numbers of waterbirds and species of international importance, and understand the importance of wetlands to humans and the planet;
2. the only place where the public can witness *gei wai* aquaculture and experience *gei wai* shrimp harvesting;

3. a place for specialist interest groups such as naturalists and wildlife photographers;
4. a resource for the scientific study of wetlands, particularly by local academic institutions; and
5. a resource to deliver environmental education in Hong Kong, and to train regional wetland managers.

Management sees the Reserve being used particularly for education, training and increasing environmental awareness. This is detailed in the Mai Po Master Plan.

1.6.3.5 Landscape

The MPNR is a long and narrow low-lying area of land orientated in a North-South direction bordering Deep Bay. From the air, the long and narrow rectangular *gei wai* are easily visible. To the north and south of these, are squarer or irregularly shaped fish ponds.

At ground-level the visual landscape is one of a network of *gei wai*, mangal and reedbeds with paths along some of the bunds between the *gei wai*.

Beyond, urban developments along the skyline are prominent. To the north, there is the urban and industrial centre of the Shenzhen Special Economic Zone, while those of Yuen Long and Tin Shui Wai can be seen to the south.

1.6.4 Ecological and Environmental Relationships and their Implications for Management

The habitats within MPNR are very much inter-related with conditions in Deep Bay and are affected to a large extent by its associated hydrology and the extent of pollution.

Each time that water exchange occurs in the *gei wai*, the incoming water brings in silt which is deposited in the perimeter and cross channels. As a result, the shrimp and fish inside become more prone to heat stress in the summer because of the shallow water and high temperatures. There is thus a need to carry out frequent medium-scale removal of silt from the *gei wai* channels as a regular management practice in order to maintain the function of the *gei wai*.

This silt also deposits in the central portion of the *gei wai*, at the base of the mangrove trees and in reedbeds. As the floors of these areas become higher there is invasion by grasses, climbers and trees so the original wetland habitat is gradually lost over time. Growth of this vegetation in the central portion of the *gei wai* can be discouraged through raising water levels, particularly in summer months, however the duration must be less than 3-months otherwise mangrove trees will drown. Eventually though desilting operations also need to be conducted.

Annual rainfall patterns influence the health of the aquatic ecosystems in the rain-fed ponds. A prolonged dry season can result in the shallower ponds drying out before the start of the summer monsoon season. In low rainfall years it may not be possible to refill ponds following the completion of enhancement works especially if the works finish in autumn months.

When tropical storms coincide with a high-tide, the resultant tidal surge can cause brackish water from the Bay to overtop the perimeter bunds and enter the rain-fed habitats. When bay water is of high salinity in autumn, the impact of salt water intrusion can be significant to the rain-fed habitats, but less of a concern in mid-summer when bay water salinity is low.

The soils in the Reserve are high in iron sulphide concentration. When disturbed or freshly exposed, sulphates are released and sulphuric acid is formed. Therefore after completion of an earthmoving project in any of the *gei wai* or ponds it is important to flush the waterbody several times to reduce the soil's acidity.

1.7 CONSERVATION STATUS OF THE SITE

In 1975, entry to the Mai Po Marshes became restricted under the 6th Schedule of the Wild Birds and Wild Animals Protection Ordinance (Cap. 170), where visitors must hold a valid Mai Po Marshes Entry Permit issued in writing by The Director of Agriculture and Fisheries (now the Director of Agriculture, Fisheries and Conservation).
The land that is now the MPNR was designated a Site of Special Scientific Interest (SSSI) in 1976. The concept of an SSSI was "... primarily a planning measure to ensure that due account is taken of the scientific importance of particular sites when changes to land use or other developments are being considered." Being an SSSI, "... implies no legal restriction on owners, tenants or occupiers

and will not, by itself, ensure protection of the Site against antipathetic activities or forms of development." (Agriculture and Fisheries Department 1984).

In 1990, Interim Development Permission Area (DPA) plans were produced by the Planning Department under the Town Planning Ordinance, which aimed to set out the types of developments which would be allowed within the different Development Permission Areas. The MPNR falls under Plan No. DPA/YL-MP/1 (Mai Po and Fairview Park), where it was zoned as an SSSI and where "... strict control will be imposed within SSSI and only development which will support the conservation of the area's special interest will be permitted."

In June 1994, the Mai Po and Fairview Park DPA plan was replaced by the draft Outline Zoning Plan (OZP Plan No. S/YL-MP/1). The Reserve was still zoned as an SSSI where in the 'Schedule of Uses', no use of the site is given automatic right ('Column 1' uses). However, a selected number of uses could be considered if an application for permission is first submitted to the Town Planning Board (TPB). These ('Column 2') uses include 'Agricultural Use, Field Study Centre, Sitting Out Area and Tree Plantation'. The 'Explanatory Statement' for this plan states that the planning intention of the SSSI zone is to '…deter human activity or urban development..(other than those which are necessary to sustain the site or to serve educational purpose) and to conserve the feature of special scientific interest.'

In February 2005, the draft OZP was renumbered to S/YL-MP/6. The Reserve was still zoned as an SSSI, where in the 'Schedule of Uses', 'Wild Animals Protection Area' is listed in 'Column 1' for uses always permitted. A selected number of uses could be considered if an application for permission is first submitted to the TPB. These ('Column 2') uses include 'Agricultural Use, Field Study/Education/visitor Centre, Government Use, Nature Reserve, Nature Trail, On-Farm Domestic Structure, Public Convenience, Public Utility Installation, and Utility Installation for Private Project'. The planning intention stated in the 'Explanatory Statement' of this zone is to conserve and protect the features of special scientific interest such as rare or particular species of fauna and flora and their habitats, corals, woodlands, marshes or areas of geological, ecological botanical/biological interest. There is a general presumption against development in this zone. No developments are permitted unless they are needed to support the conservation of the features of special scientific interest in the SSSI, to maintain and protect the existing character of the SSSI, or for educational and research purposes.

In November 1994, the Town Planning Board put out a set of revised guidelines setting out two Buffer Zones around the wetlands of Mai Po and Inner Deep Bay (TPB PG-NO. 12A). The aims of these buffer zones were to '…give MPNR and the areas around Inner Deep Bay added protection and to prevent them from becoming isolated islands of natural habitat encroached by urban type developments.'

MPNR lies within Buffer Zone 1 where the planning intention is '…primarily to protect the special ecological value of the wetland habitat in the Inner Deep Bay area, in particular, the MPNR. New development within this zone should not be allowed unless it is required to support the conservation of the area's natural features and scenic qualities…'

Furthermore, appropriate land uses for Buffer Zone 1 include conservation ('…conservation management of the wetland areas…'), and environmental education ('…research and educational uses which will facilitate the public understanding of the ecology of the area…').

In April 1999, the Town Planning Board promulgated a revised set of guidelines for land use around Mai Po and Inner Deep Bay (TPB PG-No. 12B), where the two buffer zones are replaced with a Wetland Conservation Area (WCA), and a Wetland Buffer Area (WBA).

The planning intention of the WCA is to conserve the ecological value of the Deep Bay fish ponds. Certain activities may be considered by the Town Planning Board in the WCA subject to the submission of an ecological impact assessment. These activities include conservation, environmental education and essential infrastructural projects.

The planning intention of the WBA is to protect the ecological integrity of the fish ponds and wetlands within the WCA. Therefore, a buffer area of 500m alongside the landward boundary of the WCA has been designated WBA. Within the WBA, certain activities may be considered by the Town Planning Board subject to the submission of an ecological impact assessment. These activities include wetland restoration, recreation and residential developments.

In considering applications for development or changes in land use which may impact on the WCA or WBA, the Town Planning Board will consider certain concepts. These include the 'precautionary approach' in conserving the ecological value of fish ponds and the principle of 'no-net-loss in wetland'. Where appropriate, the Town Planning Board will also consider the approach of a 'private-public partnership' in conserving the wetlands in the WCA and WBA.

In September 1995, the Mai Po Inner Deep Bay was designated as a Wetland of International Importance under Ramsar Convention. Under this convention, the Hong Kong S.A.R. Government has an international obligation to '…formulate and implement their planning so as to promote the conservation of wetlands included in the List, and as far as possible the wise use of wetlands in their territory…' After the resumption of the exercise of sovereignty over Hong Kong by the P.R.C. in July 1997, Mai Po and Inner Deep Bay was recognized as China's 7th Ramsar Site. In 1997, a management plan for the Ramsar Site was released which designated the MPNR as a 'Biodiversity Management Zone', being made up of smaller compartments. Each compartment was a group of *gei wai* each with its own broad management intention but without any detailed management prescription. A second management plan for the Ramsar Site was published in 2011.

In 2004, Birdlife International listed the 'Inner Deep Bay and Shenzhen River Catchment Area' as an Important Bird Area (non-statutory designation).

In 2008, the Partnership for the East Asian-Australasian Flyway designated the land within the Ramsar Site boundary as the 'Mai Po – Inner Deep Bay' Flyway Network Site. This non-statutory designation superseded and merged the earlier designations of 'Shorebird Flyway Network Site' (1996) and 'Anatidae Flyway Network Site' (2001).

1.8 ARCHIVE SYSTEM

1.8.1 Map Coverage

Maps of the Reserve and surrounding areas are available from the Survey and Mapping Office of the Lands Department, located at:

23/F
North Point Government Offices
333 Java Road
North Point
Hong Kong Island
Tel: 2231 3187; Fax: 2521 8726
Email: landsd@landsd.gov.hk ; Website: http://www.landsd.gov.hk

1.8.2 Photographic Coverage

Aerial photographs of the Reserve and surrounding areas are available from the Survey and Mapping Section, Lands Department. These photographs are updated on an annual basis. Satellite images are available through various web-based geographic information systems such as Google Earth or Microsoft Virtual Earth.

There are various privately owned aerial photograph collections of relevance. Contacts for these can be made through the Manager, Habitat Management and Monitoring.

Habitat photographs taken by Reserve staff and other general photos taken inside the Reserve are kept in digital format on the WWF-HK server. Several members of staff also keep private collections.

2. EVALUATION, GOALS AND OBJECTIVES

2.1 EVALUATION OF SITE AND FEATURES

2.1.1 Confirmation of Important Features

This assessment is for species and habitats recorded at the MPNR. Assessments are based on the following sources; IUCN (2013), WWF-HK *in prep [a]*, Fellowes *et al*. (2002), Wang & Xie (2004) and Chan *et al*. (2011) for butterflies. There is insufficient data for some groups to perform the assessment quantitatively, under such circumstance their relative importance is assessed using the best available information from experts in the relevant fields. The list of bird species is extensive due many qualifying under 'local concern', therefore only bird species of international importance are shown below (Tables 6 to 9) others are presented in Appendix 8. If a species is listed in the IUCN Redlist, its status is shown in brackets alongside the common name; Cr – Critically endangered, En - Endangered, Vu - Vulnerable, Nt – Near-threatened. Assessments are made at the International, Regional and Local level using a High (H) or Moderate (M) ranking.

Table 6. Important habitat/vegetation types.

	Importance		
Habitats	**International**	**Regional**	**Local**
Reedbed	-	M	H
Mangal	M	H	H
Rain-fed ponds / habitat	-	-	H
Brackish shrimp ponds (*gei wai*)	-	H	H
Brackish waterbird roosts	-	M	H

Table 7. Important plant species.

		Importance		
Common name	**Scientific name**	**International**	**Regional**	**Local**
Widgeon Grass	*Ruppia maritima*	-	M	H
Spiny Bears Breech	*Acanthus ilicifolius*	-	M	H
-	*Aegiceras corniculatum*	-	M	H
Black Mangrove	*Avicennia marina*	-	M	H
Many-petaled Mangrove	*Bruguiera gymnorrhiza*	-	M	H
Milky Mangrove	*Excoecaria agalloca*	-	M	H
Coastal Heritiera	*Heritiera littoralis*	-	M	H
-	*Kandelia obovata*	-	M	H

Table 8. Internationally important avifauna. (*- vagrant)

Common name	**Scientific name**
Christmas Island Frigatebird* (Cr)	*Fregata andrewsi*
Siberian Crane (Cr)	*Grus leucogeranus*
Spoon-billed Sandpiper (Cr)	*Eurynorhynchus pygmaeus*
Baer's Pochard (Cr)	*Aythya baeri*
Oriental Stork (En)	*Ciconia boyciana*
Black-faced Spoonbill (En)	*Platalea minor*
Nordmann's Greenshank (En)	*Tringa guttifer*
Dalmatian Pelican (Vu)	*Pelecanus crispus*
Swinhoe's Egret (Vu)	*Egretta eulophotes*
Lesser White-fronted Goose* (Vu)	*Anser erythropus*
Philippine Duck* (Vu)	*Anas luzonica*
Greater Spotted Eagle (Vu)	*Clanga clanga*
Eastern Imperial Eagle (Vu)	*Aquila heliaca*
Far Eastern Curlew (Vu)	*Numenius madagascariensis*
Great Knot (Vu)	*Calidris tenuirostris*
Saunders's Gull (Vu)	*Larus saundersi*
Manchurian Reed Warbler (Vu)	*Acrocephalus tangorum*

Table 8. Internationally important avifauna. (*- vagrant) (*cont.*)

Common name	Scientific name
Styan's Grasshopper Warbler (Vu)	*Locustella pleskei*
Japanese Yellow Bunting (Vu)	*Emberiza sulphurata*
Yellow-breasted Bunting (Vu)	*Emberiza aureola*
Fairy Pitta (Vu)	*Pitta nympha*
Brown-chested Jungle Flycatcher (Vu)	*Rhinomyias brunneatus*
Black-headed Ibis (Nt)	*Threskiornis melanocephalus*
Ferruginous Duck (Nt)	*Aythya nyroca*
Falcated Duck (Nt)	*Anas falcata*
Black Scoter* (Nt)	*Melanitta americana*
Eurasian Black Vulture (Nt)	*Aegypius monachus*
Japanese Quail (Nt)	*Coturnix japonica*
Black-tailed Godwit (Nt)	*Limosa limosa*
Eurasian Curlew (Nt)	*Numenius arquatus*
Asian Dowitcher (Nt)	*Limnodromus semipalmatus*
Japanese Paradise-Flycatcher (Nt)	*Tersiphone atrocaudata*
Collared Crow (Nt)	*Corvus torquatus*
Japanese Swamp Warbler (Nt)	*Locustella pryeri*

Table 9. Important fauna species (non-avian).

		Importance		
Common name	**Scientific name**	**International**	**Regional**	**Local**
Mammals				
Eurasian Otter (Nt)	*Lutra lutra chinensis*	M	H	H
Lesser Yellow House Bat	*Scotophilus khuli*	-	-	M
Leschenault's Rousette Bat	*Rousettus leschnaulti*	-	-	M
Intermediate Horseshoe Bat	*Rhinolophus affinis*	-	-	M
Small Asian Mongoose	*Herpestes javanicus*	-	-	M
Greater Bandicoot Rat	*Bandicota indica*	-	-	M
Reptiles				
Burmese Python	*Python molurus*	-	-	M
Common Rat Snake	*Ptyas mucosus*	-	-	M
Chinese Cobra	*Naja atra*	-	-	M
King Cobra	*Ophiophagus hannah*	-	-	M
Bennett's Water Snake	*Enhydris benetti*	-	-	H
Reeve's Turtle (En)	*Chinemys reevesi*	H	H	H
Chinese Soft-shelled Turtle (Vu)	*Pelodiscus sinensis*	M	H	H
Dragonflies and Damselflies				
Four-spot Midget (Nt)	*Mortonagrion hirosei*	H	H	H
Blue Sprite	*Pseudagrion microcephalum*	-	-	M
Blue-spotted Dusk-hawker	*Gynacantha japonica*	-	-	M
Dingy Dusk-hawker	*Gynacantha subinterrupta*	-	-	M
Tawny Hooktail	*Paragomphus capricornis*	-	-	M
Black-tipped Percher	*Diplacodes nebulosa*	-	-	M
Coastal Glider	*Macrodiplax cora*	-	-	M
Moths				
-	*Schrankia bilineata*	H	H	H
-	*Thalassodes maipoensis*	H	H	H
-	*Chasmina candida*	H	H	H
-	*Athetis hongkongensis*	H	H	H

Table 9. Important fauna species (non-avian). (*cont.)*

		Importance		
Common name	**Scientific name**	**International**	**Regional**	**Local**
Butterflies				
Chocolate Albatross	*Appias lyncida*	-	-	H
Common Awl	*Hasora badra*	-	-	H
Pale Palm Dart	*Telicota colon*	-	-	M
Burmese Bush Blue	*Arhopala birmana*	-	-	H
Common Onyx	*Horaga onyx*	-	-	M
Powdered Oak Blue	*Arhopala bazalus*	-	-	M
White Royal	*Pratapa deva*	-	-	H
Painted Lady	*Vanessa cardui*	-	-	M
Lesser Band Dart	*Potanthus trachala*	-	-	M
Colon Swift	*Caltoris bromus*	-	-	H
Swallowtail	*Papilio xuthus*	-	-	M
Other Invertebrates				
Mai Po Bent-winged Firefly	*Pteroptyx maipo*	H	H	H
-	*Parasesarma maipoensis*	H	H	H

2.1.2 Evaluation

2.1.2.1 Size

2.1.2.1.1 *Size of site*

At 377.0 ha, the MPNR is the largest contiguous area of wetland under an active conservation management programme in Hong Kong. It is small compared with many other coastal wetland sites in the region.

2.1.2.1.2 *Size of habitats/ features*

The 28.9ha reedbed inside the Reserve, together with other areas of reedbed found in the Inner Deep Bay area, form one of the largest reedbeds in southern China (Anon 2011).

The 51.8ha area of rain-fed habitat at the Reserve is currently one of the largest in Hong Kong under conservation management.

The 31.3ha mangal inside the *gei wai* is part of the Inner Deep Bay area mangal which is the largest in the Pearl River Delta (Liu *et. al* 2005).

At 161.7ha, the brackish water habitats inside the Reserve from the largest area of tidal waterbodies in Hong Kong. Nearly 58 hectares of these are currently being managed as tidal shrimp ponds (*Gei wai* #12, #13, #14, #18 and #19) using traditional practices, others are managed as waterbird roosts or to support reedbed.

2.1.2.1.3 *Size of populations*

Fifteen species of waterbird from the Mai Po Inner Deep Bay area are recorded in numbers greater than 1% of their estimated population along the East Asian-Australasian Flyway, and a further 11 species meet the staging criteria of a waterbird Flyway Network Site (0.25% of their estimated population along the EAA Flyway during migration) (Section 1.6.2.3.1). The MPNR supports many of these species through the provision of roosting and foraging habitat.

Research is needed to discover population sizes of individual species for non-avian groups so that their significance can be assessed.

2.1.2.2 Diversity

The diversity of habitat types is high for a small nature reserve and is increasing through deliberate conservation measures. The implementation of different management regimes e.g. buffalo grazing and seasonal rain-fed habitat is further diversifying the habitats.

Fauna species diversity is exceptionally high for a wetland that has undergone significant historical modification from its original state. Of the better studied fauna groups, avifauna diversity is notable.

Vascular plant species diversity is low, although considered comparable to other similar type wetlands in South China. Soil conditions – poor drainage, clay substrate and high acidity due to iron sulphide minerals – may be a restricting factor.

Wildlife diversity is expected to increase when habitats are diversified within the Reserve. It is recognised however that habitats important for significant species and the general integrity of the site should not be compromised just for the sake of increasing diversity.

2.1.2.3 Naturalness

The MPNR is man-made and a result of significant modification to the original mangal vegetation commencing in the 1940s. Nevertheless, since coming under conservation protection and the cessation of intensive aquaculture practices, the land within the Reserve has returned to a more natural state.

2.1.2.4 Rarity

2.1.2.4.1 *Habitat/feature*

Rain-fed 'marsh' habitat is uncommon in Hong Kong and the 14.7ha area being grazed by a small herd of Domestic Water Buffalo is creating habitat conditions uncommon in Hong Kong.

Reedbed is a rare outside the Deep Bay area and the mangal inside the *gei wai* is the only '*gei wai* mangal' in Hong Kong. The brackish inter-tidal *gei wai* are the last remaining ones in Hong Kong.

2.1.2.4.2 *Species*

Thirty-eight globally threatened or near-threatened fauna species have been recorded at the Reserve (34 birds, one mammal, two reptiles and one damselfly). Eighteen are regularly recorded.

2.1.2.5 Fragility

The environment has withstood a century of human manipulation, and is still of conservation value. Since the current system is man-made, it requires continued management in order to maintain its conservation value. For example, water levels in the *gei wai* must be controlled within limits for both shrimp and feeding/roosting waterbirds. Their channels must also be desilted regularly to counteract siltation.

Aquatic organisms in the brackish water habitats are vulnerable to water pollution and can be seriously affected when the Bay's water quality drops particularly in winter months. Sudden temperature drops after heavy rain can induce shrimp and fish mortality.

Overall, the MPNR is a robust system which has withstood human interference. However, studies are required to investigate how close the site is to its limit of interference or disturbance before it is seriously affected.

The threat posed to the site's ecology by the many non-native species is not well understood.

2.1.2.6 Typicalness

Impounded inter-tidal areas along the South China coast are common. At a physical landscape level, the Reserve and surrounding wetlands are typical of those being used for aquaculture in the region. However the MPNR is unique in that it is managed as a nature reserve with nature conservation as its primary goal.

Traditionally managed *gei wai* for rearing shrimp used to be a typical feature of coastal South China but now, are very uncommon. Reedbed was not a typical habitat type within the *gei wai*, but has become common following cessation of commercial management.

Generally, the flora and fauna species are typical of the South China coast.

2.1.2.7 Recorded history

Land management prior to the establishment of the Reserve is reasonably well documented. Key publications are Melville & Morton (1983), Irving & Morton (1988), and Lee & Leung (1999).

Biological records prior to the mid-1980s when WWF-HK took over management of the Reserve are sparse and general. They comprise academic studies and ornithological records gathered by the Hong Kong Bird Watching Society.

Since becoming a formal nature reserve and designation as a Ramsar Site, biological data has been collected systematically through monitoring programmes andby various specialist interest groups.

2.1.2.8 Position in ecological/geographic unit

The MPNR is essentially a sub-unit of the larger Deep Bay ecosystem, and management of the former cannot be considered in isolation from the latter.

Because the area of wetland in Deep Bay is diminishing and becoming fragmented due to extensive reclamation and urbanization, the Reserve is taking on an increasingly important role in supporting the area's wetland biodiversity.

The health of the Deep Bay ecosystem will significantly affect the welfare of MPNR. Important factors to consider are:

1. effective land-use control in the Wetland Buffer Area (WBA) and Wetland Conservation Area (WCA);
2. pollution control in the Deep Bay catchment;
3. other conservation managed wetlands; Lok Ma Chau Wetland Compensation Wetland, Hong Kong Wetland Park, Futian National Nature Reserve; and
4. the effectiveness of other conservation projects such as the Fishpond Management Agreement projects implemented by the Hong Kong Bird Watching Society.

Designation of the Mai Po Inner Deep Bay Ramsar Site in 1995 helped protect the MPNR as part of the larger ecological ecosystem.

The Inner Deep Bay area is an important staging and wintering area for migratory waterbirds. Thus, for avifauna the geographic unit may be considered as the East Asian-Australasian Flyway.

2.1.2.9 Potential value

The MPNR is already of very high ecological value. Enhancement of existing habitats could however lead to the Reserve supporting greater abundances of important species through increased management effort to optimization habitat conditions. Lack of financial resources is the main factor in preventing this being achieved. There is also potential to re-introduce species of conservation concern. Any re-introduction would however only proceed after in-depth discussion with and support from both AFCD and the Mai Po Management Committee.

2.1.2.10 Intrinsic appeal

The MPNR is somewhat of an oasis amongst what is rapidly becoming an 'unnatural desert'. Not far from the Reserve boundary are housing developments, container parks and scrap yards, all built in former wetland habitat. Immediately to the north of the Reserve is Shenzhen, one of the world's fastest growing cities. Its tall skyscrapers and brightly lit buildings are visible from all parts of the Reserve.

Conversely, the mountains of Lam Tsuen Country Park to the east provide a pleasant backdrop to the Reserve.

In the context of Hong Kong, the Reserve offers a quiet and peaceful place to get close to and appreciate nature. As such the Reserve has substantial appeal to the Hong Kong public.

2.2 MANAGEMENT GOALS

2.2.1 Habitat/Species Management Goals

1. to safeguard all threatened habitats and species occurring on the Reserve; and

2. maintain and manage the major habitats and vegetation types (reedbed, mangal, rain-fed and brackish habitats) for the benefit of native biodiversity particularly for species of conservation importance.

2.2.2 Factors Influencing the Achievement of the Habitat/Species Management Goals

2.2.2.1 Internal Natural Trends

2.2.2.1.1 *Siltation*

The *gei wai* receive a continuous input of silt and organic matter whenever water is exchanged through the sluice gates. Unchecked, this leads to a gradual loss of open water to aquatic vegetation (particularly *P. australis*), and in extreme cases to terrestrial vegetation, causing a deterioration of the existing habitats and a possible reduction in species diversity and abundance. In the *gei wai*, the loss of waterdepth causes heat stress to shrimp and fish in summer months. Silt is removed with heavy machinery from internal channels on a 10-15 year cycle.

2.2.2.1.2 *Mangrove trees*

The natural tree flora of the Reserve is mangrove. Due to deliberate avoidance of its removal over the past few decades, stands of varying maturity have developed across the site. In some instances, the stands are of a sufficiently large enough size or are growing in locations to cause conflict with specific management aims for particular *gei wai* or ponds.

2.2.2.2 *Internal Man-induced Trends*

In the past when the *gei wai* and ponds were managed commercially, economic conditions influenced management of the site. Today, under nature conservation management, the trends are largely dictated by the ecological requirements of threatened wildlife that depend upon the Reserve.

In the last 20 years there has been a cautious move towards greater habitat diversity (and thus of the species using those habitats) e.g. ponds with different salinities, vegetation and water depths, and the introduction of a wider range of management objectives for the different brackish water *gei wai*.

2.2.2.2.1 *Visitors*

There is an increasing demand from individuals to access the site. This has potential to increase disturbance to wildlife. The number of visitors entering the Reserve through the WWF-HK permit quota is capped, however WWF-HK has no control over the number of people entering the Reserve using their own personal entry-permits issued to them by Government. The effects of human disturbance on wildlife habitat use and behaviour have yet to be studied.

Recreational cycling is becoming a popular activity in Hong Kong. In the last few years large groups of cyclists have been turning up at the Reserve entrance and on occasion strayed into the Reserve via the Border Fence Road or next to the AFCD warden Post. Other groups entered via the Lut Chau bridge next to *Gei wai* #22 until it was blocked in 2012. Aside from illegally entering the Reserve, these groups are often noisy and wear brightly coloured clothing which has potential to disturb wildlife, particularly spoonbills and ducks in northern MPNR which often roost close to the road. The situation may worsen when the Mai Po village section of the Sha Po Tsuen to Shek Sheung River cycle track is constructed.

2.2.2.2.2 *Terrestrial shrubs / trees*

The construction of the Closed Area Fence road in the early 1980s led to reduced usage of the bunds between the *gei wai* creating suitable conditions for terrestrial tree species to establish. The practice of placing desilted material from the *gei wai* channels onto the bunds has made them higher and wider thus more attractive to trees. As a result, mature *M. azedarach, Ficus* spp., *M. tanarius* and *Sapium* spp. are now present along the bunds.

In addition, shrubs and trees have been planted on the landward side of MPNR since 1976. The reasons for this planting were to:

1. mark the landward boundary of the Reserve;
2. provide shade for visitors;
3. act as a visual screen against adjacent developments;
4. provide food for frugivorous birds;
5. establish an egretry (Pond #8a); and
6. enhance visitor routes e.g. to attract butterflies.

Although there are benefits from their presence e.g. roosting habitat for birds, their spread throughout the Reserve will increase the landscape profile and make the *gei wai* / ponds less attractive to waterbirds for which MPNR is important.

2.2.2.2.3 *Mud storage*

Siltation is a threat to the brackish water habitats at the Reserve (Section 1.6.4). Current practice is to place desilted material on top of bunds closest to the work areas, however after many decades of doing this the bunds are approaching full storage capacity. Without a viable off-site disposal option, earthmoving works will need to be scaled-down.

2.2.2.3 External factors

2.2.2.3.1 *Local: Water quality*

Deep Bay is the most polluted part of the Hong Kong coastline, especially in its bacterial and nutrient loads. The problem is due mainly to organic waste produced from livestock farms, unsewered villages and urban developments in the catchment being discharged into the Bay, especially via the Shenzhen River and Pearl River (Lau and Chu 2000). This problem is threatening the *gei wai* productivity at MPNR and this affects the availability of food for a number of important waterbird species.

Water quality in the MPNR *gei wai* is determined by a combination of the quality of water that is flushed in from Deep Bay, and the management of flushing by WWF-HK staff, i.e. frequency and quantity of water exchange. Traditionally, water exchange took place whenever there is a sufficiently high tide in Deep Bay to do so, however with the cessation of commercial *gei wai* shrimp production in 2000, the focus of water exchange and water-level management was shifted instead to providing habitat for waterbirds using the *gei wai*. As a result, the frequency of water exchange was reduced as well as the amount of water that was exchanged. In turn, this has elevated the levels of Chlorophyll *a* inside the *gei wai* and increased eutrophication, leading to algae blooms in late winter. The high organic nutrient load in bay water exacerbates the problem.

Water quality also impacts benthic fauna communities in the inter-tidal zones. As the major food source for migratory waterbirds, this could affect the diversity and abundance of migratory waterbirds in the Inner Deep Bay area and consequently inside the MPNR.

The Marine Water Monitoring Programme of the Environmental Protection Department (EPD) <http://epic.epd.gov.hk/ca/uid/marinehistorical/p/1> provides data for most key parameters in Deep Bay dating back to 1986. According to the data, Deep Bay complies with ~40% of the water quality objectives annually, the lowest in Hong Kong waters. Key parameters such as total inorganic nitrogen, unionised ammonia, and dissolved oxygen are consistently non-compliant. This poor water quality in Deep Bay is a result of the discharge of untreated or only partially treated organic waste from urban areas and livestock farms in the catchment. There is also some discharge of industrial effluents via rivers and streams into the head of the Bay.

Analysis of data from the closest monitoring station to MPNR (D1) shows:

1. a longer-term trend of lower salinity in the latter half of winter;
2. a long-term gradual trend of decreasing pH (annual mean); and
3. an increasing trend of 5-day biological oxygen demand BOD5 (annual mean) from the late 1990s to present.

Since 2001, the AFCD has monitored water quality in *Gei wai* #12 and #13 as part of a wider monitoring programme for the Ramsar Site (Anon 2012). According to the data, certain key parameters regularly exceed the current limit levels set by Government; BOD5 (particularly in winter

months), chlorophyll *a* (particularly *Gei wai* #12), nitrate-nitrogen and silica. It is not known if this data is representative of other similarly traditionally managed brackish *gei wai* inside MPNR due to lack of reserve-wide data.

2.2.2.3.2 *Local: Sediment quality*

Sediments in the Bay are known to be contaminated with a variety of heavy metals and organic compounds. Government data (Anon 2012) showed that in 2011 the levels of total phosphorous and DDT exceeded the limit levels in the Ramsar Site inter-tidal mudflat and *gei wai*, whilst total organic carbon exceeded the limit level in *gei wai*.

The amounts of DDT and its breakdown products in the inter-tidal mudflat sediments have been high in the last few years and are of concern. These chemicals are known to accumulate in body tissues, leading to increased concentrations in species further up the food chain. DDT has previously been found to cause thinning of egg shells in birds and was considered to be a primary cause of large declines in birds in Europe and North America during the 1960s and 1970s; further increases in Deep Bay may lead to similar impacts to waterbirds or raptors overwintering locally. The source of the DDT entering Deep Bay is currently unknown, but likely to originate from the Mainland. As a commitment to the Stockholm Convention on Persistent Organic Pollutants, China plans to cease DDT production by 2014.

2.2.2.3.3 *Local: Urban development*

In 1967 the non-sea portion of the "Deep Bay Marshes" (natural and man-made) covered an area of some 4,000 ha (Webster 1975), today it only has an area less than 2,000 ha (WWF-HK data) due to losses to reclamation, housing projects and pond filling for container ports. This gradual process has reduced the carrying capacity of the Inner Deep Bay area and affect the diversity and abundance of waterbirds inside the MPNR.

On the landward side of MPNR, there is constant pressure for reclamation of the fish ponds for urban developments. Many of the development application sites straddle the Wetland Conservation Area and Wetland Buffer Area set up by the Town Planning Board in autumn 1999 to control urban encroachment into the Deep Bay wetlands. A number of these developers have come up with innovative proposals following the 'Private – Public Partnership' approach which attempts to balance both development and wetland conservation on their sites.

On the northern side of Inner Deep Bay, the Shenzhen SEZ Government constructed the Binhai Causeway causing the loss of some 20% of the Bay's inter-tidal mudflat area. The Government continues to carry out reclamation of the coastline the most recent being the landing point of the Shenzhen Western Corridor bridge.

2.2.2.3.4 *Local: Habitat degradation*

Intensification of aquaculture practices is reducing the ecological value of fish ponds surrounding the MPNR. Practices include a reduction in draindown frequency and duration, bird deterrent devices such as pond wiring and noise generating scarers, and the installation of plastic sheeting and concrete on bunds. This degradation inside the Wetland Conservation Area and Wetland Buffer Area is likely to affect waterbird numbers inside the MPNR.

2.2.2.3.5 *Local: Disturbance*

In 2011 and 2012, observations of helicopters flying over the Reserve noted a relatively high level of activity. Several instances of low-flying helicopters disturbed birds on the waterbird roosts including flocks of *P. minor*. Over 90% of the helicopters are operated by either the People's Liberation Army (China Government) or Government Flying Services (HK SAR Government) (WWF-HK data).

2.2.2.3.6 *Local: Ramsar Site condition*

The continued expansion of the inter-tidal mangal is reducing the overall size of the inter-tidal mudflat inside the Ramsar Site. The mudflat is a critically important feeding habitat for migratory waterbirds in the Bay and its shrinkage is likely to affect waterbird numbers inside the MPNR.

The brackish *gei wai* are connected by inter-tidal water channels to the Bay (Appendix 5) and the condition of these inlet channels affects the flow of water into the Reserve. A healthy flow of water is important to carry out a number of management operations such as shrimp stocking and water

exchange. Historically, the inlet channels were desilted by the original *gei wai* operators on an approximate 10-year cycle and timed to coincide with maintenance of a connecting *gei wai*. The majority of inlet channels have not been maintained for at least 20 years, the most recent channel being in 2003 (outside *Gei wai* #16/17). WWF-HK carries out occasional clearance of overhanging vegetation and debris from the channels, maintenance desilting of the inlet channels is however a considerably larger and more complicated task. Responsibility to desilt the inlet channels needs to be clarified with Government.

2.2.2.3.7 *Global: Climate change*

On a global level, change in the climate is expected to cause a mean rise in annual surface temperatures, rainfall and sea-level. For south China, current predictions are a 1.0 - 3.5℃ temperature increase by 2100 (IPCC 2007) and a 10-20% increase in annual precipitation by 2100 (IPCC 2007). Hong Kong climate trends show a 0.22℃ temperature increase per decade during 1983-2012, and an annual total rainfall increase at the Hong Kong Observatory Headquarters of a rate of 29 mm/decade over the last 60 years (HKO 2013). Furthermore extreme rainfall events and extremely hot days have become more frequent while extremely cold days have become rarer (HKO 2013).

A Ramsar report predicts sea-level rise would inundate 39.3% of the Mai Po Inner Deep By Ramsar Site by 2100 (de Sherbinin *et al.* 2012). Other more-general predicted scenarios include increased storm intensity and greater inter-annual precipitation variation. The former could result in increased storm surges and salt-water intrusion into the lower saline habitats, whilst the latter may result in a lack of rain-water to replenish the rain-fed habitats.

The implications for the Reserve need to be assessed and a climate change adaptation strategy/plan devised.

2.2.2.4 Problem species

2.2.2.4.1 *Non-native species*

Many non-native (or introduced) flora and fauna species are present on the Reserve. Species in need of management attention are mentioned below.

The climber *M. micrantha* has adapted well to conditions in Hong Kong and grows in the drier areas of brackish ponds, on mangrove trees and on disturbed ground such as earth bunds. Frost can suppress its growth, but sub-zero temperatures are a rare event in Hong Kong. Without management this species will out-compete native flora and cause dieback in mangrove trees.

The mangrove tree *Sonneratia* spp. was first recorded in Hong Kong in the 1990s and has gained a stronghold amongst the natural mangal in the Bay. The species is fast growing and can establish stands considerably quicker than native species. So far a few individuals of this species have been recorded inside the Reserve boundary (*Gei wai* #6, #8 and #16/17) and a small stand observed along the FCA channels leading to the brackish tidal *gei wai* (particularly the inlet leading to *Gei wai* #12 and #13).

Acacia spp. is an invasive tree species continually seeding into the Reserve from the neighbouring Fairview Park. Other non-natives include Swamp Mahogany (*Eucalyptus robusta*), *M. azedarach* and Horsetail Tree (*Casuarina equisetifolia*).

The herbs Hairy Bur-marigold (*Bidens pilosa*) and *Wedelia triloba*, and shrub Lantana (*Lantana camara*) all grow abundantly on the bunds. The Narrow-leaved Cat-tail (*Typha angustifolia*) is invasive and seeds into the Reserve from neighbouring wetlands.

Tilapias (*Oreochromis* spp.) are found in high densities in brackish water *gei wai* (Lee 1992) and are present in the deeper rain-fed habitats. As omnivores, *Orepchromis* spp. compete for food with other fish species and may prey upon shrimp thus affect native species and the aquatic ecosystem. In 2011, WWF-HK ceased the trash fish stocking programme resulting in 62,500 catties (31,250 kg) of *Oreochromis* spp. no longer being stocked in the *gei wai* each year.

The Golden Apple Snail (*Pomacea canaliculata*) is prevalent in the lower saline rain-fed habitats inside the Reserve and is likely having a negative affect on the ecology of those ponds.

The Red-eared Slider (*Trachemys scripta elegans*) is prevalent across the Reserve. Its impact upon the native turtles, aquatic invertebrates and fish is not known.

The Imported Red Fire Ant (*Solenopsis invicta*) was first recorded at MPNR in 2005. This non-native highly invasive species is found on bareground and/or in sparsely vegetated areas within the Reserve. The density of nests is increasing and in 2012, 678 granular insecticide applications were made to nests inside the Reserve.

2.2.2.4.2 *Native species*

The reedbed bug *Dimorphopterus spinolae* was observed in the *Gei wai* #8b reedbed in 2011 and 2012 and caused *P. australis* die off in localized patches. In Hong Kong the bug has caused mass die off of *P. australis* at the Wetland Park, Lok Ma Chau Compensation Wetlands and at Yuen Long. Regular monitoring at the Reserve is recommended to understand the extent of the problem and study may be necessary to investigate ways to reduce the bug's impact.

Many native terrestrial herbs and grasses favour the disturbed conditions at the Reserve and require regular control e.g. *Paspalum* spp.

2.2.2.4.3 *Other*

Feral dogs are an on-going problem to wildlife. Known disturbances include numerous cases of dogs chasing roosting birds on the waterbird roosts (in 2012 this led to the abandonment of up to 26 Black-winged Stilt nests on *Gei wai* #16/17), and the killing of waterbirds (photographed by local birdwatchers) and mammals - mostly Small Asian Mongoose (*Herpestes javanicus*), Small Indian Civet (*Viverricula indica*) and Chinese Leopard Cat (*Prionailurus bengalensis*) as shown by post-mortems. The total number of feral dogs captured by WWF-HK and AFCD, and subsequently removed by AFCD between 2002 and 2012 was 158 (WWF-HK data).

2.2.2.5 Obligations

2.2.2.5.1 *Wildlife legislation*

All animals at the MPNR are protected under the Wild Animals Protection Ordinance (Cap. 170) and all plants are protected under the 1993 amendment to the Forests and Countryside Ordinance (Cap. 96), where it is an offence to fell, cut, burn or otherwise destroy any tree or growing plant on Government land without prior permission from the AFCD.

2.2.2.5.2 *Access legislation*

Under Schedule 6 of the Wild Animals Protection Ordinance (Cap. 170), the Mai Po Marshes (in which the MPNR is situated) is a Restricted Area and all visitors must hold a valid Mai Po Marshes Entry Permit issued by the Director of the AFCD. Permits are valid for periods up to 12 months.

Under Section 37(2) of the Public Order Ordinance (Cap. 245), all visitors must hold a valid FCA permit issued by the Commissioner of Police to enter the Closed Area at the western side of the Reserve. In 2007, Condition 16 under the Special Licence for the floating boardwalk and floating hides was amended to "the number of visitors admitted at any time to the Licence Area should not exceed 160."

Both permit systems apply to all WWF-HK staff and contract staff employed by WWF-HK.

2.2.2.5.3 *Formal agreements / permissions*

WWF-HK has annual agreements with the AFCD that it must abide by when carrying out site management. The obligations are to fulfill the conditions stipulated in the subvention and annual service contracts.

WWF-HK has an ongoing agreement with its neighbouring fishpond owner. The 2008 signed agreement allows the pond owner to extract water from *Gei wai* #10 to facilitate management of his ponds. A condition is for him to notify WWF-HK before pumping water.

2.2.2.5.4 *Other legislation*

Relevant to outdoor practical site management operations:

1. Occupational Safety & Health Ordinance (Cap. 509);
2. Building Ordinance (Cap. 123); and
3. Hazardous Chemical Control Ordinance (Cap. 595).

Although responsibility to follow the guidelines issued by the Ramsar Convention lies with the Hong Kong S.A.R. Government, WWF-HK is also expected to follow its guidance. WWF is a member of the Convention.

In 2015, the Convention on Biological Diversity will be implemented in Hong Kong. This may have implications for reserve management decisions.

2.2.2.5.5 *Accepted local practice*

Several households are located within the Restricted Area. Residents of these households do not require permits to enter the Reserve under Cap. 170 because the entry permit requirement does not apply to a person ordinarily residing in the Restricted Area.

2.2.2.5.6 *Legal obligations of others*

Visitors to the site must observe wildlife legislation and must not disturb wildlife or remove them.

The Environmental Protection Department (EPD) has established a notification system with the Shenzhen Government to handle Mainland China land-based pollution incidents that affect Hong Kong waters. Under such circumstance, the EPD would notify AFCD, whom would inform WWF-HK if there is a threat to the MPNR.

Within Hong Kong, the Government maintains a Maritime Oil Spill Response Plan which is coordinated by the Marine Department. Similarly, AFCD would inform WWF-HK should a pollution incident event occur close to the MPNR.

2.2.2.5.7 *Non-legal obligations of others - visitors*

Visitors to the Reserve have an obligation to follow the WWF-HK Code of Entry <http://awsassets.wwfhk.panda.org/downloads/coe_to_mp.pdf>.

2.2.2.5.8 *Non-legal obligations of others - Ramsar Site management plan*

Because the MPNR lies within the Mai Po and Inner Deep Bay Ramsar Site, WWF-HK's management must meet its obligations set out in the Ramsar Site Management Plan (Anon 2011).

The MPNR is classified as the Biodiversity Management Zone (BMZ) of the Mai Po Inner Deep Bay Ramsar Site, where the purpose "is to provide a refuge for waterfowl (including a high tide roost) and a focus for biodiversity conservation, education and training in a relatively intensively managed environment". The MPNR BMZ is divided into seven compartments (from BMZ 1 to BMZ 7), each with its own management intention (Figure 2, Table 10).

Following completion of the 2006 - 2012 MPNR Management Plan, the boundaries of the BMZ compartments need to be updated to those shown in Figure 2 (b). Major changes are: -

1. *Gei wai* #18 and #19 reclassified as BMZ 3 (traditionally managed *gei wai*). These *gei wai* were previously under BMZ 5 for which the management intention is to provide secure high-tide roost for wintering waterfowls. Over the course of the previous Management Plan neither *gei wai* performed this function, mainly due to lack of open water, enclosed conditions and close proximity to visitor paths. Both *gei wai* currently contain over 40% mangal and are managed as traditional *gei wai*.
2. Boundary of BMZ 4 (Education Centre ponds) extended to include Ponds #16a and 17a. Both ponds were converted to rain-fed habitat in 2007 and are important education resources.
3. Pond #8a reclassified as BMZ 6 (freshwater roosting area). The pond did not contribute to the aims of BMZ 2 due to absence of *P. australis* and was converted to rain-fed habitat in 2009.

4. *Gei wai* #11a, #22a and #22b reclassified as BMZ 7 (high-tide roosting sites). *Gei wai* #11a did not contribute to the management intention of BMZ 2 (reedbed habitat), and *Gei wai* #22a and #22b not to BMZ 6 (freshwater roosting area). *Gei wai* #11a is managed as a high-tide roost, and *Gei wai* #22a and #22b as an inter-tidal *gei wai*,

Two further changes are necessitated over the course of this Management Plan (changes shown in Appendix 12); explanations are provided under the relevant background/rationale sections later in the Plan.

The Ramsar Site Management Plan provides guidance on the types of permitted and incompatible activities as well as those requiring Government approvals. These are:

1. *Permitted Activities.* Existing land use practices including operation of *gei wai* where conservation of biodiversity or cultural values is the major objective; predetermined controlled access, including for purposes of education and training; prescribed monitoring and approved research; and routine and/or prescribed habitat management and maintenance including control/removal of invasive, exotic or pest species.
2. *Incompatible Activities.* Activities contrary to the purposes of the zone, including: hunting, intensive commercial harvesting, unauthorized collection, destruction, or disturbance of indigenous wild fauna and flora; intensive commercial livestock grazing; unauthorized access (including by boat); storage, dumping or disposal of waste including untreated effluent; construction of industrial facilities or dwelling places (other than dwellings required for management purposes); unauthorized use or application of chemicals (fertilizers, biocides, etc.); mining; removal of aggregates; and introduction of non-native species.
3. *Activities Requiring Management Approval.* Activities which are neither permitted nor clearly incompatible with the purposes of the zone, including: exceptional or novel habitat management intervention; change of land use or production system; keeping of limited number of livestock; construction of dwelling places required for management purposes, visitor facilities or other infrastructure; discharge of treated effluents; establishment or maintenance of collections of living organisms.

2.2.2.6 Legal constraints

Each *gei wai* is under either a separate, or group licence. Under the land licence, there are general controls on land-use, these are:

1. the licence is granted for one year and thereafter is renewable on an annual basis, nominal for one dollar per year;
2. the licence may be revoked by the Government upon three months' notice;
3. the licence area shall not be used for any purpose other than as a nature reserve;
4. approval for the erection of structures must be sought from the Government;
5. compliance with the Buildings Ordinance, Town Planning Ordinance, and all ordinances, by-laws, regulations and rules in force in Hong Kong for the control of pollution (including air, noise, water and waste pollution), and protection of the environment is required;
6. no cutting back, removal or setting back of any land within the licence area or any Government land adjoining the licence area is allowed except with prior approval from the Government; and
7. no trees growing on the licence area or adjacent area shall be interfered with or removed without prior approval from the Government.

The MPNR is zoned as a Site of Special Scientific Interest under the Outline Zoning Plan, where there are strict guidelines on activities and land-use.

The erection of new structures and replacement of existing structures requires permission from the Town Planning Board through a 'Section 16' application under the Town Planning Ordinance. Further detail on planning legislation is provided in Section 1.7.

Permission must be obtained from Districts Land Office - Yuen Long prior to commencement of the annual vegetation clearance work on the inter-tidal mudflat in front of the floating birdwatching hides.

2.2.2.7 Management constraints

Large-scale desilting operations are constrained by the need to adhere to the Deep Bay Guidelines for Dredging, Reclamation and Drainage Works (ERL 1991). The Reserve falls within the Inner

Deep Bay Special Measures Zone for which the guideline states "works should be programmed so as not to occur during the migratory-bird over-wintering period (November to March)" and "works should preferably not take place outside normal working hours (07:00 hours to 19:00 hours on the same day)".

Earthmoving projects involving machinery are affected by heavy rainfall. Repeated delays of up to two weeks are common in the height of the wet season due to muddy unworkable conditions.

The level to which MPNR is managed and the quantity of site work being undertaken annually is dependent upon financial resources. The more resources that are allocated to managing the Reserve, the higher the ecological value of the site. Funding factors include the magnitude of Government funding available, the success of WWF-HK fundraising efforts, and the relative allocation of WWF-HK resources to the management of MPNR.

HKSAR Government has a commitment to sustain MPNR under RAMSAR and the Convention on Biological Diversity, which requires a commitment of adequate support and funding. Government (AFCD and Education Bureau) funding currently covers ~27% of habitat management, research and monitoring operational costs at the Reserve. Therefore it is an objective for WWF-HK to ensure that the HKSAR Government provides adequate funding for the management of MPNR and implementation of this management plan, in order that it can continue to be managed as a world class wetland.

2.2.2.8 Summary of the main factors influencing the habitat/species management goals

1. poor water quality and algal blooms in the *gei wai* in late winter;
2. continued accretion of silt in the *gei wai* necessitating the need for frequent maintenance;
3. lack of on-site locations to store desilted materials;
4. feral dogs disturbing and killing wildlife;
5. the November to March restriction on earthmoving works coupled with wet season delays; and
6. lack of financial resources.

Figure 2. Boundaries of the seven compartments within the Biodiversity Management Zone at the Mai Po Nature Reserve.

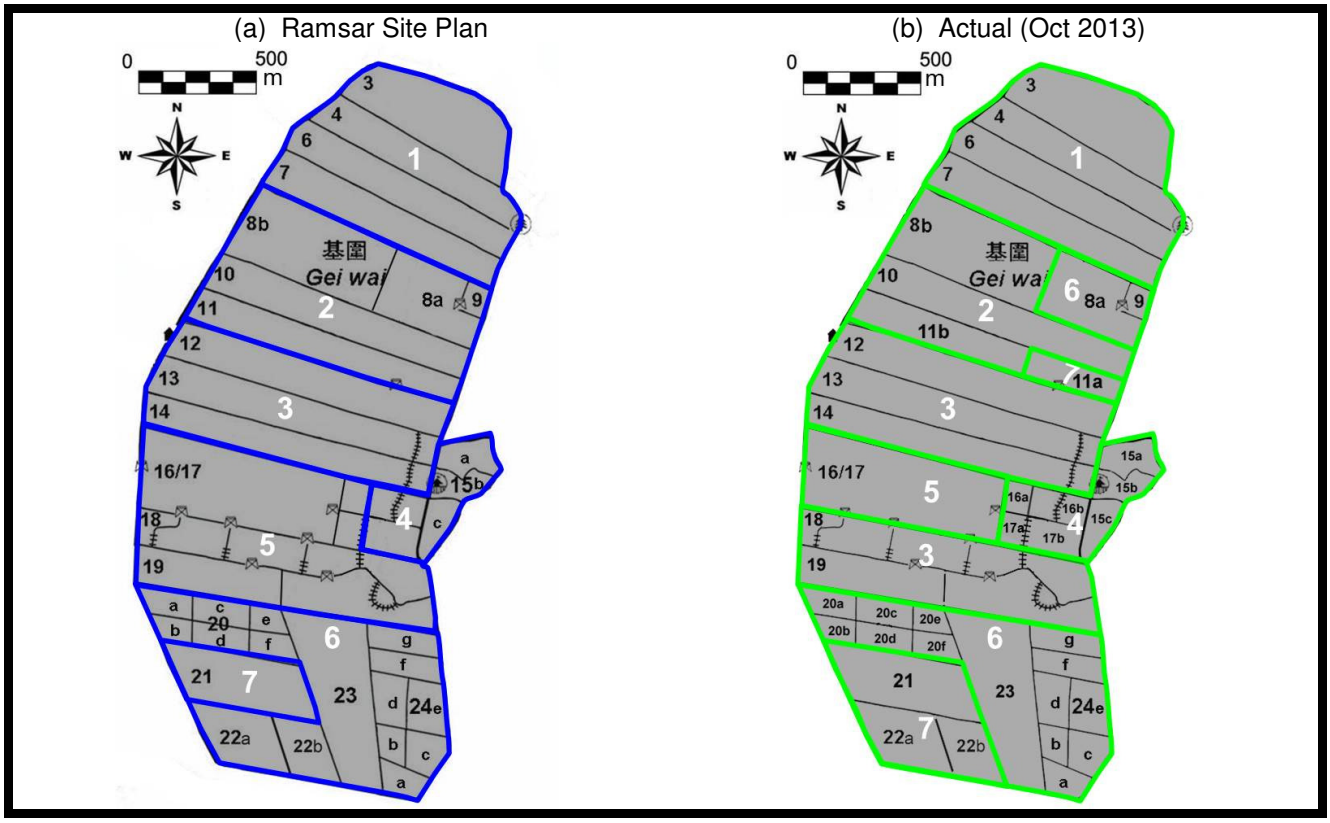


Table 10. Management intention of the seven compartments (BMZ 1 – 7) at the Mai Po Nature Reserve (updates shown in red).

Compartment	Management Intention
BMZ **1** #3, #4, #6, #7	In the medium term, to adjust conditions in favour of supporting higher numbers of the Black-faced Spoonbill.
BMZ **2** #8b, #10, #11b	In the medium term, to adjust conditions in favour of supporting a substantial block of reedbed habitat.
BMZ **3** #12, #13, #14, #18, #19	In the medium term, to maintain traditionally managed production *gei wai* with areas of mangrove vegetation.
BMZ **4** #15a, #15b, #15c, #16a, #16b, #17a, #17b	In the long-term, to maintain and improve the Education Centre and its associated waterfowl collection.
BMZ **5** #16/17	In the medium term, to adjust conditions in favour of creating an open, tidal area with fringing reeds and mangroves, shingle or tree-topped islands and pools/channels with varying sizes, heights and depths that can act as a secure high-tide roost for wintering waterfowls.
BMZ **6** #8a, #9, #20, #23, #24	(#8a, #9, #20, #22, #23) In the medium term, to adjust conditions in favour of creating an open freshwater roosting area with fringing reeds and mangroves, shingle or tree-topped islands and pools/channels with varying sizes, heights and depths. (#24) In the medium term, to adjust conditions in favour of creating a series of freshwater lakes of varying depth with surrounding areas of marsh.
BMZ **7** #11a, #21, #22a, #22b	To maintain as an open high-tide roosting site as an alternative to *Gei wai* #16/17.

2.3 FEATURES AND LIMITS

2.3.1 Features, Attributes and Limits of Acceptable Change

Five features are selected to capture the most important site features identified in Section 2.1.1 and management goals listed in Section 2.2.1; Brackish *gei wai* (BGW), Brackish waterbird roosts (BWR), Rain-fed habitats (RFH), Inter-tidal mudflat (IMF) and *Gei wai* landscape (GWL). Management-related targets are set for the first three features.

Table 11. Selected attributes and limits of acceptable change (LAC) for important features.

		Feature		
Attribute	**Description and limits of acceptable change**	**BGW**	**BWR**	**RFH**
Extent (ha)	To directly show the extent of a feature across the Reserve. The target is to be achieved by 2018, the LAC is set at ±10%.	✓	✓	✓
Area of reedbed (ha)	To directly show the area of reedbed habitat within a pond or *gei wai*. The target is be achieved by 2018, the LAC is set at ±10%. Generally: • reedbed is not preferred in the brackish waterbird roosts, although reed fringe has ecological benefits; and • areas of *P. australis* growing within the major blocks of mangal will be allowed to naturally succeed to mangal-type vegetation e.g. in BMZ 3.	✓	✓	✓
Area of mangal (ha)	An indicator to directly show the area of this vegetation type within a *gei wai*. The target is be achieved by 2018, the LAC is set at ±10%. Generally: • mangal vegetation is not preferred in the brackish waterbird roosts, although small stands of mangal (particularly mangrove trees/shrubs) can have ecological benefits; and • mangal vegetation is not desirable in the major blocks of reedbed habitat e.g. BMZ 2.	✓	✓	
Area of open water (ha)	In brackish waterbird roosts, the area of open water contributes to the general attractiveness of the roost to waterbirds. In brackish *gei wai*, the perimeter and cross channels are important in the production of fish and shrimp, and essential to carry out water exchange effectively. The area of open water is a general indicator of these. Open water is important in rain-fed ponds, but less important in rain-fed marsh areas such as the buffalo marsh or seasonally wet habitat. Target to be achieved by 2018; the LAC is set at ±5% for the brackish waterbird roosts, and ±10% for brackish *gei wai* and rain-fed habitats.	✓	✓	✓

Table 11. Selected attributes and limits of acceptable change for important features. (*cont.*)

		Feature		
Attribute	**Description and limits of acceptable change**	**BGW**	**BWR**	**RFH**
% of wet reedbed	An area is defined as 'wet' if the reedbed floor is underwater at the normal winter operating water level in the *gei wai* / pond. Water levels are kept steadier for longer periods in winter. This attribute only applies to stands of *P. australis* >0.5ha in area to purposely exclude 'reed fringe' and scattered patches so that management attention is given to the major blocks of reedbed. Target to be achieved by 2018. The target varies between *gei wai* / pond; LAC is set at ±10%.	✓		✓
% of mangrove tree canopy affected by climber (mature trees only)	If climber is estimated to be occupying greater than one quarter of canopy cover (in an approximate 4m^2 area) it is classified as 'affected'. Target to be achieved by 2018. The target is 0%; an upper LAC is set at 10%.	✓	✓	
% compliance with desired water exchange frequency	Water exchange is an activity undertaken to maintain water quality and conditions for rearing shrimp (Section 2.4.1.1.2). A high frequency (at least fortnightly) is desirable especially on the brackish *gei wai*. It is noted that water exchange may not be possible when a *gei wai* is under maintenance / repair or in the process of drawdown, hence targets do not apply under such circumstance. Target to be achieved annually. The target is 100%; a lower LAC is set at 95% for brackish *gei wai* and 90% for brackish waterbird roosts.	✓	✓	
% compliance with desired water level	Water regimes have been designed for each *gei wai* (Appendix 11). A high compliance shows the water levels are being managed appropriately. It is noted that compliance with the desired water level may not be possible when a *gei wai* is under maintenance / repair or during drawdown, hence targets do not apply under such circumstance. 'Compliance' is defined in brackish *gei wai* as ±10cm of the desired level, and ±5cm for brackish waterbird roosts. *Gei wai* #12, #13, #18 and #19 may be raised to +20cm in summer months to provide favourable conditions (i.e. deeper and cooler water) for *gei wai* shrimp. Target to be achieved annually. The target is 100%; a lower LAC is set at 90% for brackish *gei wai* and 95% for brackish waterbird roosts.	✓	✓	
% of *gei wai* channels meeting waterdepth requirement	'Waterdepth requirement' is defined as 60cm; this is based on current desilting practices at the Reserve which aim to create channel waterdepths of at least 60cm. Target to be assessed by 2015 and achieved by 2018. The target is 100%; the lower LAC is set at 50%.	✓	✓	
Salinity (ppt) [winter]	To show the water salinity level in the rain-fed habitats in winter. A low salinity is desirable. Target to be achieved annually from a selection (not all) of the rain-fed habitats. The target varies between ponds; the LAC is set at ±10%.			✓

2.3.2 Management Targets

There is insufficient data at present to set management targets for all the chosen attributes. Over the course of the Plan on-going research and monitoring is expected to generate the necessary data. Targets are shown in Tables 12 to 14. All 2018 targets include the transfer of the landward ends of *Gei wai* #18 and #19 from BMZ 3 to BMZ 6 and the transfer of *Gei wai* #23a from BMZ 6 to BMZ 7 as shown in Appendix 12. Square brackets alongside *gei wai*/pond numbers in Tables 12 to 14 indicate these changes.

Reporting requirements and protocol for these management targets is described in Section 3.3.3.

Table 12. Management targets for the brackish *gei wai*.

Biodiversity Management Zone	BMZ 2			BMZ 3					Status
Gei wai	#8b	#10	#11b	#12	#13	#14	#18[b]	#19[b]	
Extent (ha)	30.59			57.87					Current
	30.62			*48.71*					*By 2018*
Area of reedbed (ha)	11.97			4.57					Current
	14.04			*2.64*					*By 2018*
Area of mangal (ha)	2.30			22.35					Current
	0.85			*20.36**					*By 2018*
Area of open water (ha)	11.43			19.80					Current
	10.81			*16.53*					*By 2018*
% of wet reedbed	62.4%			64.0% (#14 only)					Current
	94.0%			*90.0% (#14 only)*					*By 2018*
% of mature mangrove trees affected by climber	*0.0*								*Annual*
% compliance with desired water exchange frequency	*100.0*								*Annual*
% compliance with desired water level regime	*100.0*								*Annual*
% of *gei wai* channels meeting waterdepth requirement	*100.0*								*By 2018*

Table 13. Management targets for the brackish waterbird roosts.

Biodiversity Management Zone	BMZ 1				BMZ 5	BMZ 7				Status
Gei wai	#3	#4	#6	#7	#16/17	#11a	#21	#22	#23[a]	
Extent (ha)	37.58				16.03	19.66				Current
	37.58				*16.03*	*23.60*				*By 2018*
Area of reedbed (ha)	0.26				0.25	1.63				Current
	0.26				*0.25*	*1.13*				*By 2018*
Area of mangal (ha)	6.25				0.00	0.25				Current
	6.24				*0.00*	*0.25*				*By 2018*
Area of open water (ha)	24.83				12.25	14.29				Current
	24.83				*12.42*	*18.11*				*By 2018*
% of mature mangrove trees affected by climber	*0.0*									*Annual*
% compliance with desired water exchange frequency	*100.0*									*Annual*
% compliance with desired water level regime	*100.0*									*Annual*
% of *gei wai* channels meeting waterdepth requirement	*100.0*									*By 2018*

Table 14. Management targets for the rain-fed habitats.

Biodiversity Management Zone	BMZ 4					BMZ 6							Status
Gei wai	#15	#16a	#16b	#17a	#17b	#8a	#9	#18[a]	#19[a]	#20	#23[b]	#24	
Extent (ha)	12.34					39.50							Current
	12.34					*44.70*							*By 2018*
Area of reedbed (ha)	0.93					9.28							Current
	0.71					*10.95*							*By 2018*
Area of mangal (ha)	0.14					0.03							Current
	0.14					*1.76*							*By 2018*
Area of open water (ha)	5.43					19.54							Current
	4.49					*19.48*							*By 2018*
% of wet reedbed	86.8%					35.0%							Current
	83.4%					*56.0%*							*By 2018*
Salinity (‰)	to be set in 2015												*Annual*

2.3.3 Species-related Indicators

The targets set in Section 2.3.2 are to either assess the physical condition of important features or to ensure that important management operations for each feature are carried out effectively.

To further supplement management decisions at the Reserve, species-related indicators are chosen:

1. diversity of odonates on the rain-fed habitats;
2. number of spoonbills, herons and egrets feeding during *gei wai* drawdown;
3. number and diversity of shorebird species using the high-tide roosts in BMZ 5 and BMZ 7;
4. number of *P. minor* roosting in BMZ 1;
5. number and diversity of wintering duck using BMZ 5 and *Gei wai* #21; and
6. number of individuals of important avifauna species. Note, MPNR is important for almost all wetland / wetland dependant bird species in Hong Kong, therefore upon review – applying criteria such as; recorded regularly on surveys, present in good numbers, present in internationally significant populations, etc.) - a list of 43 species has been drawn up (Table 15).

No quantitative target is set for the species-related indicators but assessment will be made against cumulative data on population and diversity to identify trends and take actions where needed. Reporting requirements and protocol for these indicators is stated in Section 3.3.3.

Table 15. Avifauna indicators.

Common Name	Scientific Name
Great Cormorant	*Phalacrocorax carbo*
Little Grebe	*Tachybaptus ruficollis*
Grey Heron	*Ardea cinerea*
Purple Heron	*Ardea purpurea*
Chinese Pond Heron	*Ardeola bacchus*
Striated Heron	*Butorides striata*
Great Egret	*Ardea alba*
Little Egret	*Egretta garzetta*
Intermediate Egret	*Egretta intermedia*
Yellow Bittern	*Ixobrychus sinensis*
Black-faced Spoonbill	*Platalea minor*
Northern Pintail	*Anas acuta*
Northern Shoveler	*Anas clypeata*
Tufted Duck	*Aythya fuligula*

Common Name	Scientific Name
Chinese Spot-billed Duck	*Anas zonorhyncha*
Black-winged Stilt	*Himantopus himantopus*
Pied Avocet	*Recurvirostra avosetta*
Pacific Golden Plover	*Pluvialis fulva*
Greater Sand Plover	*Charadrius leschenaultii*
Black-tailed Godwit	*Limosa limosa*
Eurasian Curlew	*Numenius arquatus*
Spotted Redshank	*Tringa erythropus*
Common Redshank	*Tringa totanus*
Common Greenshank	*Tringa nebularia*
Nordmann's Greenshank	*Tringa guttifer*
Terek Sandpiper	*Xenus cinereus*
Asian Dowitcher	*Limnodromus semipalmatus*
Red-necked Stint	*Calidris ruficollis*

(cont.)

Table 15. Avifauna indicators. (*cont.*)

Common Name	Scientific Name
Curlew Sandpiper	*Calidris ferruginea*
Lesser Sand Plover	*Charadrius mongolus*
Great Knot	*Calidris tenuirostris*
Whimbrel	*Numenius phaeopus*
Broad-billed Sandpiper	*Limicola falcinellus*
Gull-billed Tern	*Gelochelidon nilotica*
Western Osprey	*Pandion haliaetus*
Greater Spotted Eagle	*Clanga clanga*
Eastern Imperial Eagle	*Aquila heliaca*
Eastern Marsh Harrier	*Circus spilonotus*
Pied Kingfisher	*Ceryle rudis*
Manchurian Reed Warbler*	*Acrocephalus tangorum*
Pallas's Grasshopper Warbler*	*Locustella certhiola*
Chinese Penduline Tit*	*Remiz consobrinus*
Bluethroat*	*Luscinia svecica*

*** species surveyed by external researchers**

2.4 OBJECTIVES, RATIONALE AND MONITORING

2.4.1 Operational Objectives, Rationale, Outline Prescriptions and Projects

The MPNR is essentially a man-made habitat and it's high ecological value is in part due to past human modification. Therefore a programme of active management is required to maintain the Reserve's ecological value. This is reflected in the management intention for the Biodiversity Management Zone as stated in the Ramsar Site Management Plan which acknowledges that activities will take place in a 'relatively intensively managed environment'.

There has been a history of earthmoving projects at MPNR dating back to the construction of the *gei wai* in the mid-1940s. Since then, the *gei wai* operators carried out dredging of the channels in their *gei wai*, as well as sub-dividing a number of their *gei wai* into smaller ponds for fish cultivation in the 1970s. Since WWF-HK took over management of MPNR, it too has undertaken a number of earthmoving projects al-be-it with a different objective and in a less intensive manner. All of these projects involve draining the *gei wai* or pond, and then using heavy earthmoving machinery. Desilting - the most common earthmoving project - is now recognized as a regular and essential activity to combat the negative impacts of siltation and vegetation succession upon the wetland habitats.

Reedbed is a major habitat type occurring at the Reserve which requires regular intervention to retain its ecological value. Typically this involves cutting and removal of *P. australis* in winter, or desilting to lower the reedbed floor in summer, to prevent them from drying out and becoming invaded by mangal, climbers or terrestrial grasses. After such management, *P. australis* quickly regrows to form a healthy reedbed.

A reedbed management strategy for the Reserve is still being formulated and key research to inform the strategy is on-going. Preliminary findings from a recently completed investigation into the avian and invertebrate value of wet and dry reedbeds supports the creation of more wet reedbed habitat on the Reserve. From a management resource standpoint, wet reedbed is preferred because long-term fewer resources are required to maintain a healthy stand of *P. australis* i.e. wet reedbed is less prone to invasion by mangal, climbers and terrestrial grasses.

Mangal is another major habitat type. Generally mangal requires minimal management attention; however climbers need to be removed particularly from mature mangrove trees to promote their health and growth.

In some instances, the presence of either reedbed and mangal can give rise to conflict with a conservation aim for an individual *gei wai* / pond or BMZ. For example, where large expanses of open water are needed in the brackish waterbird roosts, or where mangal vegetation is invading reedbed.

2.4.1.1 Brackish *gei wai* (BGW)

2.4.1.1.1 *Relevant biodiversity management zones and intentions*

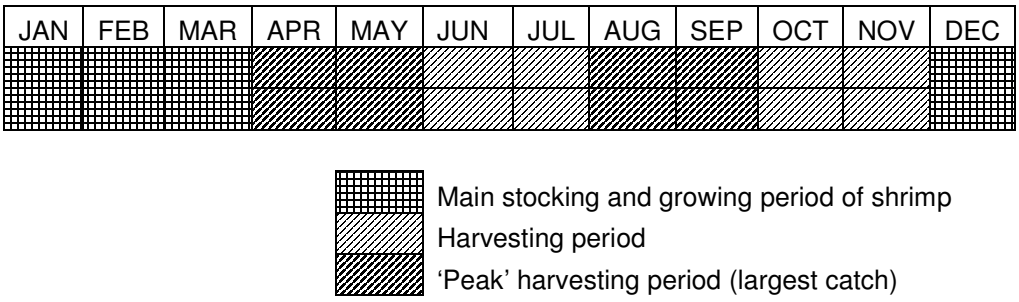
- BMZ 3 (*Gei wai* #12, #13, #14, #18 and #19). In the medium term, to maintain traditionally managed production *gei wai* with areas of mangrove vegetation.
- BMZ 2 (*Gei wai* #8b, #10 and #11b). In the medium term, to adjust conditions in favour of supporting a substantial block of reedbed habitat.

2.4.1.1.2 *Background / rationale*

The Mai Po *gei wai* were constructed in the 1940s and although many were converted to smaller fishpond units in the 1980s and 1990s, a handful remain inside the MPNR. These are now the only traditionally managed *gei wai* for rearing shrimp and fish in Hong Kong, and one of few remaining in the region.

The traditional system of *gei wai* aquaculture operation relies on the natural productivity of the Bay, and not only helps to maintain the ecological value of MPNR but has cultural benefits too. The operation includes the flushing in of shrimp larvae from the Bay from late autumn onwards and regular draining and reflooding (exchange) throughout the year to maintain water quality and appropriate growth conditions for the shrimp (Figure 3). Regular exchange of the water in the *gei wai* is also necessary to prevent mangrove trees from 'drowning' and serves to stabilize the salinity of the water for shrimps (Wong 1986) i.e. reduce the impact of continuous evaporation (which raise the salinity) and heavy downpours (which lower the salinity). Other benefits from regular water exchange include flushing away pollutants, and enhancing both oxygen content and the amount of nutrients in the water (Wong 1986). Under traditional management, *gei wai* operators exchanged *gei wai* water at least on a fortnightly basis, but adopted a shorter interval if *gei wai* water quality was poor. The quantity of water exchanged during each 'flush' was dictated by the existing quality of water in the *gei wai*, tide conditions in the Bay and time of year. In some instances almost all *gei wai* water was exchanged exposing the *gei wai* floor for a short period of time.

Figure 3. Traditional shrimp farming cycle in the Mai Po *gei wai* (source: Wong 1986).



Gei wai shrimp are no longer commercially harvested. Under conservation management, the shrimp (and fish) are now provided to waterbirds by sequentially draining the *gei wai* down across the dry season. As the water level drops in each *gei wai*, the fish and shrimps inside become concentrated in the shallow pools of water and so are available to piscivorous waterbirds. To prevent the loss of potential waterbird food items from the *gei wai* during the release of water, a net should be placed across the sluice gate. This practice (called 'drawdown') is highly beneficial to waterbirds and is now a major ecological function of traditionally managed *gei wai*. Research has shown over 1,100 waterbirds can be attracted onto a single *gei wa*i under drawdown. Maximum species counts are; 288 *P. minor*, 378 Great Egret (*Ardea alba*), 251 Little Egret (*Egretta garzetta*), 251 Grey Heron (*Ardea cinerea*) and 212 Great Cormorant (*Phalacrocorax carbo*) (WWF-HK data).

Drawdown can be compared to the traditional practice of harvesting which typically took place in the mid-dry season for a one-week period (Wong 1986). Another traditional practice is to 'sun-bake' the *gei wai* floor after harvesting i.e. oxidize the mud sediments after discharging all the water. This practice has been, and will be, continued by WWF-HK.

The *gei wai* contain large areas of mangal and reedbed. Mangal supports a unique community of wildlife that adds to the ecological value of the Ramsar Site. Reedbeds are of high ecological value, especially large contiguous stands such as those in *Gei wai* #8b, #10 and #11. Their ecological value can be maintained through regular intervention such as desilting the reedbed floor, cutting and

removal of reed and summer flooding. The latter two management techniques also serve to extend the time period between large-scale desilting operations. A reedbed strategy is still being devised for the Reserve with ongoing field studies to inform the strategy. Preliminary findings suggest more wet reedbed could be created and that wet reedbed requires significantly less frequent intervention than drier reedbeds. For example the 2.0 hectare wet reedbed created in *Gei wai* #8b in 2006 is still in favourable condition and likely to be so for many more years. Conversely the drier areas of reedbed that were cut in *Gei wai* #8b and *Gei wai* #10, were re-invaded by climbers one to two years later.

The *gei wai* require active management to ensure they retain their ability to rear shrimp and fish for the piscivorous waterbirds. WWF-HK is keen to follow traditional practices when operating the *gei wai* and will replicate as far as is practicable the 'old ways'.

Channels and internal areas need to be desilted periodically to improve the flow of water (necessary for efficient water exchange and drawdown) and maintain the volume of water available to shrimp and fish. This serves to facilitate the operation of the *gei wai*.

Research carried out by WWF-HK relevant to the management of brackish *gei wai*:

1. study into the avian value of different aged stands of *Phragmites australis* at Mai Po Nature Reserve; and
2. waterbird usage of draining *gei wai* at the Mai Po Nature Reserve (WWF-HK *in prep [d]*).

2.4.1.1.3 *Management considerations*

1. the reedbed in *Gei wai* #14 (east) is the main area of reedbed accessible to public tours and education groups and is an important interpretation point about reedbed ecology;
2. *Gei wai* #12, #13 and #14 are key areas to deliver information about *gei wai* history and ecology to public tours and education groups. *Gei wai* #12 is the main *gei wai* used to demonstrate the process of shrimp harvesting to public tour groups in summer.;
3. drawdown of *gei wai* should be timed to coincide with weekends to allow visitors to witness the spectacle of large flocks of waterbirds feeding in the *gei wai*;
4. *Gei wai* #11a and *Gei wai* #11b are hydrologically connected. Therefore the management of the water level for the reedbed in *Gei wai* #11b must consider the needs of *Gei wai* #11a which is an important shorebird roost area in BMZ 7; and
5. some areas of habitat interface and fringe comprising reed, mangal and/or open water should be retained for habitat heterogeneity purposes. Such interfaces and assemblages can be valuable wildlife habitats in their own right.

2.4.1.1.4 *Projects*

A number of recurrent and capital work projects are prescribed (Table 16). Capital projects require heavy machinery (backhoe and bulldozer), technically difficult works may require a skillful contractor. Spoil generated from desilting works is to be placed on nearby bunds and after drying, leveled to provide a smooth surface for access and vegetation management. For guidance on the location of major works refer to Section 2.4.2.

2.4.1.1.5 *Resource dependant works*

The quantity and scale of work prescribed for the brackish *gei wai* is based on a business as usual approach and a status quo regarding financial and manpower resources. If additional resources become available other beneficial works related to the brackish *gei wai* should be considered. These are shown in Appendix 13 and include:

1. *Gei wai* #8b, #10, #11, #12, #13, #14, #18 and #19 - Remove internal earth bunds to increase the area of open water for waterbirds. Because these bunds are often invaded by the climber *M. micranthus*, their removal would reduce the annual number of man-days required to clear climbers. Bund removal work should only proceed after an acceptable off-site mud disposal solution is found;
2. *Gei wai* #10 & 11 – Desilt reedbed blocks at the seaward end of *Gei wai* #10 and central part of *Gei wai* #11 and lower the reedbed floor to create conditions for the establishment of a wet reedbed; and
3. *Gei wai* #18 – Remove the area of rank mangal and desilt to restore open water.

2.4.1.1.6 *Monitoring requirements*

Monitoring is required to assess the management targets and species indicators for the brackish *gei wai*. These include:

1. habitat mapping (extent, reedbed, mangal, open water, wet reedbed, mature mangrove trees affected by *M. micranthus*);
2. frequency of water exchange;
3. water level; and
4. waterdepth.

Further details are provided in Volume II – Sections 1 to 2.

Table 16. Brackish *gei wai* - operational objectives, outline prescriptions and projects.

Outline Prescription		Project Code / Description
Operational Objective 1 - Maintain the ecological value of the habitats within brackish *gei wai* in BMZs 2 and 3		
1.1	Cut bund vegetation	*BGW/R01 – Bund vegetation, cutting* Cut grasses, *M. micrantha* and small trees (< 9.5cm dbh) along all perimeter bunds and internal bunds during winter months according to the recommended schedule shown in Appendix 10.
1.2	Maintain open water	*BGW/R03 – Emergent vegetation, control* Control the spread of emergent vegetation, particularly *P. australis* by manual removal or by limited herbicide application to retain areas of open water. *T. angustifolia* is to be removed immediately or treated with herbicide. *BGW/C01a – Desilt channels, Gei wai #10* *BGW/C01b – Desilt channels, Gei wai #11a* *BGW/C01c – Desilt channels, Gei wai #13* Desilt the *gei wai* perimeter and cross channels in order to maintain water depth and improve waterflow. Only the northern channel is required in *Gei wai* #13.
1.3	Provide foraging opportunities for waterbirds	*BGW/R12 – Water levels, drawdown (dry season)* Sequentially drawdown all traditionally managed *gei wai* in the dry season according to the timetable shown in Appendix 9. Each drawdown should last at least seven days, but may extend to ten days if needed.
1.4	Manage water levels	*BGW/R09 – Water levels, sluice gate operation* Manage water levels according to the desired annual regime (refer to Appendix 11). This is achieved through careful operating the sluice gates at the seaward end of each *gei wai*. In *gei wai* dominated by mangal (#12, #13, #14, #18 and #19), the operational water level is generally constant throughout the year. Exceptions are in summer months; *Gei wai* #14 is lowered to reduce flooding of the Education Centre access track; *Gei wai* #12, #13, #18 and #19 raised to provide more favourable conditions (i.e. deeper and cooler water) for *gei wai* shrimp. In *gei wai* containing reedbed the aim is to raise water levels during the summer to reduce the spread of unwanted grasses (e.g. *Echinochloa* sp.) and climbers. The period for raising water levels is three months in #8b to accommodate research activities in autumn, and only six weeks in *Gei wai* #11b to ensure *Gei wai* #11a is available to migratory shorebirds. Water levels in *Gei wai* #10 should remain relatively high throughout the year.
1.5	Maintain water and sediment quality	*BGW/R10 – Water quality, water exchange* Carry out water exchange in all *gei wai* on a fortnightly basis as dictated by suitable tides. Nets should be placed across the sluice gates to prevent loss of fish and shrimp during outflow, and used on *Gei wai* #8b, #10 and #11b to prevent mangrove tree seedlings from entering during inflow. *BGW/R13 – Sediment quality, sun-bake* At the end of drawdown, remove all remaining water and sun-bake the floor of the *gei wai*. The number of sun-baking days varies, and is determined by following the general principle that the total number of days (drawdown plus sun-baking) should not exceed 14.

Table 16. Brackish *gei wai* - operational objectives, outline prescriptions and projects. *(cont.)*

Outline Prescription		Project Code / Description
Operational Objective 1 - Maintain the ecological value of the habitats within brackish *gei wai* in BMZs 2 and 3		
1.6	Remove predatory fish species	*BGW/R20 – Predatory fish, control* Remove predatory fish species from each *gei wai* especially Lady Fish (*Elops saurus*) by manual methods at the end of drawdown (*BGW/R12*) and at least once per month during water exchange (*BGW/R10*) particularly in summer months.
1.7	Manage climbers in mangrove tree stands	*BGW/R15a – Invasive climbers, control (manual)* Control the spread of climbers, e.g. *D. trifoliata* and *M. micrantha* on mangrove trees by cutting and uprooting. Aftermath flooding may be used to suppress climber regrowth. Cutting should avoid main flowering periods. Optimum work periods are June to July for *D. trifoliata*, August to November for *M. micrantha* i.e. prior to their main flowering periods. *BGW/R15b – Invasive climber, control (planting C. manghas)* On a small-scale trial basis, plant *C. manghas* on bare areas of internal bunds in *Gei wai* #12/#13 to reduce *M. micrantha* dominance.
1.8	Cut reedbed	*BGW/C05a – Cut reedbed, Gei wai #8b* *BGW/C05b – Cut reedbed, Gei wai #10* Drain down the existing two hectare wet reedbed in *Gei wai* #8b, cut and remove *P. australis*, then reflood after *P. australis* has begun to reshoot. Cut and remove *P. australis* from the dry reedbed in *Gei wai* #10. Small trees and shrubs (< 9.5cm dbh), including mangrove species, are to be removed. Cutting is only required once within the five-year planning period.
Operational Objective 2 - Enhance the ecological value of the habitats within brackish *gei wai* in BMZs 2 and 3		
2.1	Create wet reedbed conditions	*BGW/C04a – Desilt reedbed, Gei wai #8b* *BGW/C04b – Desilt reedbed, Gei wai #10* *BGW/C04c – Desilt reedbed, Gei wai #14 (east)* Desilt the reedbed and lower the reedbed floor to create conditions for the establishment of a wet reedbed. These three projects aim to enhance 3.3 hectares of existing reedbed in those *gei wai*.

2.4.1.2 Brackish waterbird roosts (BWR)

2.4.1.2.1 *Relevant biodiversity management zones and intentions*

- BMZ 1 (*Gei wai* #3, #4, #6 and #7). In the medium term, to adjust conditions in favour of supporting higher numbers of the Black-faced Spoonbill.
- BMZ 5 (*Gei wai* #16/17). In the medium term, to adjust conditions in favour of creating an open, tidal area with fringing reeds and mangroves, shingle or tree-topped islands and pools/channels with varying sizes, heights and depths that can act as a secure high-tide roost for wintering waterfowls.
- BMZ 7 (*Gei wai* #11a, #21, #22a and #22b). To maintain as an open high-tide roosting site as an alternative to *Gei wai* #16/17.

2.4.1.2.2 *Background / rationale*

Nine *gei wai* inside MPNR have been modified since 1986 to provide roosting habitat for waterbirds. Internal modification has included the creation of extensive areas of shallow water and the construction of islands of varying shapes and heights above the waterline, operational modification has included manipulation of water levels for target waterbirds species or groups.

The brackish waterbird roosts are designed and operated to provide roosting and loafing habitat to:

1. wintering *P. minor*, particularly during their inactive foraging periods (daytime);
2. migratory shorebirds in spring and autumn during high-tide conditions in Deep Bay; and
3. wintering ducks, particularly during high tide conditions in Deep Bay.

The roosts also offer safe disturbance-free conditions at night hence are often used by large numbers of waterbirds overnight. *Gei wai* #16/17 in particular is known to attract ducks and shorebirds, especially when there is an overnight high tide.

Due to the migratory nature of the target species, most roosts are multifunctional across the seasons. For example *Gei wai* #16/17 is managed as a shorebird roost during the peak migration periods in spring and autumn, and managed as a duck roost throughout winter. The primary function of each roost is shown in Figure 4.

Regular maintenance and occasional enhancement of the interior of roost are both necessary in order to optimize their attractiveness to the target species. The retention of open water is important, but requires high effort because the shallow water conditions required by waterbirds to roost are prone to invasion by emergent vegetation.

Larger scale works typically involve the clearance of vegetation - sometimes with heavy machinery - to retain areas of open water, and repairs to eroded islands. Perimeter channels need to be desilted periodically to improve the flow of water (necessary for efficient water exchange and drawdown) and/or to prevent invasion of emergent vegetation from bund margins, particularly *P. australis*. The roosting islands in several brackish waterbird roosts were successfully enhanced in recent years through re-profiling however they are now more prone to erosion due to their low height (~10cm above the operational water level) and therefore require more frequent repair.

The *gei wai* are to be drained in the wet season to provide foraging opportunities to Ardeids. Drawdown in the wet season is a relatively new management practice and its introduction follows successful trials held in 2009 which recorded over 1,000 waterbirds on draining *gei wai*, including peak counts of 576 *E. garzetta* , 547 *A. alba*, 70 Black-crowned Night Heron (*Nycticorax nycticorax*) and 35 Chinese Pond Heron (*Ardeola bacchus*) (WWF-HK data). To prevent the loss of potential waterbird food items from the *gei wai* during drawdown, a net should be placed across the sluice gate.

Although drawdown in the wet season is not a traditional practice, it adds ecological value to the brackish waterbird roosts. As a summer activity, there is need to minimize the effect of heat stress on aquatic organisms. This is to be achieved by limiting the drawdown period to three days, with an option to sun-bake the *gei wai* floor for a further two days should the weather be cool enough.

Gei wai #3, #4, #6 and #7 form BMZ 1 and are collectively managed to provide a roost and loafing site for *P. minor*. The Zone is the most important roost area in Hong Kong for this species and has attracted up to 366 individuals (12 December 2006, WWF-HK data). Peak usage generally occurs during the middle part of the day.

The *Gei wai* #21 waterbird roost was constructed between 2008-2009 with the specific purpose to provide a large alternative roost site for waterbirds should *Gei wai* #16/17 be under maintenance during a critical period for waterbirds.

Gei wai #22 is operated as an inter-tidal *gei wai* from November to March. This is achieved through permanent removal of the sluice boards from the sluice gate. The rise and fall of water each day attracts foraging waterbirds and provides temporary roost habitat.

Research carried out by WWF-HK relevant to the management of brackish waterbird roosts:

1. trial on improvements to the high-tide roosting habitat for migratory waterbirds at *Gei wai* #16/17 Mai Po Nature Reserve (Anon 2006a);
2. waterbird usage of a newly created brackish shallow water high-tide roost in *Gei wai* #21 (WWF-HK *in prep [b]*); and
3. waterbird usage of inter-tidal *gei wai* at the Mai Po Nature Reserve (WWF-HK *in prep [e]*).

2.4.1.2.3 *Management considerations*

1. The brackish waterbird roosts can attract waterbird species/groups other than those for which they were designed or are being managed (Figure 5). For example *Gei wai* #3, #4, #6 and #7 are being managed for *P. minor*, but attract up to 800 duck in mid-winter and monitoring data indicates an increasing trend. Where possible, management should accommodate these additional species/groups provided their presence or any management activity implemented for their benefit, does not negatively impact upon or restrict management for target species/groups.
2. *Gei wai* #11a and #11b are hydrologically linked, therefore management decisions at the *Gei wai* #11a roost must consider the needs of the reedbed in *Gei wai* #11b.
3. The brackish waterbird roosts support the largest breeding population of Black-winged Stilt (*Himantopus himantopus*) in Hong Kong. The islands in *Gei wai* #16/17 and *Gei wai* #21 are core nesting areas. A small breeding population of Greater Painted Snipe (*Rostratula benghalensis*) is known from *Gei wai* #16/17.
4. Grasscutting work should not be carried out at any waterbird roost site during peak migration periods when there is a high-tide in the Bay.

Figure 4. Illustration showing the target waterbird groups / species for management at the brackish waterbird roosts at the Mai Po Nature Reserve.

Gei wai	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
#3, #4, #6 & #7				Black-faced Spoonbill								
#11a		Shorebird							Shorebird			
#16/17		Shorebird				Duck			Shorebird			
#21		Shorebird				Duck			Shorebird			
#22a-b					Black-faced Spoonbill*							
					Herons and egrets*							

*** - and foraging**

Figure 5. Illustration showing other waterbird groups / species that benefit from existing management operations on the brackish waterbird roosts at the Mai Po Nature Reserve.

Gei wai	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
#3, #4, #6 & #7					Duck							
#11a					Shorebird (Night)							
					Black-faced Spoonbill (Day/Night)							
#16/17					Shorebird (Night)					Black-winged Stilt (breeding)		
#21					Duck					Black-winged Stilt (breeding)		
					Cormorant (Day)							

2.4.1.2.4 *Projects*

A number of recurrent and capital work projects are prescribed (Table 17). Capital projects require heavy machinery (backhoe and bulldozer), technically difficult works may require a skillful contractor. Spoil generated from desilting works is to be placed on nearby bunds and after drying, leveled to provide a smooth surface for access and vegetation management. For guidance on the location of major works refer to Section 2.4.2.

The northern and southern ends of *Gei wai* #23 are to be hydrologically separated. This follows field trials on the *gei wai* conducted between 2010-2012 (WWF-HK *in prep [c]*) to investigate the feasibility of supporting rain-fed habitat. Based on that trial and subsequent discussion, separation will improve water-level control in the southern 3.94 ha area (*Gei wai* #23a) for roosting waterbirds (it also serves to benefit reddbed habitat in the eastern end).

The construction of new waterbird roosting islands and repairs to existing ones should follow designs already being used on the brackish waterbird roosts and seek guidance from the WWF-HK report on improvements to the *Gei wai* #16/17 high-tide roost (Anon 2006a).

2.4.1.2.5 *Resource dependant works*

The quantity and scale of work prescribed for the brackish waterbird roosts is based on a business as usual approach and a status quo regarding financial and manpower resources. If additional resources become available other beneficial works related to the brackish waterbird roosts should be considered. These are shown in Appendix 13 and include: -

1. *Gei wai* #3, #4, #6 and #7 - Remove internal earth bunds to increase the area of open water for waterbirds, particularly *P. minor*. Because these bunds are often invaded by the climber *M. micranthus*, their removal would reduce the annual number of man-days required to clear climbers. Bund removal work should only proceed after an acceptable off-site mud disposal solution is found; and
2. *Gei wai* #3, #4, #6 and #7 - Remove small stands of mangrove trees/shrubs or individual shrubs from areas closest to the Border Fence Road to facilitate the movement of waterbirds and lessen the potential for birds to flush should a disturbance occur from road users.

2.4.1.2.6 *Monitoring requirements*

Monitoring is required to assess the management targets and species indicators for the brackish shallow water ponds. These include (further details are provided in Volume II – Sections 1 to 2): -

1. habitat mapping (reedbed, mangal, open water, mature mangrove trees affected by *M. micranthus*);
2. frequency of water exchange;
3. water level; and
4. waterdepth.

Table 17. Brackish waterbird roosts - operational objectives, outline prescriptions and projects.

Outline Prescription		Project Code / Description
Operational Objective 3 - Maintain the ecological value of the habitats within the brackish waterbird roosts in BMZs 1, 5 and 7		
3.1	Cut bund and island vegetation	*BWR/R01 – Bund vegetation, cutting* Cut grasses, *M. micrantha* and small trees (< 9.5cm dbh) along all perimeter bunds and internal bunds during winter months according to the recommended schedule shown in Appendix 10. The bunds of BMZ 1 are an exception and are cut in late September, prior to the arrival of the wintering Black-faced Spoonbills. *BWR/R02 – Island vegetation, cutting* Cut all vegetation on islands in *Gei wai* #16/17 and #21 in March (prior to the arrival of shorebirds), in July (post *H. himantopus* breeding season and prior to the arrival of shorebirds) and in late September (prior to the arrival of wintering ducks). *Gei wai* #23a (created under project BWR/C06) islands, to be cut in March and late September. Cutting to follow the recommended schedule shown in Appendix 10.
3.2	Maintain open water	*BWR/R03 – Emergent vegetation, control* Control the spread of emergent vegetation, particularly *P. australis* by manual removal or by limited herbicide application to retain areas of open water. All *T. angustifolia* is to be removed immediately or treated with herbicide. *BWR/C01a – Desilt channels, Gei wai #3* *BWR/C01b – Desilt channels, Gei wai #22* Desilt the perimeter channels in order to improve waterflow and prevent vegetation encroachment from bund margins. Only the northernmost channels are required in *Gei wai* #3. *BWR/C03 – Desilt gei wai floor, Gei wai #21* *Gei wai* #21, remove emergent vegetation from the landward end of the *gei wai* by desilting to maintain the area of open water.
3.3	Provide foraging opportunities to waterbirds	*BWR/R12a – Water levels, drawdown (wet season)* Sequentially drawdown all brackish waterbird roost *gei wai* in the wet season according to the timetable shown in Appendix 9. Each drawdown should last no longer than three days, then the *gei wai* is either sun-baked (*BWR/R11*) or refilled immediately. *BWR/R12b – Water levels, inter-tidal gei wai* *Gei wai* #22 to be operated as inter-tidal from 01 November to 31 March each year. (Appendix 11)
3.4	Manage water levels	*BWR/R09 – Water levels, sluice gate operation* Manage water levels according to the desired annual regime (Appendix 11) for the target waterbird groups or species. This is achieved through careful operation of the sluice gates at the landward end of each *gei wai*.

Table 17. Brackish waterbird roosts - operational objectives, outline prescriptions and projects. (*cont.*)

Outline Prescription		Project Code / Description
Operational Objective 3 - Maintain the ecological value of the habitats within the brackish waterbird roosts in BMZs 1, 5 and 7		
3.5	Maintain water and sediment quality	*BWR/R10 – Water quality, water exchange* Carry out water exchange in all brackish waterbird roost *gei wai* on a fortnightly basis as dictated by suitable tides. Nets should be placed across the sluice gates to prevent mangrove tree seedlings from entering the *gei wai* during inflow. *BWR/R13 – Sediment quality, sun-bake* At the end of drawdown, remove all remaining water and sun-bake the floor of the *gei wai*. The total number of days (drawdown plus sun-baking) should not exceed five days.
3.6	Remove predatory fish species	*BWR/R18 – Predatory fish, control* Remove predatory fish species from each *gei wai* especially *E. saurus* by manual methods at the end of drawdown (*BWR/R12a*) and on a needs basis during water exchange (*BWR/R10*).
3.7	Manage climbers in mangrove tree stands	*BWR/R15 – Invasive climbers, control (manual)* Control the spread of climbers, e.g. *D. trifoliata* and *M. micrantha* from mangrove trees in *Gei wai* #3, #4, #6 and #7 by cutting and uprooting. Aftermath flooding may be used to suppress climber regrowth. Optimum work periods are June to July for *D. trifoliata*, August to November for *M. micrantha* i.e. before their main flowering periods.
Operational Objective 4 - Enhance the ecological value of the habitats within the brackish waterbird roosts in BMZs 5 and 7		
4.1	Create/repair Islands	*BWR/C09a – Build islands, Gei wai #16/17* *BWR/C09b – Build islands, Gei wai #21* *Gei wai* #16/17; repair the two eroded large islands (known as Islands '2' and '3'), construct two new small-sized islands close to Hide #5, and remove stands of emergent vegetation from the landward end of the *gei wai*. *Gei wai* #21; construct a medium-sized low height island (~10cm above the waterline) at the landward end of the *gei wai*.
Operational Objective 5 - Increase the area of brackish waterbird roosts in BMZs 5 and 7		
5.1	Increase the area of brackish waterbird roosts	*BWR/C06 – Construct earth bund sections, Pond #23* Construct two sections of earth bund to hydrologically separate the northern section from the southern section. The southern end will become *Gei wai* #23a and managed as a brackish waterbird roost. This project aims to increase the area of brackish waterbird roost on the Reserve by 3.9ha.

2.4.1.3 Rain-fed habitats (RFH)

2.4.1.3.1 *Relevant biodiversity management zones and intentions*

- BMZ 4 (Ponds #15a, #15b, #15c, #16a, #16b, #17a and #17b)
  In the long-term, to maintain and improve the Education Centre and its associated waterfowl collection.
- BMZ 6
  - (Ponds #8a, #9, #20, #22 and #23). In the medium term, to adjust conditions in favour of creating an open freshwater roosting area with fringing reeds and mangroves, shingle or tree-topped islands and pools/channels with varying sizes, heights and depths.
  - (Pond #24). In the medium term, to adjust conditions in favour of creating a series of freshwater lakes of varying depth with surrounding areas of marsh.

2.4.1.3.2 *Background / rationale*

In the late-1990s, a project was initiated within the MPNR to create 'freshwater' habitat in an attempt to attract freshwater associated species, particularly Odonates into the Reserve, and replace former habitats that once existed in the Mai Po area, but were lost to development. For example the site over which the present Fairview Park housing estate now stands, used to be a freshwater marsh that was of particular interest because it was the last known breeding site for the Pheasant-tailed Jacana (*Hydrophasianus chirurgus*) in Hong Kong, as well as being a breeding site for the now scarce Watercock (*Gallicrex cinerea*) (Webster 1979).

In recent decades the water quality in Deep Bay has been poor (Section 2.2.2.3.1), hence the rain-fed habitats provide cleaner less polluted aquatic environments within the Reserve. An additional benefit is the removed threat of siltation originating from sediment in the bay water.

The rain-fed habitats require active management to maintain their attractiveness to wildlife. In the absence of management, aquatic vegetation, particularly aggressive species such as *P. australis* and sedges, would dominate at the expense of open water habitat. A continued accumulation of organic material would ultimately result in the ponds drying out and a loss in their ecological value. Similar to fishponds, the rain-fed habitats can become stagnated if water is not exchanged periodically, and sediment can become nutrient enriched if not periodically sun-baked.

A variety of different rain-fed habitats is found at the Reserve including buffalo grazed marshland, shallow water ponds with islands for roosting/breeding waterbirds, and attractive 'water-lily ponds'. Management requirements vary according to type.

Ponds #16a and #17a will be managed as seasonal rain-fed habitat on a trial basis and set aside for a possible series of freshwater vegetation establishment trials.

Research carried out by WWF-HK relevant to the management of rain-fed habitats:

1. trials to improve the roosting habitat for wintering waterfowl in Ponds #20 and #24 at Mai Po Nature Reserve (Anon 2006);
2. study upon the wildlife impact and potential economic habitat management benefits of introducing Asian Water Buffalo *Bubalus bubalis* into the freshwater ponds at Mai Po Nature Reserve (WWF-HK 2008);
3. freshwater pond vegetation management trial using Asian Water Buffalo *Bubalus bubalis* at Mai Po Nature Reserve (WWF-HK 2012a); and
4. waterbird usage of a rain-fed pond following conversion from brackish (WWF-HK *in prep [c]*).

2.4.1.3.3 *Management considerations*

1. Pond #20 is an important roost site for ducks supporting up to 5,300 individuals (January 2007, WWF-HK data);
2. *H. himantopus* has been known to nest in Ponds #8a, #15a, #15b and Pond #17b in summer;
3. in winter, *P. minor* regularly use the shallow water areas and islands in Pond #8a as an overnight roost. Flocks containing up to 150 individual have been recorded (WWF-HK data);
4. during high-tide periods in spring and autumn, small flocks of migratory shorebirds occasionally roost in Pond #8a;

5. Pond #24 is ring-fenced to contain a small herd of Asian Water Buffalo;
6. to facilitate water level management, a network of 'L-pipes' is installed (Appendix 4);
7. over 80% of Odonata at MPNR emerge by the end of May (WWF-HK data), therefore ponds should only be drained for summer management operations from June onwards;
8. areas/features important for education and public visits:
    - Pond #8a in front of the Tower Hide;
    - Pond #16b ('water-lily pond') and Pond #17b (a buffalo grazed pond);
    - the *P. carbo* roost on trees along the eastern boundary of Pond #15; and
    - the Education Centre duck ponds (Ponds #15a-b) supporting up to 100 ducks; and
9. after periods of heavy rain, the water level in Pond #16b needs to be quickly lowered so the boardwalk and platforms can be used by visitors / school groups.

2.4.1.3.4 *Projects*

A number of recurrent and capital work projects are prescribed (Table 18). Capital projects require heavy machinery (backhoe and bulldozer), technically difficult works may require a skillful contractor. Spoil generated from desilting works is to be placed on nearby bunds and after drying, leveled to provide a smooth surface for access and vegetation management. For guidance on the location of major works refer to Section 2.4.2.

Over the course of the previous two management plans *Gei wai* #18 and #19 only partially satisfied the management intention of BMZ 5 which is to provide secure high-tide roost for wintering waterfowls. This was mainly due to lack of open water, enclosed conditions and close proximity to visitor paths. In addition, due to the narrow linear shape of both *gei wai*, the landward ends suffer from poor drainage during water exchange. To optimize their ecological value, overcome management problems and benefit surrouding rain-fed habit (through connectivity of BMZ 4 and BMZ 6), the eastern and western ends are to be hydrologically separated. The interiors of the rain-fed eastern ends (to be renamed as Pond #18a and Pond #19a) will be enhanced through vegetation management.

The northern and southern ends of *Gei wai* #23 are to be hydrologically separated. This follows field trials conducted in the *gei wai* between 2010-2012 (WWF-HK *in prep [c]*) to investigate the feasibility of supporting rain-fed habitat. Based on that trial and subsequent discussion, separation will allow higher water levels to be set at the northern 7.73 ha end (*Gei wai* #23b) to benefit the large *P. australis* stand.

2.4.1.3.5 *Resource dependant works*

The quantity and scale of works prescribed for the rain-fed habitats is based on a business as usual approach and a status quo regarding financial and manpower resources. If additional resources become available, an extra work item is the restoration of the reedbed in Pond #23b (currently the northern section of Pond #23), as shown in Appendix 13. This would involve lowering the pond floor by removing silt and allowing a wet reedbed to establish. This work may not be required if the water-level in Pond #23b can be successfully raised and sustained following its hydrological separation from *Gei wai* #23a (OP5.1, project *BWR/C06*).

2.4.1.3.6 *Monitoring requirements*

Monitoring is required to assess the management targets and species indicators for the rain-fed habitats. These include: -

1. habitat mapping (extent, open water, reedbed, mangal, wet reedbed); and
2. water quality (salinity).

An additional monitoring action is to assess the quality of water in several of the rain-fed habitats to inform decisions related to project *RFH/C02*. This is required annually in early summer.

Further detail on these is provided in Volume II – Sections 1 to 2.

Table 18. Rain-fed habitats - operational objectives, outline prescriptions and projects.

Outline Prescription		Project Code / Description
Operational Objective 6 - Maintain the ecological value of the rain-fed habitats in BMZs 4 and 6		
6.1	Cut bund and island vegetation	*RFH/R01 – Bund vegetation, cutting* Cut grasses, *M. micrantha* and small trees along all rain-fed habitat bunds between May to November according to the recommended schedule shown in Appendix 10. In Pond #20, bund vegetation is to be cut at least twice each year, once in April and again in late September, in order to suppress grass growth and provide areas of short grass prior to the arrival of wintering waterfowl. *RFH/R02 – Island vegetation, cutting* Cut all vegetation on islands in Ponds #8a, #15a, #15b and #17a according to the recommended schedule shown in Appendix 10. Cutting in the first half of the year is to prepare the islands for roosting shorebirds or nesting *H. himantopus*, cutting in the second half is to create suitable roost conditions for ducks and *P. minor* prior to their arrival. Herbicide may be applied after cutting to suppress vegetation regrowth. Islands in Pond #17b may require cutting if buffalo grazing is insufficient.
6.2	Maintain open water	*RFH/R03 – Emergent vegetation, control* Control the spread of emergent vegetation by manual removal or mechanical removal, by limited herbicide application, or by introducing Grass Carp (*Ctenopharyngodon idellus*), to retain areas of open water. Note, *C. idellus* requires flowing water to spawn hence cannot breed in the ponds. Ponds #8a and #16b are both shallow water ponds and especially prone to vegetation colonization e.g. stands of Coastal Bulrush (*Scirpus subulatus*) and encroaching *P. australis*. *T. angustifolia* is to be removed immediately or treated with herbicide. *RFH/C01 – Desilt channels, Pond #16b* Desilt perimeter channel sections to prevent vegetation encroachment from pond margins and to maintain the area of open water. Within the five-year planning period, two desilting operations are required, each clearing 50% of the channel lengths.
6.3	Maintain water and sediment quality	*RFH/R10 – Water quality, water exchange* On a needs basis, remove nutrient rich or poor quality water from a pond and allow it to re-fill with rainwater during summer months. Ponds used by large numbers of waterbirds e.g. Ponds #15 and Pond #20 are a priority and may need annual flushing. If water quality deteriorates to an unacceptable level in winter, water is to be flushed out, and then replaced with cleaner water from a neighbouring rain-fed habitat or the rain storage pond (#15c). *RFH/C02 – Desilt pond floor, Pond #20* On a needs basis (based on water and sediment quality), desilt the six smaller pond units (a - f). Fully drain the pond unit in summer to expose the mud floor, bulldoze the dry mud to facilitate oxidization and the reduction of nutrient levels, and then re-fill with rainwater.

Table 18. Rain-fed habitats - operational objectives, outline prescriptions and projects. (*cont.*)

Outline Prescription		Project Code / Description
Operational Objective 6 - Maintain the ecological value of the rain-fed habitats in BMZs 4 and 6		
6.3	Maintain water and sediment quality (*cont.)*	*RFH/C08a – Modify earth bund sections, southern perimeter MPNR* Raise the height of the perimeter bund around the southern part of the Reserve to prevent overtopping by water from the Fairview Nullah during storms/floods. Priority is the perimeter bund of Pond #24. Levelling surveys are required beforehand. *RFH/C08b – Modify earth bund sections, Pond #15b* Raise the height of the innermost section of the perimeter bund in Pond #15b to prevent *P. carbo* faeces from the roost directly entering the waterbody. Height to be determined in relation to the winter operational water level.
6.4	Manage water levels	*RFH/R11 – Water levels, L-pipes/pumping* Manage water levels according to the desired annual regime. Water is moved in or out by either mechanical pumping or using the 'L-pipe' network. Regimes vary according to type of habitat and are pond specific (Appendix 11); however a commonality is for high water level in summer to prevent vegetation encroachment. Exceptions are: - 1. Pond #8a. Low water level in spring to encourage roosting by migratory shorebirds, low in early summer to encourage nesting by *H. himantopus*; 2. Pond #15a-b. Low water level in early summer if *H. himantopus* nest on the islands; 3. Pond #17b. Low water level during summer to create seasonal wet grassland habitat and encourage vegetation growth to increase the amount of buffalo fodder for the following winter; and 4. Pond #23. Low water level in early summer to encourage *H. himantopus* to nest. Water levels generally fall through the winter dry season due to evapo-transpiration and natural leakage. Under such condition, and dependent upon availability, water will need to be moved from another pond to 'top-up' the level e.g. from the rain storage pond (#15c)
6.5	Remove predatory fish species	*RFH/R20 – Predatory fish, control* Remove predatory fish species especially *Oreochromis* spp. and Spotted Snakehead (*Channa maculata*) by manual methods. Catfish (*Clarias fuscus*) are known to burrow holes into earth bunds which can lead to leakages, therefore if any are captured in the nets, they are to be removed. This is achieved by pumping out water to a neighbouring rain-fed habitat, catching the fish with nets, and then re-filling by pumping water back in. The process takes around three days and is typically carried out in mid-winter to minimise any impact to Odonata.

Table 18. Rain-fed habitats - operational objectives, outline prescriptions and projects. (*cont.*)

Outline Prescription		Project Code / Description
Operational Objective 6 - Maintain the ecological value of the rain-fed habitats in BMZs 4 and 6		
6.6	Control the population of Golden Apple Snail	*RFH/R14 – Golden Apple Snail, control* Control the population of the non-native *P. canaliculata* in summer/autumn months by removing adults and eggs. Adults must be removed from the pond, eggs can be removed or alternatively scraped off vegetation and allowed to drop into the water. Pond #16b is a priority for management due to heavy infestation, other ponds to be managed on a needs basis. During peak infestation periods or in bad years, clearance may be necessary on a weekly basis.
6.7	Manage grazed compartments	*RFH/R07 – Vegetation, grazing* Graze Pond #17b and Pond #24 with Asian Water Buffalo. The size of the grazing herd in Pond #24 is currently four; it is to be increased gradually pending observation of their impact to the pond environment and wildlife. Pond #17b is designed to hold up to two livestock in summer, however this may need to be reduced to one animal in winter months if natural fodder material is limited.
Operational Objective 7 - Enhance the ecological value of the rain-fed habitats in BMZs 4 and 6		
7.1	Create seasonal rain-fed habitat	*RFH/C08c – Modify earth bund sections, Pond #24* Reduce the height of several internal bunds to create conditions for wet grassland habitat to establish in the wet season. Pond #24c will be converted to seasonal wet grassland by removing *P. australis* (cutting / mechanical methods). *RFH/R29 – Seasonal rain-fed pond, trial (Ponds #16a and #17a)* On a trial basis, manage Ponds #16a and #17a as seasonal rain-fed habitat. Both ponds are to be filled with rainwater during the wet season and topped up with brackish water (from Pond #16/17) during the dry season on a needs basis.
7.2	Provide food for Anatidae	*RFH/R08 – Emergent vegetation, planting* Plant Barnyard millet (*Echinochloa crus-galli*) into selected areas in Pond #20. *E. crus-galli* is a grass species palatable to ducks (Anon 2006b). *RFH/R21 – Supplementary feeding (ducks)* Limited feeding of grain to the wintering ducks in Ponds #15a and #15b. Carried out twice daily; 09:00 and 16:00 hours.
7.3	Create wet reedbed conditions	*RFH/C04a – Desilt reedbed, Pond #18a* *RFH/C04b – Desilt reedbed, Pond #19a* Reedbed areas within both ponds are to be enhanced through the removal of invading vegetation and by lowering sections of the pond floor. These two projects aim to enhance 1.1 hectares of existing reedbed in those Ponds.

Table 18. Rain-fed habitats - operational objectives, outline prescriptions and projects. (*cont.*)

Outline Prescription		Project Code / Description
Operational Objective 8 - Increase the area of rain-fed habitat in BMZs 4 and 6		
8.1	Increase the area of rain-fed habitat	*RFH/C06a – Construct earth bund sections, Ponds #18a* *RFH/C06b – Construct earth bund sections, Pond #19a* Construct earth bund sections to hydrologically separate portions of the eastern ends of *Gei wai* #18 and *Gei wai* #19 from the western ends. The eastern ends (total = 11.7 ha) will become Ponds #18a and Ponds #19 and managed as rain-fed habitat. *RFH/C07 – Remove earth bund sections, Pond #15a* Remove one length of bund between Pond #15a and Pond #15b. This is to hydrologically connect those ponds to improve management operations and facilitate Anatidae movement between the two ponds (similar bund removal work was undertaken in Pond #15 in the 1980s to improve conditions for Anatidae).

2.4.1.4 Inter-tidal mudflat (IMF)

2.4.1.4.1 *Background / rationale*

An area of inter-tidal mudflat in front of the floating bird observation hides has been managed by WWF-HK since 1986 to maintain an open area for waterbirds to roost and feed. The works involve the manual clearance of mangrove tree seedlings and control of encroaching grasses (e.g. *Paspalum* spp.) and sedges (e.g. *Schoenoplectus* spp.) with limited herbicide application.

2.4.1.4.2 *Monitoring requirements*

The total number of wintering waterbirds using the 45ha area is reported to Government as a general indicator of the success of the works. Further detail is provided in Volume II – Sections 1 to 2.

Table 19. Inter-tidal mudflat - operational objective, outline prescription and project.

Operational Objective 9 - Maintain an area of inter-tidal mudflat suitable for roosting and feeding waterbirds		
Outline Prescription		**Project Code / Description**
9.1	Clear vegetation	*IMF/R03 – Emergent vegetation, control* Annually clear vegetation from a 45ha area of mudflat in front of the floating bird observation hides. To avoid disturbing wintering waterbirds, the works are to take place in autumn and be completed by the end of October.

2.4.1.5 *Gei wai* landscape (GWL)

2.4.1.5.1 *Background / rationale*

The natural landscape was radically changed when the original mangal was converted to *gei wai* starting in the 1940s. In the following decades all the land on which the MPNR current sits was under commercial shrimp production and it is generally considered by WWF-HK that during this time period a 'traditional' *gei wai* landscape existed.

Historical photographs show the traditional physical landscape was one of low profile and dominated by large areas of open water with stands of mangal, particularly mangrove trees. The photos show the original *gei wai* to be characteristically rectangular, up to ~10ha in area, separated by earth bunds several metres wide. These earth bunds were kept open and generally unvegetated to facilitate access by fishermen along them.

Various artefacts associated with the period of commercial shrimp production e.g. *gei wai* huts, sluice gates for draining and flooding the *gei wai* are still very evident inside the Reserve, and are an important part of the experience by visitors.

WWF-HK is keen to maintain a traditional *gei wai* landscape at the Reserve, provided it does not conflict with conservation goals. Particular attention will be given to the traditionally managed *gei wai* in BMZ 3. An important component of the original landscape and one that relates to the achievement of the conservation goals is tree management.

After construction of the Closed Area Fence road in the early 1980s, the bunds were used less by fishermen and eventually became vegetated with grasses and trees (Section 2.2.2.2.2). The cessation of regular burning of bund vegetation in the early 1980's (D.S. Melville *pers. comm.*) also allowed vegetation to establish. The placement of silt on the bunds has further encouraged trees to establish. Today, many bund sections are lined by mixes of *M. azedarach*, *Ficus* spp., *M. tanarius* and *Sapium* spp. trees. Figure 6 illustrates how a typical *gei wai* bund has changed due to tree establishment. Figure 7 illustrates the typical profile found today along a *gei wai* bund.

Figure 6. Photographs showing the landscape at the Mai Po Nature Reserve in a) the 1980s and b) in 2013.

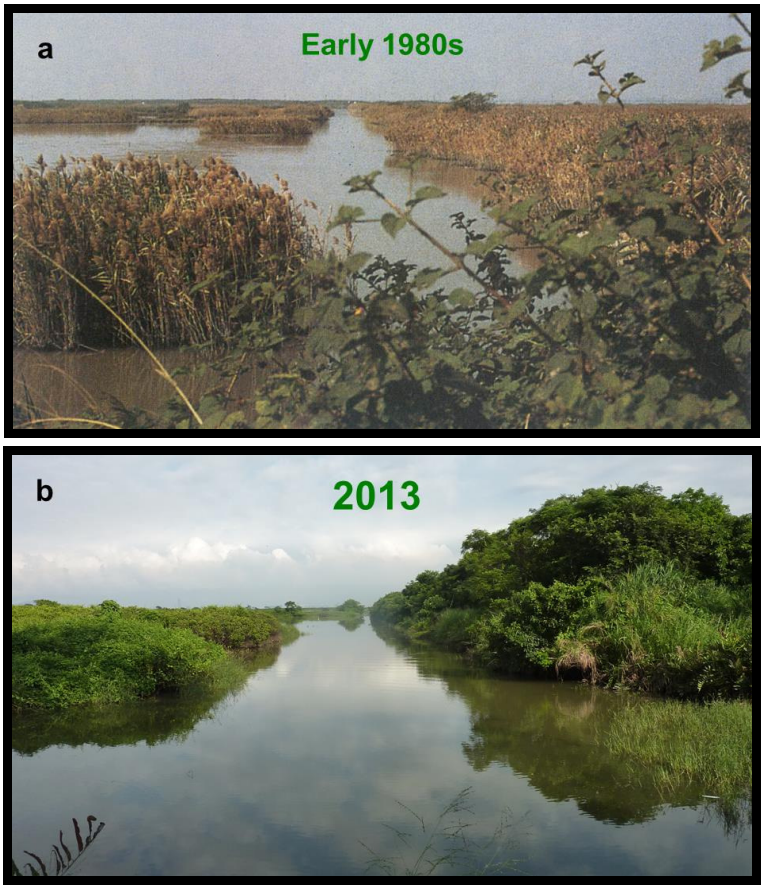
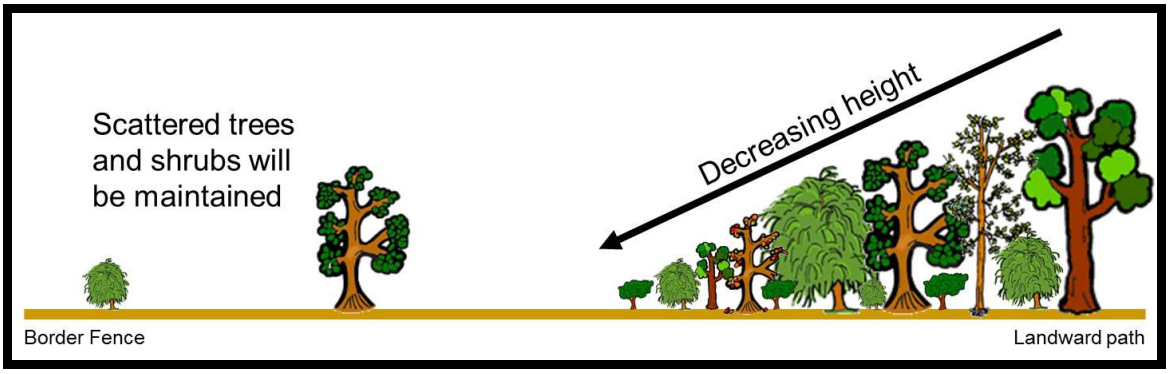
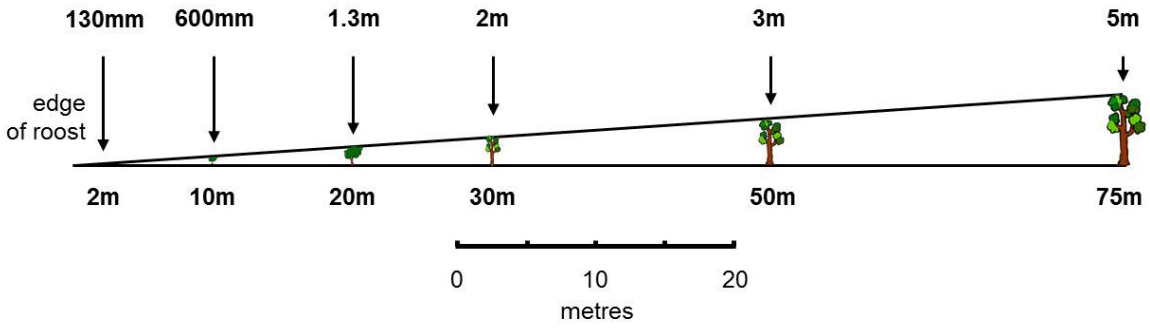


Figure 7. Diagram showing a typical vegetation profile along a typical *gei wai* bund at the Mai Po Nature Reserve.



The existing terrestrial trees along the bunds and paths at the Reserve fulfil a number of important roles. Among the many benefits, trees provide food to frugivorous birds, act as roosts for many bird species, act as a visual screen to reduce disturbance to wildlife, support a variety of invertebrates and provide shade to visitors. For these reasons, a number of trees have been planted at the Reserve; in 1976 with *C. equisetifolia* (to mark the boundary of the Reserve) and since 1985 with *M. tanarius* (for shelter), and *F. microcarpa* (as a food source for wildlife), However, if the MPNR were to become too forested, there would be an adverse impact on the migratory waterbirds for which the Reserve is important. Tall trees in particular can affect flight lines and within a *gei wai* / pond create 'enclosed' conditions whereby avian predators may be concealed in the trees. For example, observation of shorebirds using *Gei wai* #16/17 showed that as the perimeter bunds became more forested in the early 1990s, fewer shorebirds began to roost at high tide. When the tall trees were removed in 1996, the shorebirds returned again. The adverse impact of tall vegetation on the number of waterbirds using roost sites has also been found in Australia, where Lawler (1995) stated that "…roosts need to be open areas…with 30m buffer to visual obstructions of 2m height (wider if obstructions are higher)…" (Figure 8).

Figure 8. Relationship between distance to and height of visual barriers at a shorebird roost, expressed as an angle (Source: Lawler 1995).



There is thus a need to strike a balance on the Reserve between the benefits and problems associated with trees. It is recommended to devise a tree management strategy including a tree database and monitoring plan if resources allow. Such a strategy should not only consider management prescriptions, but also staff training in order to raise the arboriculture work standards.

In the absence of a formal tree management strategy, the current general practice will continue (outlined below, projects listed in Table 20) and appropriate reference made to Figure 8 for decisions related to waterbird roosts:

1. manage the height and lateral growth of the trees along the western two thirds of the bunds to create an open low profile landscape;
2. maintain the height of the trees on the eastern one third of the bunds at around 6m;
3. manage the height and lateral growth of the trees close to waterbird roosts;
4. manage trees so they do not obstruct earthmoving operations in *gei wai* or ponds e.g. prevent mud from being placed on bunds;
5. trees alongside footpaths will be managed so their branches do not obstruct the footpaths or the view from birdwatching hides nor pose a safety threat to visitors or site infrastructure;
6. manage trees along the perimeter bunds of traditionally managed *gei wai* in BMZ 3 to promote the growth of mangal underneath;

7. any saplings found along the bunds with a diameter at breast height of < 9.5 cm will be removed;
8. where possible, management will avoid trees regularly used by roosting *P. carbo*, birds of prey and *C. torquatus*;
9. invasive non-native tree species such as *Acacia spp*. will be removed; and
10. less invasive non-native trees such as *E. robusta*, *M. azedarach* and *C. equisetifolia* will be gradually removed, and native shrubs such as Hong Kong Hawthorn (*Rhaphiolepis indica*) planted in their place.

Figure 9. Tree management areas in the Mai Po Nature Reserve; a) along the western two-thirds of the Reserve (green), and b) in or close to waterbird roost areas (red).

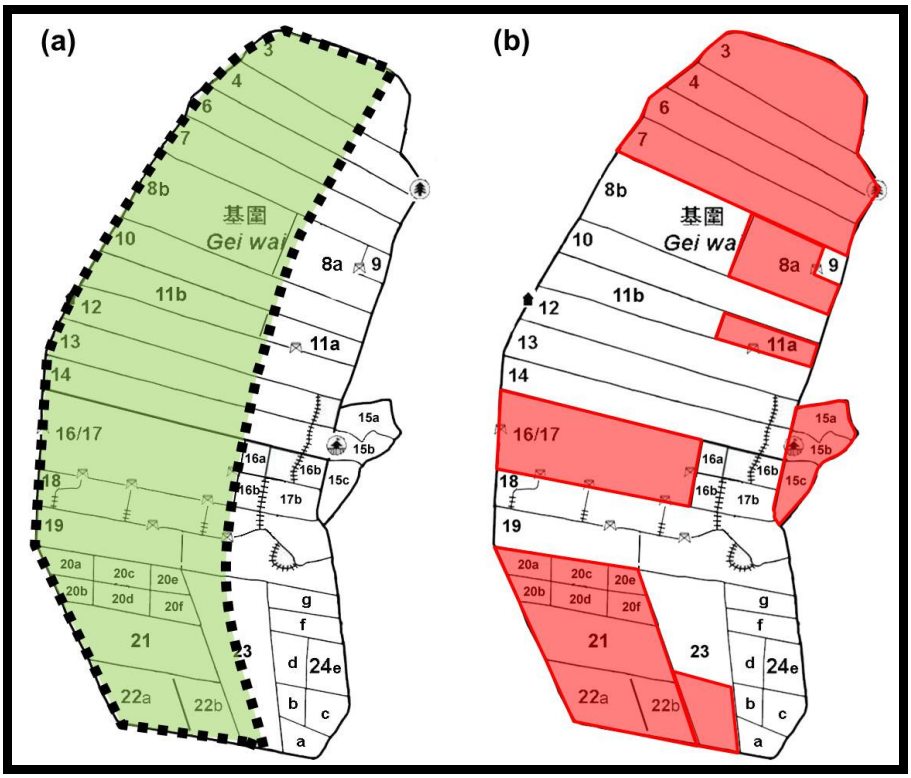


Table 20. *Gei wai* landscape - operational objective, outline prescriptions and projects.

Operational Objective 10 - Maintain a low profile tree landscape		
Outline Prescription		**Project Code / Description**
10.1	Trim trees	*GWL/R04 – Trees, trim (landscape)* Annually trim trees in the identified tree management areas to manage their height and lateral growth, and remove all saplings with a dbh < 9.5cm. *GWL/R05a – Trees, trim (visitor paths)* Trim overhanging tree branches along all visitor paths. *GWL/R05b – Trees, trim (overhanging mangrove trees)* Trim tree branches overhanging mangal along perimeter bunds of *gei wai* in BMZ 3.
10.2	Remove non-native tree species	*GWL/R16 – Non-native trees/shrubs, remove* Remove non-native tree species and replace with native shrubs. Priority to invasive species. It is expected that such tree management work will be small-scaled so as to minimize any impacts to wildlife.
10.3	Tree management strategy	*GWL/A01 – Tree management strategy, prepare* Prepare a strategy to guide all tree management decisions at the Reserve.

2.4.1.6 Additional activities (AA)

2.4.1.6.1 *Additional activities – site management*

Additional activities are required to achieve the conservation goals for the Reserve. These activities are generic and often reserve-wide (Table 21).

2.4.1.6.2 *Resource dependant works*

The quantity and scale of the additional works are both based on a business as usual approach and a status quo regarding financial and manpower resources. If additional resources become available removal of the desilted material being stored along the many *gei wai* and pond perimeter bunds (Section 2.2.2.2.3) should be considered. This will involve height and width reduction of the bunds. Because these bunds are often invaded by the climber *M. micranthus*, their removal would reduce the annual number of man-days required to clear climbers. Bund removal work should only proceed after an acceptable off-site mud disposal solution is found.

Table 21. Additional activities - operational objectives, outline prescriptions and projects.

Operational Objective 11 - Carry out additional site management activities		
Outline Prescription		**Project Code / Description**
11.1	Control non-native invasive species	*AA1/R17 – Imported Red Fire Ant, control* Control the spread of *S. invicta* by treating active mounds with an approved granular insecticide. Apply only if rain is not forecast in the following days. Land areas used by roosting and/or nesting waterbirds are a priority for treatment. Application is focused on three main periods in the year: 1. late September and early October before the arrival of wintering birds; 2. late March and early April before *H. himantopus* nest; and 3. July and August if resources allow. *AA1/R18 – Invasive plants, control* Control the spread of *L. camara* and *W. triloba* – by manual cutting and removal.
11.2	Tree/shrub planting and aftercare	*AA1/R23 – Gei wai #7 bird ringing island, maintain* Maintain the planted trees and shrubs on the island in *Gei wai* #7. Tasks include occasional watering in the dry season and replacement planting; both activities required on a needs basis. *AA1/R28 – Pond #8a egretry, maintain* Maintain the planted egretry in Pond #8a. Tasks include occasional watering in the dry season, and replacement planting of the trees or bamboo die; both activities required on a needs basis.
11.3	Maintain features or areas important for education-related activities	*AA1/R25 – Butterfly garden, maintain* Maintain the small butterfly garden beside the Education Centre. Tasks include frequent watering of the shrubs and plants in the dry season, and the regular removal of weeds. *AA1/R26 – Education Centre pond, maintain* Maintain the small pond beside the entrance to the Education Centre. Tasks include periodic exchange of water, removal of *P. canaliculata* and transplanting aquatic vegetation and vegetation control. *AA1/R27 – Visitor paths/facilities, maintain* Cut vegetation obscuring the view from bird observation hides and along visitor footpaths according to the recommended schedule shown in Appendix 10.
11.4	Repair leaking bunds and sluice gates	*AA1/R29 – Leaking bunds and sluice gates, repair* Repair all leaks at the sluice gates and between the bunds of all *gei wai* and ponds on a needs basis. Major repairs will require mini-digger or backhoe assistance.

Table 21. Additional activities - operational objectives, outline prescriptions and projects. (*cont.*)

Operational Objective 11 - Carry out additional site management activities		
Outline Prescription		**Project Code / Description**
11.5	Clear vegetation along FCA inlet channels	*AA1/R06 – Shrubs, trim (FCA inlet channels)* Trim vegetation along the sides of the FCA inlet channels connected to the *gei wai*. This is to facilitate *gei wai* operations by maintaining the flow of water to and from the *gei wai*. Vegetation along each channel, particularly overhanging branches, is to be trimmed from both sides at least once within the planning period.
11.6	Reduce disturbances to wildlife	*AA1/R19a – Feral dogs, control* Operate the five walk-in cages on a daily basis. Cages are to be baited and checked twice daily. To increase capture rate, cages should be periodically placed close to locations frequented by feral dogs. *AA1/R19b – Feral dogs, liaise with AFCD Animal Management Division* Liaise with the AFCD Animal Management Division to facilitate their operations to capture feral dogs. Detailed information on dog locations and identification to be given to the Division. *AA1/R24 – Natural screens, planting* Plant native shrubs and grasses e.g. Guinea Grass (*Panicum maximum*) along the side of the *gei wai* / ponds adjacent to: 1. the Border Road to screen the relevant compartments from users of the road; 2. the Fairview Nullah, to act as a screen against disturbance along the footpath that runs round the southern part of MPNR; and 3. the main visitor path beside Pond #8a to act as a screen against disturbance from visitors. Shrubs will require aftercare, tasks include occasional watering in the dry season and replacement planting; both activities required on a needs basis. *AA1/R30 – Liaise, helicopter operators* Regular liasion with the major helicopter operators if activities are excessive or cause a disturbance to waterbirds roosting inside the Reserve.

Table 21. Additional activities - operational objectives, outline prescriptions and projects. (*cont.*)

Operational Objective 12 - Fulfil all legal and non-legal obligations		
12.1	Comply with legal obligations	*AA2/R31 - Comply with legal obligations* Adhere to all legislation that affects the management of MPNR, such as: 1. Wild Animals Protection Ordinance (Cap. 170); 2. Forestry and Countryside Ordinance (Cap. 96); 3. Town Planning Ordinance (Cap. 131); 4. Environmental Impact Assessment Ordinance (Cap. 499); 5. Water Pollution Control Ordinance (Cap. 358); 6. Public Order Ordinance (Cap. 245); 7. Occupational Safety & Health Ordinance (Cap. 509); 8. Building Ordinance (Cap. 123); 9. Hazardous Chemical Control Ordinance (Cap. 595); 10. the Articles, recommendations and resolutions of the Ramsar Convention and the Bonn Convention on Migratory Species; 11. conditions set out in each Special Licence for the *gei wai* and ponds; and 12. and any other legal obligations.
12.2	Liaise with relevant parties	*AA2/R32 - Liaise with relevant parties* It is important to maintain dialogue and/or good working relationships with: 1. AFCD, ACE Nature Conservation Sub-committee, Districts Land Office – Yuen Long and other relevant Government Departments and bodies; 2. Government officials and departments on the Mainland, P.R.C.; 3. East Asian-Australasian Flyway Partnership; 4. Ramsar Bureau and the offices of other relevant international conventions; 5. other ENGOs, e.g. the Hong Kong Birdwatching Society; and 6. land neighbours such as fishermen and villagers. This is an on-going process and requires continued and close communication with all the above. Specific activities include: 1. quarterly site management meetings to be held with AFCD staff; 2. arrange exchange visits to MPNR for Town Planning Board and District Lands Office staff; and 3. regular meetings of the Mai Po Management Committee. Further detail on the communication and liaison requirements is provided in the Mai Po Master Plan.

Table 22. Summary table of operational objectives, outline prescriptions and project codes.

OPERATIONAL OBJECTIVE	OUTLINE PRESCRIPTIONS		PROJECT CODES
1. Maintain the ecological value of the habitats within brackish *gei wai* in BMZs 2 and 3	1.1	Cut bund vegetation	*BGW/R01*
	1.2	Maintain open water	*BGW/R03, BGW/C01a, BGW/C01b, BGW/C01c*
	1.3	Provide foraging opportunities to waterbirds	*BGW/R12*
	1.4	Manage water levels	*BGW/R09*
	1.5	Maintain water and sediment quality	*BGW/R10, BGW/R13*
	1.6	Remove predatory fish species	*BGW/R20*
	1.7	Manage climbers in mangrove tree stands	*BGW/R15a, BGW/R15b*
	1.8	Cut reedbed	*BGW/C05a, BGW/C05b*
2. Enhance the ecological value of the habitats within brackish *gei wai* in BMZs 2 and 3	2.1	Create wet reedbed conditions	*BGW/C04a, BGW/C04b,BGW/C04c*
3. Maintain the ecological value of the habitats within the brackish waterbird roosts in BMZs 1, 5 and 7	3.1	Cut bund and island vegetation	*BWR/R01, BWR/R02*
	3.2	Maintain open water	*BWR/R03, BWR/C01a, BWR/C01b, BWR/C03*
	3.3	Provide foraging opportunities for waterbirds	*BWR/R12a, BWR/R12b*
	3.4	Manage water levels	*BWR/R09*
	3.5	Maintain water and sediment quality	*BWR/R10, BWR/R13*
	3.6	Remove predatory fish species	*BWR/R18*
	3.7	Manage climbers in mangrove tree stands	*BWR/R15*
4. Enhance the ecological value of the habitats within the brackish waterbird roosts in BMZs 5 and 7	4.1	Create/repair islands	*BWR/C09a, BWR/C09b*
5. Increase the area of brackish waterbird roosts in BMZs 5 and 7	5.1	Increase the area of brackish waterbird roosts	*BWR/C06*
6. Maintain the ecological value of the rain-fed habitats in BMZs 4 and 6	6.1	Cut bund and island vegetation	*RFH/R01, RFH/R02*
	6.2	Maintain open water	*RFH/R03, RFH/C01*
	6.3	Maintain water and sediment quality	*RFH/R10, RFH/C02a, RFH/C08a, RFH/C08b*
	6.4	Manage water levels	*RFH/R11*
	6.5	Remove predatory fish species	*RFH/R20*
	6.6	Control the population of Golden Apple Snail	*RFH/R14*
	6.7	Manage the grazed compartments	*RFH/R07*

Table 22. Summary table of operational objectives, outline prescriptions and projects. (*cont.*)

OPERATIONAL OBJECTIVE	OUTLINE PRESCRIPTIONS		PROJECTS
7. Enhance the ecological value of the rain-fed habitats in BMZs 4 and 6	7.1	Create seasonal rain-fed habitat	*RFH/C08c, RFH/R29*
	7.2	Provide food for Anatidae	*RFH/R08, RFH/R21*
	7.3	Create wet reedbed conditions	*RFH/C04a, RFH/C04b*
8. Increase the area of rain-fed habitat in BMZs 4 and 6	8.1	Increase the area of rain-fed habitat	*RFH/C06a, RFH/C06b, RFH/C07*
9. Maintain an area of inter-tidal mudflat suitable for roosting and feeding waterbirds	9.1	Clear vegetation	*IMF/R03*
10. Maintain a low profile tree landscape	10.1	Trim trees	*GWL/R04, GWL/R05a, GWL/R05b*
	10.2	Remove non-native tree species	*GWL/R16*
	10.3	Tree management strategy	*GWL/A01*
11. Carry out additional site management activities	11.1	Control non-native invasive species	*AA1/R17, AA1/R18*
	11.2	Tree/shrub planting and aftercare	*AA1/R23, AA1/R28*
	11.3	Maintain features or areas important for education-related activities	*AA1/R25, AA1/R26, AA/R27*
	11.4	Repair leaking bunds and sluice gates	*AA1/R29*
	11.5	Clear vegetation along FCA inlet channels	*AA1/R06*
	11.6	Reduce disturbances to wildlife	*AA1/R19a, AA1/R19b, AA1/R24, AA1/R30*
12. Fulfil all legal and non-legal obligations	12.1	Comply with legal obligations	*AA2/R31*
	12.2	Liaise with relevant parties	*AA2/R32*

2.4.2 Desired Habitat

The distribution and areas of major habitats inside the Reserve will change over the course of the Plan. The desired state by 2018 is shown in Figure 10 and proposed area changes in Table 23. Habitat quality is not illustrated in Figure 10.

Figure 10. Habitat distribution at the Mai Po Nature Reserve in 2013 and proposed by 2018.

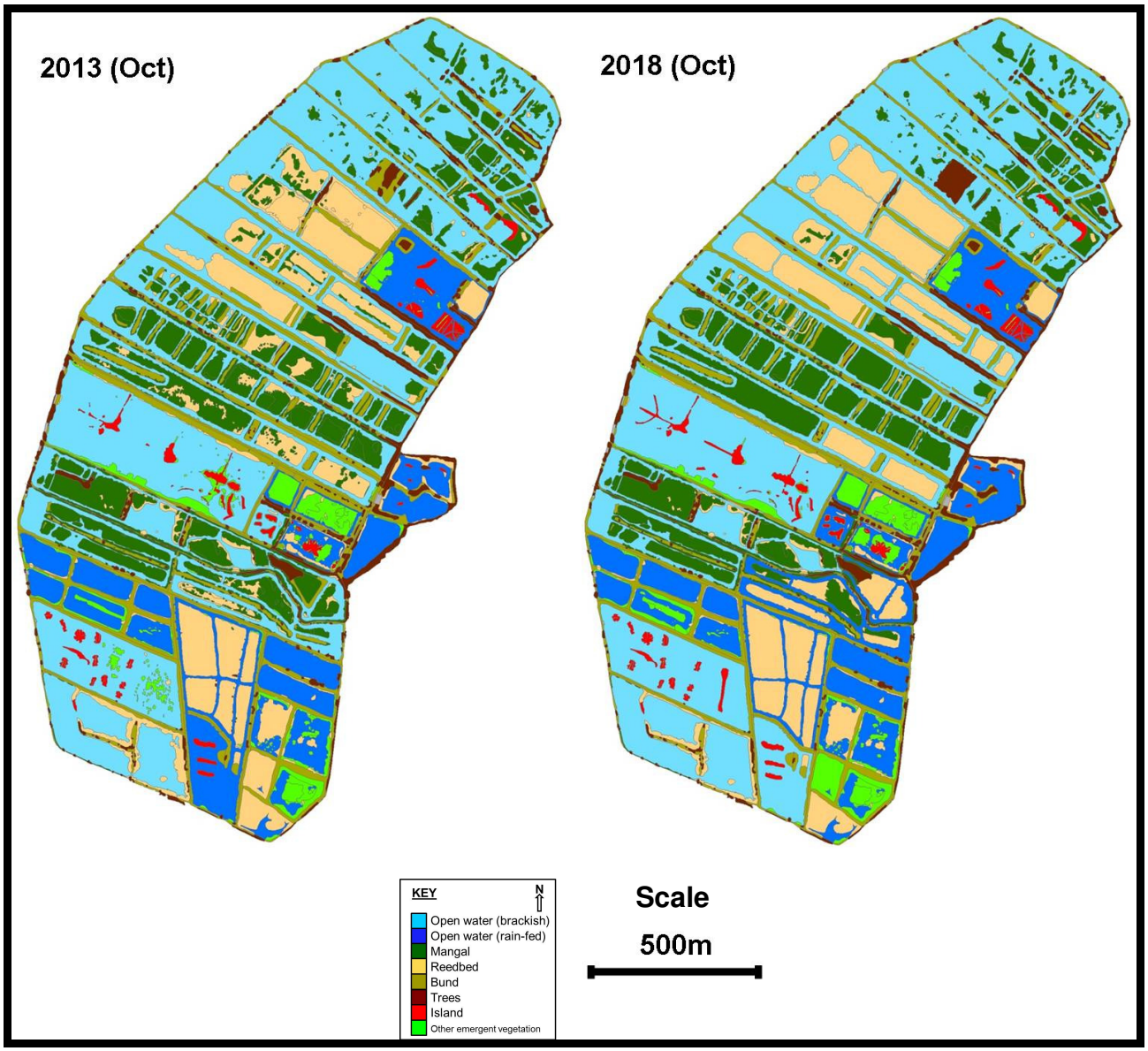


Table 23. Areas of different habitats at the Mai Po Nature Reserve in 2013 and proposed by 2018.

Habitat type	2013 Total area (ha)	2018 Total area (ha)	Area change (ha)	Area change (%)
Mangal	31.32	29.70	1.72	-5.5%
Open water (brackish)	83.18	83.35	0.48	-0.6%
Open water (rain-fed)	24.38	24.37	-0.59	+2.4%
Reedbed[a]	28.90	30.14	-1.09	+3.8%
Bunds (inc. vegetation)	36.36	35.71	0.27	-0.7%
Islands[b]	2.74	3.07	-0.29	+10.6%
Other emergent vegetation[c]	6.69	7.20	-0.51	+7.6%
TOTAL	**213.57**	**213.57**	**-**	**-**

[a] – good (pure stands of *P. australis*) and poor (various mixes of *P. australis* / climber / patches of mangal vegetation inc. ferns) quality
[b] – islands (bare and vegetated) [<50cm in height, designed for roosting waterbirds]
[c] – water-lilies, sedges, emergent grasses

3. WORK SCHEDULES AND REPORTING

3.1 FIVE-YEAR WORK SCHEDULE

The projects listed in Section 2.4.1 (and Table 22) are to be carried out over a five-year period, which extends from 01 November 2013 to 31 October 2018. They are assigned to one or more years within this period and prioritized in Table 24.

Table 24. Five-year work schedule.

Key to priorities
(1) Core projects that are essential to maintain the existing conservation and/or education value of MPNR.
(2) Important projects that should be undertaken to improve the conservation and/or education value of MPNR.
(3) Projects to improve the conservation and/or education value of MPNR that should be carried out only if resources allow.

Project Code	Feature / Project description	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Brackish *gei wai*					
BGW/R01	Bund vegetation, cutting (biannual)	1	1	1	1	1
BGW/R03	Emergent vegetation, control	1	1	1	1	1
BGW/R09	Water levels, sluice gate operation	1	1	1	1	1
BGW/R10	Water quality, water exchange	1	1	1	1	1
BGW/R11	Sediment quality, sun-bake	1	1	1	1	1
BGW/R12	Water levels, drawdown (dry season)	1	1	1	1	1
BGW/R15a	Invasive climber, control (manual)	1	1	1	1	1
BGW/R15b	Invasive climber, control (planting *C. manghas*)	3	3	3	3	3
BGW/R20	Predatory fish, control	1	1	1	1	1
BGW/C01a	Desilt channels, *Gei wai* #10					1
BGW/C01b	Desilt channels, *Gei wai* #11b			1		
BGW/C01c	Desilt channels, *Gei wai* #13	1				
BGW/C04a	Desilt reedbed, *Gei wai* #8b				1	
BGW/C04b	Desilt reedbed, *Gei wai* #10					1
BGW/C04c	Desilt reedbed, *Gei wai* #14 (east)				1	
BGW/C05a	Cut reedbed, *Gei wai* #8b				1	
BGW/C05b	Cut reedbed, *Gei wai* #10		1			
	Brackish waterbird roosts					
BWR/R01	Bund vegetation, cutting	1	1	1	1	1
BWR/R02	Island vegetation, cutting	1	1	1	1	1
BWR/R03	Emergent vegetation, control	1	1	1	1	1
BWR/R09	Water levels, sluice gate operation	1	1	1	1	1
BWR/R10	Water quality, water exchange	1	1	1	1	1
BWR/R12a	Water levels, drawdown (wet season)	1	1	1	1	1
BWR/R12b	Water levels, inter-tidal *gei wai*	1	1	1	1	1
BWR/R13	Sediment quality, sun-bake	2	2	2	2	2
BWR/R15	Invasive climber, control (manual)	2	2	2	2	2
BWR/R18	Predatory fish, control	2	2	2	2	2
BWR/C01a	Desilt channels, *Gei wai* #3			2		
BWR/C01b	Desilt channels, *Gei wai* #22		1			
BWR/C03	Desilt gei wai floor, *Gei wai* #21	1				
BWR/C06	Construct earth bund sections, Pond #23	2				
BWR/C09a	Build islands, *Gei wai* #16/17		1			
BWR/C09b	Build islands, *Gei wai* #21	1				

(cont.)

Table 24. Five-year work schedule (*cont.*).

Project Code	Feature / Project description	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
	Rain-fed habitats					
RFH/R01	Bund vegetation, cutting	1	1	1	1	1
RFH/R02	Island vegetation cutting	1	1	1	1	1
RFH/R03	Emergent vegetation, control	1	1	1	1	1
RFH/R07	Vegetation, grazing	1	1	1	1	1
RFH/R08	Emergent vegetation, planting		2			
RFH/R10	Water quality, water exchange	1	1	1	1	1
RFH/R11	Water levels, L-pipe/pumping	1	1	1	1	1
RFH/R14	Golden Apple Snail, control	1	1	1	1	1
RFH/R20	Predatory fish, control	1	1	1	1	1
RFH/R21	Supplementary feeding (ducks)	3	3	3	3	3
RFH/R29	Seasonal rain-fed pond, trial (Ponds #16a & #17a)	2	2	2	2	2
RFH/C01	Desilt channels, Pond #16b			2		2
RFH/C02	Desilt pond floor, Pond #20		1		1	
RFH/C04a	Desilt reedbed, Pond #18a					2
RFH/C04b	Desilt reedbed, Pond #19a	2				
RFH/C06a	Construct earth bund sections, Pond #18a			2		
RFH/C06b	Construct earth bund sections, Pond #19a	2				
RFH/C07	Remove earth bund sections, Pond #15a				3	
RFH/C08a	Modify earth bund sections, southern perimeter MPNR	3				
RFH/C08b	Modify earth bund sections, Pond #15b				2	
RFH/C08c	Modify earth bund sections, Pond #24				2	
	Inter-tidal mudflat					
IMF/R03	Emergent vegetation, control	1	1	1	1	1
	Landscape					
GWL/R04	Trees, trim (landscape)	1	1	1	1	1
GWL/R05a	Trees, trim (visitor paths)	1	1	1	1	1
GWL/R05b	Trees, trim (overhanging mangrove trees)	1	1	1	1	1
GWL/R16	Non-native trees/shrubs, remove	1	1	1	1	1
GWL/A01	Tree management strategy, prepare			1		
	Additional management activities					
AA1/R06	Shrubs, trim (FCA inlet channels)	1	1	1	1	1
AA1/R17	Imported Red Fire Ant, control	1	1	1	1	1
AA1/R18	Invasive non-native plants, control	1	1	1	1	1
AA1/R19a	Feral dogs, control	1	1	1	1	1
AA1/R19b	Feral dogs, liaise with AFCD Animal Management Div.	1	1	1	1	1
AA1/R23	*Gei wai* #7 bird ringing island, maintain	3	3	3	3	3
AA1/R24	Natural screens, planting	2	2	2	2	2
AA1/R25	Butterfly garden, maintain	2	2	2	2	2
AA1/R26	Education Centre pond, maintain	1	1	1	1	1
AA1/R27	Visitor paths/facilities, maintain	1	1	1	1	1
AA1/R28	Pond #8a egretry, maintain	1	1	1	1	1
AA1/R29	Leaking bunds and sluice gates, repair	1	1	1	1	1
AA1/R30	Liaise, helicopter operators	1	1	1	1	1
	Fulfil all legal and non-legal obligations					
AA2/R31	Comply with legal obligations	1	1	1	1	1
AA2/R32	Liaise with relevant parties	1	1	1	1	1

3.2 ANNUAL WORK PLAN (recurrent works)

Table 25. Annual work schedule.

Project Code	Feature / Project description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Brackish *gei wai*												
BGW/R01	Bund vegetation, cutting												
BGW/R03	Emergent vegetation, control												
BGW/R09	Water levels, sluice gate operation												
BGW/R10	Water quality, water exchange												
BGW/R11	Sediment quality, sun-bake												
BGW/R12	Water levels, drawdown (dry season)												
BGW/R15a	Invasive climber, control (manual)												
BGW/R15b	Invasive climber, control (planting *C. manghas*)												
BGW/R20	Predatory fish, control												
	Brackish waterbird roosts												
BWR/R01	Bund vegetation, cutting												
BWR/R02	Island vegetation, cutting												
BWR/R03	Emergent vegetation, control												
BWR/R09	Water levels, sluice gate operation												
BWR/R10	Water quality, water exchange												
BWR/R12a	Water levels, drawdown (wet season)												
BWR/R12b	Water levels, inter-tidal *gei wai*												
BWR/R13	Sediment quality, sun-bake												
BWR/R15	Invasive climber, control (manual)												
BWR/R18	Predatory fish, control												
	Rain-fed habitats												
RFH/R01	Bund vegetation, cutting												
RFH/R02	Island vegetation cutting												
RFH/R03	Emergent vegetation, control												
RFH/R07	Vegetation, grazing												
RFH/R08	Emergent vegetation, planting												
RFH/R10	Water quality, water exchange												
RFH/R11	Water levels, L-pipe/pumping												
RFH/R14	Golden Apple Snail, control												
RFH/R20	Predatory fish, control												
RFH/R21	Supplementary feeding (ducks)												
RFH/R29	Seasonal rain-fed pond, trial (Ponds #16a & #17a)												
	Inter-tidal mudflat												
IMF/R03	Emergent vegetation, control												
	Landscape												
GWL/R04	Trees, trim (landscape)												
GWL/R05a	Trees, trim (visitor paths)												
GWL/R05b	Trees, trim (overhanging mangrove trees)												
GWL/R16	Non-native trees/shrubs, remove												
AA1/R06	Shrubs, trim (FCA inlet channels)												
AA1/R17	Imported Red Fire Ant, control												
AA1/R18	Invasive plants, control												
AA1/R19a	Feral dogs, control												
AA1/R19b	Feral dogs, liaise with AFCD AM Unit												
AA1/R23	*Gei wai* #7 bird ringing island, maintain												
AA1/R24	Natural screens, planting												
AA1/R25	Butterfly garden, maintain												
AA1/R26	Education Centre pond, maintain												
AA1/R27	Visitor paths/facilities, maintain												
AA1/R28	Pond #8a egretry, maintain												
AA1/R29	Leaking bunds and sluice gates, repair												
AA1/R30	Liaise, helicopter operators												
AA2/R31	Comply with legal obligations												
AA2/R32	Liaise with relevant parties												

3.3 CONTROL

3.3.1 Project Recording System

Information related to each project is to be recorded and stored on a database or filed. This includes administration files (e.g. contracts), photographs, records of man-days and work dates.

3.3.2 Progress Reports

The Manager, Habitat Management and Monitoring (Manager) will report work updates to the Mai Po Management Committee at regular meetings. Prior to the commencement of the main work season in April, the Manager is to present all works for the coming 12-month period for the committee's endorsement.

3.3.3 Plan Review

From the ecological information and management records collected by reserve staff, the Manager will:

1. report management targets and species indicators;
2. review data collected through the baseline ecological monitoring programme (Volume II – Section 1.4); and
3. report findings or conclusions from on-going research projects (Volume II – Sections 6 to 9) including the effectiveness of the larger-scale habitat management works;

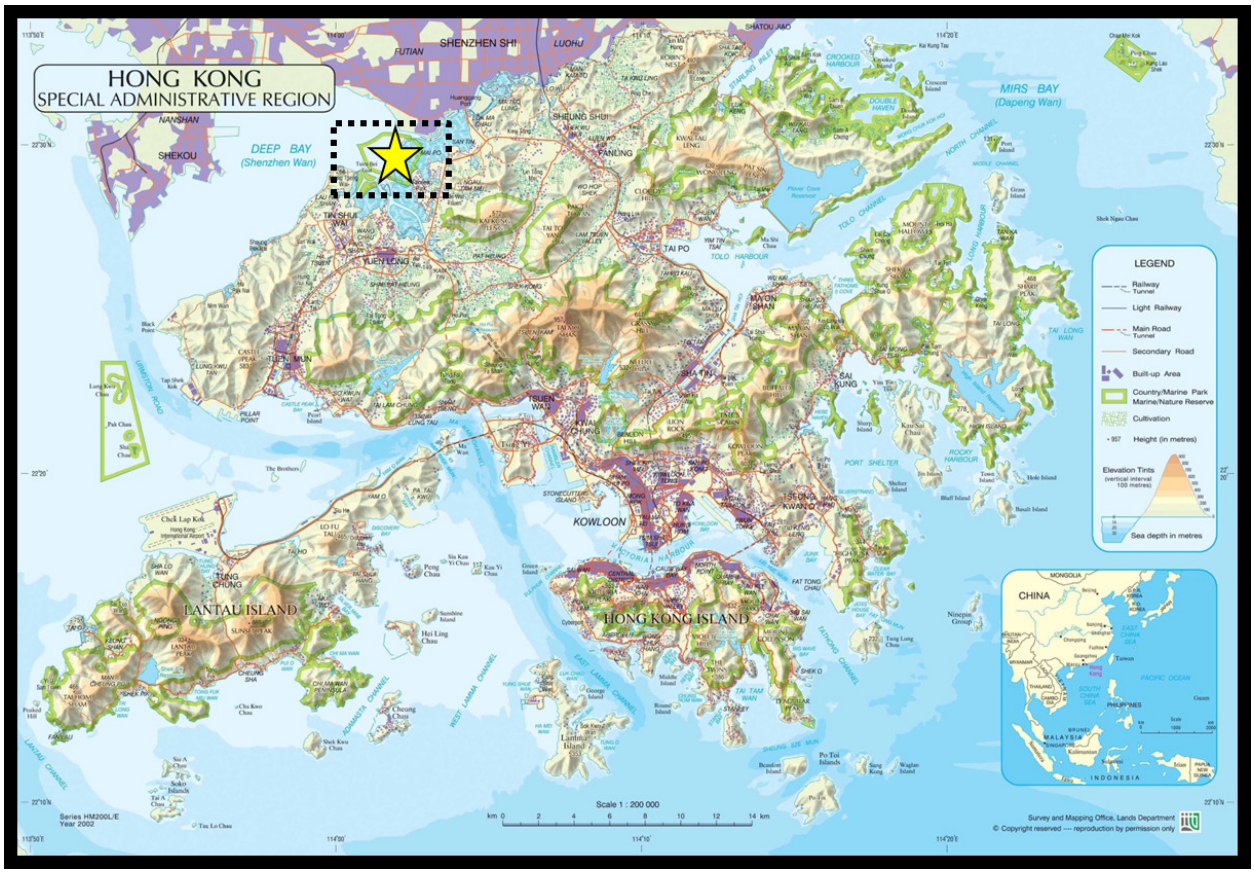
to the management committee, then upon it's advice and approval, make adaptive changes where necessary, to the Habitat Management Plan.

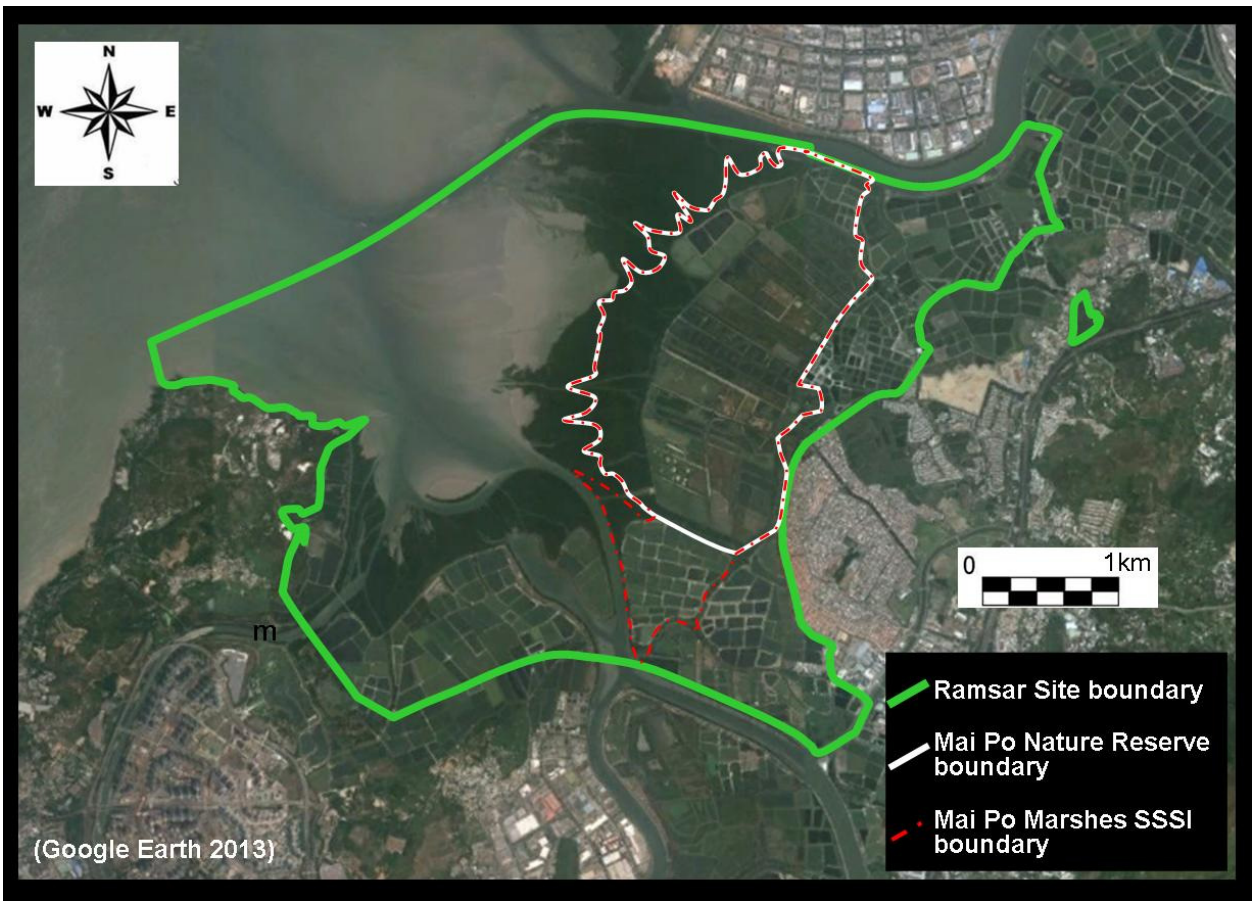
If an annual management target is not achieved, or progress towards a 2018 target is poor, the Manager will make changes to management operations at the Reserve to rectify the situation under advice from the management committee. For species indicators, a general comparison will be made against previous data (e.g. mean population, mean diversity, etc.) to analyse trends. If an undesirable trend is observed and confirmed to be related to conditions at the Reserve, under advice of the management committee, appropriate action will be taken by the Manager.

Progress against implementing the five-year work plan will be reported annually by the Manager, and assessed by the management committee.

A detailed review of this Plan will be conducted at the end of the planning period.

Appendix 1. Location map of the Mai Po Nature Reserve and the Mai Po Inner Deep Bay Ramsar Site

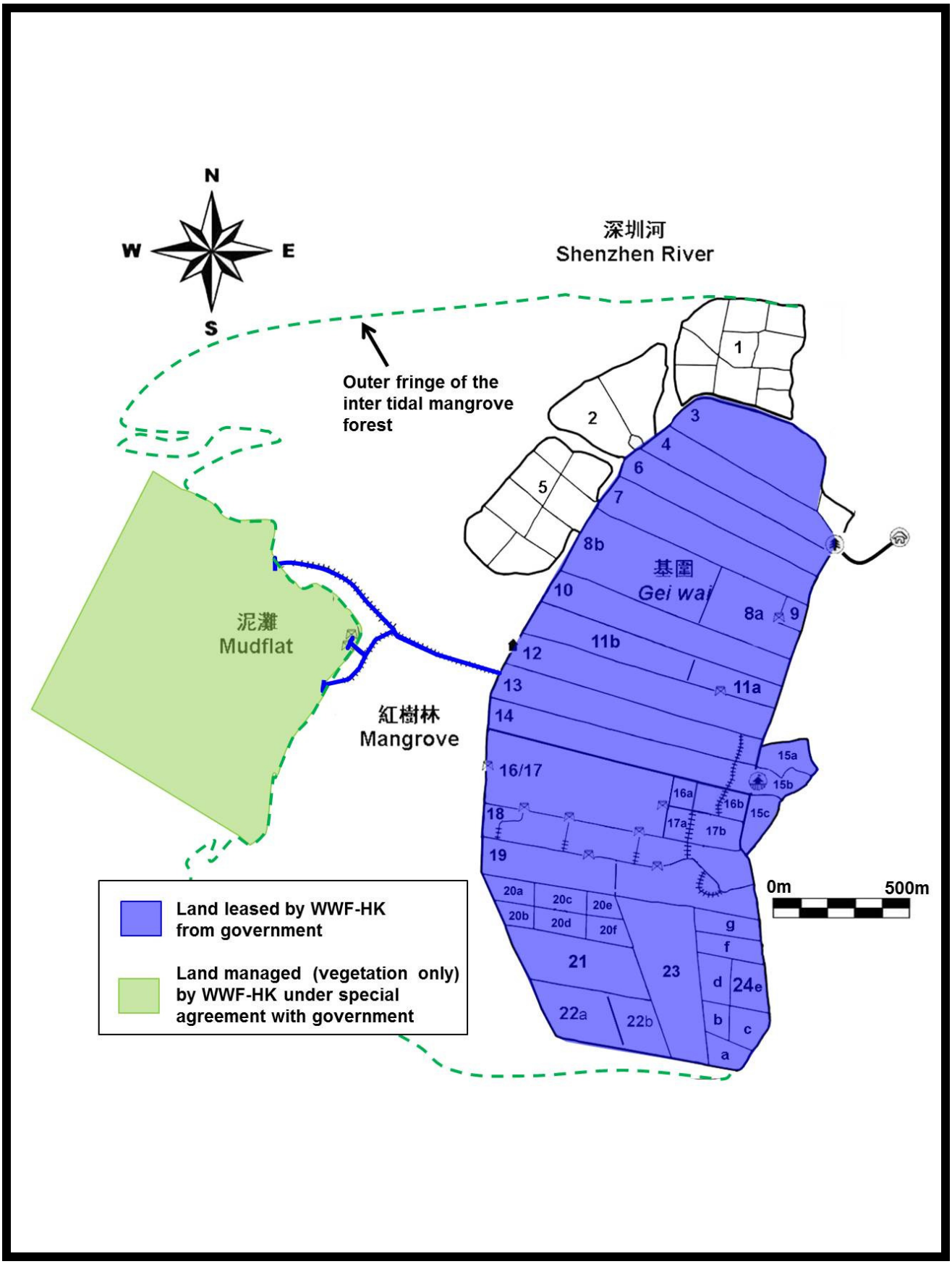




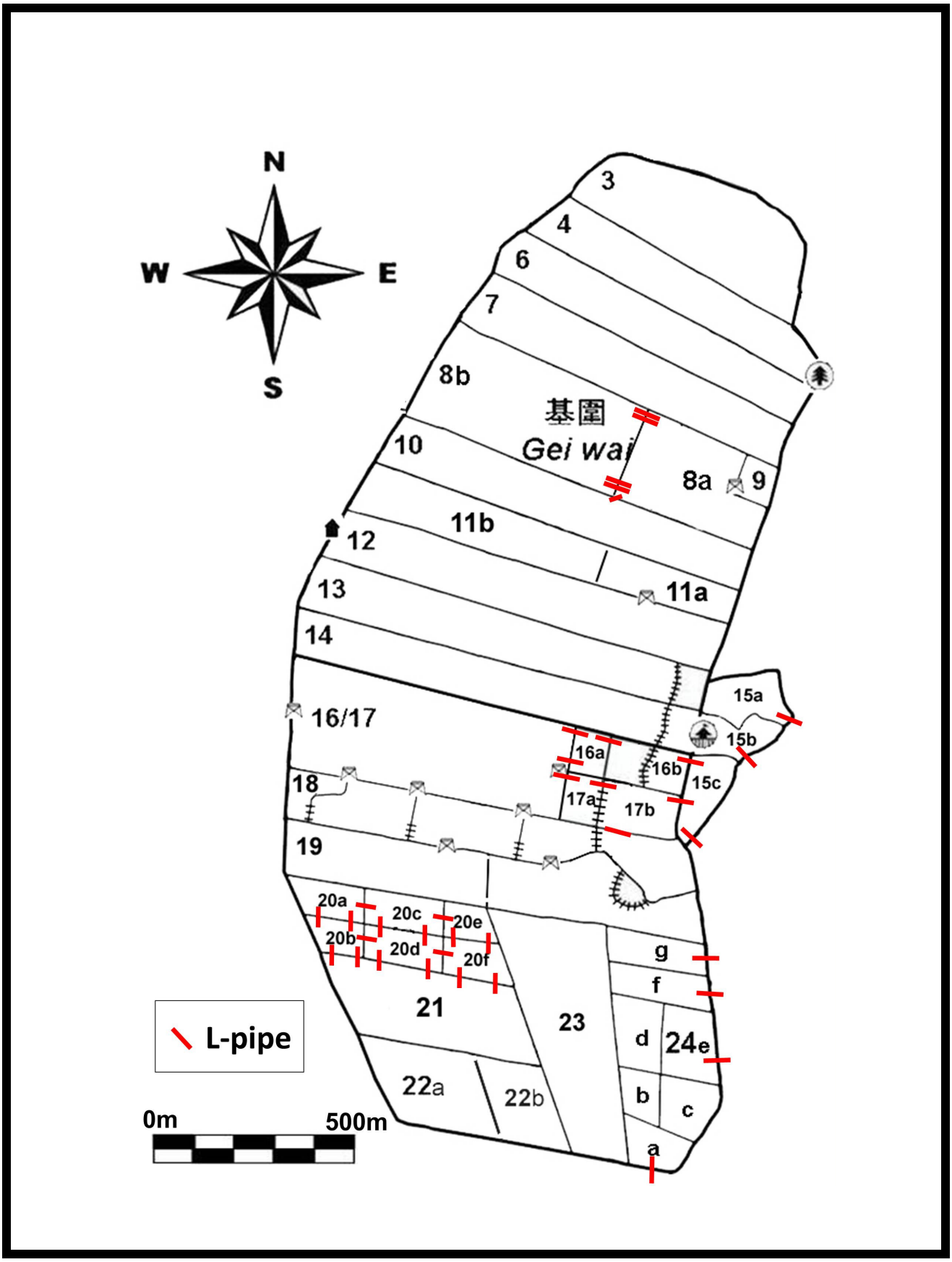
Appendix 2. Reserve map showing paths and facilities

Visitor Centre and Peter Scott Field Studies Centre	Floating Bird-watching Hide
AFCD Nature Warden Post	Main Bird-watching Hide
Mai Po Wildlife Education Centre	3-Storey Bird-watching Hide
Boardwalk	Observation Screen
Main Access Paths	Small Bird-watching Hide
Rainshelter / *Gei wai* Museum	6 — *Gei wai* Number

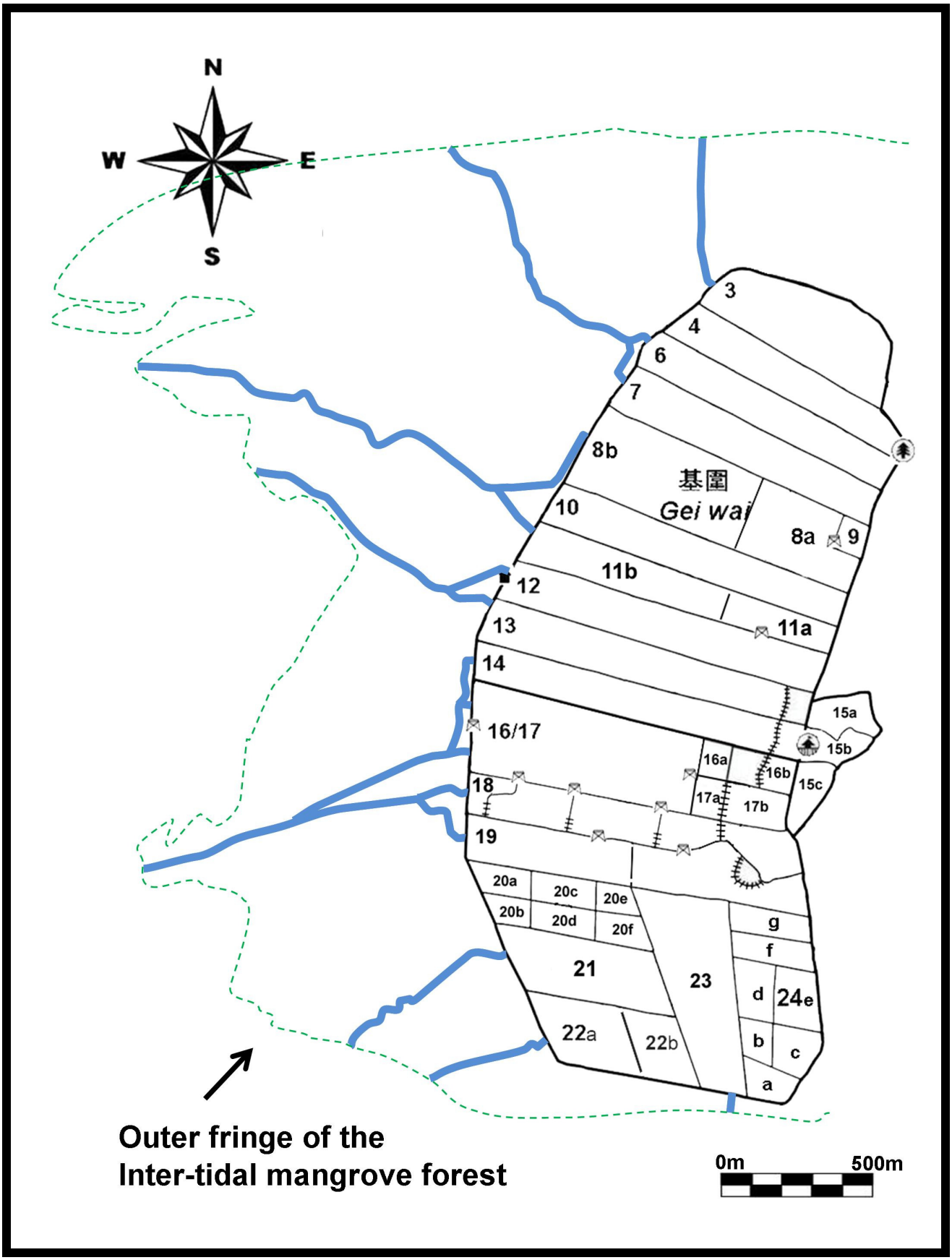
Appendix 3. Land tenure



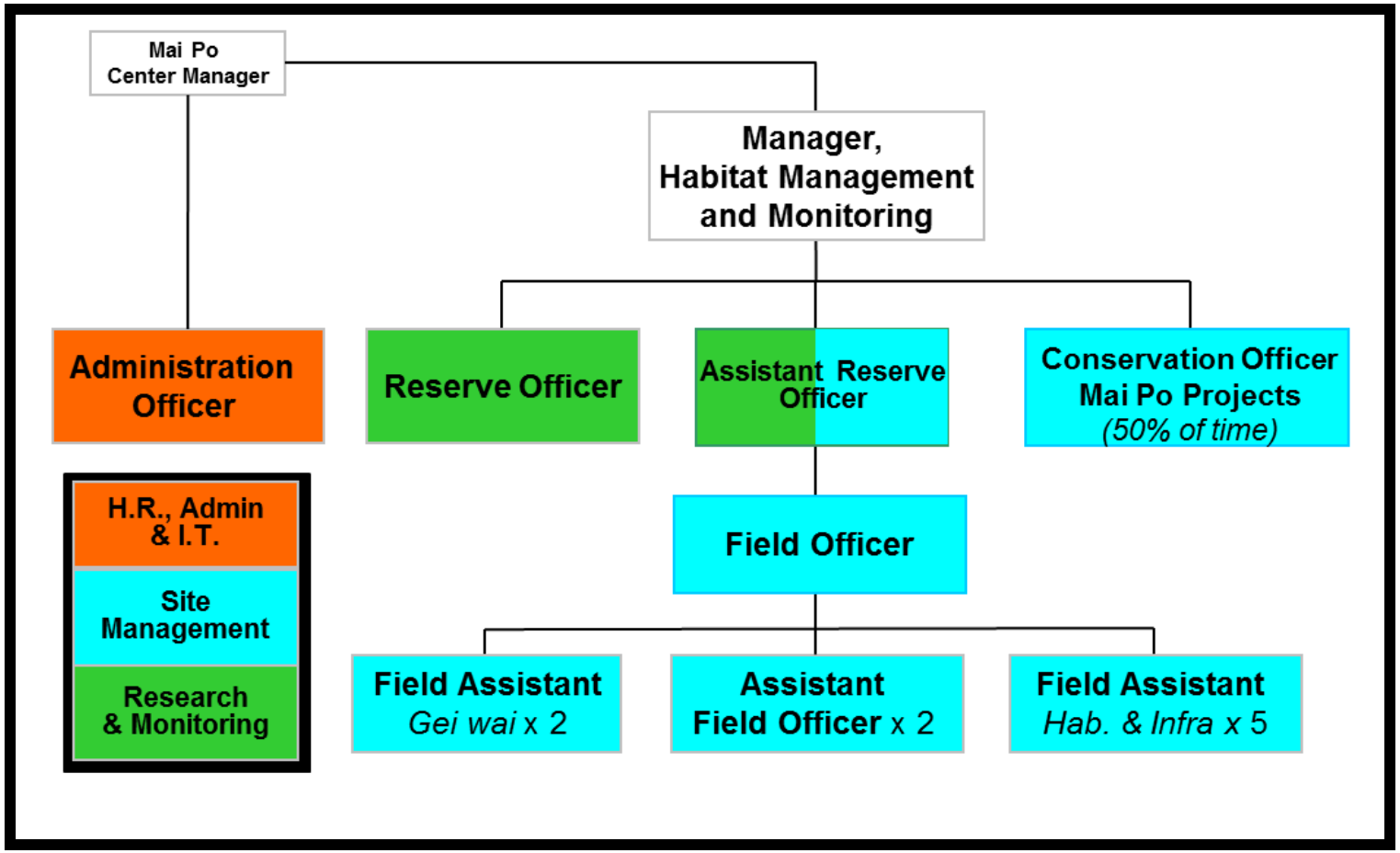
Appendix 4. Map showing the 'L-pipe' network in the rain-fed habitats



Appendix 5. Location map of the inter-tidal channels connected to the Mai Po Nature Reserve



Appendix 6 - Reserve staff structure at the Mai Po Nature Reserve



Appendix 7 – Species lists

Plants

Common Name	Scientific Name
Ferns	
Native Species:	
Mangrove Fern	*Acrostichum aureum*
Oriental Blechnum	*Blechnum orientale*
Water Fern	*Ceratopteris thalictroides*
Hairy Wood-fern	*Cyclosorus acuminatus*
Interrupted Tri-vein Fern	*Cyclosorus interruptus*
Linear Forked Fern	*Dicranopteris linearis*
Flexuose Climbing Fern	*Lygodium flexuosum*
Climbing Fern	*Lygodium japonicum*
Scansorial Climbing Fern	*Lygodium scandens*
Rough Sword Fern	*Nephrolepis hirsutala*
Sword-fern	*Nephrolepis* sp.
Nodding Clubmoss	*Palhinhaea cernua*
Silver Fern	*Pityrogramma calomelanos*
Herbs	
Native Species:	
Common Achyranthes	*Achyranthes aspera*
Sessile Alternanthera	*Alternanthera sessilis*
Alyce Clover	*Alysicarpus vaginalis*
Green Amaranth	*Amaranthus viridis*
Water hyssop	*Bacopa monnieri*
Malay Blumea	*Blumea lacera*
Moneywort	*Centella asiatica*
Lamb's Quarters	*Chenopodium album*
Taro	*Colocasia esculenta*
Mock Jute	*Corchorus aestuans*
Crinum	*Crinum* spp.
Rattlebox	*Crotalaria retusa*
Dianella	*Dianella ensifolia*
Eclipta	*Eclipta prostrata*
Tassel-Flower	*Emilia sonchifolia*
Wild Globe Amaranth	*Gomphrena celosioides*
-	*Gynura divaricata*
Beach Morning-glory	*Ipomoea pes-caprae*
-	*Ipomoea triloba*
Lesser Duck-weed	*Lemna minor*
Brittle False Pimpernel	*Lindernia crustacea*
Lily Turf	*Liriope spicata*
Water-dragon	*Ludwigia adscendens*
Jute-leaved Melochia	*Melochia corchorifolia*
Naked Flower Murdannia	*Murdannia nudiflora*
Sorrel	*Oxalis corniculata*
Chinese Knotweed	*Polygonum chinense*
Spiny Knotweed	*Polygonum perfoliatum*
Purslane	*Portulaca oleracea*
Toothed-fruited Dock	*Rumex dentatus*
Widgeon Grass	*Ruppia maritima*
-	*Senecio scandens*
Sida Hemp	*Sida rhombifolia*

Common Name	Scientific Name
Herbs (*cont.*)	
Black Nightshade	*Solanum nigrum*
Gold Button	*Spilanthes paniculata*
South Sea-Blite	*Suaeda australis*
Rose Mallow	*Urena lobata*
Procumbent Indian Mallow	*Urena procumbens*
Iron Weed	*Vernonia cinerea*
Common Zeuxine	*Zeuxine strateumatica*
Non-native Species	
Billygoat-weed	*Ageratum conyzoides*
Variegated Shell Ginger	*Alpinia zerumbet*
Alligator-weed	*Alternanthera philoxeroides*
Malabar-Nightshade	*Basella alba*
Hairy Bur-marigold	*Bidens pilosa*
Canna Lily	*Canna* Hybride
Indian Canna	*Canna indica*
Sickle Senna	*Senna tora*
-	*Conyza bonariensis*
-	*Crassocephalum crepidioides*
Smooth Crotalaria	*Crotalaria pallida*
-	*Eupatorium odoratum*
Red-involure Euphorbia	*Euphorbia cyathophora*
Garden spurge	*Euphorbia hirta*
-	*Gynura bicolor*
Water Spinach	*Ipomoea aquatica*
Sweet Potato	*Ipomoea batatas*
One-leaved Clover	*Macroptilium lathyroides*
Sensitive Plant	*Mimosa pudica*
Common Banana	*Musax paradisiaca*
Red Water-lily	*Nymphaea alba*
Lavender Sorrel	*Ocalis debitis*
Ground Cherry	*Physalia angulata*
India Poberry	*Phytolacca acinosa*
-	*Ruellia brittoniana*
Java Sesbania	*Sesbania javanica*
Tetrongan	*Solanum torvum*
Sow-Thistle	*Sonchus oleraceus*
African Evergreen	*Syngonium podophyllum*
-	*Wedelia triloba*
Yellow Rain Lily	*Zephyranthes citrina*
Grasses / **Sedges**	
Native Species:	
Glutene-rice Grass	*Apluda mutica*
Bamboo	*Bambusa* sp.
Australian Bluestem	*Bothriochloa bladhii*
Couch Grass	*Cynodon dactylon*
Imbricate Galingale	*Cyperus imbricatus*
Rice Galingale	*Cyperus iria*

Plants (*cont.*)

Common Name	Scientific Name
Grasses / Sedges (*cont.*)	
Malacca Galingale	*Cyperus malaccensis*
Nut-grass Galingale	*Cyperus rotundus*
-	*Cyrtococcum patens*
Two-flowered Golden-beard	*Dichanthium annulatum*
Hispid Crabgrass	*Digitaria setigera*
Common Crabgrass	*Digitaria sanguinalis*
Barn-yard Grass	*Echinochloa crusgalli*
Needle Spikesedge	*Eleocharis acicularis*
Goose Grass	*Eleusine indica*
Thalia Lovegrass	*Eragrostis atrovirens*
Ceylon	*Eragrostis zeylanica*
Dichotomous Fimbristylis	*Fimbristylis dichotoma*
Centipede Grass	*Imperata cylindrical*
Duck-beak Grass	*Ischaemum aristatum* var. *glaucum*
India Duck-beak	*Ischaemum ciliare*
Rice Grass	*Leersia hexandra*
Chinese Sprangletop	*Leptochloa chinensis*
Sawgrass	*Mariscus cyperoides*
Burma-reed	*Neyraudia reynaudiana*
Panic Grass	*Panicum repens*
Knot Grass	*Paspalum distichum*
Ditch Millet	*Paspalum scrubiculatum var. orbiculare*
India Paspalum	*Paspalum scrobiculatum*
Beach Paspalum	*Paspalum vaginatum*
Common Reedgrass	*Phragmites australis*
Reed	*Phragmites vallatorius*
Golden-hair Grass	*Pogonatherum crinitum*
Branch Pycreus	*Pycerus polystachyos*
Reed-like Sugarcane	*Saccharum arundinaceum*
Coastal Bulrush	*Scirpus subulatus*
Australian Smut-grass	*Sporobolus fertilis*
Seashore Dropgrass	*Sporobolus virginicus*
Chinese Lawn Grass	*Zoysia sinica*
Non-native Species:	
Weaver's Bamboo	Bambusa textilis
Blunt Signal-grass	*Brachiaria mutica*
Water Chestnut	*Eleocharis dulcis*
Aromatic Kyllinga	*Kyllinga polyphylla*
Guinea Grass	*Panicum maximum*
Hilo Grass	*Paspalum conjugatum*
Mission Grass	*Pennisetum polystachtion*
Napier Grass	*Pennisetum purpureum*
Redtop	*Melinis repens*
Narrow-leaved Cat-tail	*Typha angustifolia*
Climbers	
Native Species:	
Two-flowered Aniseia	*Ipomoea biflora*
Sea Sword Bean	*Canavalia maritima*
Balloon Vine	*Cardiospermum halicacabum*
Cassytha	*Cassytha filiformis*

Common Name	Scientific Name
Climbers (*cont.*)	
Snail Seed	*Cocculus orbiculatus*
Chinese Dodde	*Cuscuta chinensis*
Ivy-like Merremia	*Merremia hederacea*
White-flowered Derris	*Derris alborubra*
Derris	*Derris trifoliata*
Creeping Fig	*Ficus pumila*
Oblong Gymnanthera	*Gymnanthera oblonga*
Common Indian-mulberry	*Morinda umbellata*
Chinese Feverine	*Paederia scandens*
Goat Horns	*Strophanthus divaricatus*
Wight's Toxocarpus	*Toxocarpus wightianus*
Indian Zehneria	*Zehneria indica*
Non-native Species:	
Malabar Nightshade	*Basella alba*
White Gourd	*Benincasa hispida*
Hairy Gourd	*Benincasa hispida* var. *chieh qua*
Brazil Bougainvillea	*Bougainvillea spectabilis*
Cairo Morning Glory	*Ipomoea cairica*
Mile-a-minuted Weed	*Mikania micrantha*
Passion Flower	*Passiflora foetida*
Triangular Passion Flower	*Passiflora suberosa*
Philodendron	*Philodendron* spp.
Shrubs	
Native Species:	
Spiny Bears Breech	*Acanthus ilicifolius*
-	*Aegiceras corniculatum*
Chinese Antirhea	*Antirhea chinensis*
Hilo Holly	*Ardisia crenata*
Spotted Ardisia	*Ardisia lindleyana*
Chinese Aucuba	*Aucuba chinensis*
Black Mangrove	*Avicennia marina*
Waxy Leaf	*Breynia fruticosa*
Many-petaled Mangrove	*Bruguiera gymnorhiza*
-	*Cansjera rheedii*
-	*Clerodendrum inerme*
Thick-leaved Croton	*Croton crassifolius*
Demos	*Demos chinensis*
Small Persimmon	*Diospyros vaccinioides*
Chinese Eurya	*Eurya chinensis*
Pear-fruit Fig	*Ficus pyriformis*
Cape Jasmine	*Gardenia jasminoides*
Rough-leaved Holly	*Ilex asprella*
Chinese Ixora	*Ixora chinensis*
-	*Kandelia obovata*
Chinese Privet	*Ligustrum sinense*
Round-leaved Litsea	*Litsea rotundifolia*
-	*Maesa perlarius*
Common Melastoma	*Melastoma malabathricum*
Blood-red Melastoma	*Melastoma sanguineum*
Thorny Wingnut	*Paliurus ramosissimus*

Plants (*cont.*)

Common Name	Scientific Name
Shrubs (*cont.*)	
Hong Kong Pavetta	*Pavetta hongkongensis*
Marsh Fleabane	*Pluchea indica*
Wild Coffee	*Psychotria asiatica*
Hong Kong Hawthorn	*Rhaphiolepis indica*
Red Azalea	*Rhododendron simsii*
Chinese Scolopia	*Scolopia chinensis*
Rose Myrtle	*Rhodomyrtus tomentosa*
Sumac	*Rhus chinensis*
Hedge Sageretia	*Sageretia thea*
Sarcandra	*Sarcandra glabra*
Box-leaved Atalantia	*Atlantia buxifolia*
Triquetrous Tadehagi	*Tadehagi triqueturm*
Triumfetta	*Triumfetta rhomboidea*
Indian Wikstroemia	*Wikstroemia indica*
Non-native Species:	
Mock Lime	*Aglaia odorata*
Allamanda	*Allamanda cathartica*
-	*Ardisia elliptica*
Blood-flower	*Asclepias curassavica*
Philippine Violet	*Barleria cristata*
Pink Power Puff	*Calliandra haematocephala*
Double-fruited Cassia	*Senna bicapsularis*
Garden Croton	*Codiaeum variegatum*
Blue Eranthemum	*Eranthemum pulchellum*
Oval Kumquat	*Fortunella margarita*
Chinese Hibiscus	*Hibiscus rosa-sinensis*
Lantana	*Lantana camara*
White Popinac	*Leucaena leucocephala*
Matrimony Vine	*Lycium chinense*
Turk's Cap	*Malvaviscus arboreus* var. *penduliflorus*
Orange-jessamine	*Murraya paniculata*
Pomegranate	*Punica granatum*
Yellow Oleander	*Thevetia peruviana*
Bush Thunbergia	*Thunbergia erecta*
Shrubby Woodfordia	*Woodfordia fruticosa*
Trees	
Native Species:	
Autumn Maple	*Bischofia javanica*
Pop-gun Seed	*Bridelia tomentosa*
Chinese Hackberry	*Celtis sinensis*
Cerbera	*Cerbera manghas*
Camphor Tree	*Cinnamomum camphora*

Common Name	Scientific Name
Trees (*cont.*)	
Lidded Cleistocalyx	*Cleistocalyx operculatus*
Milky Mangrove	*Excoecaria agallocha*
Chinese Banyan	*Ficus microcarpa*
Big-leaved Fig	*Ficus virens*
Water Pine	*Glyptostrobus pensilis*
Coastal Heritiera	*Heritiera littoralis*
Cuban Bast	*Hibiscus tiliaceus*
Sweet Gum	*Liquidambar formosana*
Pond Spice	*Litsea glutinosa*
Elephant's Ear	*Macaranga tanarius*
Turn-in-the-wind	*Mallotus paniculatus*
Microcos	*Microcos nervosa*
White Mulberry	*Morus alba*
Wax Tree	*Rhus succedanea*
Box-leaved Syzygium	*Syzygium buxifolium*
Mountain Tallow Tree	*Sapium discolor*
Chinese Tallow Tree	*Sapium sebiferum*
Ivy Tree	*Schefflera heptaphylla*
Lance-leaved Sterculia	*Sterculia lanceolata*
Box-leaved Syzygium	*Syzygium buxifolium*
Non-native Species:	
Ear-leaved Acacia	*Acacia auriculiformis*
Taiwan Acacia	*Acacia confusa*
Lebbeck Tree	*Albizia lebbeck*
Formosan Alder	*Alnus japonica*
Sugar-apple	*Annona squamosa*
Purple Camel's Foot	*Bauhinia purpurea*
Tree Cotton	*Bombax ceiba*
Fishtail Palm	*Caryota ochlandra*
Horsetail Tree	*Casuarina equisetifolia*
Citrus	*Citrus* sp.
Obtuse-leaved Crateva	*Crateva trifoliata*
Flame Tree	*Delonix regia*
Ivory Coral Tree	*Erythrina speciosa*
Swamp Mahogany	*Eucalyptus robusta*
Chinese Holly	*Ilex rotunda*
China-berry	*Melia azedarach*
Frangipani	*Plumeria rubra*
Guava	*Psidium guajava*
Weeping Willow	*Salix babylonica*
-	*Sonneratia apetala*
-	*Sonneratia caseolaris*
Rose Apple	*Syzygium jambos*

Birds (of Mai Po and Inner Deep Bay)

Common Name	Scientific Name
GREBES *Podicipidae*	
Little Grebe	*Tachybaptus ruficollis*
Great Crested Grebe	*Podiceps cristatus*
Horned Grebe	*Podiceps auritus*
Black-necked Grebe	*Podiceps nigricollis*
SHEARWATERS *Procellariidae*	
Streaked Shearwater	*Calonectris leucomelas*
PELICANS *Pelecanidae*	
Dalmatian Pelican	*Pelecanus crispus*
CORMORANTS *Phalacrocoracidae*	
Great Cormorant	*Phalacrocorax carbo*
FRIGATEBIRDS *Fregatidae*	
Christmas Island Frigatebird	*Fregata andrewsi*
Lesser Frigatebird	*Fregata ariel*
BITTERNS, HERONS AND EGRETS *Ardeidae*	
Grey Heron	*Ardea cinerea*
Purple Heron	*Ardea purpurea*
Great Egret	*Ardea alba*
Intermediate Egret	*Egretta intermedia*
Little Egret	*Egretta garzetta*
Swinhoe's Egret	*Egretta eulophotes*
Pacific Reef Heron	*Egretta sacra*
Eastern Cattle Egret	*Bubulcus coromandus*
Chinese Pond Heron	*Ardeola bacchus*
Striated Heron	*Butorides striata*
Black-crowned Night Heron	*Nycticorax nycticorax*
Yellow Bittern	*Ixobrychus sinensis*
Von Schrenck's Bittern	*Ixobrychus eurhythmus*
Cinnamon Bittern	*Ixobrychus cinnamomeus*
Black Bittern	*Dupetor flavicollis*
Eurasian Bittern	*Botaurus stellaris*
STORKS *Ciconiidae*	
Black Stork	*Ciconia nigra*
Oriental Stork	*Ciconia boyciana*
IBISES AND SPOONBILLS *Threskiornithidae*	
Black-headed Ibis	*Threskiornis melanocephalus*
Glossy Ibis	*Plegadis falcinellus*
Eurasian Spoonbill	*Platalea leucorodia*
Black-faced Spoonbill	*Platalea minor*
DUCKS, GEESE AND SWANS Anatidae	
Lesser Whistling Duck	*Dendrocygna javanica*
Whooper Swan	*Cygnus cygnus*
Taiga Bean Goose	*Anser fabalis*
Tundra Bean Goose	*Anser serrirostris*
Greylag Goose	*Anser anser*

Common Name	Scientific Name
DUCKS, GEESE AND SWANS Anatidae	
Greater White-fronted Goose	*Anser albifrons*
Lesser White-fronted Goose	*Anser erythropus*
Ruddy Shelduck	*Tadorna ferruginea*
Common Shelduck	*Tadorna tadorna*
Cotton Pygmy-Goose	*Nettapus coromandelianus*
Mandarin Duck	*Aix galericulata*
Eurasian Wigeon	*Anas penelope*
Falcated Duck	*Anas falcata*
Gadwall	*Anas strepera*
Baikal Teal	*Anas formosa*
Eurasian Teal	*Anas crecca*
Green-winged Teal	*Anas carolinensis*
Mallard	*Anas platyrhynchos*
Philippine Duck	*Anas luzonica*
Indian Spot-billed Duck	*Anas poecilorhyncha*
Chinese Spot-billed Duck	*Anas zonorhyncha*
Northern Pintail	*Anas acuta*
Garganey	*Anas querquedula*
Northern Shoveler	*Anas clypeata*
Common Pochard	*Aythya ferina*
Baer's Pochard	*Aythya baeri*
Ferruginous Duck	*Aythya nyroca*
Tufted Duck	*Aythya fuligula*
Greater Scaup	*Aythya marila*
Red-crested Pochard	*Netta rufina*
White-winged Scoter	*Melanitta deglandi*
Black Scoter	*Melanitta americana*
Common Goldeneye	*Bucephala clangula*
Smew	*Mergellus albellus*
Red-breasted Merganser	*Mergus serrator*
OSPREYS *Pandionidae*	
Western Osprey	*Pandion haliaetus*
EAGLES AND HAWKS *Accipitridae*	
Crested Honey Buzzard	*Pernis ptilorhynchus*
Black-winged Kite	*Elanus caeruleus*
Black Kite	*Milvus migrans*
Brahminy Kite	*Haliastur indus*
White-bellied Sea Eagle	*Haliaeetus leucogaster*
Eurasian Black Vulture	*Aegypius monachus*
Crested Serpent Eagle	*Spilornis cheela*
Grey-faced Buzzard	*Butastur indicus*
Pied Harrier	*Circus melanoleucos*
Eastern Marsh Harrier	*Circus spilonotus*
Crested Goshawk	*Accipiter trivirgatus*
Chinese Sparrowhawk	*Accipiter soloensis*
Japanese Sparrowhawk	*Accipiter gularis*
Besra	*Accipiter virgatus*
Eurasian Sparrowhawk	*Accipiter nisus*
Northern Goshawk	*Accipiter gentilis*
Eastern Buzzard	*Buteo japonicus*

Birds (of Mai Po and Inner Deep Bay) (*cont.*)

Common Name	Scientific Name
EAGLES AND HAWKS *Accipitridae*	
Greater Spotted Eagle	*Clanga clanga*
Steppe Eagle	*Aquila nipalensis*
Eastern Imperial Eagle	*Aquila heliaca*
Bonelli's Eagle	*Aquila fasciata*
FALCONS *Falconidae*	
Common Kestrel	*Falco tinnunculus*
Amur Falcon	*Falco amurensis*
Eurasian Hobby	*Falco subbuteo*
Peregrine Falcon	*Falco peregrinus*
PHEASANTS AND ALLIES *Phasianidae*	
Japanese Quail	*Coturnix japonica*
BUTTONQUAILS *Turnicidae*	
Yellow-legged Buttonquail	*Turnix tanki*
Barred Buttonquail	*Turnix suscitator*
CRANES *Gruidae*	
Common Crane	*Grus grus*
Siberian Crane	*Grus leucogeranus*
RAILS, CRAKES AND COOTS *Rallidae*	
Slaty-breasted Rail	*Gallirallus striatus*
Eastern Water Rail	*Rallus indicus*
Western Water Rail	*Rallus aquaticus*
White-browed Crake	*Porzana cinerea*
Baillon's Crake	*Porzana pusilla*
Ruddy-breasted Crake	*Porzana fusca*
White-breasted Waterhen	*Amaurornis phoenicurus*
Watercock	*Gallicrex cinerea*
Common Moorhen	*Gallinula chloropus*
Eurasian Coot	*Fulica atra*
JACANAS *Jacanidae*	
Pheasant-tailed Jacana	*Hydrophasianus chirurgus*
PAINTED SNIPES *Rostratulidae*	
Greater Painted-snipe	*Rostratula benghalensis*
STONE-CURLEWS *Burhinidae*	
Great Stone-curlew	*Esacus recurvirostris*
OYSTERCATCHERS *Haematopodidae*	
Eurasian Oystercatcher	*Haematopus ostralegus*
AVOCETS AND STILTS *Recurvirostridae*	
Black-winged Stilt	*Himantopus himantopus*
Pied Avocet	*Recurvirostra avosetta*
PRANTINCOLES *Glareolidae*	
Oriental Pratincole	*Glareola maldivarum*

Common Name	Scientific Name
PLOVERS *Charadriidae*	
Northern Lapwing	*Vanellus vanellus*
Grey-headed Lapwing	*Vanellus cinereus*
Pacific Golden Plover	*Pluvialis fulva*
Grey Plover	*Pluvialis squatarola*
Common Ringed Plover	*Charadrius hiaticula*
Long-billed Plover	*Charadrius placidus*
Little Ringed Plover	*Charadrius dubius*
Kentish Plover	*Charadrius alexandrinus*
Lesser Sand Plover	*Charadrius mongolus*
Greater Sand Plover	*Charadrius leschenaultii*
Oriental Plover	*Charadrius veredus*
SANDPIPERS, SNIPES, CURLEWS AND ALLIES *Scolopacidae*	
Black-tailed Godwit	*Limosa limosa*
Bar-tailed Godwit	*Limosa lapponica*
Little Curlew	*Numenius minutus*
Whimbrel	*Numenius phaeopus*
Eurasian Curlew	*Numenius arquatus*
Far Eastern Curlew	*Numenius madagascariensis*
Spotted Redshank	*Tringa erythropus*
Common Redshank	*Tringa totanus*
Marsh Sandpiper	*Tringa stagnatilis*
Common Greenshank	*Tringa nebularia*
Nordmann's Greenshank	*Tringa guttifer*
Lesser Yellowlegs	*Tringa flavipes*
Green Sandpiper	*Tringa ochropus*
Wood Sandpiper	*Tringa glareola*
Terek Sandpiper	*Xenus cinereus*
Common Sandpiper	*Actitis hypoleucos*
Grey-tailed Tattler	*Tringa brevipes*
Ruddy Turnstone	*Arenaria interpres*
Red-necked Phalarope	*Phalaropus lobatus*
Red Phalarope	*Phalaropus fulicarius*
Eurasian Woodcock	*Scolopax rusticola*
Pintail Snipe	*Gallinago stenura*
Swinhoe's Snipe	*Gallinago megala*
Common Snipe	*Gallinago gallinago*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Asian Dowitcher	*Limnodromus semipalmatus*
Red Knot	*Calidris canutus*
Great Knot	*Calidris tenuirostris*
Sanderling	*Calidris alba*
Red-necked Stint	*Calidris ruficollis*
Little Stint	*Calidris minuta*
Temminck's Stint	*Calidris temminckii*
Long-toed Stint	*Calidris subminuta*
Pectoral Sandpiper	*Calidris melanotos*
Sharp-tailed Sandpiper	*Calidris acuminata*
Dunlin	*Calidris alpina*
Curlew Sandpiper	*Calidris ferruginea*
Spoon-billed Sandpiper	*Eurynorhynchus pygmaeus*
Broad-billed Sandpiper	*Limicola falcinellus*
Ruff	*Philomachus pugnax*

Birds (of Mai Po and Inner Deep Bay) (*cont.*)

Common Name	Scientific Name
SKUAS *Stercorariidae*	
Long-tailed Jaeger	*Stercorarius longicaudus*
GULLS AND TERNS *Laridae*	
Black-tailed Gull	*Larus crassirostris*
Mew Gull	*Larus canus*
Heuglin's Gull	*Larus fuscus*
Vega Gull	*Larus vegae*
Caspian Gull	*Larus cachinnans*
Slaty-backed Gull	*Larus schistisagus*
Glaucous-winged Gull	*Larus glaucescens*
Glaucous Gull	*Larus hyperboreus*
Pallas's Gull	*Ichthyaetus ichthyaetus*
Brown-headed Gull	*Chroicocephalus brunnicephalus*
Relict Gull	*Ichthyaetus relictus*
Black-headed Gull	*Chroicocephalus ridibundus*
Slender-billed Gull	*Chroicocephalus genei*
Little Gull	*Hydrocoloeus minutus*
Saunders's Gull	*Chroicocephalus saundersi*
Black-legged Kittiwake	*Rissa tridactyla*
Whiskered Tern	*Chlidonias hybrida*
White-winged Tern	*Chlidonias leucopterus*
Gull-billed Tern	*Gelochelidon nilotica*
Caspian Tern	*Hydroprogne caspia*
Common Tern	*Sterna hirundo*
Little Tern	*Sternula albifrons*
Greater Crested Tern	*Thalasseus bergii*
AUKS *Alicidae*	
Ancient Murrelet	*Synthliboramphus antiquus*
DOVES *Columbidae*	
Oriental Turtle Dove	*Streptopelia orientalis*
Red Turtle Dove	*Streptopelia tranquebarica*
Spotted Dove	*Spilopelia chinensis*
Common Emerald Dove	*Chalcophaps indica*
White-bellied Green Pigeon	*Treron sieboldii*
CUCKOOS *Cuculidae*	
Chestnut-winged Cuckoo	*Clamator coromandus*
Large Hawk Cuckoo	*Hierococcyx sparverioides*
Indian Cuckoo	*Cuculus micropterus*
Oriental Cuckoo	*Cuculus optatus*
Lesser Cuckoo	*Cuculus poliocephalus*
Plaintive Cuckoo	*Cacomantis merulinus*
Fork-tailed Drongo Cuckoo	*Surniculus dicruroides*
Asian Koel	*Eudynamys scolopaceus*
Greater Coucal	*Centropus sinensis*
Lesser Coucal	*Centropus bengalensis*
BARN-OWLS *Tytonidae*	
Eastern Grass Owl	*Tyto longimembris*

Common Name	Scientific Name
OWLS *Strigidae*	
Oriental Scops Owl	*Otus sunia*
Collared Scops Owl	*Otus lettia*
Eurasian Eagle Owl	*Bubo bubo*
Asian Barred Owlet	*Glaucidium cuculoides*
Northern Boobook	*Ninox scutulata*
Short-eared Owl	*Asio flammeus*
NIGHTJARS *Caprimulgidae*	
Grey Nightjar	*Caprimulgus jotaka*
Savanna Nightjar	*Caprimulgus affinis*
SWIFTS *Apodidae*	
Himalayan Swiftlet	*Aerodramus brevirostris*
White-throated Needletail	*Hirundapus caudacutus*
Silver-backed Needletail	*Hirundapus cochinchinensis*
Common Swift	*Apus apus*
Pacific Swift	*Apus pacificus*
House Swift	*Apus nipalensis*
KINGFISHERS *Alcedinidae*	
Pied Kingfisher	*Ceryle rudis*
Common Kingfisher	*Alcedo atthis*
White-throated Kingfisher	*Halcyon smyrnensis*
Black-capped Kingfisher	*Halcyon pileata*
Collared Kingfisher	*Todiramphus chloris*
BEE-EATERS *Meropidae*	
Blue-throated Bee-eater	*Merops viridis*
Blue-tailed Bee-eater	*Merops philippinus*
ROLLERS *Coraciidae*	
Oriental Dollarbird	*Eurystomus orientalis*
HOOPOES *Upupidae*	
Eurasian Hoopoe	*Upupa epops*
WOODPECKERS *Picidae*	
Eurasian Wryneck	*Jynx torquilla*
PITTAS *Pittidae*	
Fairy Pitta	*Pitta nympha*
LARKS *Alaudidae*	
Eurasian Skylark	*Alauda arvensis*
Oriental Skylark	*Alauda gulgula*
SWALLOWS AND MARTINS *Hirundinidae*	
Pale Martin	*Riparia diluta*
Barn Swallow	*Hirundo rustica*
Red-rumped Swallow	*Cecropis daurica*
Common House Martin	*Delichon urbicum*
Asian House Martin	*Delichon dasypus*

Birds (of Mai Po and Inner Deep Bay) (*cont.*)

Common Name	Scientific Name
PIPITS AND WAGTAILS *Motacillidae*	
Forest Wagtail	*Dendronanthus indicus*
Eastern Yellow Wagtail	*Motacilla tschutschensis*
Citrine Wagtail	*Motacilla citreola*
Grey Wagtail	*Motacilla cinerea*
White Wagtail	*Motacilla alba*
Richard's Pipit	*Anthus richardi*
Olive-backed Pipit	*Anthus hodgsoni*
Red-throated Pipit	*Anthus cervinus*
Pechora Pipit	*Anthus gustavi*
Buff-bellied Pipit	*Anthus rubescens*
Water Pipit	*Anthus spinoletta*
CUCKOOSHRIKES AND MINIVETS *Campehagidae*	
Black-winged Cuckooshrike	*Coracina melaschistos*
Swinhoe's Minivet	*Pericrocotus cantonensis*
Ashy Minivet	*Pericrocotus divaricatus*
Scarlet Minivet	*Pericrocotus speciosus*
BULBULS *Pycnonotidae*	
Red-whiskered Bulbul	*Pycnonotus jocosus*
Chinese Bulbul	*Pycnonotus sinensis*
Sooty-headed Bulbul	*Pycnonotus aurigaster*
Chestnut Bulbul	*Hemixos castanonotus*
Black Bulbul	*Hypsipetes leucocephalus*
SHRIKES *Laniidae*	
Tiger Shrike	*Lanius tigrinus*
Bull-headed Shrike	*Lanius bucephalus*
Brown Shrike	*Lanius cristatus*
Red-backed Shrike	*Lanius collurio*
Long-tailed Shrike	*Lanius schach*
CHATS AND OLD WORLD FLYCATCHERS *Muscicapidae*	
Rufous-tailed Robin	*Luscinia sibilans*
Siberian Rubythroat	*Luscinia calliope*
Siberian Blue Robin	*Luscinia cyane*
Bluethroat	*Luscinia svecica*
Red-flanked Bluetail	*Tarsiger cyanurus*
Oriental Magpie Robin	*Copsychus saularis*
Daurian Redstart	*Phoenicurus auroreus*
Plumbeous Water Redstart	*Rhyacornis fuliginosa*
Stejneger's Stonechat	*Saxicola stejnegeri*
Grey Bush Chat	*Saxicola ferreus*
Blue Rock Thrush	*Monticola solitarius*
Brown-chested Jungle Flycatcher	*Rhinomyias brunneatus*
Grey-streaked Flycatcher	*Muscicapa griseisticta*
Dark-sided Flycatcher	*Muscicapa sibirica*
Asian Brown Flycatcher	*Muscicapa latirostris*
Ferruginous Flycatcher	*Muscicapa ferruginea*
Verditer Flycatcher	*Eumyias thalassinus*
Yellow-rumped Flycatcher	*Ficedula zanthopygia*
Narcissus Flycatcher	*Ficedula narcissina*

Common Name	Scientific Name
CHATS AND OLD WORLD FLYCATCHERS *Muscicapidae (cont.)*	
Mugimaki Flycatcher	*Ficedula mugimaki*
Red-breasted Flycatcher	*Ficedula parva*
Red-throated Flycatcher	*Ficedula albicilla*
Blue-and-white Flycatcher	*Cyanoptila cyanomelana*
Hainan Blue Flycatcher	*Cyornis hainanus*
THRUSHES *Turdidae*	
Blue Whistling Thrush	*Myophonus caeruleus*
Orange-headed Thrush	*Geokichla citrina*
White's Thrush	*Zoothera aurea*
Japanese Thrush	*Turdus cardis*
Common Blackbird	*Turdus merula*
Grey-backed Thrush	*Turdus hortulorum*
Pale Thrush	*Turdus pallidus*
Eyebrowed Thrush	*Turdus obscurus*
Naumann's Thrush	*Turdus naumanni*
Dusky Thrush	*Turdus eunomus*
LAUGHINGTHRUSHES *Leiothrichidae*	
Masked Laughingthrush	*Garrulax perspicillatus*
Chinese Hwamei	*Garrulax canorus*
CETTIA BUSH WARBLERS AND ALLIES *Cettidae*	
Asian Stubtail	*Urosphena squameiceps*
Pale-footed Bush Warbler	*Urosphena pallidipes*
Japanese Bush Warbler	*Horornis diphone*
Manchurian Bush Warbler	*Horornis borealis*
Brown-flanked Bush Warbler	*Horornis fortipes*
Mountain Tailorbird	*Phyllergates cuculatus*
LEAF WARBLERS AND ALLIES *Phylloscopidae*	
Common Chiffchaff	*Phylloscopus collybita*
Dusky Warbler	*Phylloscopus fuscatus*
Yellow-streaked Warbler	*Phylloscopus armandii*
Radde's Warbler	*Phylloscopus schwarzi*
Pallas's Leaf Warbler	*Phylloscopus proregulus*
Yellow-browed Warbler	*Phylloscopus inornatus*
Arctic Warbler	*Phylloscopus borealis*
Two-barred Warbler	*Phylloscopus plumbeitarsus*
Pale-legged Leaf Warbler	*Phylloscopus tenellipes*
Sakhalin Leaf Warbler	*Phylloscopus borealoides*
Eastern Crowned Warbler	*Phylloscopus coronatus*
Goodson's Leaf Warbler	*Phylloscopus goodsoni*
Alstrom's Warbler	*Seicercus soror*
REED WARBLERS AND ALLIES *Acrocephalidae*	
Black-browed Reed Warbler	*Acrocephalus bistrigiceps*
Manchurian Reed Warbler	*Acrocephalus tangorum*
Paddyfield Warbler	*Acrocephalus agricola*
Blunt-winged Warbler	*Acrocephalus concinens*
Blyth's Reed Warbler	*Acrocephalus dumetorum*
Oriental Reed Warbler	*Acrocephalus orientalis*

Birds (of Mai Po and Inner Deep Bay) (*cont.*)

Common Name	Scientific Name
REED WARBLERS AND ALLIES *Acrocephalidae (cont.)*	
Thick-billed Warbler	*Iduna aedon*
Sykes's Warbler	*Iduna rama*
GRASSBIRDS AND ALLIES *Locustellidae*	
Baikal Bush Warbler	*Locustella davidi*
Brown Bush Warbler	*Locustella luteoventris*
Russet Bush Warbler	*Locustella mandelli*
Lanceolated Warbler	*Locustella lanceolata*
Pallas's Grasshopper Warbler	*Locustella certhiola*
Middendorff's Grasshopper Warbler	*Locustella ochotensis*
Styan's Grasshopper Warbler	*Locustella pleskei*
Japanese Swamp Warbler	*Locustella pryeri*
CISTICOLAS AND ALLIES *Cisticolidae*	
Zitting Cisticola	*Cisticola juncidis*
Golden-headed Cisticola	*Cisticola exilis*
Yellow-bellied Prinia	*Prinia flaviventris*
Plain Prinia	*Prinia inornata*
Common Tailorbird	*Orthotomus sutorius*
SYLVIID BABBLERS *Sylviidae*	
Lesser Whitethroat	*Sylvia curruca*
FAIRY FLYCATCHERS *Stenostiridae*	
Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*
MONARCHS *Monarchidae*	
Black-naped Monarch	*Hypothymis azurea*
Asian Paradise-Flycatcher	*Terpsiphone paradisi*
Japanese Paradise-Flycatcher	*Terpsiphone atrocaudata*
PENDULINE TITS *Remizidae*	
Chinese Penduline Tit	*Remiz consobrinus*
TITS *Paridae*	
Yellow-bellied Tit	*Periparus venustulus*
Cinereous Tit	*Parus cinereous*
FLOWERPECKER *Dicaeidae*	
Scarlet-backed Flowerpecker	*Dicaeum cruentatum*
SUNBIRDS *Nectariniidae*	
Fork-tailed Sunbird	*Aethopyga christinae*
WHITE-EYES *Zosteropidae*	
Chestnut-collared Yuhina	*Yuhina castaniceps*
Chestnut-flanked White-eye	*Zosterops erythropleurus*
Japanese White-eye	*Zosterops japonicus*
BUNTINGS *Emberizidae*	
Crested Bunting	*Emberiza lathami*
Tristram's Bunting	*Emberiza tristrami*

Common Name	Scientific Name
BUNTINGS *Emberizidae (cont.)*	
Chestnut-eared Bunting	*Emberiza fucata*
Little Bunting	*Emberiza pusilla*
Yellow-browed Bunting	*Emberiza chrysophrys*
Rustic Bunting	*Emberiza rustica*
Yellow-breasted Bunting	*Emberiza aureola*
Red-headed Bunting	*Emberiza bruniceps*
Chestnut Bunting	*Emberiza rutila*
Black-headed Bunting	*Emberiza melanocephala*
Japanese Yellow Bunting	*Emberiza sulphurata*
Black-faced Bunting	*Emberiza spodocephala*
Pallas's Reed Bunting	*Emberiza pallasi*
Common Reed Bunting	*Emberiza schoeniclus*
FINCHES *Fringillidae*	
Brambling	*Fringilla montifringilla*
Grey-capped Greenfinch	*Chloris sinica*
Eurasian Siskin	*Spinus spinus*
Common Rosefinch	*Carpodacus erythrinus*
Chinese Grosbeak	*Eophona migratoria*
Japanese Grosbeak	*Eophona personata*
MUNIAS *Estrildae*	
White-rumped Munia	*Lonchura striata*
Scaly-breasted Munia	*Lonchura punctulata*
SPARROWS *Passeridae*	
Eurasian Tree Sparrow	*Passer montanus*
STARLINGS AND MYNAS *Sturnidae*	
Chestnut-tailed Starling	*Sturnia malabarica*
Red-billed Starling	*Spodiopsar sericeus*
Chestnut-cheeked Starling	*Agropsar philippensis*
Daurian Starling	*Agropsar sturninus*
Rosy Starling	*Pastor roseus*
Common Starling	*Sturnus vulgaris*
White-cheeked Starling	*Spodiopsar cineraceus*
Black-collared Starling	*Gracupica nigricollis*
White-shouldered Starling	*Sturnia sinensis*
Crested Myna	*Acridotheres cristatellus*
ORIOLES *Oriolidae*	
Black-naped Oriole	*Oriolus chinensis*
DRONGOS *Dicruridae*	
Black Drongo	*Dicrurus macrocercus*
Ashy Drongo	*Dicrurus leucophaeus*
Hair-crested Drongo	*Dicrurus hottentottus*
CROWS *Corvidae*	
Eurasian Jay	*Garrulus glandarius*
Red-billed Blue Magpie	*Urocissa erythroryncha*
Grey Treepie	*Dendrocitta formosae*

Birds (of Mai Po and Inner Deep Bay) (*cont.*)

CROWS *Corvidae (cont.)*

Eurasian Magpie	*Pica pica*
Daurian Jackdaw	*Coloeus dauuricus*
Carrion Crow	*Corvus corone*
Large-billed Crow	*Corvus macrorhynchos*
Collared Crow	*Corvus torquatus*

Birds that have escaped or have been released from captivity

Common Name	Scientific Name	Common Name	Scientific Name
Domestic Pigeon	*Columba livia*	Alexandrine Parakeet	*Psittacula eupatria*
Eurasian Collared Dove	*Streptopelia decaocto*	Rosy-faced Lovebird	*Agapornis roseicollis*
Yellow-crested Cockatoo	*Cacatua sulphurea*	Fischer's Lovebird	*Agapornis fischeri*
Rose-ringed Parakeet	*Psittacula krameri*	Red-and-green Macaw	*Ara chloropterus*
Vinous-throated Parrotbill	*Sinosuthora webbiana*	Bohemian Waxwing	*Bombycilla garrulus*
Chestnut Munia	*Lonchura atricapilla*	Bearded Reedling	*Panurus biarmicus*
Russet Sparrow	*Passer rutilans*	Mongolian Lark	*Melanocorypha mongolica*
Baya Weaver	*Ploceus philippinus*	White-winged Lark	*Melanocorypha leucoptera*
Common Myna	*Acridotheres tristis*	Brown-breasted Bulbul	*Pycnonotus xanthorrhous*
Azure-winged Magpie	*Cyanopica cyanus*	Pale-bellied Myna	*Acridotheres cinereus*
House Crow	*Corvus splendens*	Pied Bush Chat	*Saxicola caprata*
Common Pheasant	*Phasianus colchicus*	Yellow-crowned Bishop	*Euplectes afer*
Swan Goose	*Anser cygnoides*	Southern Red Bishop	*Euplectes orix*
Wood Duck	*Aix sponsa*	White-headed Munia	*Lonchura maja*
Red-crested Pochard	*Netta rufina*	Java Sparrow	*Lonchura oryzivora*
Great White Pelican	*Pelecanus onocrotalus*	Red Avadavat	*Amandava amandava*
Northern Goshawk	*Accipiter gentilis*	Pin-tailed Whydah	*Vidua macroura*
Purple Swamphen	*Porphyrio porphyrio*	Yellow-fronted Canary	*Crithagra mozambica*
Red Lory	*Eos bornea*	European Goldfinch	*Carduelis carduelis*
Budgerigar	*Melopsittacus undulatus*	Grey-necked Bunting	*Emberiza buchanani*

Mammals

Common Name	Scientific Name	Common Name	Scientific Name
<u>Native:</u>		<u>Native (cont.):</u>	
Japanese Pipistrelle	*Pipistrellus abramus*	Indochinese Forest Rat	*Rattus andamanensis*
Noctule Bat	*Nycatalus noctula*	Asian House Rat	*Rattus tanezumi*
Lesser Yellow House Bat	*Scotophilus khuli*	Ryuku Mouse	*Mus caroli*
Lesser Bent-winged Bat	*Miniopterus pusillus*	Chestnut Spiny Rat	*Niviventer fulvescens*
Short-nosed Fruit Bat	*Cynopterus sphinx*	Musk Shrew	*Suncus murinus*
Leschnault's Rousette (Bat)	*Rousettus leschnaulti*		
Intermediate Horseshoe Bat	*Rhinolophus affinis*	<u>Non-native/domestic origin:</u>	
Eurasian Otter	*Lutra lutra chinensis*	Rhesus Macaque	*Macaca mulatta*
Small Asian Mongoose	*Herpestes javanicus*	Domestic Water Buffalo	*Bubalus bubalis*
Chinese Leopard Cat	*Prionailurus bengalensis*	Domestic Cat	*Felis catus*
Small Indian Civet	*Viverricula indica*	Domestic Dog	*Canis familiaris*
Eurasian Wild Pig	*Sus scrofa*	House Mouse	*Mus musculus*
Greater Bandicoot Rat	*Bandicota indica*	Brown Rat	*Rattus norvegicus*

Fish

Common Name	Scientific Name
Freshwater fish	
Mosquito Fish*	*Gambusia affinis*
Catfish	*Clarias fuscus*
Climbing Perch	*Anabas testudineus*
Bald Glassy	*Ambassis gymnocephalus*
Grass Carp	*Ctenopharyngodon idellus*
Brackish water fish	
Small Snakehead	*Channa asiatica*
Spotted Snakehead	*Channa maculata*
Bigmouth Sleeper	*Gobiomorus dormitor*
Black Sleeper	*Eleotris melanosoma*
Common Mud-skipper	*Periophthalmus cantonensis*
Blue-spotted Mud Skipper	*Boleophthalmus pectinirostris*
Estuarine Goby	*Mugilogobius abei*
Chameleon Goby	*Tridentiger trigonocephalus*
Walking Goby	*Scartelaos viridis*
Mozambique Tilapia*	*Oreochromis mossambicus*
Nile Tilapia*	*Oreochromis niloticus*
-	*Ochetobius elongatus*

Common Name	Scientific Name
Brackish water fish (*cont.*)	
Mud Carp	*Cirrhinus molitorella*
Ladyfish	*Elops saurus*
Grey Mullet	*Mugil cephalus*
Green-backed Mullet	*Mugil dussumieri*
Bartail Flathead	*Platycephalus indicus*
Japanese Eel	*Anguilla japonica*
-	*Ophichthus celebicus*
Swampy Eel	*Monopterus albus*
Marine vagrant	
Jarbua Terapon	*Terapon jarbua*
Black Bream	*Acanthopagrus schlegeli*
White Seabream	*Acanthopagrus berda*
Yellowfin Seabream	*Acanthopagrus latus*
Spotted Silver Scat	*Scatophagus argus*
Barramundi	*Lates calcarifer*
Common Sea Bass	*Lateolabrax japonicus*
Spottail Needlefish	*Tylosurus strongylurus*

(* = Non native)

Reptiles and Amphibians

Common Name	Scientific Name
Native:	
Chinese Soft-shelled Turtle	*Pelodiscus sinensis*
Burmese Python	*Python molurus bivittatus*
Common Rat Snake	*Ptyas mucosus*
Chinese Cobra	*Naja atra*
King Cobra / Hamadryad	*Ophiophagus hannah*
Stump-toed Gecko	*Gehyra mutilata*
Browring's Gecko	*Hemidactylus bowringii*
Reeve's Smooth Skink	*Scincella reevesii*
Chinese Skink	*Eumeces chinensis*
Long-tailed Skink	*Mabuya longicaudata*
Striped Grass Lizard	*Takydromus sexlineatus*
Common Blind Snake	*Ramphotyphlops braminus*
Copperhead Racer	*Elaphe radiata*
Indo-chinese rat snake	*Ptyas korros*
Taiwan Kukri Snake	*Oligodon formosanus*
Checkered Keel-back	*Xenochrophis piscator*

Common Name	Scientific Name
Native (cont.):	
Reeves Terrapin	*Chinemys reevsii*
Mangrove Water Snake	*Enhydris bennetti*
Common Water Snake	*Enhydris chinensis*
Many-banded Krait	*Bungarus multicinctus*
Asian Common Toad	*Bufo melanostictus*
Asiatic Painted Frog	*Kaloula pulchra pulchra*
Ornate Narrow-mouthed Frog	*Microphla ornata*
Brown Tree Frog	*Polypedates megacephalus*
Paddy Frog	*Rana limnocharis*
Günther's frog	*Rana guentheri*
Chinese Bullfrog	*Rana rugulosa*
Non-native:	
Red-eared Slider	*Trachemys scripta elegans*
Malaysian Box Turtle	*Cuora amboinensis*

Butterflies

Common Name	Scientific Name
Swallowtails, Birdwings	**Papilionidae**
Common mime	*Chilasa clytia clytia*
Tailed Jay	*Graphium agamemnon agamemnon*
Common Jay	*Graphium doson axion*
Common Bluebottle	*Graphium sarpedon sarpedon*
Lime Butterfly	*Papilio demoleus*
Red Helen	*Papilio helenus helenus*
Great Mormon	*Papilio memnon agenor*
Paris Peacock	*Papilio paris paris*
Common Mormon	*Papilio polytes polytes*
Swallowtail	*Papilio xuthus*
Five-bar Swordtail	*Pathysa antiphates antiphates*
Common Birdwing	*Troides helena*
Whites, Yellows	**Pieridae**
Chocolate Albatross	*Appias lyncida*
Mottled Emigrant	*Cataopsilia pyranthe pyranthe*
Lemon Emigrant	*Catopsilia pomona pomona*
Common Gull	*Cepora nerissa*
Painted Jezebel	*Delias hyparete hierte*
Red-base Jezebel	*Delias pasithoe pasithoe*
Three-spot Grass Yellow	*Eurema blanda*
Common Grass Yellow	*Eurema hecabe hecabe*
Great Orange Tip	*Hebomoia glaucippe*
Indian Cabbage White	*Pieris canidia canidia*
Skippers	**Hesperiidae**
Bush Hopper	*Ampittia dioscorides*
Formosan Swift	*Borbo cinnara*
Colon Swift	*Caltoris bromus*
Banana Skipper	*Erionota torus*
Common Awl	*Hasora badra*
Common Redeye	*Matapa aria*
Chestnut Angle	*Odontoptilum angulatum*
Common Straight Swift	*Parnara guttata*
Little Branded Swift	*Pelopidas agna agna*
Contiguous Swift	*Polytremis lubricans lubricans*
Chinese Dart	*Potanthus confucius confucius*
Lesser Band Dart	*Potanthus trachala*
Pale Palm Dart	*Telicota colon*
Blues	**Lycaenidae**
Common Hedge Blue	*Acytolepis puspa gisca*
Powdered Oak Blue	*Arhopala bazalus*
Burmese Bush Blue	*Arhopala birmana*
Lime Blue	*Chilades lajus leucofasciatus*
Plains Cupid	*Chilades pandava*
Gram Blue	*Euchryspos cnejus cnejus*
Tailed Cupid	*Everes lacturnus rileyi*
Purple Sapphire	*Heliophorus epicles*
Common Onyx	*Horaga onyx*
Silver Streak Blue	*Iraota timoleon timoleon*
Dark Cerulean	*Jamides bochus*
Long-tailed Blue / Pea Blue	*Lampides boeticus*
Transparent Six-line Blue	*Nacaduba kurava*
White Royal	*Pratapa deva*

Common Name	Scientific Name
Blues (*cont.*)	**Lycaenidae**
Pale Grass Blue	*Pseudozizeeria maha* serica
Slate Flash	*Rapala manea*
Chocolate Royal	*Remelana jangala*
Long-banded Silverline	*Spindasis lohita formosana*
Dark Grass Blue	*Zizeeria karsandra*
Lesser Grass Blue	*Zizina otis*
Metalmarks	**Ridinidae**
Plum Judy	*Abisara echerius echerius*
Nymphs	**Nymphalidae**
Angled Castor	*Ariadne ariadne*
Staff Sergeant	*Athyma selenophora*
Red Lacewing	*Cethosia bibles*
Tawny Rajah	*Charaxes bernardus*
Rustic	*Cupha erymanthis erymanthis*
Common Mapwing	*Cyrestis thyodamas*
White-edged Blue Baron	*Euthalia phemius*
Red Ring Skirt	*Hestina assimilis assimilis*
Great Egg-fly	*Hypolimnas bolina kezia*
Indian Fritillary	*Argyreus hyperbius*
Danaid Egg-fly	*Hypolimnas misippus*
Peacock Pansy	*Junonia almana almana*
Grey Pansy	*Junonia atlites atlites*
Lemon Pansy	*Junonia lemonias lemonias*
Blue Pansy	*Junonia orithya*
Blue Admiral	*Kaniska canace canace*
Common Sailer	*Neptis hylas hylas*
Short-banded Sailor	*Phaedyma columella columella*
Common Nawab	*Polyyura athamas*
Painted Lady	*Vanessa cardui*
Indian Red Admiral	*Vanessa indica*
Duffer, Faun	**Amathusiidae**
Common Duffer	*Discophora sondaica*
Large Faun	*Faunis eumeus*
Tigers, Crows	**Danaidae**
Common Tiger	*Danus genutia genutia*
Common Indian Crow	*Euploea core amymone*
Blue-spotted Crow	*Euploea midamus midamus*
Striped Blue Crow	*Euploea mulciber*
Ceylon Blue Glassy Tiger	*Ideopsis similis similis*
Blue Tiger	*Tirumala limniace limniace*
Browns	**Satyridae**
Common Palmfly	*Elymnias hypermnestra*
Banded Tree Brown	*Lethe confusa confusa*
Bamboo Tree Brown	*Lethe europa*
Common Evening Brown	*Melanitis leda leda*
Dark Evening Brown	*Melanitis phedima muskata*
Dark Brand Bush Brown	*Mycalesis mineus mineus*
South China Bush Brown	*Mycalesis zonata*
Common Five-ring	*Ypthima baldus baldus*

Dragonflies and Damselflies

Common Name	Scientific Name
Orange-tailed Midget	*Agriocenemis femina*
Wandering Midget	*Agriocenemis pygmaea*
Orange-tailed Sprite	*Ceriagrion aurantiacum*
Asian Bluetail	*Ischnura asiatica*
Common Bluetail	*Ischnura senegalensis*
Four-spot Midget	*Mortonagrion hirosei*
Marsh Dancer	*Onychargia atrocyana*
Eastern Lilysquatter	*Paracercion melanotum*
Black Threadtail	*Prodasineura autumnalis*
Blue Sprite	*Pseudagrion microcephalum*
Orange-faced Sprite	*Pseudagrion rubriceps*
Black-kneed Featherlegs	*Copera ciliata*
Yellow Featherlegs	*Copera marginipes*
Common Evening Hawer	*Anaciaeschna jaspidea*
Pale-spotted Emperor	*Anax guttatus*
Lesser Emperor	*Anax parthenope*
Little Dusk-hawker	*Gynacantha saltatrix*
Blue-spotted Dusk-hawker	*Gynacantha japonica*
Dingy Dusk-hawker	*Gynacantha subinterrupta*
Common Flangetail	*Ictinogomphus pertinax*
Golden Flangetail	*Sinictogomphus clavatus*
Tawny Hooktail	*Paragomphus capricornis*
Regal Pond Cruiser	*Epopthalmia elegans*
Asian Pintail	*Acisoma panorpoides*
Blue Dasher	*Brachydiplax chalybea*
Asian Amberwing	*Brachythemis contaminata*
Crimson Darter	*Crocothemis servilia*
Black-tipped Percher	*Diplacodes nebulosa*
Blue Percher	*Diplacodes trivalis*
Amber-winged Glider	*Hydrobasileus croceus*
Forest Chaser	*Lyriothemis elegantissima*
Coastal Glider	*Macrodiplax cora*
Russet Percher	*Neurothemis fulvia*
Pied Percher	*Neurothemis tullia*
Red-faced Skimmer	*Orthetrum chrysis*
Marsh Skimmer	*Orthetrum luzonicum*
Greater Blue Skimmer	*Orthetrum melania*
Common Red Skimmer	*Orthetrum pruinosum*
Green Skimmer	*Orthetrum sabina*
Common Blue Skimmer	*Orthetrum glaucum*
Asian Widow	*Palpopleura sexmaculata*
Wandering Glider	*Pantala flavescens*
Blue Chaser	*Potamarcha congener*
Pied Skimmer	*Pseudothemis zonata*
Variegated Flutterer	*Rhyothemis variegata*
Evening Skimmer	*Tholymis tillarga*
Saddlebag Glider	*Tramea virginia*
Crimson Dropwing	*Trithemis aurora*
Indigo Dropwing	*Trithemis festiva*
Scarlet Basker	*Urothemis signata*
Dingy Dusk-darter	*Zyxomma petiolatum*

Appendix 8. Additional bird species of conservation importance

The bird species listed below have all been recorded at the Mai Po Nature Reserve and are assessed to be of regional and/or local importance by Fellowes *et al.* 2002. Refer to Section 2.1.1.

Common Name	Scientific Name
Little Grebe	*Tachybaptus ruficollis*
Great Crested Grebe	*Podiceps cristatus*
Great Cormorant	*Phalacrocorax carbo*
Grey Heron	*Ardea cinerea*
Purple Heron	*Ardea purpurea*
Great Egret	*Ardea alba*
Intermediate Egret	*Egretta intermedia*
Little Egret	*Egretta garzetta*
Chinese Pond Heron	*Ardeola bacchus*
Striated Heron	*Butorides striata*
Black-crowned Night Heron	*Nycticorax nycticorax*
Yellow Bittern	*Ixobrychus sinensis*
Cinnamon Bittern	*Ixobrychus cinnamomeus*
Black Bittern	*Dupetor flavicollis*
Eurasian Bittern	*Botaurus stellaris*
Eurasian Spoonbill	*Platalea leucorodia*
Common Shelduck	*Tadorna tadorna*
Eurasian Wigeon	*Anas penelope*
Eurasian Teal	*Anas crecca*
Chinese Spot-billed Duck	*Anas zonorhyncha*
Northern Pintail	*Anas acuta*
Northern Shoveler	*Anas clypeata*
Tufted Duck	*Aythya fuligula*
Western Osprey	*Pandion haliaetus*
Black-winged Kite	*Elanus caeruleus*
Pied Harrier	*Circus melanoleucos*
Eastern Marsh Harrier	*Circus spilonotus*
Slaty-breasted Rail	*Gallirallus striatus*
Eastern Water Rail	*Rallus indicus*
Ruddy-breasted Crake	*Porzana fusca*
Eurasian Coot	*Fulica atra*
Pheasant-tailed Jacana	*Hydrophasianus chirurgus*
Greater Painted-snipe	*Rostratula benghalensis*
Black-winged Stilt (breeding)	*Himantopus himantopus*
Pied Avocet	*Recurvirostra avosetta*
Oriental Pratincole	*Glareola maldivarum*
Grey-headed Lapwing	*Vanellus cinereus*
Pacific Golden Plover	*Pluvialis fulva*
Grey Plover	*Pluvialis squatarola*
Little Ringed Plover	*Charadrius dubius*
Kentish Plover	*Charadrius alexandrinus*
Lesser Sand Plover	*Charadrius mongolus*
Greater Sand Plover	*Charadrius leschenaultii*
Bar-tailed Godwit	*Limosa lapponica*
Whimbrel	*Numenius phaeopus*

Common Name	Scientific Name
Spotted Redshank	*Tringa erythropus*
Common Redshank	*Tringa totanus*
Marsh Sandpiper	*Tringa stagnatilis*
Common Greenshank	*Tringa nebularia*
Wood Sandpiper	*Tringa glareola*
Terek Sandpiper	*Xenus cinereus*
Common Sandpiper	*Actitis hypoleucos*
Grey-tailed Tattler	*Tringa brevipes*
Ruddy Turnstone	*Arenaria interpres*
Red Knot	*Calidris canutus*
Sanderling	*Calidris alba*
Red-necked Stint	*Calidris ruficollis*
Little Stint	*Calidris minuta*
Temminck's Stint	*Calidris temminckii*
Long-toed Stint	*Calidris subminuta*
Sharp-tailed Sandpiper	*Calidris acuminata*
Dunlin	*Calidris alpina*
Curlew Sandpiper	*Calidris ferruginea*
Broad-billed Sandpiper	*Limicola falcinellus*
Black-tailed Gull	*Larus crassirostris*
Heuglin's Gull	*Larus fuscus*
Black-headed Gull	*Chroicocephalus ridibundus*
Gull-billed Tern	*Gelochelidon nilotica*
Caspian Tern	*Larus cachinnans*
Little Tern	*Sternula albifrons*
Pied Kingfisher	*Ceryle rudis*
White-throated Kingfisher	*Halcyon smyrnensis*
Black-capped Kingfisher	*Halcyon pileata*
Barn Swallow (roosting)	*Hirundo rustica*
Eastern Yellow Wagtail (roosting)	*Motacilla tschutschensis*
Red-throated Pipit	*Anthus cervinus*
Pechora Pipit	*Anthus gustavi*
Buff-bellied Pipit	*Anthus rubescens*
Bluethroat	*Luscinia svecica*
Pallas's Grasshopper Warbler	*Locustella certhiola*
Golden-headed Cisticola	*Cisticola exilis*
Zitting Cisticola	*Cisticola juncidis*
Asian Paradise-Flycatcher	*Terpsiphone paradisi*
Chinese Penduline Tit	*Remiz consobrinus*
Chestnut-eared Bunting	*Emberiza rutila*
Chinese Grosbeak	*Eophona migratoria*
Red-billed Starling	*Spodiopsar sericeus*
White-cheeked Starling	*Spodiopsar cineraceus*
White-shouldered Starling	*Sturnia sinensis*
Black-naped Oriole	*Oriolus chinensis*

Appendix 9 – Recommended annual drawdown timetable

	Dry Season						Wet Season					
Gei wai	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
#3/4												
#6												
#7												
#8b												
#10												
#11												
#12												
#13												
#14												
#16/17												
#18 (b)												
#19 (b)												
#21												
#22												
#23 (a)												

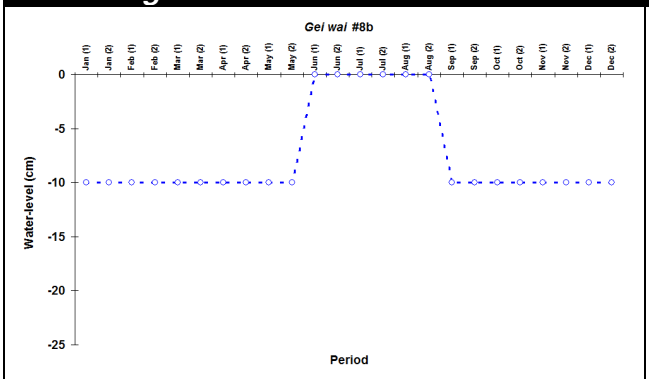
Appendix 10. Recommended grasscutting schedule

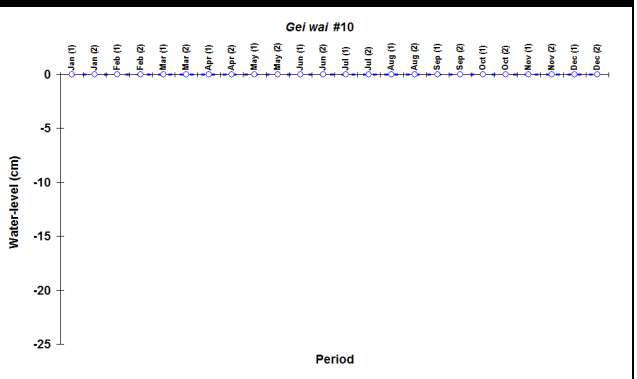
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Annual												
Islands : Pond #8a												
Islands : Pond #15a-b												
Islands : *Gei wai* #16/17 & #21												
Islands : *Gei wai* #23												
Perimeter and internal bunds : Pond #20												
Visitor footpaths*												
Bund section in front of Hides #1, #3, #5, #6, #7 and #8												
At least every 2 years												
Perimeter bunds : *Gei wai* #3/#4, #4/#6 & #6/#7												
Perimeter bunds : All other ponds and *gei wai*												
Internal bunds : All *gei wai*												

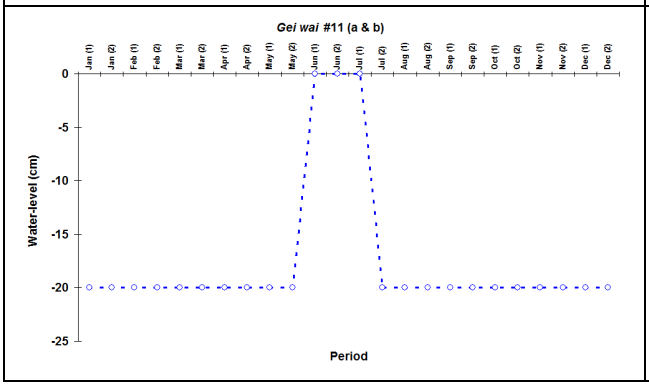
*AFCD warden path, footpaths leading to all hides, round table boardwalk, rotary trails, footpath #15a/#15b, footpath #12/#13, footpath #18//#19, southern reserve. Cut every two weeks during Jun - Oct.

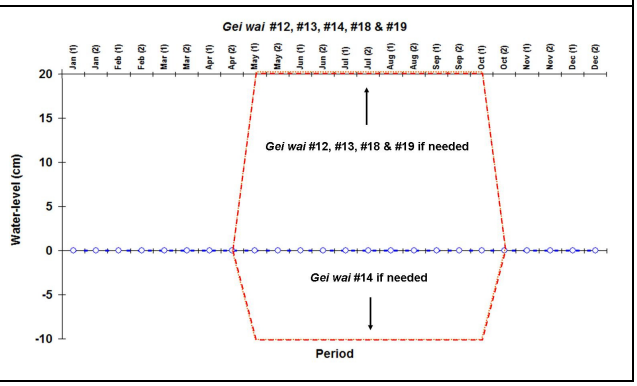
Appendix 11 – Recommended water levels

Brackish *gei wai*

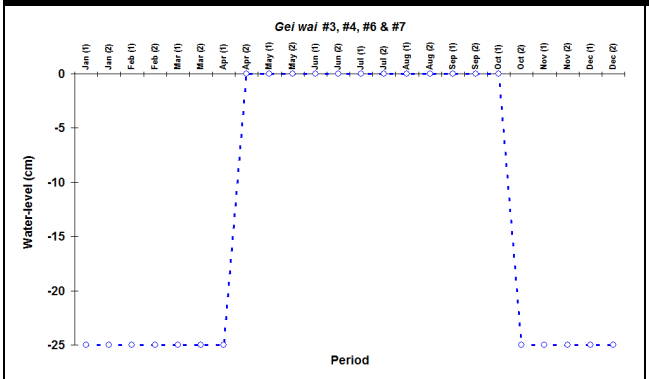


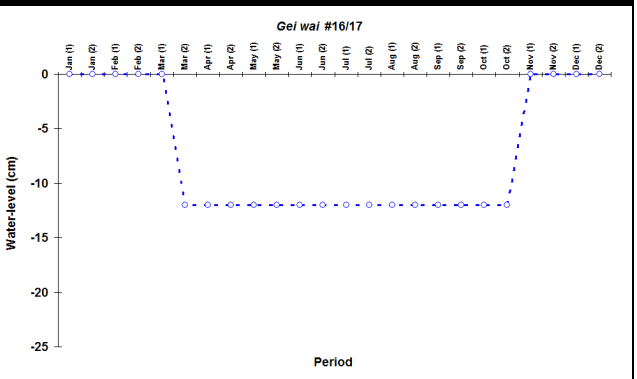


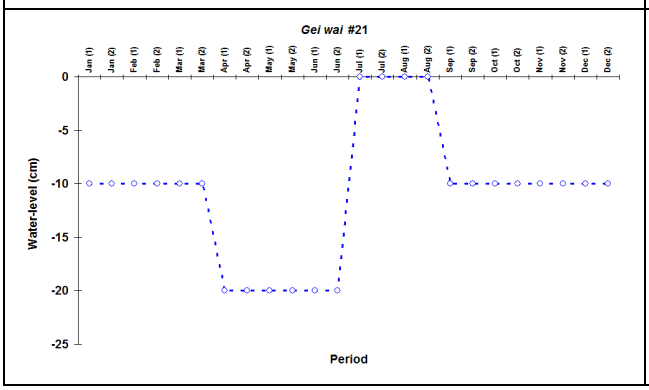


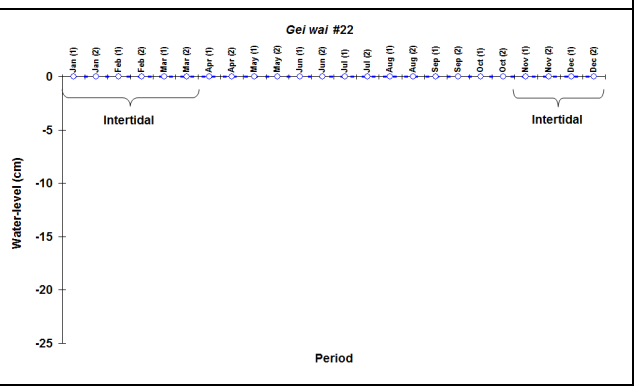


Brackish waterbird roosts

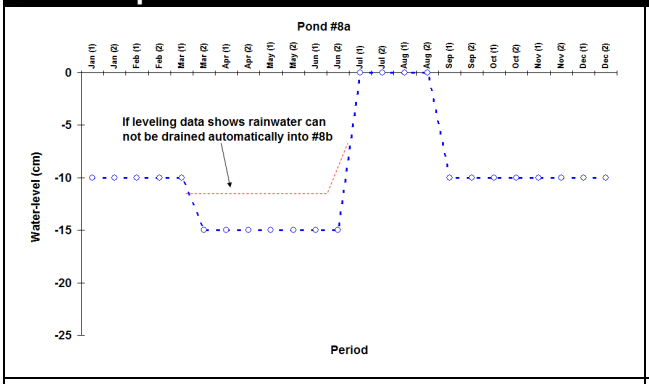


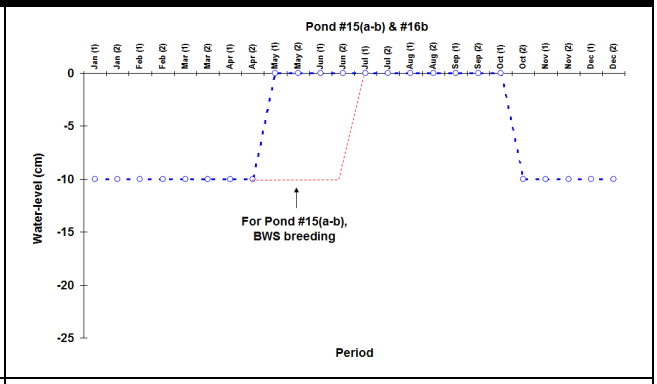


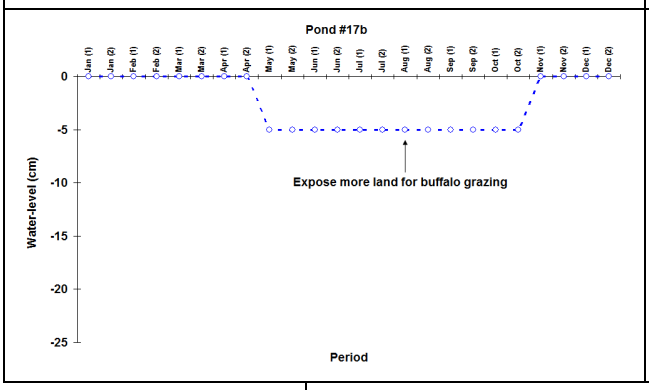


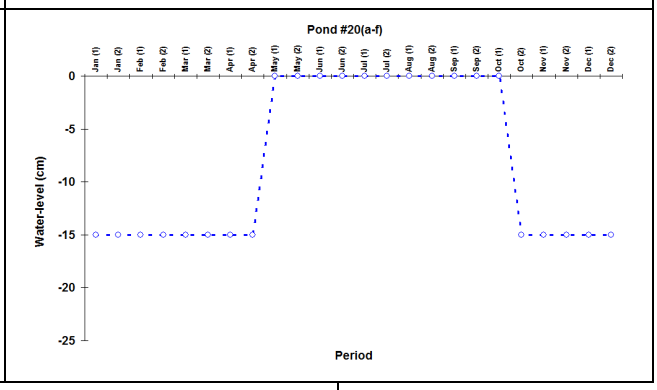


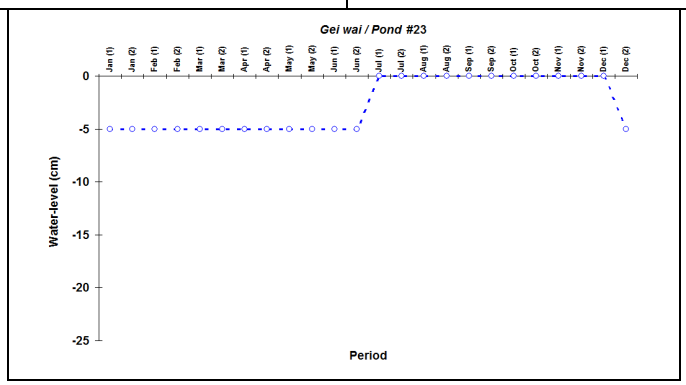
Rain-fed ponds/marshes



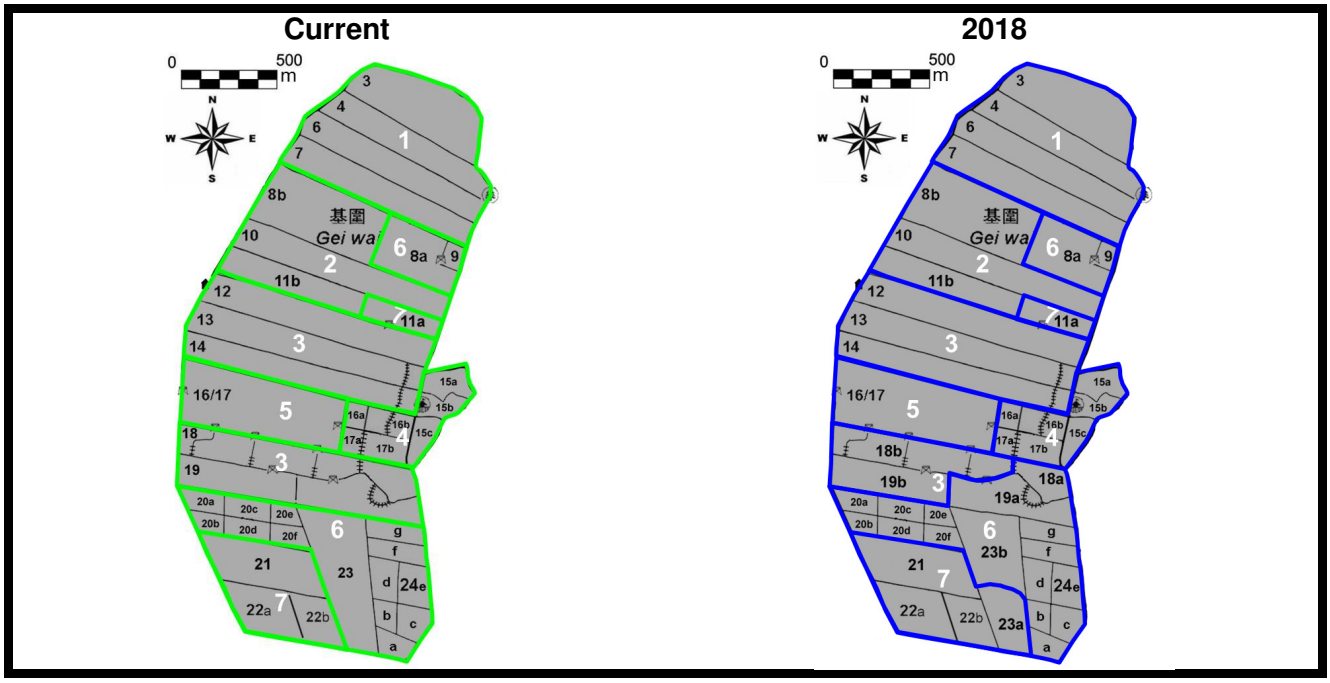






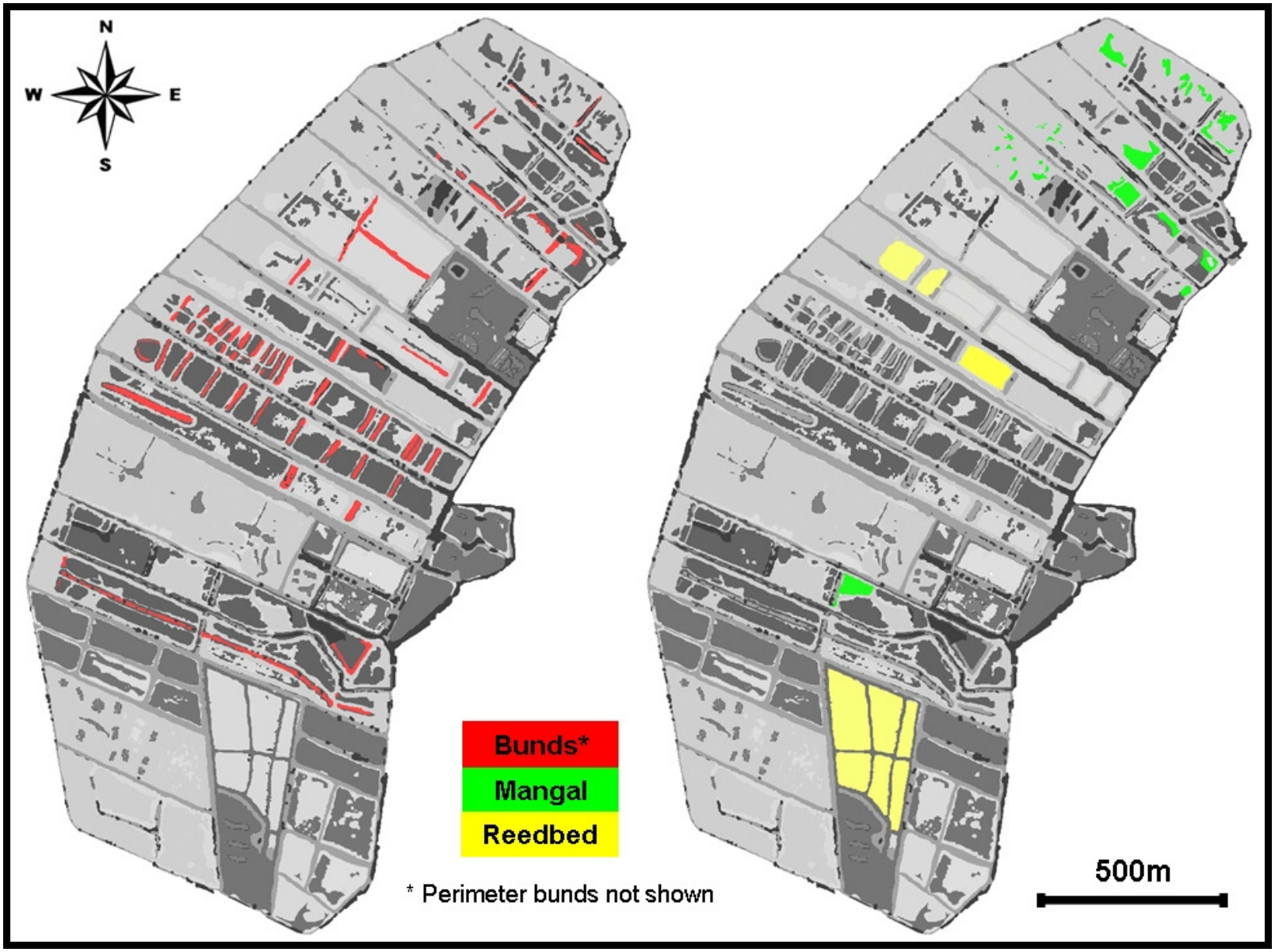


Appendix 12. Proposed revisions to the BMZ boundaries (also showing revised *gei wai* /pond referencing system) by 2018



BMZ Compartment *Gei wai* /pond code	BMZ Management Intention
BMZ 1 #3, #4, #6, #7	In the medium term, to adjust conditions in favour of supporting higher numbers of the Black-faced Spoonbill. Proposed change: None
BMZ 2 #8b, #10, #11b	In the medium term, to adjust conditions in favour of supporting a substantial block of reedbed habitat. Proposed change: None
BMZ 3 #12, #13, #14, #18b, #19b	In the medium term, to maintain traditionally managed production *gei wai* with areas of mangrove vegetation. Proposed changes: Boundary change, removal of Ponds #18a and #19a (refer OP8.1, projects *RFH/C06a* & *RFH/C06b*)
BMZ 4 #15a, #15b, #15c, #16a, #16b, #17a, #17b	In the long-term, to maintain and improve the Education Centre and its associated waterfowl collection. Proposed change: None
BMZ 5 #16/17	In the medium term, to adjust conditions in favour of creating an open, tidal area with fringing reeds and mangroves, shingle or tree-topped islands and pools/channels with varying sizes, heights and depths that can act as a secure high-tide roost for wintering waterfowls. Proposed change: None
BMZ 6 #8a, #9, #18a, #19a, #20, #23b, #24	(#8a, #9, #18a, #19a, #20, #22, #23b) In the medium term, to adjust conditions in favour of creating an open freshwater roosting area with fringing reeds and mangroves, shingle or tree-topped islands and pools/channels with varying sizes, heights and depths. Proposed changes: Boundary change, inclusion of Pond #18a and #19a (refer OP8.1, projects *RFH/C06a* & *RFH/C06b*), removal of Pond #23a (refer OP5.1, project *BWR/C06*) (#24) In the medium term, to adjust conditions in favour of creating a series of freshwater lakes of varying depth with surrounding areas of marsh. Proposed change: None
BMZ 7 #11a, #21, #22a, #22b, #23a	To maintain as an open high-tide roosting site as an alternative to *Gei wai* #16/17. Proposed change: Boundary change, inclusion of Pond #23a (refer OP5.1, project *BWR/C06*)

Appendix 13. Resource dependant works



Appendix 14. References

Anderson, C. 1994. **The Production Ecology of the Mangrove at the Mai Po Marshes Nature Reserve, Hong Kong**. Unpublished Ph.D. thesis, University of Hong Kong.

Anon, 2006a. **Trial on Improvements to the High-tide Roosting Habitat for Migratory Waterbirds at *Gei wai* #16/17 Mai Po Nature Reserve 2005-06 : Final Report**. Report by World Wide Fund For Nature Hong Kong to the Agriculture, Fisheries and Conservation Department, Hong Kong Special Administrative Region Government.

Anon. 2006b. **Trials to Improve the Roosting Habitat for Wintering Waterfowl in Ponds #20 and #24 at Mai Po Nature Reserve 2005-06 : Final Report**. Report by World Wide Fund for Nature Hong Kong to the Agriculture, Fisheries and Conservation Department, Hong Kong Special Administrative Region Government.

Anon. 2011. **Mai Po Inner Deep Bay Ramsar Site Management Plan**. The Agriculture, Fisheries and Conservation Department, Hong Kong SAR Government, Hong Kong.

Anon. 2012. **Mai Po Inner Deep Bay Ramsar Site Baseline Ecological Monitoring Project 2011-12: Fieldwork and Laboratory Analysis (BEMP 11-12 F&LA) - Final Report**. Submitted to Agriculture, Fisheries and Conservation Department, The Hong Kong SAR Government by Division of Life Science The Hong Kong University of Science and Technology.

Ballantyne L., Fu X. H., Shih, C.H., Cheng C.Y. & Yiu V., 2011. ***Pteroptyx maipo Ballantyne*, A New Species of Bent-winged Firefly (Coleoptera: Lampyridae) from Hong Kong, and its Relevance to Firefly Biology and Conservation**. Zootaxa 2931:8-34

Chan, A., Cheung, J., Sze, P.,Wong, A., Wong, E. and Yau, E. 2011. **A Review of the Local Restrictedness of Hong Kong Butterflies**. In Hong Kong Biodiversity: Agriculture, Fisheries and Conservation Department Newsletter, Issue No.21. Hong Kong Special Administrative Region Government.

de Sherbinin, A., Lacko, A., and Jaiteh, M. 2012. **Evaluating the risk to Ramsar Sites from Climate Change Induced Sea Level Rise**. Ramsar Scientific and Technical Briefing Note no. 5. Gland, Switzerland: Ramsar Convention Secretariat.

Environmental Protection Department. 2011. **Marine Water Quality in Hong Kong - 2011**. Hong Kong S.A.R. Government, Hong Kong.

ERL (Asia) Ltd. 1991. **Deep Bay Guidelines for Dredging, Reclaimation and Drainage Works**. Report to the Environmental Protection Department of the Hong Kong Government.

Fellowes, J.R., Lau, M.W.N., Dudgeon, D., Reels, G., Ades, G.W.J., Carey, G.J., Chan, B.P.L., Kendrick, R.C., Lee, K.S., Leven, M.R., Wilson, K.D.P. & Yu, Y.T. 2002. **Wild Animals to Watch: Terrestrial and Freshwater Fauna of Conservation Concern in Hong Kong**. *Memoirs of the Hong Kong Natural History Society* 25: 123-159.

Hong Kong Observatory. 2012. **Data from the Lau Fau Shan Automated Meteorological Station**. <http://www.hko.gov.hk/cis/data/awsext_e.htm>. Downloaded on 01 December 2012.

Hong Kong Observatory. 2013. **Climate Change summaries for Hong Kong.** <http://www.hko.gov.hk/climate_change/climate_change_e.htm >. Accessed 15 October 2013.

IPCC, 2007. **Climate Change 2007 : Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment. Report of the Intergovernmental Panel on Climate Change** [Core Writing Team, Pachauri, R.K and Reisinger, A.(eds.)]. IPCC, Geneva, Switzerland, 104 pp.

Irving, R. & Morton, B. 1988. **A Geography of the Mai Po Marshes. World Wide Fund for Nature Hong Kong, Hong Kong.**

IUCN. 2013. **The IUCN Red List of Threatened Species. Version 2013.1**. <http://www.iucnredlist.org>. Downloaded on 15 October 2013.

Landford, R. I., Lai, K. W., Arthurton, R. S. & Shaw, R. 1989. **Geology of the Western New Territories, 1:20000 Sheets, 2, 5 & 6**. *Hong Kong Geological Survey Memoir No. 3*. Hong Kong Government Printer.

Lau, S.S.S. & Chu, L.M. 2000. **The Significance of Sediment Contamination in a Coastal Wetland, Hong Kong, China**. *Water Research* 34: 379-386.

Lawler. W. 1995. **Wader Roost Construction in Morton Bay : A feasibility Study into the Construction of Migratory Wader (shorebird) High Tide Roosts in Moreton Bay, Queensland, Australia**. Prepared on behalf of the Queensland Wader Study Group by ECOPIX for the Queensland Department of Lands, Australia.

Lee, S.Y. 1992. **The Management of Traditional Tidal Ponds for Aquaculture and Wildlife Conservation in Southeast Asia : Problems and Prospects**. *Biological Conservation*, 63, 113-118.

Lee, S.Y. & Leung, V. 1999. **The Brachyuran Fauna of the Mai Po Marshes Nature Reserve and Deep Bay, Hong Kong**. pp. 57-82. In: Lee, S.Y. (ed.) *The mangrove ecosystem of Deep Bay and the Mai Po Marshes, Hong Kong*. Hong Kong University Press, Hong Kong.

Lee, J.H.W. & Qian, A. 2003. **Three-dimensional Modeling of Hydrodynamic and Flushing in Deep Bay**. *International Conference on Estuaries and Coasts*. November 9-11, 2003, Hangzhou, China.

Liu, K., Li, X., Wang, S.G., Qian, J.P., and Zhong, K.W. 2005. **Monitoring the Changes of Mangrove Wetland around Zhujiang Estuary in the Past Two Decades by Remote Sensing**. *Tropical Geography*. 25(2): 111-116.

MacKinnon, J., Verkuil, Y.I. & Murray, N. 2012. **IUCN Situation Analysis on East and Southeast Asian Intertidal Habitats, with Particular Reference to the Yellow Sea (including the Bohai Sea)**. Occasional Paper of the IUCN Species Survival Commission No. 47.IUCN, Gland, Switzerland and Cambridge, UK.ii + 70 pp.

Melville, D.S. & Chan, S.Y. 1992. **The Discovery of *Ruppia maritima* L. (Ruppiaceae) at Mai Po, Hong Kong**. *Memoirs of the Hong Kong Natural History Society*, 19, 123-125.

Melville, D.S. & Morton, B. 1983. **Mai Po Marshes**. World Wildlife Fund Hong Kong, Hong Kong.

Morton, B. & Wong, P.S. 1975. **The Pacific Oyster Industry in Hong Kong**. *Journal of the Hong Kong Branch of the Royal Asiatic Society* 15: 139-149.

Ng, P.K. L., Khac, H.N. & Rahayu, D.L. 2010. **On the Taxonomy and Ecology of the Mangrove Crab Perisesarma Maipoense (SOH, 1978) (Crustacea: Decapoda: Bracyura: Sesarmidae) from Vietnam**. The Raffles Bulletin Of Zoology 2010 58(2): 239–243.

Reels, G.T. 1994. **Management Strategies for the Reed *Phragmites australis* (Cav.) Steud. at Mai Po Marshes Nature Reserve, Hong Kong, with Observations on the Associated Insect Fauna**. M.Phil. thesis. University of Hong Kong.

Qin P., Wong, Y.S. & Tam N.F.Y. 2000. **Energy Evaluation of Mai Po Mangrove Marshes**. Ecological Engineering 16:271-280.

Wang, S. and Xie, Y. 2004. **China Species Red List. Vol. 1 Red List**. Higher Education Press, Beijing, China.

Webster, M.A. 1975. **Conservation of the Deep Bay Marshes, Hong Kong**. Hong Kong Bird. Report 1974: 41-53.

Webster, M.A. 1979. **Hong Kong Bird Report 1977**. Hong Kong Birdwatching Society, Hong Kong.

Wong, C.M. 1986. **Shrimp Farming in Deep Bay - The Evolution and Present Situation of a Traditional Industry**. B.A. thesis. University of Hong Kong, Hong Kong.

WWF-HK. 2006. **Management Plan for the Mai Po Nature Reserve**. World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK. 2008. **Study upon the Wildlife Impact and Potential Economic Habitat Management Benefits of Introducing Asian Water Buffalo *Bubalus bubalis* into the Freshwater Ponds at Mai Po Nature Reserve – Final Project Report 2008.** Report to the Environmental Conservation Fund by World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK & HKBRG. 2008. **Study into the Avian Value of Different Aged Stands of *Phragmites Australis* at Mai Po Nature Reserve**. Joint report by the World Wide Fund for Nature Hong Kong and the Hong Kong Bird Ringing Group.

WWF-HK 2010. **WWF-HK 5-year Strategic Plan**. The World Wide Fund for Nature Hong Kong, Hong Kong. (internal document).

WWF-HK. 2012a. **Freshwater Pond Vegetation Management Trial using Asian Water Buffalo *Bubalus bubalis* at Mai Po Nature Reserve. Phase II (2009-10): Project Report**. World Wide Fund for Nature Hong Kong.

WWF-HK 2012b. **Mai Po Master Plan.** The World Wide Fund for Nature Hong Kong, Hong Kong. (internal document).

WWF-HK 2012c. **Review of the 2006 Mai Po Management Plan.** The World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK *in prep [a]*. **Prioritizing Migratory Shorebird Species for Conservation in the EAA Flyway**. The World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK *in prep [b]*. **Waterbird Usage of a Newly Created Brackish Shallow Water High-tide Roost in *Gei wai* #21**. The World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK *in prep [c]*. **Waterbird Usage of a Rain-fed Pond Following Conversion from Brackish**. The World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK *in prep [d]*. **Waterbird Usage of Draining *Gei wai* at the Mai Po Nature Reserve.** The World Wide Fund for Nature Hong Kong, Hong Kong.

WWF-HK *in prep [e]*. **Waterbird Usage of Inter-tidal *Gei wai* at the Mai Po Nature Reserve.** The World Wide Fund for Nature Hong Kong, Hong Kong.

MAI PO NATURE RESERVE
HABITAT MANAGEMENT, MONITORING AND RESEARCH PLAN 2013-2018

VOLUME II
MONITORING AND RESEARCH

October 2013

WWF Hong Kong
15/F Manhattan Centre
8 Kwai Cheong Road
Kwai Chung
New Territories
Tel: [852] 2526 1011
Fax: [852] 2845 2764
e-mail: maipo@wwf.org.hk
website: www.wwf.org.hk

CONTENTS

Chapter / Section *Page*

Citation:
WWF-HK 2013. **Mai Po Nature Reserve Habitat Management, Monitoring and Research Plan : 2013 – 2018**. The World Wide Fund for Nature Hong Kong, Hong Kong.

Author:
Volume II: John Alcock, WWF Hong Kong

[Cover photo: © John and Jemi Holmes]

Appendices

List of Tables

Tables

MONITORING PLAN

1. INTRODUCTION

1.1 GENERAL INTRODUCTION TO THE MAI PO NATURE RESERVE

The Mai Po Nature Reserve (MPNR) is an area of brackish coastal wetland set up and managed by the World Wide Fund for Nature Hong Kong (WWF-HK). The Reserve and surrounding wetlands (collectively referred to as the Inner Deep Bay area) are designated as a Wetland of International Importance under the Ramsar Convention, an Important Bird Area by Birdlife International, a Flyway Network Site by the Partnership for the East Asian-Australasian Flyway and are identified as one of 16 critical inter-tidal areas in Asia for migratory waterbirds by the International Union for the Conservation of Nature (Mackinnon *et al.* 2012). The Reserve is also a Site of Special Scientific Interest.

The Reserve lies in the north-western New Territories of the Hong Kong S.A.R on the eastern shore of Deep Bay (Appendix 1). On the opposite side of the Bay is the Shenzhen Special Economic Zone, Guangdong Province, People's Republic of China (P.R.C). Deep Bay is an eastern branch of the Pearl River estuary.

Throughout this Plan, the term '*gei wai*' and 'pond' are used to refer to the different impounded waterbodies inside the MPNR. *Gei wai* (plural *gei wai*) is a Chinese term and is synonymous with the rearing of shrimp. A direct translation of *gei wai* is earth bunded pond. *Gei wai* is the official name used in all land licence documentation, but for the purposes of this Plan, '*gei wai*' refers to any brackish water pond which has an operational sluice gate, and 'pond' refers to rain-fed ponds (or former ponds now managed as rain-fed habitat) that do not have a sluice gate, or the sluice gate is blocked and is non-functional.

1.2 SCOPE OF THE MONITORING PLAN

The Monitoring Plan includes all monitoring conducted at MPNR, which can be broadly divided into two categories; Baseline Monitoring and Surveillance of species of importance, and Follow-up Monitoring of habitat management actions. Most monitoring is conducted in within the boundary of MPNR, but the Plan also covers follow-up monitoring of management work conducted on the mudflat outside the floating bird hides.

Full details of the monitoring methodologies are provided in Appendicies 1 to 15. These include full details of the timing, frequency and route of the monitoring survey, as well as the parameters to be surveyed (where appropriate).

1.2.1 Ecological Baseline Monitoring and Surveillance

Ecological Baseline Monitoring is designed to investigate the prevailing ecological conditions at the site. This is important so that future changes from this baseline can be identified and the significance of these can be assessed, permitting adaptive modification of the habitat management regime if necessary.

For some species groups, Baseline Monitoring has been conducted at MPNR for several years. Monitoring of these species groups has now entered a surveillance stage, where continued monitoring is carried out to identify any changes in abundance of the species which may be related to a change in conditions. This means any deterioration in conditions or decline in species of importance can be rapidly identified, so that the cause for the change can be investigated and prompt action can be taken where appropriate. In many cases the species covered by surveillance monitoring are included as Species-related Indicators in Volume I - Habitat Management Plan. Surveillance is carried out for Morning Bird Count, Black-faced Spoonbill, roosting Anatidae, Collared Crow, nesting Black-winged Stilts, adult odonata and habitat mapping.

Other species groups and environmental parameters do not currently have baseline monitoring data against which any change in abundance could be compared. Methodologies are proposed to collect data on the baseline conditions of these parameters for future surveillance or for monitoring of habitat management actions. Parameters for which baseline data will be collected during this five-year plan include shorebirds/terns, amphibians, water quality and water depth.

1.2.2 Follow-up Monitoring of Habitat Management Actions

It is useful after a management action has been implemented that follow-up monitoring is carried out to evaluate the success of that habitat management action and to ensure that habitat management is achieving the desired results.

Regular follow-up monitoring is carried out for the mangrove seedling clearance on the intertidal mudflats and for the effectiveness of *gei wai* drawdown for attracting ardeids and spoonbills. These annual activities require monitoring to ensure the desired benefits are achieved through the management action.

Larger-scale habitat management changes are not a routine action to be conducted on a regular basis, and specific projects for follow-up monitoring are not included in this plan. Follow-up monitoring may, however, be appropriate for evaluation of the success of certain large-scale habitat management projects over the course of the five-year plan. The requirement for follow-up monitoring will be assessed by the Manager, Habitat Management and Monitoring on a case-by-case basis, or may be recommended by the Mai Po Management Committee. Data for follow-up monitoring could either be collected specifically for that monitoring or could be taken from the routine surveillance monitoring of the site.

1.3 FACTORS AFFECTING THE DESIGN OF MONITORING METHODOLOGIES AND DATA QUALITY

1.3.1 Seasonality

1.3.1.1 *Climate*

Hong Kong has a typically wet, sub-tropical climate exhibiting pronounced seasonality, especially in temperature, humidity and rainfall. Average temperature are lowest during January and highest during July. The wettest months are June, July and August.

Tropical cyclones occur from June to October (although gales may occur any time between May and November). Heavy rain from tropical cyclones may last for a few days, and subsequent flooding may cause more damage than the winds.

This annual variation in climatic conditions produces a pronounced seasonality in Hong Kong with a strong influence on species. The warm, wet season is generally suitable for breeding of most species, particularly wetland species. Most invertebrates and herpetofauna are most active at this time, and this is also the peak growing season for most plant species.

During the dry season, when temperatures, humidity and rainfall are lower, some species become dormant. Many invertebrates spend the dry season in egg or larval form, while annual plants will remain as seeds until suitable conditions return in the wet season. Monitoring of species showing strong seasonality is therefore best carried out at the times when the species involved is most active and easily surveyed, which in many cases this occurs during the wet season.

It is important to bear in mind, however, that other factors (for example, abundance of prey or predators, impact of heavy rainfall or typhoons) may also influence the seasonality of a particular species and thus different species may peak during different months. Prevailing conditions on the day of the survey may also affect results. Most monitoring methodologies therefore involve conducting multiple surveys over a span of several months each year, to cover the peak activity period of the species or group involved.

1.3.1.2 *Bird migration*

Many of the bird species occurring at MPNR are migratory. In most cases, these species breed to the north of Hong Kong during the northern summer and migrate south during the northern winter.

Certain bird species winter at MPNR, with the greatest numbers occurring during the months of November to March. Other species spend the northern winter to the south of Hong Kong but occur at MPNR during northward and southward migration. The peak migration months on the reserve are April - May for northward migration and September - November for southward migration (although southward migration of some shorebird species can commence as early as mid-July).

Most breeding bird species in Hong Kong are resident and do not undertake migratory movements, although some breeding species (most notably cuckoos) move south during the northern winter and occur in Hong Kong mostly during the period April – September.

1.3.2 Habitats

Habitat has a major influence on the species present. Monitoring methodologies therefore are designed to focus on surveying the most important habitat for the species or group being monitored. When the monitoring is investigating a species or group with specific habitat requirements and low mobility, the monitoring methodology may focus solely on a particular habitat type. In cases where there is a higher level of mobility and less exacting habitat requirements, monitoring is generally carried out across the entire site.

A brief overview of habitats on the reserve is provided here. More details of habitats, management intentions and management actions to maintain these habitats can be found in the Habitat Management Plan, Volume I. A habitat map for the reserve is provided in Appendix 17.

The Reserve is composed entirely of brackish and rain-fed habitats. The salinities of brackish habitats typically range from 2-3 ‰ in summer (lowest in July) to 16-18 ‰ in late winter. The salinities of rain-fed habitats vary greatly between ponds, but range from 2-9 ‰ between summer and late winter. The rain-fed habitats cannot be classified as 'freshwater' due to this range. There is a general salinity gradient across the Reserve, decreasing northward towards the Shenzhen River mouth.

1.3.2.1 *Rain-fed habitats*

A variety of rain-fed habitats occur, mainly in the southern and eastern portions of the Reserve. They support a range of flora and are particularly important for the Reserve's Odonata and Amphibian species. Rain-fed ponds are located at Ponds #8a, #9, #15, #16a, #16b, #17b, #20, #23 and #24. These vary in water depth, vegetation and management intention, as detailed in the Habitat Management Plan, Volume I. Buffalo grazing is carried out in Ponds #17b and #24.

1.3.2.2 *Brackish water habitats*

There are eight brackish waterbodies (called *gei wai*) being managed to rear fish and shrimp following traditional management practices. These contain open water and stands of vegetation; in *Gei wai* #12, #13, #14, #18 and #19 this vegetation is dominated by mangal, mostly mature *Kandelia obovata*, while in *Gei wai* #8b, #10 and #11 the vegetation is dominated by reedbed.

Seven brackish waterbodies are managed as habitat for roosting waterbirds through the provision of shallow water areas. *Gei wai* #16/17 and #21 are largely devoid of internal vegetation and are managed to provide open water and shallow islands for roosting shorebirds and ducks. *Gei wai* #3, #4, #6 and #7 contain scattered mangal vegetation and are designed for roosting Black-faced Spoonbills. *Gei wai* #22 is flanked by *P. australis*, with a few vegetated internal bunds, and is operated as intertidal habitat during the dry season.

1.3.2.3 *Terrestrial habitats*

Bunds of varying height and width are found throughout the Reserve. Vegetated bunds are dominated by grasses and a variety of tree/shrub species. Unvegetated bunds are typically found close to recently completed de-silting works. Given that most monitoring concentrates on wetland species, these terrestrial habitats may not be surveyed by some monitoring methodologies.

1.3.3 Time of Day

Activity patterns of different species vary according to the time of day. The time of the survey therefore influences how effective the survey will be at recording the particular species or group being monitored. For example, certain bird species are most effectively surveyed when entering into communal roosts at particular locations, whereas other birds are best monitored in the early morning when they are most active.

1.3.4 Tidal Level

The MPNR comprises enclosed waterbodies which are not generally subject to significant tidal

variation in water levels (the main exception being *Gei wai* #22 when under tidal operation in the dry season). Some bird species using the reserve are, however, significantly influenced by daily variation in tidal level, foraging on the exposed mudflats during low tide and roosting on the reserve during high tide. Monitoring of these species requires timing of the survey according to the tide, and where necessary this is specified in the methodology.

1.4 MONITORING SURVEYS

1.4.1 Faunal Monitoring Surveys

1.4.1.1 FM01 - Morning bird count (Appendix 1)

Surveys of all birds (including both wetland and terrestrial species) are carried out along a transect around the perimeter of MPNR. Surveys are conducted twice per month in all months of the year, starting at sunrise.

1.4.1.2 FM02 - Black-faced Spoonbill (Appendix 2)

Surveillance of the number of Black-faced Spoonbills roosting at MPNR during the middle of the day. Surveys to cover all of reserve but with a particular focus on BMZ1, and conducted during the peak period for Black-faced Spoonbills (November – March).

1.4.1.3 FM03 - Roosting anatidae (Appendix 3)

Monitoring of the number of ducks roosting at MPNR in evening by survey conducted at sunset. Surveys to cover all of MPNR but with a particular focus on ponds used by roosting ducks (especially BMZ5 and 7). Surveys conducted during main period of occurrence of ducks (October – April).

1.4.1.4 FM04 - Roosting shorebirds and terns (Appendix 4)

Baseline monitoring of the number of shorebirds and terns roosting at MPNR during high tide period. Main focus is on BMZ5 and 7 but to cover entire reserve. Surveys conducted during period of daytime high tides, mostly during migration period (March – May and July – October).

1.4.1.5 FM05 - Roosting Collared Crow (Appendix 5)

Collared Crow is a globally near-threatened species for which Deep Bay supports an important population. The species roosts communally in mangroves adjacent to MPNR and surveillance is carried out of the number of individuals seen entering the roost in the evening. Surveys are conducted in summer (July-August) and winter (late December – early February).

1.4.1.6 FM06 - Breeding Black-winged Stilt (Appendix 6)

Black-winged Stilt first nested at MPNR in 2003, and has subsequently bred annually on the reserve. Surveys are carried out for the number of nests of the species as well as the number of chicks seen, as an approximation for nesting success. Most nests in recent years have been on *Gei wai* #16/17 and #21.

1.4.1.7 FM07 - Ardeid and spoonbill use of *gei wai* during drawdown (Appendix 7)

Drawdown of *gei wai* is carried out to provide food for ardeids and spoonbills which are attracted as falling water levels trap shrimp and fish in water depths accessible to these species. Monitoring of these species during the drawdown period provides an assessment of the effectiveness of this measure as a management tool. Drawdown is conducted in both the brackish *gei wai* and in the brackish waterbird roosts, and can be carried out in either the wet season or the dry season (the timing varying in each *gei wai*).

1.4.1.8 FM08 - Waterbird use of mudflats (Appendix 8)

Management is carried out each year to control vegetation on 45ha of intertidal mudflat in front of the floating birdwatching hides. Surveys are carried out on the managed area each winter to monitor the total number of waterbirds using this managed area of mudflat.

1.4.1.9 FM09 - Amphibians (Appendix 9)

Amphibians are largely absent from the brackish *gei wai* at MPNR but are present in the rain-fed ponds. Although amphibians were monitored in the 1990s following the enhancement of Pond #20, regular monitoring across all rain-fed ponds has not been conducted prior to 2013. Baseline monitoring will provide information about the abundance and diversity of this group on the reserve, to help inform future management of the rain-fed habitat. Monitoring is carried out in the evening during the wet season, when male amphibians call to attract mates.

1.4.1.10 FM10 - Adult odonata (Appendix 10)

Similar to amphibians, most odonata (dragonflies and damselflies) are reliant on the rain-fed ponds on the reserve. Baseline surveys have been conducted at the rain-fed ponds since 2006 and ongoing surveillance of these species will provide information to inform the ongoing management of these ponds.

1.4.2 **Environmental Monitoring Surveys**

1.4.2.1 EM01 - Water quality (Appendix 11)

Water quality affects aquatic life and can therefore have implications for wetland management. Prior to 2013 water quality has been monitored only in certain rain-fed ponds at the reserve. Baseline monitoring of the water quality in other ponds and *gei wai* is needed to identify any existing issues with water quality that may require management action and to study the interaction between water quality and site ecology to inform future management practices.

1.4.2.2 EM02 - Water level (Appendix 12)

Control of water levels is necessary to ensure that conditions are suitable for wetland species. The Habitat Management Plan, Volume I - Appendix 11, sets out target water levels for each of the waterbodies across the site, which require regular monitoring on a weekly basis to ensure the conditions are suitable for the targets.

1.4.2.3 EM03 - Water depth (Appendix 13)

Sediment brought into *gei wai* during water exchange causes sedimentation within the *gei wai*, leading to a shallowing of the perimeter channels and a consequent impact on water quality. Monitoring of the depth of water in these perimeter channels is required to identify the need for desilting work so that this can be carried out promptly in *gei wai* when required. The Habitat Management Plan identifies a target water depth of 60cm (Volume I - Table 11).

1.4.2.4 EM04 - Habitat mapping (Appendix 14)

Mapping of MPNR enables the tracking of the distribution and the total area of each habitat type present on the reserve. This information is important for habitat management decisions, to determine whether a particular habitat is increasing or decreasing and how this relates to targets set in the Habitat Management Plan. Habitats change gradually and this mapping is not required on a regular basis, only on two occasions over the course of the five-year plan.

1.4.2.5 EM05 - Fixed-point photography (Appendix 15)

As well as the distribution of habitats, monitoring of the quality of habitat is important for management. Habitat condition generally changes fairly gradually and thus is difficult to observe directly. Fixed-point photography is carried out to compare the condition of habitats at particular locations around the reserve in subsequent years, so that long-term changes can be monitored. Fixed-point photography at the mudflat hides is also used to monitor the effectiveness of the mangrove seedling clearance each year.

2. MANAGEMEMENT TARGETS AND REFERENCE INDICATORS

2.1 MANAGEMENT TARGETS

The Habitat Management Plan has identified target levels for certain environmental parameters. These are provided either to assess the physical condition of important features or to ensure that

important management operations for each feature are carried out effectively. Monitoring is required for each of these parameters to ensure that prescribed target levels are being met.

A complete list of Management Targets and the relevant Monitoring Methodology for evaluation of these targets is provided in Table 1. Details of the actual target levels for each attribute in each *Gei wai* or Pond are provided in the Habitat Management Plan (Volume I - Section 2.3).

2.2 SPECIES-RELATED INDICATORS

To further inform management decisions at the Reserve, species-related indicators are chosen for which numerical targets are not set. Indicators are for species / groups specific to the management objectives of particular Biodiversity Management Zones (BMZ) on the site or for which the reserve is important.

The way in which these indicators are used to inform management of the reserve is described in the Habitat Management Plan, Volume I - Section 2.3.

A complete list of species-related Indicators and the Monitoring Methodology relevant for monitoring of these is provided in Table 2.

Table 1. Management target attributes and relevant monitoring methodologies.

Attribute *	Project Code
Extent of feature	EM04
Area of reedbed	EM04
Area of mangal	EM04
Area of open water	EM04
% of wet reedbed	EM04
% of mature mangrove trees affected by climbers	EM04
% compliance with desired water exchange frequency	-
% compliance with desired water level	EM02
% of *gei wai* channels meeting waterdepth requirement	EM03
Salinity (winter)	EM01

* For details of target levels, please refer to Habitat Management Plan, Volume I - Section 2.3.

Table 2. Species-related indicators.

Species Indicator		Project Code
Diversity of odonates in rain-fed habitat		FM10
Number of spoonbills, herons and egrets using brackish *gei wai* during drawdown in the dry season		FM07
Number of spoonbills, herons and egrets using brackish waterbird roosts during drawdown in the wet season		FM07
The number and diversity of shorebird species using the high-tide roosts in BMZ5 and BMZ7		FM04
The number of Black-faced Spoonbill roosting in BMZ1		FM02
The number and diversity of wintering duck using BMZ5 and *Gei wai* #21		FM03
Number of individuals of important avifauna species		
Great Cormorant	*Phalacrocorax carbo*	FM01
Little Grebe	*Tachybaptus ruficollis*	FM01
Grey Heron	*Ardea cinerea*	FM01, FM07
Purple Heron	*Ardea purpurea*	FM01
Chinese Pond Heron	*Ardeola bacchus*	FM01, FM07
Striated Heron	*Butorides striata*	FM01
Great Egret	*Ardea alba*	FM01, FM07
Little Egret	*Egretta garzetta*	FM01, FM07
Intermediate Egret	*Egretta intermedia*	FM01
Yellow Bittern	*Ixobrychus sinensis*	FM01
Black-faced Spoonbill	*Platalea minor*	FM01, FM02, FM07
Northern Pintail	*Anas acuta*	FM01, FM03
Northern Shoveler	*Anas clypeata*	FM01, FM03
Tufted Duck	*Aythya fuligula*	FM01, FM03
Chinese Spot-billed Duck	*Anas zonorhyncha*	FM01, FM03
Black-winged Stilt	*Himantopus himantopus*	FM01, FM04, FM06
Pied Avocet	*Recurvirostra avosetta*	FM04
Pacific Golden Plover	*Pluvialis fulva*	FM04
Greater Sand Plover	*Charadrius leschenaultii*	FM04
Black-tailed Godwit	*Limosa limosa*	FM04
Eurasian Curlew	*Numenius arquatus*	FM04
Spotted Redshank	*Tringa erythropus*	FM04
Common Redshank	*Tringa totanus*	FM04
Common Greenshank	*Tringa nebularia*	FM04
Nordmann's Greenshank	*Tringa guttifer*	FM04
Terek Sandpiper	*Xenus cinereus*	FM04
Asian Dowitcher	*Limnodromus semipalmatus*	FM04
Red-necked Stint	*Calidris ruficollis*	FM04
Curlew Sandpiper	*Calidris ferruginea*	FM04
Lesser Sand Plover	*Charadrius mongolus*	FM04
Great Knot	*Calidris tenuirostris*	FM04
Whimbrel	*Numenius phaeopus*	FM04
Broad-billed Sandpiper	*Limicola falcinellus*	FM04
Gull-billed Tern	*Gelochelidon nilotica*	FM04
Western Osprey	*Pandion haliaetus*	FM01
Greater Spotted Eagle	*Aquila clanga*	FM01
Eastern Imperial Eagle	*Aquila heliaca*	FM01
Eastern Marsh Harrier	*Circus spilonotus*	FM01
Pied Kingfisher	*Ceryle rudis*	FM01
Manchurian Reed Warbler*	*Acrocephalus tangorum*	(To be monitored by external researchers)
Pallas's Grasshopper Warbler*	*Locustella certhiola*	(To be monitored by external researchers)
Chinese Penduline Tit*	*Remiz consobrinus*	(To be monitored by external researchers)
Bluethroat*	*Luscinia svecica*	(To be monitored by external researchers)

3. MAINTENANCE OF SPECIES LISTS

3.1 SPECIES LISTS

Species lists have previously been compiled for a number of taxonomic groups at MPNR, and these are presented the Haitat Management Plan, Volume I - Appendix 7. These species lists contain all species recorded on the reserve, but do not reveal information about the current status of these species. Changes in habitats and conditions on the reserve or in the surrounding area may have facilitated the colonization of new species, while other species may no longer occur regularly on the reserve. One aim during the period of the current plan (2013-2018) will be to update these species lists to reflect current conditions at MPNR through conducting baseline surveys for targeted groups. The species lists will be maintained according to the results from Regular Monitoring Surveys (Details in Section 1), Baseline Biodiversity Surveys (Paragraph 3.2) and Incidental Observations (Paragraph 3.3).

3.2 BASELINE BIODIVERSITY SURVEYS

3.2.1 Flora

The top priority for updated baseline surveys is considered to be flora. Plants have not been comprehensively surveyed at MPNR since 2003 and subsequent changes in management, particularly the expansion of rain-fed habitats, are expected to have led to changes in the floral community on site. An updated baseline of plant species present on the reserve, including not only the species list but also information about the distribution of certain species, will help inform habitat management. Given the time requirements and expertise required, such work may not be possible in-house and may require input from external parties, for example researchers, other NGOs or volunteers.

3.2.1 Fauna

Species lists and baseline conditions are relatively comprehensive and up-to-date for birds, mammals and dragonflies. Monitoring of amphibians proposed in FM09 will provide baseline conditions for this group.

Other faunal groups are less comprehensively studied, but in-house expertise and resource limitations make it difficult to conduct routine monitoring of these. WWF will liaise with appropriate external experts where these are available, to encourage further study into the species present on the reserve and to update species lists. Some of the studies carried out under the Research Plan (especially the studies looking at the ecological value of *gei wai* mangroves and the ecological value of freshwater vegetation) are expected to provide baseline information for certain taxonomic groups. Faunal groups considered to be high priority for updated species lists or baseline surveys include reptiles, fish, crustaceans, freshwater invertebrates and moths.

Monitoring methodologies for Baseline Biodiversity Surveys will depend upon the taxonomic group to be surveyed. Because the groups to be surveyed will be dependent upon the availability of experts and on other constraints, detailed methodologies for the surveys are not provided in this plan. The Mai Po Management Committee will be kept informed about proposed Baseline Biodiversity Surveys, and methodologies will be discussed with the committee when appropriate.

3.3 INCIDENTAL RECORDS

Being present in low densities and with cryptic behavior, mammals and reptiles are more difficult to record during scheduled transect surveys. For this reason regular surveys of these groups are not conducted by WWF at MPNR (although mammals are monitored at MPNR by AFCD through camera trapping, bat box surveys and bat trapping). In order to monitor the presence of mammals and reptiles on site, WWF maintains a database of any incidental sightings of these groups by WWF staff or reported by visitors to the reserve.

Databases are also maintained for incidental records of other groups when these are reported. Such incidental observations are useful for maintenance of updated species lists at the site and to record the presence of species of interest.

4. DATA STORAGE, WORK SCHEDULES AND REPORTING

4.1 DATA STORAGE

All data collected during the monitoring will be stored on the server at MPNR Education Centre. Back-up of all data on the server is carried out on daily basis to prevent accidental loss of data.

4.2 FIVE-YEAR MONITORING SCHEDULE

The monitoring listed in this Plan is to be carried out over a five-year period, which extends from 01 November 2013 to 31 October 2018.

Table 3. Five-year monitoring work schedule.

Project Code	Description	Yr1	Yr2	Yr3	Yr4	Yr5
	Monitoring Survey					
FM01	Morning Bird Count					
FM02	Black-faced Spoonbill					
FM03	Roosting Anatidae					
FM04	Roosting Shorebirds & Terns					
FM05	Roosting Collared Crow					
FM06	Breeding Black-winged Stilt					
FM07	Ardeid and spoonbill use of *gei wai* during drawdown (dry season)					
FM07	Ardeid and spoonbill use of *gei wai* during drawdown (wet season)					
FM08	Waterbird use of mudflat					
FM09	Amphibians					
FM10	Adult Odonata					
EM01	Water Quality					
EM02	Water Level					
EM03	Water Depth					
EM04	Habitats					
EM05	Fixed Point Photography					
EM05b	Fixed Point Photography (mudflat)					

4.3 ANNUAL WORK PLAN (recurrent)

Table 4. Annual monitoring work schedule.

Project Code	Description	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	Monitoring Survey												
FM01	Morning Bird Count												
FM02	Black-faced Spoonbill												
FM03	Roosting Anatidae												
FM04	Roosting Shorebirds & Terns												
FM05	Roosting Collared Crow												
FM06	Breeding Black-winged Stilt												
FM07	Ardeid and spoonbill use of *gei wai* during drawdown (dry season)												
FM07	Ardeid and spoonbill use of *gei wai* during drawdown (wet season)												
FM08	Waterbird use of mudflat												
FM09	Amphibians												
FM10	Adult Odonata												
EM01	Water Quality												
EM02	Water Level												
EM03	Water Depth												
EM04	Habitats												
EM05	Fixed Point Photography												
EM05b	Fixed Point Photography (mudflat)												

4.4 REPORTING

4.4.1 Progress Reports

The Manager, Habitat Management and Monitoring will verbally report work updates to the Mai Po Management Committee during the committee meetings. This will include a summary of the relevant Management Targets and Species-related Indicators monitored since the previous meeting.

Complete monitoring results of the previous year will be summarised during Mai Po Management Committee meetings on an annual basis. Written progress reports of monitoring results will not be prepared, but results will be summarised as part of the review at the end of the plan.

4.4.2 Plan Review

A detailed review of the MPNR Habitat Management, Monitoring and Research Plan will be conducted towards the end of the five-year plan, whilst WWF-HK's Mai Po Management Committee will conduct annual reviews of the progress on implementing the Plan and they will also approve any appropriate changes to the Plan.

RESEARCH PLAN

5. INTRODUCTION

5.1 GENERAL INTRODUCTION

In order to maximise the effectiveness of habitat management at MPNR, it is recognised that management decisions should be based upon the best available information. This requires a comprehensive understanding of existing conditions on the site as well as knowledge of the way that management impacts upon species, communities and habitat at the site. An understanding of potential threats, such as the impact of climate change, is also important to inform reserve management decisions.

In many cases, little information is available from existing literature concerning habitat management techniques or outcomes at the site. Considerable research into habitat management has been conducted in Europe and North America, but equivalent research is lacking for the habitats and species present in South China. In such cases, more research may be needed so that informed decisions can be made about habitat management.

The Research Plan details research to be conducted by WWF at MPNR during the period 2013-2018 to help fill the information gaps identified as crucial to management of the reserve.

WWF has previously conducted similar research projects at MPNR. A list of previous research topics is available in Appendix 16.

5.2 EXTERNAL RESEARCH

In addition to research conducted by WWF, the reserve also provides an important resource for universities and other researchers studying wetland ecology in South China. WWF will continue to promote and facilitate this research, which can help fill information gaps and even inform management of the site. Some priority research areas identified in sections 6 to 8 may be beyond the capacity of WWF staff, and such areas may require collaboration between WWF and external researchers.

Some of this external research is of direct benefit to management of the reserve, while other research increases scientific understanding of local wetlands. WWF will continue to provide assistance and support for these external researchers, including the maintenance of laboratory facilities, advice about obtaining permits for the reserve, and any other logistical assistance as required.

It has been recommended that some research projects would benefit from better co-ordination to ensure that research is not duplicated by multiple researchers and that data are shared between researchers where appropriate, to maximize the efficiency of data collection and to get maximum benefit from restricted research budgets. During the period of this plan, WWF will work towards better coordination between research projects at MPNR and sharing of resources where appropriate, to maximize the value of research.

5.3 PRIORITY RESEARCH LIST

In consultation with external experts and researchers, WWF compiles a list of Priority Research topics for Deep Bay in 2009. This list is available on the WWF website (in English and Chinese) and is also recommended to students or other parties looking for possible research topics in the Deep Bay area. This list will continue to be updated and provided in order to facilitate and encourage further ecological research in Deep Bay. Future lists may include the items identified as information gaps in Section 9 of this plan, as well as any recommended further research into habitats or species outside the boundaries of MPNR.

5.4 DISSEMINATION OF FINDINGS

WWF recognizes that it is important that the results of research projects are shared to a wider audience so that the findings can be followed up with further research or with management actions. Results of research projects conducted by WWF at MPNR are posted to the WWF website to provide a resource for other researchers, wetland managers or other parties. Where appropriate, the findings of monitoring and research projects on the reserve will also be written up and published in relevant journals to reach a wider audience of interested parties.

In April 2013, WWF organised a symposium to facilitate the sharing of results from wetland research, monitoring and management in the Deep Bay area, and to encourage discussion between relevant stakeholders, including researchers, wetland managers, government authorities and other stakeholders from both Hong Kong and Shenzhen. Following the success of the 2013 symposium, it is anticipated that similar events will be organised every two years with future symposia in 2015 and 2017.

6. HABITAT MANAGEMENT RESEARCH PROJECTS

6.1 INTRODUCTION

The importance and practice of actively managing the major habitats at MPNR to provide suitable conditions for target species is well established and is the basis for the Habitat Management Plan (Volume I). Management of MPNR aims to provide a diversity of wetland habitats in optimal condition in order to benefit the biodiversity value of the site. To achieve this aim and factoring in the limited area of MPNR, past land management history and availability of similar habitat in the surrounding Inner Deep Bay area, management decisions at the Reserve may at times necessitate a trade-off in the area of each habitat present, in which case research into the relative ecological value of different habitats is required so that informed science-based decisions can be made. Research is also required into management approaches (e.g. vegetation management techniques) in various habitats around the site so that their ecological value can be increased. In some cases, follow-up monitoring may be appropriate to ensure that habitat management has achieved the desired outcome (see Monitoring Plan, Sections 1 to 4).

Results from these research studies are important for future management of the reserve, and may also inform site managers at other sites in Hong Kong or elsewhere in the region. After completion of each study, data will be analysed and written into reports which will be made available on the WWF website and/or in other appropriate locations.

Habitat management research projects will sometimes span a period of several years to account for seasonal and inter-annual variations in species abundance and weather conditions. Three such projects are planned for the period 2013-2018. Research into reedbed management (RP01) has been ongoing for several years and is scheduled for completion in 2013. The other two research projects cover areas for which it is known that there is currently a shortage of information to inform habitat management, but details of these two projects have not yet been finalized. Details will be discussed and established with local experts, and a research plan for each will be appended to this Plan once completed.

6.1.1 RP01 - Reedbed Management: Comparison of Wet and Dry Reedbeds

Reedbed is one of the dominant habitats at MPNR, and provides habitat for a number of specialized bird and invertebrate species, including globally-threatened species such as Manchurian Reed Warbler *Acrocephalus tangorum*. A historical loss of reedbed in Hong Kong and elsewhere in South China means that the large area of habitat remaining at MPNR is particularly important. Vegetation succession leads to reedbed gradually being invaded by terrestrial vegetation, and regular management is required to maintain reedbeds in optimum condition.

Studies into the ecological importance of reedbeds at MPNR have been undertaken for several years. Reels (1994) and Lee (1997) looked at the value of reedbeds and management techniques. More recently, a study has looked into the value to passerine birds of reed stands of different ages; a report on this study is available at:
< http://awsassets.wwfhk.panda.org/downloads/reedbed_report___2009.pdf >

One question arising which has not been addressed in previous studies is the comparative value of wet and dry reedbeds to fauna. Studies overseas have shown wet reedbed to be important for birds, but no comparable studies have been undertaken in Asia. Wet reedbeds may also facilitate habitat management by slowing the colonisation of terrestrial vegetation. The excavation of a portion of reedbed at *Gei wai* #8b in 2006 provides an opportunity to conduct a comparative study of wet and dry reedbeds.

This study has been underway since 2011 (data for birds are also available since 2008, although the vegetation structure of the dry reedbed differed in 2008-2010). The collection of data into the comparative use of wet and dry reedbeds by birds and invertebrates has mostly been completed but data collection will continue until December 2013. Data collection will continue to study the

colonisation rate of terrestrial vegetation into wet and dry reed stands, and collection of data for this aspect of the study is scheduled to continue until 2015, although this timetable may be adjusted if the rate of colonisation of non-reed vegetation necessitates management action to restore reedbed conditions.

6.1.2 RP02 - Management of *Gei Wai* Mangroves and Associated Vegetation – Phase I

It is known that the intertidal mangrove habitat in Deep Bay is important for a number of locally- and globally-threatened species, but less research has previously been conducted on the mangrove habitats within the *gei wai* at MPNR. These mangrove habitats differ significantly in hydrological conditions, with water levels within the *gei wai* maintained at a set level without the daily tidal cycle experienced in mangroves outside the *gei wai*. Certain species characteristic of the intertidal mangroves (such as mudskippers and fiddler crabs) are largely absent from the *gei wai* mangroves. Areas of mangrove within the *gei wai* include stands dominated by true mangroves (mostly *Kandelia obovata* and *Aegiceras corniculatum*) as well as stands of *Acanthus ilicifolius* and Mangrove Fern *Acrostichum aureum*. Some stands are invaded by climbers, including the exotic pest *Mikania micrantha* and also native species such as *Derris trifoliata*.

Current management practices generally maintain the status quo of these areas of mangrove and mangrove associates. In the long-term this leads to a gradual succession and maturation of mangrove stands in the *gei wai* to a climax community. Given the limited area of the reserve, the retention of all climax mangroves has implications for other habitats, particularly open water, reedbeds and early-successional mangroves (for example stands of mangrove fern or *Acanthus*). The retention of the status quo also contrasts with the approach taken with other habitats, where habitat interventions are carried out at appropriate. In the long-term it may be desirable to carry out similar interventions on areas of mangrove, which may help to enhance biodiversity of the site by providing a greater diversity of microhabitats. This proposed research project aims to investigate the existing value of mangrove stands as a first step towards assessing the optimal management approach for mangroves on the reserve.

Mangrove Fern has a restricted distribution in Hong Kong and is not found in all mangrove areas in the territory. It is common in the *gei wai* at MPNR, where it also readily colonises drier reedbeds, thus contributing to the succession of reedbed into terrestrial habitat and long-term loss of reedbed habitat. In some areas, this can become the dominant vegetation type. Because of this, some areas of mangrove fern have been removed in recent years to restore open water and reedbed. It is not currently known, however, the extent to which mangrove fern is used by faunal species and whether stands of the species may be desirable for overall biodiversity at MPNR. Similarly, *Acanthus ilicifolius* is common in the *gei wai*, but the relative value of stands of this species compared to larger mangrove trees/shrubs is not known.

Research is scheduled to take place during 2014 and 2015. The exact scope of the research has not yet been determined, but will seek to collect information on the ecological value within the *gei wai* of true mangroves and associated vegetation including mangrove ferns and *Acanthus ilicifolius*. The study may investigate the use of these habitats by birds, invertebrates and/or plants. Similar to the reedbed management research, it is anticipated that this study is likely to be the first phase of a longer-term investigation into the optimal way to manage mangrove habitats within the *gei wai* at Mai Po, and may require a further phase of study in the next Research Plan.

6.1.3 RP03 - Ecological Value of Freshwater Habitats at MPNR

Management of MPNR in recent years has included an increase in the area of freshwater wetland. There is planned to be a further increase in the area of freshwater between 2013 and 2018, with the conversion to freshwater of the landward (eastern) end of *Gei wai* #18 and #19. Freshwater habitats provide important habitat for species which may not be found in the brackish gei wai, especially plants, aquatic invertebrates (including odonata), amphibians and fish.

In order to maximize the potential value of the freshwater ponds throughout the reserve, it is essential to understand the relationship between habitat and freshwater-dependent species. Environmental factors such as water depth, water quality and seasonality (whether ponds are permanently flooded or allowed to dry out during the dry season) may affect the use of these habitats by freshwater species. The relationships between freshwater flora and fauna in South China are also poorly known.

Previous research at MPNR has looked into the impacts of buffalo grazing on birds and vegetation at

freshwater ponds and the relative value of different species of emergent vegetation to the number of ducks roosting on Ponds #20 and #24. These results of these studies help to inform the management of freshwater ponds across the reserve, but further questions arise about management requirements to enhance freshwater species diversity. In particular, little is known about the impacts to freshwater species of water depth, water management regimes, relative value of different species of emergent vegetation (grasses, herbs, sedges, water lilies and reeds) and water quality.

Further study on this topic is scheduled to take place in 2016-2018. Details of the study are not yet finalized but it is anticipated that this research will involve the comparison of existing habitat currently under different management regimes, rather than the creation of new freshwater habitats.

7. MAI PO CLIMATE CHANGE IMPACT STUDY

Rapid climate change is recognised as a potential high threat to the biodiversity of wetlands with coastal wetlands particularly at risk from rising sea-levels. Generic information on the likely impacts to wetlands is widely available, however changes in climate and sea-level are predicted to vary across the planet, and the severity of an impact is influenced by localised conditions at each wetland.

Little is currently known about how rapid climate change will affect the MPNR. A preliminary desk-top study on this topic (WWF-HK 2007) identified a number of changes at the Reserve likely to have been driven by climate change. For example an earlier arrival time of several species of shorebird on their northward migration, and a suggestion that birds at the southern limit of their non-breeding range seem to be wintering further north. A more recent report by the Ramsar Bureau predicted that 39.3% of the Mai Po Inner Deep Ramsar Site would be lost to the rising sea by the end of the 21st Century under the 1m rise scenario (Ramsar 2012). Therefore to facilitate management decisions at the Reserve on how best to address the impacts of climate change, a study is proposed involving an assessment of the vulnerability and resilience of the MPNR to the effects of climate change. Academic involvement is necessary to model the data and generate scenarios. These assessments will form the backbone of a climate change adaptation and mitigation plan for the Reserve.

The undertaking of this study is subject to funding from a donor or a successful application to a relevant funding programme. WWF's role will be to coordinate the input of these experts and oversee the assessments. The non-research part of the project will require technical experts such as engineers to devise practical mitigation solutions to offset negative impacts.

8. BIRD RINGING AND MIGRATION RESEARCH

8.1 BIRD RINGING (banding)

MPNR is particularly important as a site for migratory birds, including both overwintering species and passage migrants which stop at the reserve during northward or southward migration. In order to understand more about bird migration and/or behaviour, birds are trapped and fitted with a metal ring (or band) carrying a unique code. If the bird is subsequently retrapped (in Hong Kong or elsewhere), information can be collected about the movements of birds within or beyond Hong Kong.

Much of the research into bird migration carried out using bird ringing is passive, and relies upon recoveries or observations of birds elsewhere. Although the recoveries provide useful information about migration routes, ringing at a single site such as MPNR may not be sufficient to answer specific questions about the migration of a particular species.

Bird ringing can also be used more actively for research at a single site into a particular aspect of bird ecology or habitat preferences, especially for passerines inhabiting dense habitats where they are difficult to observe in the field. At MPNR, this is particularly the case in reedbed habitat which can support a high abundance of species which are difficult to observe in the dense stands of reed (including species of conservation importance such as Manchurian Reed Warbler and Styan's Grasshopper Warbler). Bird ringing in the reedbed at *Gei wai* #8b is a vital part of the reedbed management study (RP01) and monitors the presence of certain Species-related Indicators in the Habitat Management Plan, Volume I.

Bird ringing is currently carried out at MPNR by volunteers from two ringing groups, both of which include members of staff from WWF. The Hong Kong Bird Ringing Group (HKBRG) traps birds mostly at *Gei wai* #7 and #8b, largely as part of the study into reedbed management. The Hong Kong Bird Watching Society Ringing Group (HKBWSRG) mostly rings birds at *Gei wai* #18 and #19. To assist with the work, WWF maintains the trapping sites in suitable condition, maintains facilities to

provide a location for ringing and when appropriate (and when budget allows) assists with purchase of equipment. WWF collects data at the end of each year regarding the number of individuals of each species trapped at MPNR over the course of the year.

8.2 SHOREBIRD LEG-FLAGGING

As well as the uniquely coded metal ring, shorebirds trapped at MPNR since 2001 have also been fitted with small plastic leg flags, which can easily be seen in the field. Under the shorebird leg-flagging protocol for the East Asian-Australasian Flyway, each country or region in the flyway has a particular colour combination for leg flags that allow field observers to recognize where the bird was trapped and flagged; the leg flags used in Hong Kong involve a combination of a white flag over a yellow flag on the right leg. By collecting observations from sites along the flyway, it is possible to gain further understanding of the migration strategy of shorebird species. Since 2010, most leg flags used in Hong Kong also involve an alphanumeric code to allow individual birds to be recognized in the field, allowing further information about movements of individual birds both within Hong Kong and to other sites in the region.

WWF cooperates with Hong Kong Bird Watching Society and with other organisations along the flyway to collate observations of shorebirds flagged in Hong Kong and resighted in other locations and observations of birds flagged in other locations and resighted in Hong Kong.

8.3 SATELLITE TRACKING AND OTHER MIGRATION RESEARCH TECHNOLOGIES

The use of ringing and leg-flagging for migration research is relatively low-cost but relies on observers reporting the birds from elsewhere. Technology is available for remote monitoring of individual birds to understand more about their movements, even if no observers are present. Tracking technologies include:

- *Radio-tracking*. Birds are fitted with a radio-transmitter and tracked using a receiver. Effective over relatively short distances. Equipment relative inexpensive but typically requires high time input to collect locations.
- *Satellite tracking*. Birds are fitted with a tag that collects data on location and relays it back to the researcher via satellite. Can use either GPS or Argos satellites to track anywhere. Low time input required but tags and satellite time are relatively expensive and cannot be used on smaller species.
- *Geolocators*. A datalogger attached to the bird records information that allows the location to be determined from the datalogger. Relatively inexpensive technology and low time input required, but it is necessary for the same individual bird to be recaptured to retrieve the datalogger.

Previous migration research conducted at MPNR (by WWF, ringing groups, AFCD and other parties) has included satellite tracking and radio-tracking of Black-faced Spoonbills, and satellite tracking of ducks. When opportunities arise, WWF will provide facilities to support further migration research of this type to gain a more comprehensive understanding of the movements of birds along the flyway. If resources are available over the course of this plan, it is expected that shorebirds would be a particular focus of future tracking studies, particularly species for which MPNR is important or which are poorly studied at other sites on the flyway, to help understand more about the migration stop-over and breeding sites of these species.

9. POTENTIAL FUTURE RESEARCH REQUIREMENTS TO INFORM RESERVE MANAGEMENT

9.1 INTRODUCTION

During the review of the previous Habitat Management Plan and the preparation of this Habitat Management, Monitoring and Research Plan, several gaps in knowledge have been identified relating to the environmental and ecological conditions and processes on the reserve, and the ways in which these are influenced by reserve management. Future management of the reserve would benefit from research targeting these particular information gaps, so that informed decisions can be made about the most beneficial management techniques to be employed.

While some of these information gaps will be addressed by the proposed research detailed in Sections 2 to 4, resource limitations have prevented the inclusion of other areas of research which are considered important for reserve management. Some potential topics are detailed below, which

may be suitable areas for external research or if additional funding for research becomes available in future.

9.2 *GEI WAI* MANAGEMENT, SHRIMP PRODUCTIVITY AND AQUATIC ECOLOGY

9.2.1 Ecology, Diversity and Production Cycles of *Gei wai* Shrimp and Fish

The operation of the *gei wai* is a crucial aspect of the historical, cultural and ecological value of the site. Current operation is based on techniques that have been handed down from previous *gei wai* operators. The scientific reasons behind these aspects of site management have not previously been studied in-depth, especially with regards to the ways in which the management relates to the life cycles and productivity of the shrimp and fish populations of the *gei wai*. Anecdotal evidence suggests that the species composition of the *gei wai* has changed over the years, but evidence is not available to detail the nature of this change or the way in which this may affect *gei wai* operation.

9.2.2 Effects of Habitat Management and Desilting Work on Gei wai Water Quality

Many of the traditional practices in *gei wai* management relate to management of water quality within the *gei wai*. Some practices, such as water exchange and channel desilting, have been retained as part of the current management practice of the reserve, although sometimes at a different frequency or extent than was practised previously. Other practices, for example sun-baking of drained *gei wai*, are no longer used routinely at MPNR, usually because these affect other aspects of reserve management. Research into the impacts of the various traditional or current *gei wai* management practices on water quality would be beneficial for informing the best approach towards *gei wai* management and the response required to an observed change in water quality. Data collected under the Monitoring Plan (especially baseline data on water quality) may be useful in a study of this type.

9.2.3 Impacts of Water Quality, Desilting and Habitat Management on Aquatic Ecology of *Gei wai* (including Shrimp Ecology & Productivity)

Although there has been some previous research into the way in which the productivity of the *gei wai* is affected by reserve management, some of the effects of environmental conditions on shrimp productivity are not fully understood. Potential factors affecting shrimp include water quality, water depth, frequency and timing of water exchange or dominant *gei wai* vegetation (mangroves or reedbed). The impacts of active management, especially desilting or drain-down, on *gei wai* shrimp also requires further study. Results of research in this study would be highly beneficial for future management of the reserve, and this should be considered higher priority for future research.

9.3 ECOLOGY OF THREATENED SPECIES AT MPNR

9.3.1 Ecological Requirements of Indicator Species and Other Species of Importance

MPNR is an important site for many species which are threatened globally or locally, and one of the aims of reserve management is to ensure that suitable habitat is provided for these threatened species. Some of these are identified as species-related indicators the Habitat Management Plan (Volume I), while others are so poorly known or difficult to survey that they are not considered suitable indicators. The habitat requirements of a few species have been the subject of previous study, which has informed habitat management on the reserve; Black-faced Spoonbill *Platalea minor* is a good example of a species that has been well studied in this respect. Other species, however, have not been the subject of detailed study locally and the habitat requirements of these are often not well understood. Without further details of habitat and other requirements, management of the reserve for targeted protection of these species can be difficult. Examples of species include Eurasian Otter *Lutra lutra* (this species has been studied overseas, but not in Hong Kong), Styan's Grasshopper Warbler *Locustella pleskei*, Bennett's Water Snake *Enhydris bennetti*, Four-spot Midget *Mortonagrion hirosei*, Mai Po Bent-winged Firefly *Pteroptyx maipo* and moths *Chasmina candida*, *Schrankia bilineata* and *Thalassodes maipoensis*. Given the lack of existing information on these species, further research should be considered a high priority, although it is unlikely that all species could be covered during the duration of this plan.

9.3.2 Feasibility of Reintroduction /Introduction of Threatened Species

Several native wetland-dependent species have declined in Hong Kong or have disappeared in the territory as a result of long-term habitat changes. Some of these species may have previously

disappeared from MPNR, while others (particularly freshwater species) may not have been present at the site previously because of a lack of suitable habitat. The protection and management of habitats within the reserve may now provide suitable conditions for these species, but the species may be unable to colonise due to local absence, low levels of mobility or barriers from potential sources. In such cases, introduction or reintroduction of the species into MPNR may be feasible as an approach to ensure the long-term future of the species in Hong Kong, thus enhancing native biodiversity at the site. Possible species worthy of consideration include Reeve's Terrapin (possibly still present on the reserve), Rough-skinned Floating Frog and Rice Fish.

9.4 THREATS TO MPNR AND APPROACHES TO MINIMISE THREATS

9.4.1 Sedimentation of *Gei Wai*

Sediment is brought into the MPNR *gei wai* during water exchange, which is carried out approximately every two weeks throughout the year to maintain water quality. The accumulation of sediment leads to problems in *gei wai* management, both by reducing the depth of channels (thus affecting water flow and encouraging vegetation growth) and by silting of reedbeds and mangroves, allowing the colonisation of terrestrial vegetation. Desilting of channels and/or restoration of open water in areas invaded by terrestrial vegetation is required in several *gei wai*. Although the problem of sedimentation has been known for a number of years, there has been little research into the rate of sedimentation in the *gei wai*, into approaches to reduce sedimentation or into approaches to deal with the problems caused. Further research on this issue would help to understand the processes involved so that a long-term solution can be investigated. Sedimentation is acknowledged to be a severe and immediate problem, and this research is a higher priority if resources are available.

9.4.2 Impacts of Exotic Species and Most Effective Methods for Control

Several non-native species are present at MPNR, some of which impact upon the ecology of the site and may affect the native species present. Management measures on the reserve currently address the problems caused by some non-native species, such as *Mikania micrantha*, *Bidens alba*, *Lantana camara*, *Acacia* spp., Golden Apple Snail *Pomacea lineata* and Imported Red Fire Ant *Solenopsis invicta*. Other species, for example *Typha angustifolia*, are emerging problems following recent colonisation and may require increased management in future. Other species known or suspected to impact local species, for example Red-eared Slider *Trachemys scripta elegans*, are not actively controlled at present but may benefit from increased management in future. Further research would help to elucidate the impacts of non-native species on native biodiversity at MPNR, and could investigate the most appropriate methods for control of these species to minimise their impact. Given that management is already conducted into some species, and that invasive species are considered a major threat to global biodiversity, research into this area is a high priority, although I t is recognised that it is unlikely all species could be researched during the duration of this plan.

9.4.3 Impacts of *Dimorphopterus spinolae* on Reedbeds

Dimorphopterus spinolae is a species of bug that feeds on *Phragmites* reeds and can affect the health of reed stands. Previous outbreaks of this species have occurred at Hong Kong Wetland Park, at Yuen Long Bypass Floodway Engineered Wetland (Chan et al. 2008), and at the MTR Lok Ma Chau Spur Line Wetland Compensation Area (AEC, pers. comm.). Outbreaks have also occurred in reedbeds at MPNR in 2011, 2012 and 2013. Such outbreaks result in poor health or die-back of *Phragmites* within affected reedbeds, but the causes and impacts of outbreaks are not known. Previous outbreaks in Hong Kong have been treated by cutting and removal of affected reeds, but this option is not considered suitable for the large reedbeds at MPNR, and approaches to minimise the impacts of the species on reedbeds at MPNR require further study.

9.4.4 Visitor Disturbance to Wildlife

MPNR attracts around 40,000 visitors annually, and the number of people using the reserve has increased over the years. It is well known that human activities cause disturbance to certain species, especially large waterbirds. Site management actions are in place at MPNR to limit the numbers of people visiting the most ecologically-sensitive parts of the site. To date, however, no studies have looked at the impacts of the increased number of visitors, at the possible carrying capacity of the reserve in terms of visitors, or at any additional measures required to minimise the impacts to local biodiversity. A precautionary approach is currently undertaken to minimise disturbance, and this research is of lower priority.

9.5 ECOLOGICAL VALUE AND PRODUCTIVITY OF THE MANAGED MUDFLAT AREA

The mudflats are of high importance for the number and diversity of wetland birds they support, as well as mudskippers and invertebrates. Although the mudflats are outside MPNR, and thus outside the scope of this plan, regular management of an area of mudflat close to MPNR is conducted annually by WWF (under subvention of AFCD) by the control of colonising vegetation, particularly mangrove seedlings, sedges and grasses. This management not only maintains an area of open mudflat for waterbirds but also provides an open area in front the floating hides for the benefit of visitors and researchers to the reserve. Although previous monitoring has investigated the productivity of the mudflats in Deep Bay (e.g. McChesney 1997), there has been little research into the area of mudflats requiring management to maintain existing waterbird populations and the optimal area or distribution of mudflat and mangrove in the Deep Bay intertidal system. Research would help to define resource requirements for the current management, but given the location outside the reserve this research may be more appropriate for researchers outside WWF.

10. DATA STORAGE, WORK SCHEDULES AND REPORTING

10.1 DATA STORAGE

All data collected during the monitoring will be stored on the server at MPNR Education Centre. A Back-up of all data on the server is carried out on daily basis to prevent accidental loss of data.

10.2 FIVE-YEAR WORK SCHEDULE

The monitoring listed in this Plan is to be carried out over a five-year period, which extends from 01 November 2013 to 31 October 2018 Work scheduled for each quarterly period is summarized in Table 5.

Table 5. Five-year quarterly research schedule.

	Yr 1				Yr 2				Yr 3				Yr 4				Yr 5			
Research Project																				
Comparison of wet and dry reedbeds																				
Management of *gei wai* mangroves and associated vegetation – Phase I																				
Ecological value of freshwater habitats at MPNR																				
Mai Po Climate Change Impact Study																				
Bird Ringing (Banding)																				
Shorebird leg-flagging																				

APPENDICIES

Appendix 1 - Faunal Monitoring Surveys : Morning Bird Count

FM01. Morning Bird Count

(version: October 2013)

FEATURE	Avifauna
PARAMETERS	Abundance and distribution of bird species at MPNR.
OBJECTIVE(S)	1. To systematically record bird species present along a fixed transect at MPNR for long-term tracking of bird populations. 2. To monitor the abundance and distribution of indicator bird species at MPNR to evaluate effectiveness of habitat management and to inform future management decisions.
BACKGROUND	Being relatively easy to observe and record and using a variety of habitats, birds are good indicator species for habitat quality. Several species of conservation importance, either locally or at a regional or global scale, are present at MPNR. They are also the main attraction for many of the visitors to the reserve. Regular monitoring of birds allows a greater understanding of the use of the reserve by these species and can inform future management decisions, not only of the wetland habitats but also of the bunds and other terrestrial areas. WWF commenced systematic bird surveys in June 2003 to provide data on the abundance of bird species along a transect following the perimeter of the reserve to cover most *gei wai* and ponds inside MPNR. The methodology was refined prior to June 2006, but has remained consistent since that time. Major changes to the methodology were: 1. The inclusion of birds located outside the perimeter of MPNR but recorded during surveys, to generate an overall picture of bird use of the area; 2. The inclusion of all wetland dependent and terrestrial bird species in addition to waterbird species, to provide greater information about the overall bird populations of MPNR. Although the methodology of the Morning Bird Count does not provide information on the total abundance of each species on the reserve as a whole, by following a fixed transect on a regular basis it permits the monitoring of any changes in the abundance of bird species which may indicate a change in habitat condition, and is therefore suitable for tracking of several bird indicator species.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicators* Little Grebe Great Cormorant Grey Heron Purple Heron Chinese Pond Heron Striated Heron Great Egret Little Egret Intermediate Egret Yellow Bittern Black-faced Spoonbill Northern Pintail Northern Shoveler Tufted Duck Chinese Spot-billed Duck Black-winged Stilt Western Osprey Eastern Imperial Eagle Greater Spotted Eagle Eastern Marsh Harrier Pied Kingfisher

METHODOLOGY

Equipment (essential)	1. Bicycle 2. Binoculars (8x magnification or above) 3. Voice recorder 4. Watch

Equipment (optional)	1. Telescope and tripod 2. Hand tally counter 3. Pencil/pen and paper
Sampling site(s)	1. A 6.2km transect running anti-clockwise encircling the perimeter of the MPNR: - Start and finish location at Gate 103 on the Frontier Closed Area (FCA) road 2. Side paths: - Path between Pond #8a and #9 - Path between Pond #16b and #17b 3. Mandatory scan points: - Pond #8a: Tower Hide (top floor) - Pond #15b: Education Center (roof top) - *Gei wai* #16/17: Hide #7; - Pond #16a and #17a: crossroads between Pond #16a, #16b, #17a and #17b; 4. Discretionary scan points: - *Gei wai* #11: Hide #8 - *Gei wai* #16/17: Hides #1, #3, #5 - *Gei wai* #21: Hut #21 See Figure 1
Sampling technique	1. The entire transect route is cycled and all birds seen/heard are recorded. 2. The recorder should stop at several locations alongside each *gei wai*/pond (where possible) to provide uninterrupted views into the open areas of water and water channels. 3. Cycling speed should be slow enough to allow the recorder to stop quickly if needed, observe bird movements between waterbodies (to avoid double counting) and listen for bird calls. 4. The recorder should stop at all mandatory scan points (as listed above) to count birds. Discretionary scan points can be used if appropriate to provide a better view of the ponds for more accurate counts. 5. All birds recorded are divided into Category A or Category B. - Category A: all non-flying birds inside the MPNR *gei wai*/ponds; - Category B: All flying birds (including those within the MPNR perimeter) and other non-flying birds outside MPNR or not recorded under Category A; - Birds located on the MPNR perimeter trees belong to Category A, but those on the FCA fence belong to Category B. 6. Category A - The species and number of birds are recorded according to location. *Gei wai* are divided into East and West by an imaginary line across the middle of the site. Bunds are recorded according to the water bodies these divide. Birds on the perimeter road or path are assigned according to the adjacent water (Figure 2). - More precise locations should be collected for waterbird / bird of prey species (as listed below) and these should be verbally recorded in the field (using voice recorder) then transcribed to a map after completion of the count. 7. Mapping is required for the following observations: - The roosting location(s) of each individual/flock of Black-faced Spoonbill *Platalea minor*; - The roosting location(s) of each Great Cormorant *Phalacrocorax carbo* flock containing >5 individuals (October – March) on trees, bunds or islands; - The location of congregations of any waterbird group (i.e. 'Anatidae.', 'Ardeidae', 'Gulls and Terns', 'Rails and Coots, etc.' or 'Shorebirds') containing >50 individuals located in any sub-pond or *gei wai*; - The locations of each 'Bird of Prey'; - The location(s) of breeding evidence for any waterbird species;

	- At the discretion of the recorder, the location of any other bird(s) considered unusual or of interest for MPNR. 8. Category B - Only the species and number of birds are recorded. 9. All factors likely to significantly influence the data (e.g. drained *gei wai*, recent vegetation cutting on islands, disturbances, etc.) should be noted.
Sampling time of year	All months of the year.
Sampling time of day	Each count commences 15 minutes before sunrise and should last no more than 3 hours. (Note: Longer time (<60min) may be necessary in winter due to higher bird numbers.)
Sampling frequency	Two samples should be collected each month. The dates of the counts are set according to the following criteria: 1. One of the two monthly counts should be conducted within a 7-day period on either side of the AFCD's Deep Bay Monthly Waterbird Count, to enable a direct comparison between MPNR, the Ramsar Site and Deep Bay waterbird numbers; 2. There should be at least a 7-day interval between any 2 counts. 3. One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day. 4. Both counts should be conducted on the best available high tides in Deep Bay (i.e. tide height >2.1m) during the first hour of the survey so there is a greater chance of encountering shorebirds on *Gei wai* #16/17. If this is not possible then a further consideration should be if the tide reaches >2.2m by the expected time of arrival at the eastern side of *Gei wai* #11 (approx. 2.5 hours after the survey starts). 5. Where no early morning high tides are available, the count should be undertaken on the morning following a high over-night tide (>2.2m).
No. of samples	24 per year
Repeat interval	Annually
Weather conditions	The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count. When visibility is especially poor (e.g. morning mist or air pollution), such that the recorder can not see clearly into the central areas of the *gei wai*, the count should be rescheduled. Under any unusual or exceptional circumstances that the count is interrupted for a prolonged period of time, the current count should be abandoned and rescheduled.

DATA MANAGEMENT

Data format	1. Species, number and location data - MS Excel Spreadsheet (Appendix I) 2. Mapping location – ArcGIS 10 (Appendix II)

Location of data	All data are stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. A "Morning Bird Count Summary" is produced for each count and uploaded to the WWF-HK website (Appendix III). 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". <2005 – 2010 Report download link> 3. Summary graphs are produced every 5 years and are published in the report "Morning Bird Count Five-year Summary Graphs". <2005-10 Report download link> Report #2 and #3 are circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website.

Figure 1: Transect Route

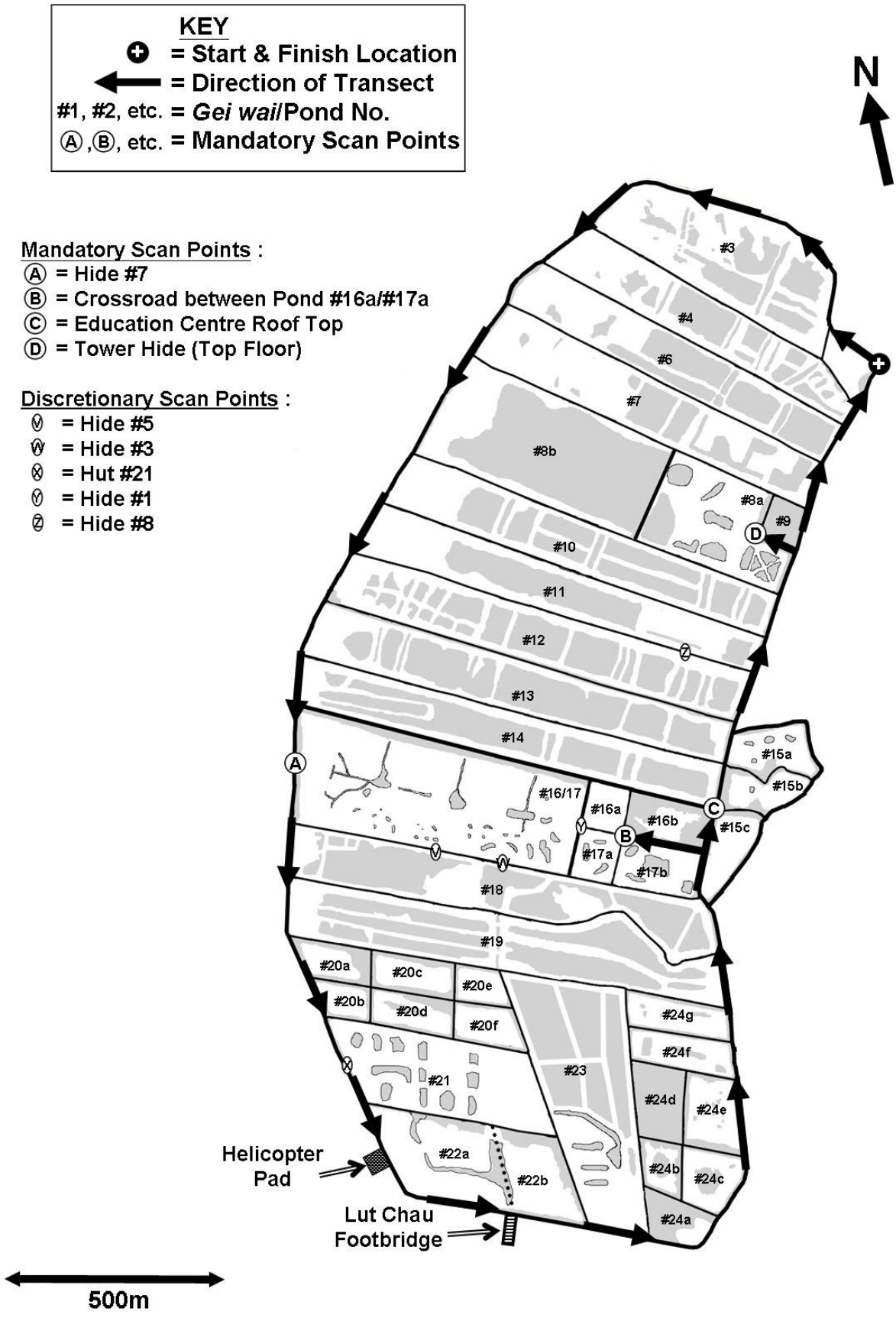
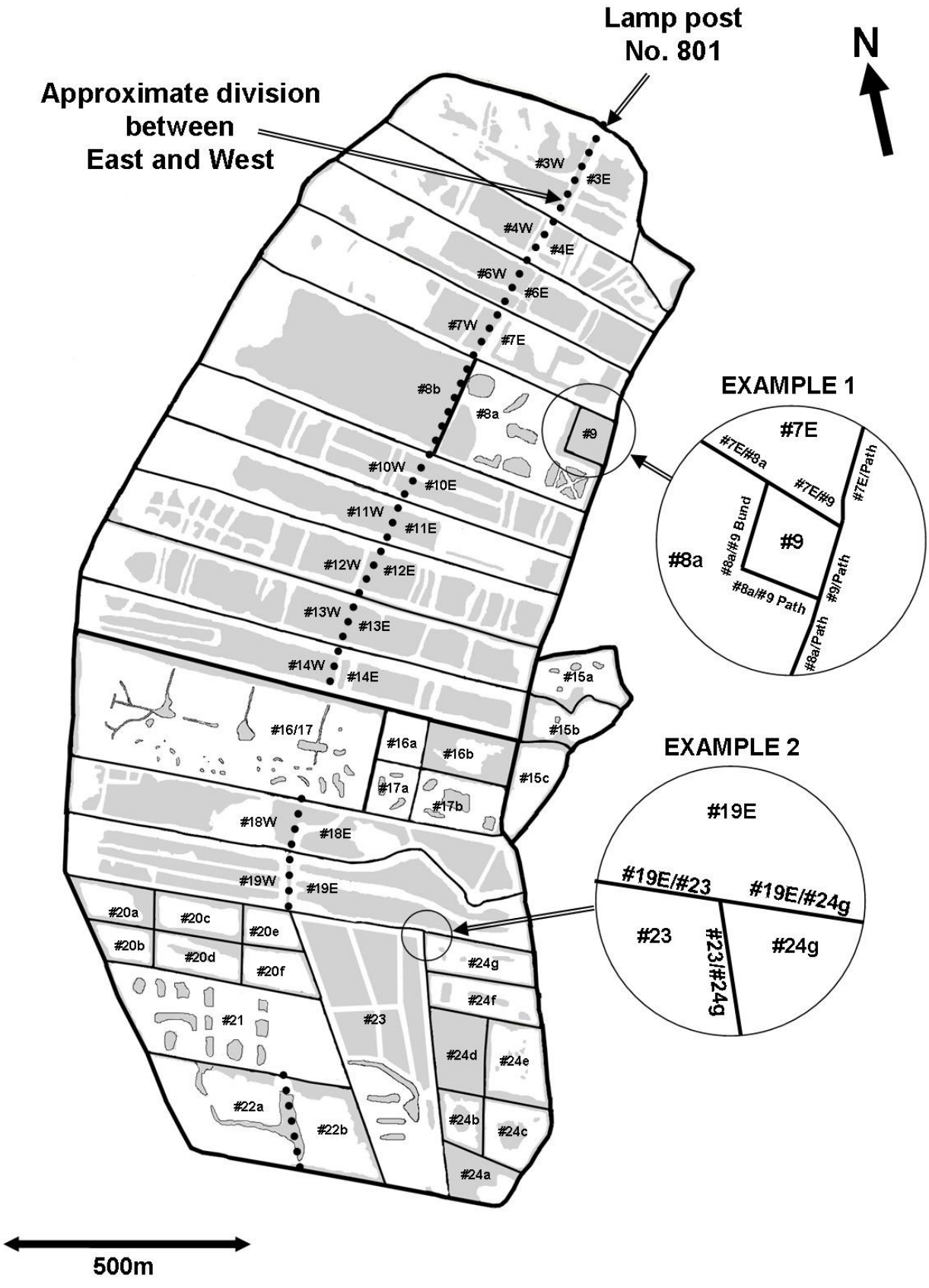
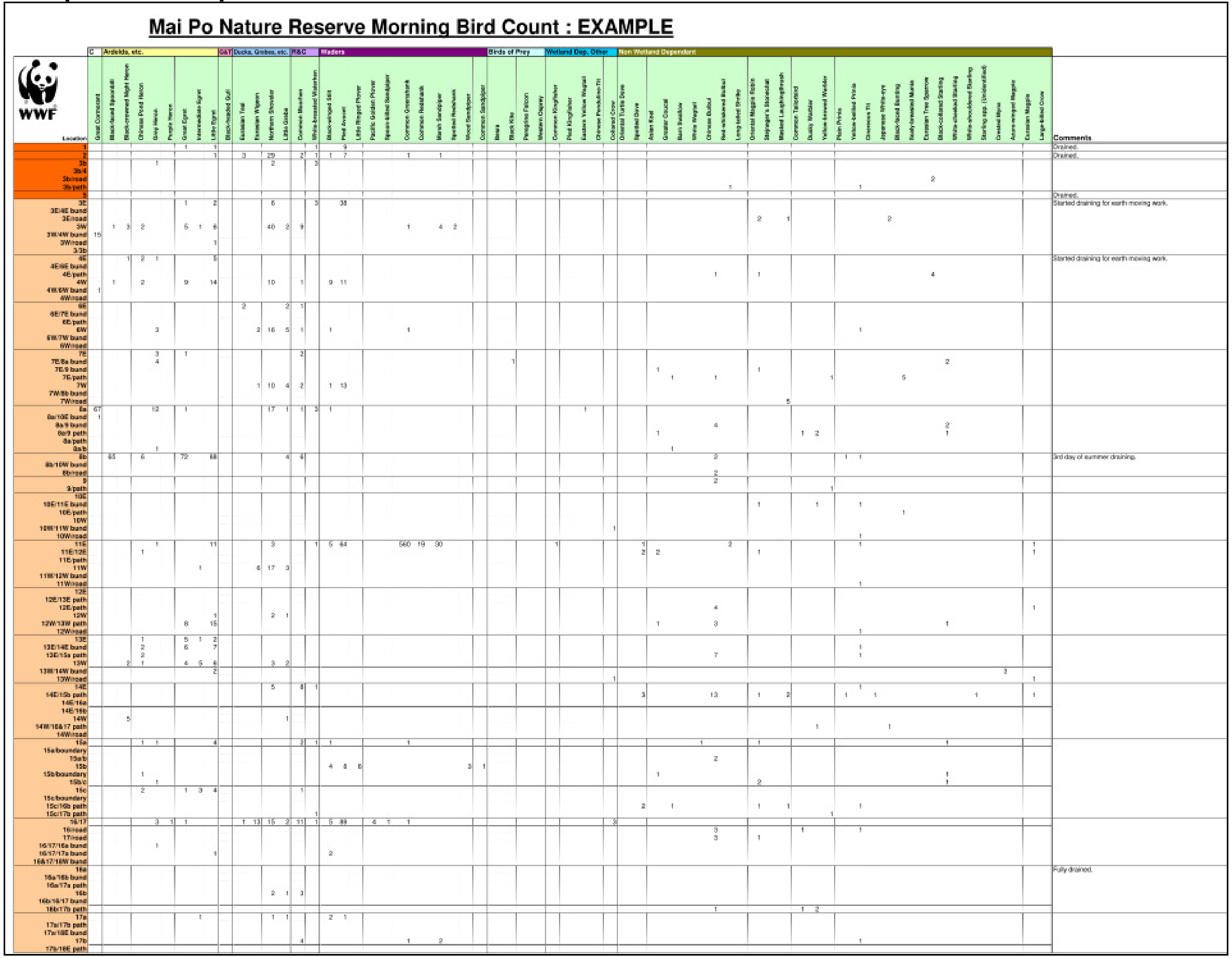


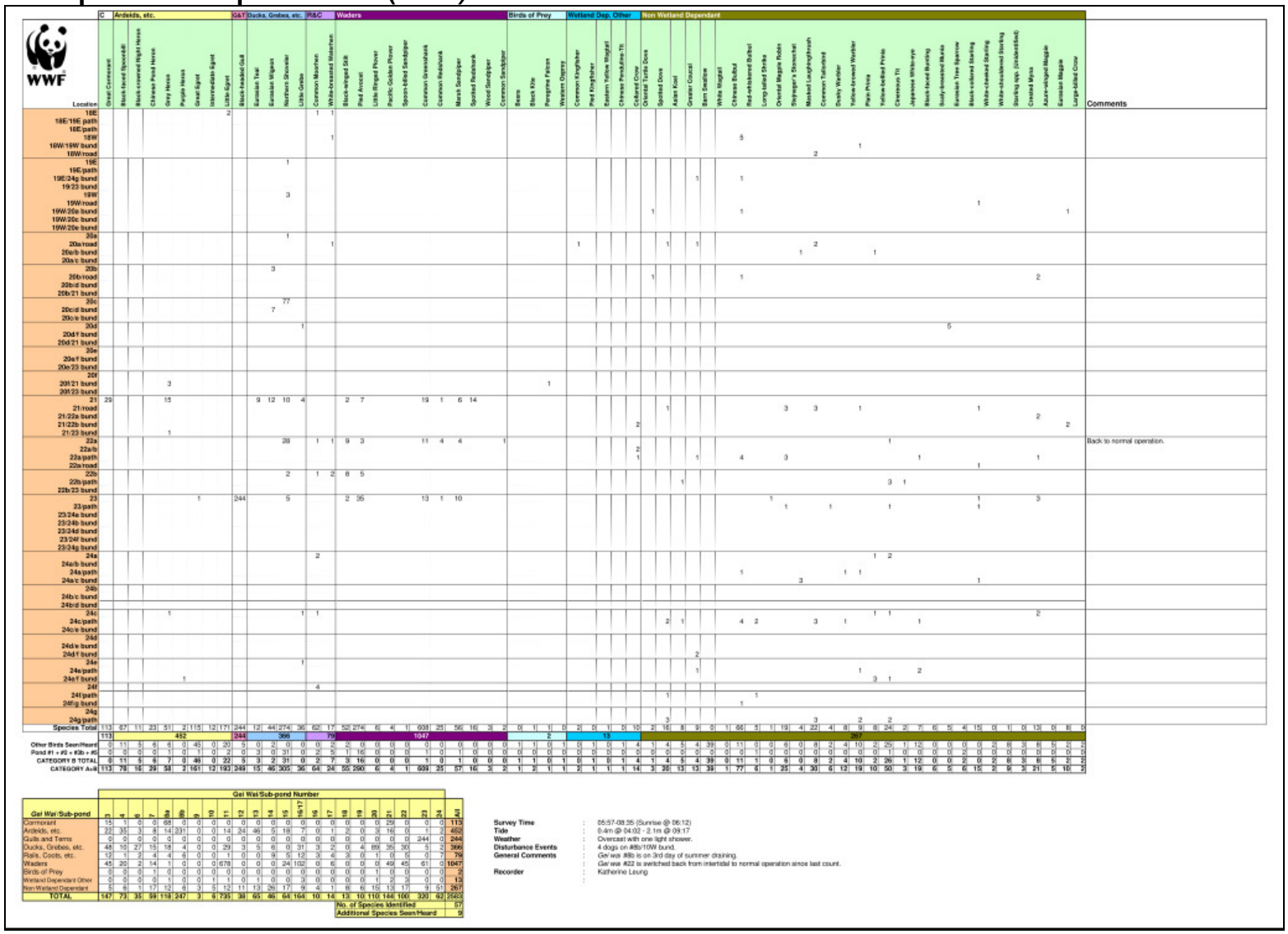
Figure 2: Location Codes



Appendix I : Example of Data SpreadSheet



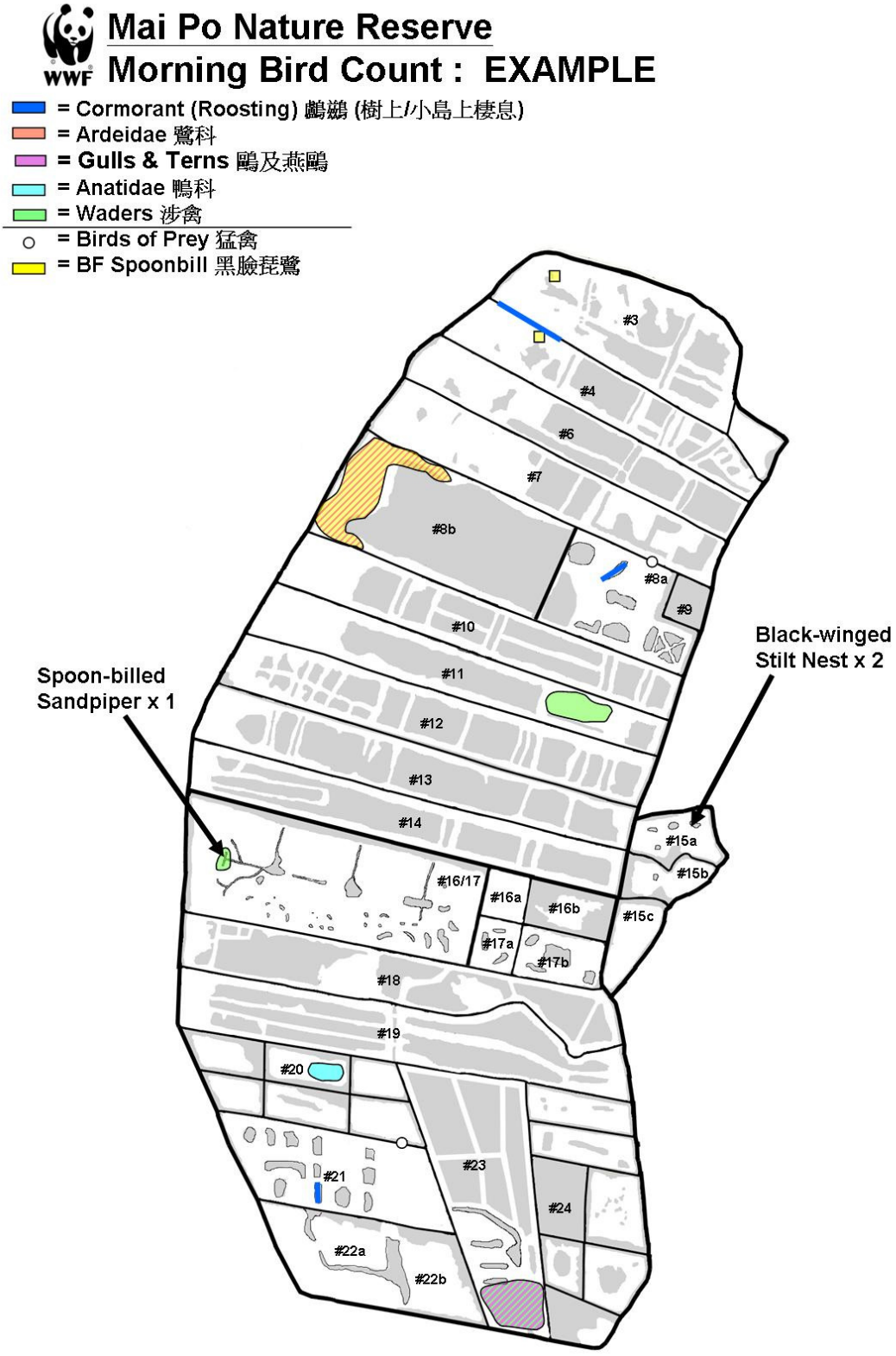
Appendix I : Example of Data SpreadSheet (*cont.*)



Gei Wai Sub-pond Number																									
Gei Wai Sub-pond	3	4	6	7	8a	8b	9	10	11	12	13	14	15	16/17	16	17	18	19	20	21	22	23	24	All
Cormorant	15	1	0	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	113
Ardeids, etc.	22	35	3	8	14	231	0	0	14	24	66	5	19	7	0	1	2	0	3	16	0	1	2	482
Gulls and Terns	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	244	0	244
Ducks, Grebes, etc.	48	10	27	15	18	4	0	0	29	3	5	6	0	31	3	2	0	4	89	35	30	5	2	366
Rails, Coots, etc.	12	1	2	4	4	6	0	0	1	0	0	9	5	12	3	4	3	0	1	0	5	0	7	79
Waders	45	20	2	14	1	0	0	0	678	0	0	0	24	102	0	6	0	0	0	49	45	61	0	1047
Birds of Prey	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Wetland Dependant Other	0	0	0	0	1	0	0	1	1	0	1	0	0	3	0	0	0	0	1	2	3	0	0	13
Non Wetland Dependant	5	6	1	17	12	0	3	5	12	11	13	26	17	9	4	11	6	6	15	13	17	9	57	267
TOTAL	147	73	35	59	118	247	3	6	735	39	65	49	64	164	10	14	13	10	110	144	100	320	82	2663
																						No. of Species Identified		57
																						Additional Species Seen/Heard		9

Survey Time : 05:57-08:35 (Sunrise @ 06:12)
Tide : 0.4m @ 04:02 - 2.1m @ 09:17
Weather : Overcast with one light shower.
Disturbance Events : 4 dogs on #8b/10W bund.
General Comments : Gei wai #8b is on 3rd day of summer draining.
Gei wai #22 is switched back from intertidal to normal operation since last count.
Recorder : Katherine Leung

Appendix II : Example of Mapping Data Sheet



Appendix III : Example of Count Summary

Mai Po Nature Reserve 米埔自然保護區
Morning Bird Count : EXAMPLE

BIRD SPECIES 雀鳥品種	*Gei Wai*/Pond/Sub-pond Code 基圍/淡水塘 號碼																							TOTAL	Others*
	#3	#4	#6	#7	#8a	#8b	#9	#10	#11	#12	#13	#14	#15(a-c)	#16/17	#16(a-b)	#17(a-b)	#18	#19	#20(a-f)	#21	#22(a-b)	#23	#24(a-g)		
Great Cormorant 普通鸕鷀	15	1	-	-	68	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	-	-	-	113	-
Black-faced Spoonbill 黑臉琵鷺	1	1	-	-	-	65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	67	11
Black-crowned Night Heron 夜鷺	3	1	-	-	-	-	-	-	-	-	2	5	-	-	-	-	-	-	-	-	-	-	-	11	5
Chinese Pond Heron 池鷺	2	4	-	-	-	6	-	-	1	-	6	-	4	-	-	-	-	-	-	-	-	-	-	23	6
Grey Heron 蒼鷺	-	1	3	7	13	-	-	-	1	-	-	-	2	4	-	-	-	-	3	16	-	-	1	51	7
Purple Heron 草鷺	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	2	-
Great Egret 大白鷺	6	9	-	1	1	72	-	-	-	8	15	-	1	1	-	-	-	-	-	-	-	1	-	115	46
Intermediate Egret 中白鷺	1	-	-	-	-	-	-	-	1	-	6	-	3	-	-	1	-	-	-	-	-	-	-	12	-
Little Egret 小白鷺	9	19	-	-	-	88	-	-	11	16	17	-	8	1	-	-	2	-	-	-	-	-	-	171	22
Black-headed Gull 紅嘴鷗	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	244	-	244	5
Eurasian Teal 綠翅鴨	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	9	-	-	-	12	3
Eurasian Wigeon 赤頸鴨	-	-	2	1	-	-	-	-	6	-	-	-	-	13	-	-	-	-	10	12	-	-	-	44	2
Northern Shoveler 琵嘴鴨	46	10	16	10	17	-	-	-	20	2	3	5	-	15	2	1	-	4	78	10	30	5	-	274	31
Little Grebe 小䴙䴘	2	-	7	4	1	4	-	-	3	1	2	1	-	2	1	1	-	-	1	4	-	-	2	36	-
Common Moorhen 黑水雞	9	1	2	4	1	6	-	-	-	-	-	8	3	11	3	4	1	-	-	-	2	-	7	62	2
White-breasted Waterhen 白胸苦惡鳥	3	-	-	-	3	-	-	-	1	-	-	1	2	1	-	-	2	-	1	-	3	-	-	17	7
Black-winged Stilt 黑翅長腳鷸	-	9	1	1	1	-	-	-	5	-	-	-	5	7	-	2	-	-	-	2	17	2	-	52	3
Pied Avocet 反嘴鷸	38	11	-	13	-	-	-	-	64	-	-	-	8	89	-	1	-	-	-	7	8	35	-	274	16
Little Ringed Plover 金眶鴴	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	-	-	-	-	-	6	-
Pacific Golden Plover 太平洋金斑鴴	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	4	-
Spoon-billed Sandpiper 勺嘴鷸	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Common Greenshank 青腳鷸	1	-	1	-	-	-	-	-	560	-	-	-	1	1	-	1	-	-	-	19	11	13	-	608	1
Common Redshank 紅腳鷸	-	-	-	-	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-	1	4	1	-	25	-
Marsh Sandpiper 澤鷸	4	-	-	-	-	-	-	-	30	-	-	-	-	-	-	2	-	-	-	6	4	10	-	56	1
Spotted Redshank 鶴鷸	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	-	-	-	16	-
Wood Sandpiper 林鷸	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3	-
Common Sandpiper 磯鷸	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	2	-
Besra 松雀鷹	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1
Black Kite 黑鳶	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Peregrine Falcon 遊隼	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-
Western Osprey 鶚	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1
Common Kingfisher 普通翠鳥	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2	-
Pied Kingfisher 斑魚狗	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1
Eastern Yellow Wagtail 黃鶺鴒	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Chinese Penduline-Tit 中華攀雀	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1
Collared Crow 白頸鴉	-	-	-	-	-	-	-	1	-	-	1	-	-	3	-	-	-	-	-	2	3	-	-	10	4
Oriental Turtle Dove 山斑鳩	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	2	1
Spotted Dove 珠頸斑鳩	-	-	-	-	-	-	-	-	3	-	-	3	2	-	-	-	-	-	1	1	-	-	6	16	4
Asian Koel 噪鵑	-	-	-	1	1	-	-	-	2	1	-	-	1	-	-	-	-	-	-	-	1	-	1	8	5
Greater Coucal 褐翅鴉鵑	-	-	-	1	1	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	1	-	3	9	4
Barn Swallow 家燕	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	39
White Wagtail 白鶺鴒	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
Chinese Bulbul 白頭鵯	-	1	-	1	4	4	2	-	-	7	7	13	2	6	1	-	5	2	1	-	4	-	6	66	11
Red-whiskered Bulbul 紅耳鵯	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	3	5	1
Long-tailed Shrike 棕背伯勞	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-
Oriental Magpie Robin 鵲鴝	2	1	-	1	-	-	-	1	1	-	-	1	4	1	-	-	-	-	-	3	3	1	-	19	6
Steineger's Stonechat 黑喉石(即)鳥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	4	-
Masked Laughingthrush 黑臉噪鶥	1	-	-	5	-	-	-	-	-	-	-	2	1	-	-	-	2	-	2	3	-	-	6	22	8
Common Tailorbird 長尾縫葉鶯	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	-	4	2
Dusky Warbler 褐柳鶯	-	-	-	-	2	-	-	1	-	-	-	1	-	-	2	-	-	-	-	-	-	-	2	8	4
Yellow-browed Warbler 黃眉柳鶯	-	-	-	1	-	-	1	-	-	-	-	-	1	-	-	-	1	-	-	1	-	-	4	9	10
Plain Prinia 純色鷦鶯	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	5	8	2
Yellow-bellied Prinia 黃腹鷦鶯	-	-	1	-	-	1	-	2	2	1	2	1	1	1	-	1	-	-	-	-	4	1	6	24	26
Cinereous Tit 大山雀	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	2	1
Japanese White-eye 暗綠繡眼鳥	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	3	7	12
Black-faced Bunting 灰頭鵐	-	-	-	5	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-
Scaly-breasted Munia 斑文鳥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	5	-
Eurasian Tree Sparrow 樹麻雀	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	2
Black-collared Starling 黑領椋鳥	-	-	-	2	3	-	-	-	-	1	-	-	3	-	-	-	-	1	-	1	1	2	1	15	-
White-cheeked Starling 灰椋鳥	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2
White-shouldered Starling 灰背椋鳥	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	8
Starling spp. (Unidentified) 椋鳥(未能分辨品種)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	3
Crested Myna 八哥	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	2	2	1	3	2	13	8
Azure-winged Magpie 灰喜鵲	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	5
Eurasian Magpie 喜鵲	-	-	-	-	-	-	-	-	2	1	1	1	-	-	-	-	-	1	-	2	-	-	-	8	2
Large-billed Crow 大嘴烏鴉	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	2

* - Other birds seen or heard during the survey, but not recorded using the standard WWF methodology. 其他在普查範圍/方法以外看見或聽見的雀鳥。

Appendix III : Example of Count Summary (*cont.*)

BIRD GROUPS 雀鳥種類	*Gei Wai*/Pond/Sub-pond Code 基圍/淡水塘 號碼																						
	#3	#4	#6	#7	#8a	#8b	#9	#10	#11	#12	#13	#14	#15(a-c)	#16/17	#16(a-b)	#17(a-b)	#18	#19	#20(a-f)	#21	#22(a-b)	#23	#24(a-g)	TOTAL
Cormorant 鸕鷀	15	1	0	0	68	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	113
Ardeids, etc. 鷺科	22	35	3	8	14	231	0	0	14	24	46	5	18	7	0	1	2	0	3	16	0	1	2	452
Gulls and Terns 鷗及燕鷗科	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	244	0	244
Ducks, Grebes, etc. 鴨及鸊鷉科	48	10	27	15	18	4	0	0	29	3	5	6	0	31	3	2	0	4	89	35	30	5	2	366
Rails, Coots, etc. 秧雞科	12	1	2	4	4	6	0	0	1	0	0	9	5	12	3	4	3	0	1	0	5	0	7	79
Waders 涉禽	45	20	2	14	1	0	0	0	678	0	0	0	24	102	0	6	0	0	0	49	45	61	0	1047
Birds of Prey 猛禽	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Wetland Dependant Other 依賴濕地	0	0	0	0	1	0	0	1	1	0	1	0	0	3	0	0	0	0	1	2	3	0	0	13
Non Wetland Dependant 非依賴濕地	5	6	1	17	12	6	3	5	12	11	13	26	17	9	4	1	8	6	15	13	17	9	51	267
No. of Birds 雀鳥數目	147	73	35	59	118	247	3	6	735	38	65	46	64	164	10	14	13	10	110	144	100	320	62	2583
No. of Species Identified 辨認到的品種數目																								57
Additional Species Seen/Heard 其他看見或聽見的品種數目																								9

Notes:

Survey Time
05:57-08:35 (Sunrise @ 06:12)

Tide (Predicted)
0.4m @ 04:02 - 2.1m @ 09:17

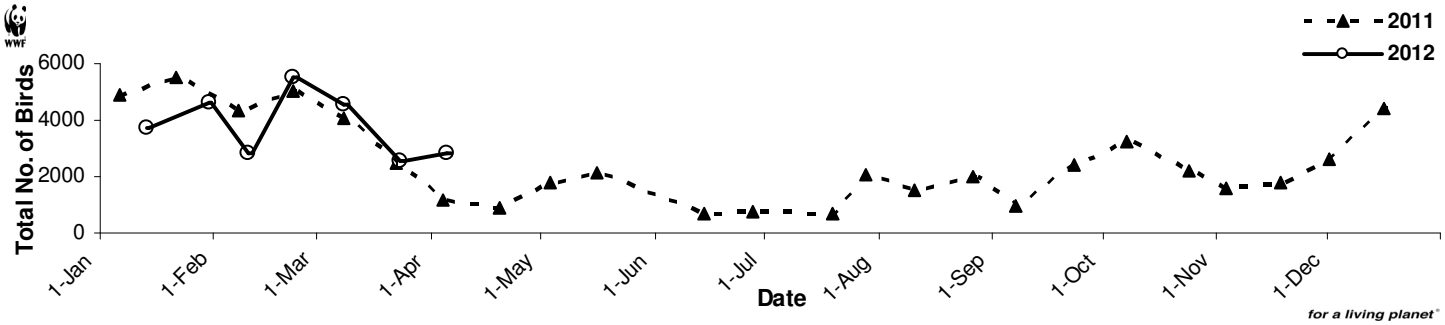
Weather
Overcast with one light shower.

Factors affecting the count
4 dogs on #8b/10W bund.

Comments
Gei wai #8b is on 3rd day of summer draining.
Gei wai #22 is switched back from intertidal to normal operation since last count.

Recorder
Katherine Leung

[Summary Sheet Version 1]



Appendix 2 - Faunal Monitoring Surveys : Black-faced Spoonbill

FM02. Black-faced Spoonbill

(version: October 2013)

FEATURE	Black-faced Spoonbill
PARAMETERS	Abundance and distribution at MPNR
OBJECTIVE(S)	1. To monitor the population of this globally-threatened species. 2. To inform habitat management decisions at MPNR to permit enhancement of habitat for the species.
BACKGROUND	Black-faced Spoonbill *Platalea minor* is listed as a globally Endangered species under the IUCN Red List (BirdLife 2013). Deep Bay is the second most important site globally for the wintering population of the species, and has regularly supported over 400 individuals in recent years, representing approximately 15% of the total global population of this species. Due to the global importance of the Deep Bay population, provision of habitat for Black-faced Spoonbills is the management intention of BMZ 1 (corresponding to *Gei wai* #3, #4, #6 and #7) of the Mai Po Inner Deep Bay Ramsar Site Management Plan. Provision of habitat is also one of the management intentions of the Mai Po Habitat Management Plan (Section A). Previous observations of Black-faced Spoonbills, including a radio-tracking study in 2002, have found that birds are most active in the morning and evening, but typically return to roosting areas (including the *gei wai* at MPNR) during the middle of the day and at night. Counting of birds during the middle of the day therefore provides a better estimate for total numbers using MPNR than during early morning or late afternoon counts. Night-time counts are not considered suitable because birds often return after dark, and may be difficult to count, especially if distant from the path. Birds roost at a number of different locations around the reserve, so surveys are required to cover the entire reserve.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicator* Black-faced Spoonbill

METHODOLOGY

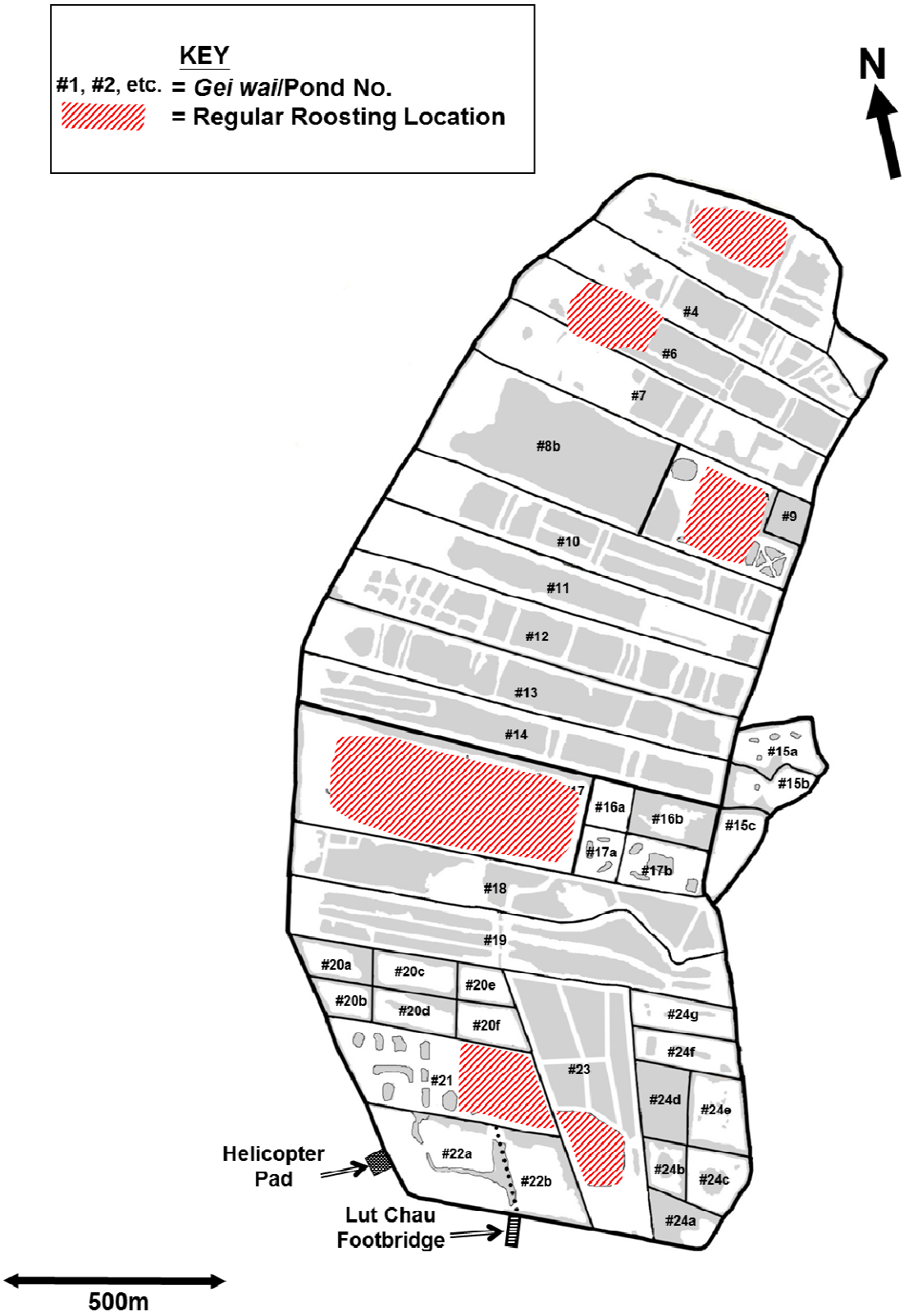
Equipment (essential)	1. Binoculars (8x magnification or above). 2. Voice recorder or paper with pen. 3. Bicycle.
Equipment (optional)	1. Telescope and tripod. 2. Hand tally counter.
Sampling site(s)	Main roosting areas for Black-faced Spoonbills are *Gei wai* #3, #4, #6, #7, #11, #16/17, #21 and #22, and Ponds #8a, #20 and #23. Surveys should be carried out throughout MPNR by following route around perimeter of reserve. See Figure 1 for usual roosting locations.
Sampling technique	1. Surveyor should cycle around perimeter of reserve to cover all *gei wai* and ponds. Particular attention is required at waterbodies known to be used regularly by roosting spoonbills. 2. Number of spoonbills roosting at each *gei wai* / pond should be recorded.

	3. Birds located on bunds should be assigned to a waterbody by using an imaginary line dissecting the bund equally between neighbouring *gei wai*/sub-ponds. 4. Birds flying over should not be counted, but birds seen arriving or leaving a waterbody should be recorded to that waterbody. Any movement of birds between waterbody should be noted to avoid double-counting. All factors likely to significantly influence the data (e.g. drained *gei wai*, recent vegetation cutting on islands, disturbances, etc.) should be noted.
Sampling time of year	1st November – 31st March
Sampling time of day	Surveys should start at 12.00 (noon) and should last for approximately 1 hour.
Sampling frequency	Twice per month. One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day. There should be at least a 7-day interval between successive counts. Priority should be given to dates with higher tide in Deep Bay. Where possible, surveys should be conducted within a day of the AFCD coordinated Black-faced Spoonbill monitoring.
No. of samples	Ten surveys per year.
Repeat interval	Annually
Weather condition	The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue/abandon the count by assessing local weather condition and the remaining time duration of the count. When visibility is especially poor (i.e. evening haze or air pollution), such that the recorder can not see clearly into the central areas of the *gei wai*, the count should be rescheduled. Under any unusual or exceptional circumstances that the count is considerably interrupted, the current count should be abandoned and rescheduled.

DATA MANAGEMENT

Data format	Roosting number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data are stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. Summary graphs are presented at the Mai Po Management Committee. 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". The report is circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website. <2005-10 Report download link>

Figure 1: Regular Roosting Locations of Black-faced Spoonbill



Appendix 3 - Faunal Monitoring Surveys : Roosting Anatidae

FM03. Roosting Anatidae

(version: October 2013)

FEATURE	Roosting Anatidae
PARAMETERS	Abundance and distribution of Anatidae roosting in evening at MPNR
OBJECTIVE(S)	1. To provide data on the abundance and distribution of roosting Anatidae at MPNR to inform habitat management. 2. To track changes in abundance or distribution of Anatidae species. 3. To monitor population levels of indicator Anatidae species.
BACKGROUND	Anatidae (mostly ducks) are one of the most abundant waterbird groups wintering in Deep Bay area, and certain species are present in internationally important numbers in the Mai Po Inner Deep Bay Ramsar Site. Reliable data upon species, abundance and distribution within MPNR is essential to ensure habitats are managed successfully for their benefit. Numbers of Anatidae at MPNR increase overnight as birds roost in the safety of the reserve after spending the day foraging elsewhere (especially on the intertidal mudflats). Numbers are greatest during overnight high tides. WWF commenced roosting Anatidae surveys on a number of targeted *gei wai* and rain-fed ponds in October 2003. The survey was extended to cover the whole of MPNR in winter 2007/08.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicators* Northern Pintail Northern Shoveler Tufted Duck

METHODOLOGY

Equipment (essential)	1. Binoculars (8x magnification or above). 2. Telescope and tripod. 3. Voice recorder or paper with pen. 4. Watch. 5. Bicycle (optional for recorder at fixed locations).
Equipment (optional)	1. Hand tally counter. 2. Bird field guide
Sampling site(s)	Transect count encircling perimeter of the MPNR. See Figure 1. Particular attention is required at four locations, which may necessitate additional observers at fixed locations when large numbers of ducks are present (mostly December – February): - Pond #8a: Tower Hide (top floor). - Pond #15a and #15b. - *Gei wai* #16/17: Hide #1, #3, #5, #6 or #7. - Pond #20 and *Gei wai* #21

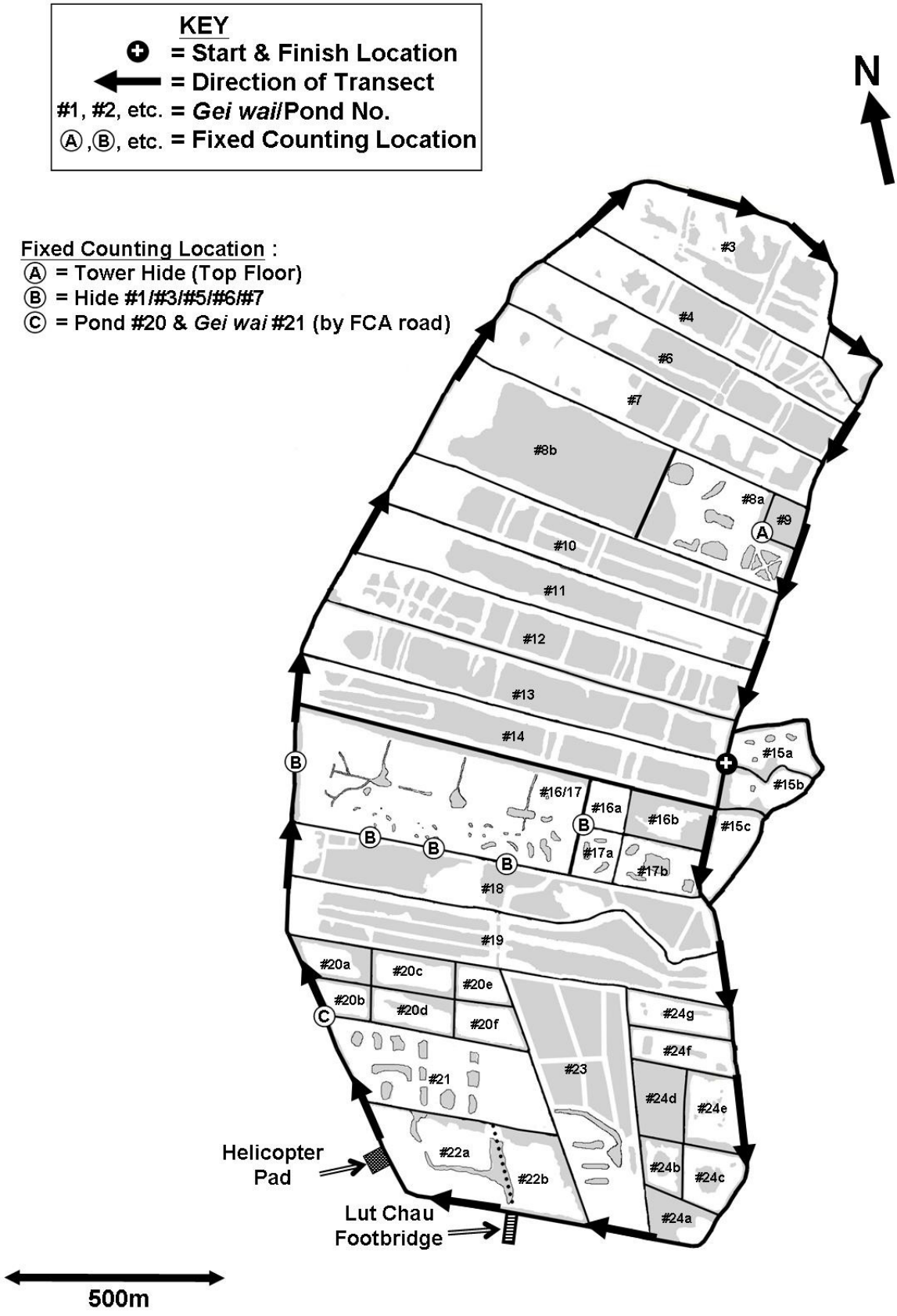
Sampling technique	1. The entire transect route is cycled and all non-flying Anatidae inside the MPNR are recorded. 2. The recorder should stop at several locations alongside each *gei wai*/pond (where possible) to provide uninterrupted views into the open areas of water and water channels. 3. The number and location of each Anatidae species per waterbody is recorded. 4. Birds located on internal bunds should be assigned to a waterbody by using an imaginary line dissecting the bund equally between neighbouring *gei wai*/sub-ponds. 5. Only non-flying birds are recorded and movements between waterbodies should be noted where possible to avoid double counting. 6. When large numbers of birds are expected at particular locations (especially those mentioned above), additional observers should be located at those sites at the start of the count and should record the number of birds present during this period. In this case, the *gei wai*/sub-ponds covered by additional observers need not be surveyed as part of the cycled transect. All factors likely to significantly influence the data (e.g. drained *gei wai*, recent vegetation cutting on islands, disturbances, etc.) should be noted.
Sampling time of year	From 15th October to 15th April.
Sampling time of day	Count commences 45 minutes before sunset and last for 1 hour.
Sampling frequency	Sample should be collected every half month. Date of the counts are set according to the following criteria: 1. One of the two monthly counts should be conducted within a 7-day period either side of the AFCD's Deep Bay Monthly Waterbird Count to enable a direct comparison between MPNR, the Ramsar Site and Deep Bay waterbird numbers; 2. There should be at least a 7-day interval between any 2 counts. 3. One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day. 4. Both counts should be conducted on the best available high tides in Deep Bay (i.e. tide height >2.2m) during the survey so there is a greater chance of encountering more Anatidae coming in to MPNR from the Bay. 5. Where no high tides are available the count should be undertaken in the evening before a high over-night tide (>2.2m).
No. of samples	12 per year
Repeat interval	Annually
Weather conditions	The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey. When visibility is especially poor (e.g. evening haze or air pollution) , such that the recorder can not see clearly into the central areas of the *gei wai*, the survey should be rescheduled.

	Under any unusual or exceptional circumstances that the survey is interrupted for a prolonged period of time, the current survey should be abandoned and rescheduled.

DATA MANAGEMENT

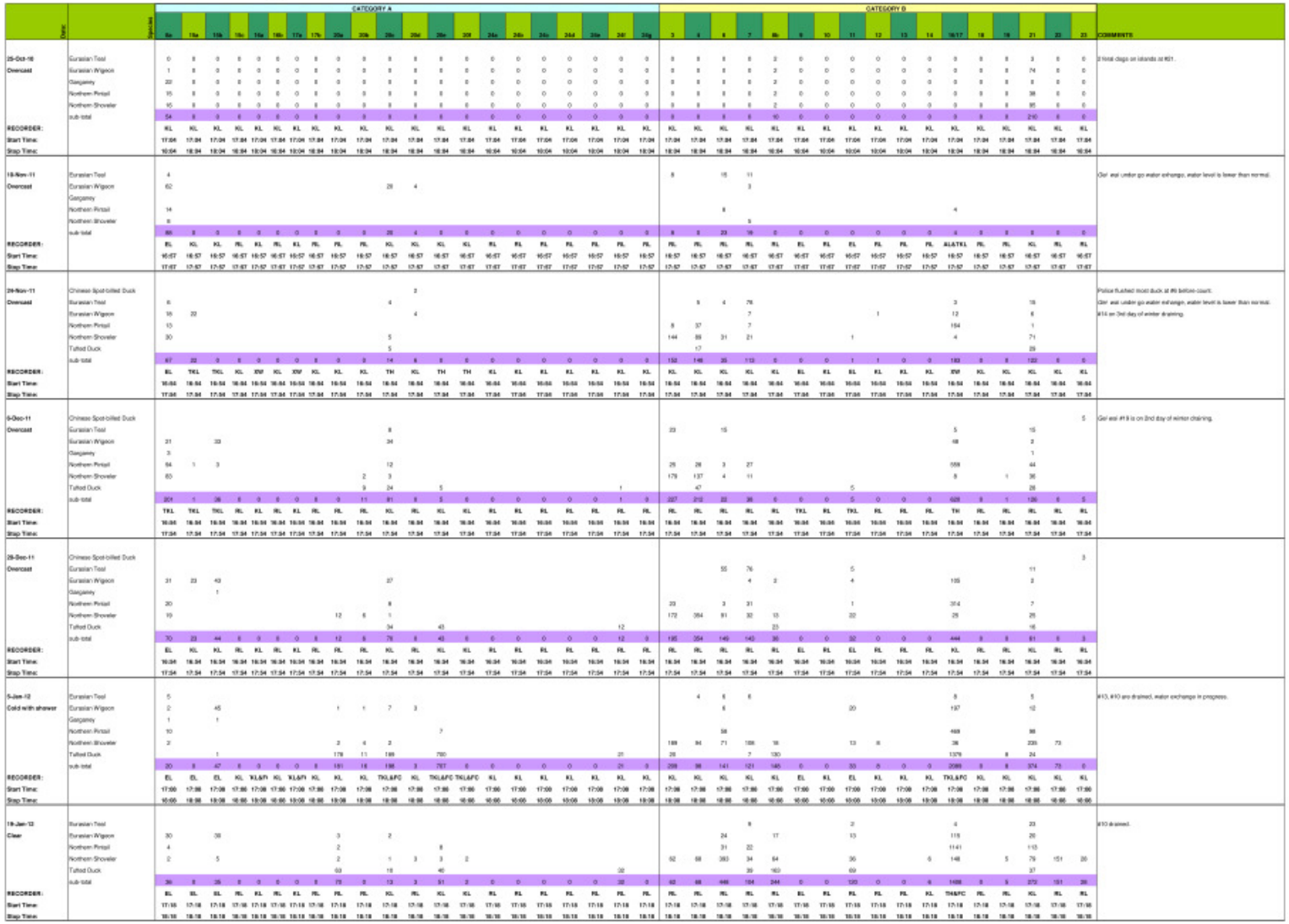
Data format	Species, number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data are stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. Summary graphs are presented at the Mai Po Management Committee 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". The report is circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website. <2005-10 Report download link>

Figure 1: Fixed Counting Locations and Transect Route



Appendix I : Example of Data SpreadSheet

Roosting Anatidae Count: Winter 11/12



Appendix 4 - Faunal Monitoring Surveys : Roosting Shorebirds and Terns

FM04. Roosting Shorebirds and Terns

(version: October 2013)

FEATURE	Shorebirds and Terns
PARAMETERS	Abundance and distribution of each shorebird and tern species using MPNR during high tide.
OBJECTIVE(S)	1. To provide abundance and distributional data on roosting shorebirds and terns to inform habitat management. 2. To monitor abundance of shorebirds and terns to identify any change in long-term abundance so that action can be taken.
BACKGROUND	Mai Po Inner Deep Bay Ramsar Site provides habitat for internationally important numbers of several shorebird species during winter and on migration between breeding and wintering sites. Provision of a safe high tide roost site is one of the Management Objectives of MPNR in BMZ5 & 7. Regular surveys of shorebirds at the high tide roosts provide data about the use of roosts and number of shorebirds, so that if any problems were to arise at the roost sites, appropriate action could be identified and implemented promptly. In addition to shorebirds, high numbers of two tern species (Gull-billed and Caspian Tern) also roost on the reserve at high tide during spring migration periods. Deep Bay qualifies as an important stop-over site for Gull-billed Tern, supporting more than 0.25% of the regional population during migration in recent years. These two species use the same sites as roosting shorebirds and the numbers of each will also be counted during the shorebird surveys. Most species use MPNR primarily or exclusively during high tide period, so all surveys should be conducted at high tide. Because the time of high tide varies over the course of the year, the time of the surveys will also need to change over the year. Despite the presence of wintering shorebirds in Deep Bay, high tides during the winter months mostly occur during the hours of darkness when accurate surveys are not possible and therefore high tide surveys will not be conducted between 1st November and 15th March.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicators* Black-winged Stilt Pied Avocet Pacific Golden Plover Lesser Sand Plover Greater Sand Plover Black-tailed Godwit Whimbrel Eurasian Curlew Spotted Redshank Common Redshank Common Greenshank Nordmann's Greenshank Terek Sandpiper Asian Dowitcher Great Knot Red-necked Stint Curlew Sandpiper Broad-billed Sandpiper Gull-billed Tern

METHODOLOGY

Equipment (essential)	For each recorder: 1. Binoculars (8x magnification or above). 2. Telescope and tripod. 3. Voice recorder or paper with pen. 4. Watch. 5. Bicycle.

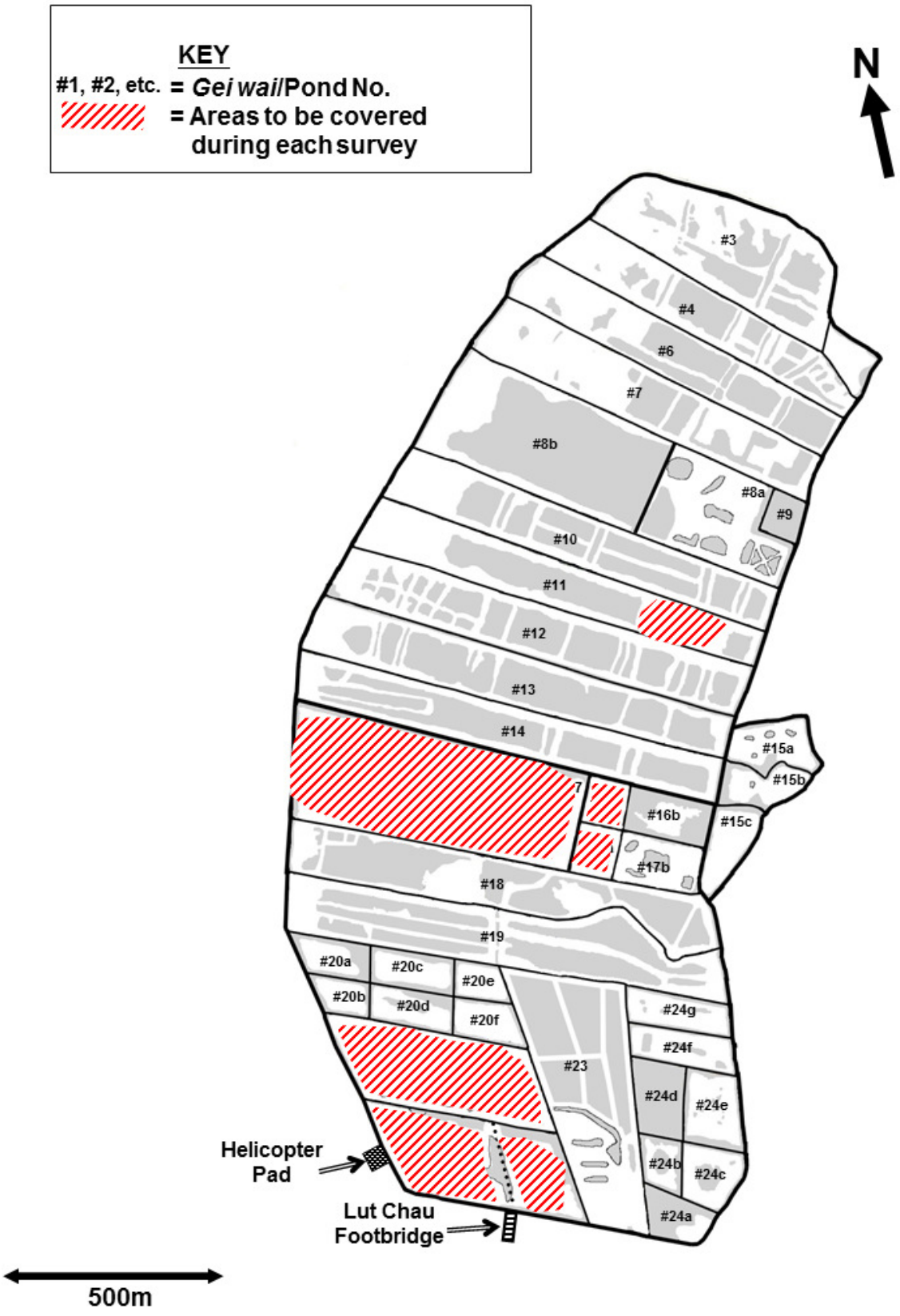
Equipment (optional)	1. Hand tally counter. 2. Bird field guide.
Sampling site(s)	Fixed locations (to be surveyed during each survey): - *Gei wai* #16/17 and Ponds #16a and #17a: Hide #1, #3, #5, #6 or #7; - *Gei wai* #11: Hide #8; - *Gei wai* #21 and #22. Any other *gei wai* or rain-fed ponds in which the prevailing water level may be suitable for use by waterbirds (especially during drain-down or water exchange) See Figure 1
Survey Technique	1. Surveyor should visit all sites managed for roosting shorebirds as listed above. Use of bicycle is required to travel rapidly between survey locations. 2. Where conditions on another waterbody may provide conditions suitable for roosting shorebirds (particularly if water levels are low during periods of drain-down or water exchange), surveyor should also additionally visit these locations to check for the presence of shorebirds. 3. Surveyor should record which waterbodies have been checked during survey (even if no shorebirds are present). 4. At each waterbody, surveyor should record the total number of individuals of each shorebird species (i.e. species of Recurvirostridae, Charadriidae, Rostratulidae, Jacanidae, Scolopacidae or Glareolidae) present. Numbers of Gull-billed Terns or Caspian Terns should also be recorded if these are present. 5. Birds located on internal bunds should be assigned to a waterbody by using an imaginary line dissecting the bund equally between neighbouring *gei wai*/sub-ponds. 6. Only non-flying birds are recorded and movements between waterbodies should be noted to avoid double counting. Two or more surveyors may be required during times of peak abundance (particularly during peak spring migration period in April and May). Tide height (taken from the Real Time Tide value for Tsim Bei Tsui: http://www.hko.gov.hk/tide/marine/hko_tb.htm) should be recorded at start and end of survey, as well as the peak tide height during the survey. Predicted tide should also be recorded. All factors likely to significantly influence the data (e.g. drained *gei wai*, recent vegetation cutting on islands, disturbances, etc.) should be noted.
Sampling time of year	From 15th March to 30th May and from 15th July to 30th October. Despite the presence of wintering shorebirds, few suitable daytime tides occur in Deep Bay between 1st November and 15th March.
Sampling time of day	Survey conducted to coincide with daytime high tide period (Tide > 2.2m at Tsim Bei Tsui between 06:00 and 18:00); time of day of high tide will change according to season.
Sampling frequency	Surveys should be conducted every half month, on each cycle of peak high tides during migration period. Date of the surveys are set according to the following criteria: 1. One survey should be conducted in the first half of the month (before 15th) and one survey in the second half of the month (after 15th); 2. Periods of spring tides reoccur on a cycle of approximately every two weeks and one survey should be conducted during each cycle, with at least a seven-day interval between surveys;

	3. Where possible, surveys should coincide with the peak predicted tidal height of each spring tide cycle, to maximize the chance that birds have left the mudflats.
No. of samples	12 per year
Repeat interval	Annually
Weather conditions	The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey. When visibility is especially poor (e.g. rainfall, haze or air pollution), such that the recorder can not see clearly into the central areas of the *gei wai*, the survey should be rescheduled. Under any unusual or exceptional circumstances that the survey is interrupted for a prolonged period of time, the current survey should be abandoned and rescheduled.

DATA MANAGEMENT

Data format	Species, number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data should be stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. Summary graphs should be presented at the Mai Po Management Committee. 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". The report is circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website.

Figure 1: Areas to be Covered During Shorebird Surveys



Appendix 5 - Faunal Monitoring Surveys : Roosting Collared Crow

FM05. Roosting Collared Crow

(version: October 2013)

FEATURE	Collared Crow *Corvus torquatus*
PARAMETERS	1. Roosting population 2. Roosting location
OBJECTIVE(S)	1. To monitor the population of this globally near-threatened species. 2. To monitor habitat use or pre-roosting flock within MPNR to assess whether enhancement of habitat is feasible.
BACKGROUND	Collared Crow *Corvus torquatus* is listed as a globally Near threatened species under the IUCN Red List (BirdLife 2013). Deep Bay supports the largest population currently known globally, with peak counts of more than 100 individuals in recent years. Most birds in Deep Bay roost communally at night in the intertidal mangroves at the Frontier Closed Area (FCA) adjacent to MPNR. This roost location is outside the boundary of MPNR, but most birds do gather into pre-roost gatherings within MPNR before going to the final roosting location. Although no habitat enhancement is possible at the roost location, it is recognised that the population of this species should be monitored given the apparent global importance of the Deep Bay roosting population. Regular recording of the roosting population started in August 2003. Data shows MPNR and the surrounding habitats provide year-round roosting habitat for the species, but that numbers peak in two periods of the year: the two month period between July and August; and in mid-winter (late December to early February). Monitoring of the species at MPNR therefore concentrates on these two periods.
MANAGEMENT PLAN TARGETS / INDICATORS	None (Collared Crow is not included as an indicator species because the roosting site is located outside the boundary of MPNR and the habitats on the reserve are not considered critical for the species).

METHODOLOGY

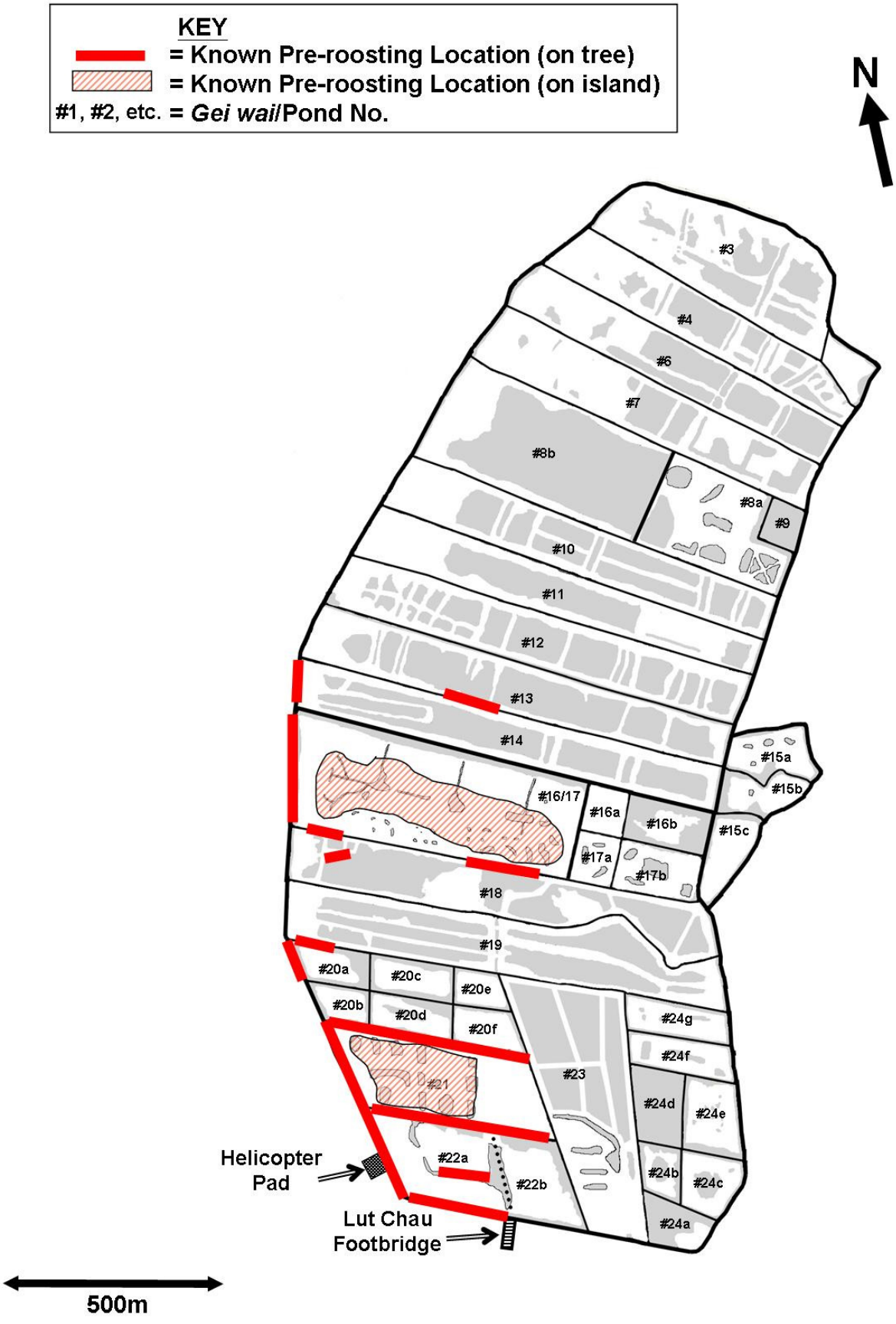
Equipment (essential)	1. Binoculars (8x magnification or above) 2. Voice recorder or paper with pen 3. Watch
Equipment (optional)	1. Bicycle 2. Hand tally counter
Sampling site(s)	Count should be carried out at locations where pre-roosting flocks inside MPNR can be observed undisturbed (usually along the Frontier Closed Area road). Recorder might need to move between locations to observe birds' movement. See Figure 1 for known locations.
Sampling technique	1. The recorder should locate the pre-roosting flocks inside MPNR and be in position within the first 15 minutes of the survey. 2. Sampling time is split into 15-minute intervals. For each interval, the recorder should count the total number seen and record the net increase/decrease in the number of pre-roosting individuals within MPNR. 3. As birds enter their final roost, the recorder should count the total roosting population and record the location of the final roost.

	4. Where possible, the recorder should take notes of the followings: - Location of the pre-roosting flocks; - Direction and time of arrival of birds joining the pre-roosting flock; - Movement of the pre-roosting flocks between locations; - Number and time that the pre-roosting flocks enter the final roost.
Sampling time of year	- Winter: mid-December to mid-February - Summer: July to August
Sampling time of day	Count commences 1 hour before sunset (survey ends when the last bird enters the final roost).
Sampling frequency	Sample should be collected every half-month. One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day. There should be at least a 7-day interval between any 2 counts.
No. of samples	8 per year
Repeat interval	Annually
Weather condition	The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue/abandon the count by assessing local weather condition and the remaining time duration of the count. When visibility is especially poor (i.e. evening haze or air pollution), such that the recorder can not see clearly into the central areas of the *gei wai*, the count should be rescheduled. Under any unusual or exceptional circumstances that the count is considerably interrupted, the current count should be abandoned and rescheduled.

DATA MANAGEMENT

Data format	Roosting number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data are stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. Summary graphs are presented at the following Mai Po Management Committee meeting. 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". The report is circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website. <2005-10 Report download link>

Figure 1: Known Pre-roosting Locations



Appendix I : Example of Data SpreadSheet

	Collared Crow : Winter 2010-11			
Date	Time	No. observed Net +/-	Comments	Recorder
21-Dec-10	17:29-17:44	65	all birds at #20, 21	
21-Dec-10	17:44-17:59	3	birds join from Lut Chau and FCA direction.	
21-Dec-10	17:59-18:10	27	All birds head to roost at #16/17/FCA mangrove from 18:01-18:10	
21-Dec-10	Total roosting	95		
21-Dec-10	Max No. seen	95		KL
10-Jan-11	17:27-17:42	26	26 birds from North and South head to FCA Mangrove	
10-Jan-11	17:42-17:57	-6	More birds join from Deep Bay direction, most roosting birds leave FCA Mangrove	
10-Jan-11	17:57-18:12	30	All birds leave FCA Mangrove at 18:01, flock of 34 enter roost again at 18:08	
10-Jan-11	18:12-18:25	42	42 birds head to roost from 18:18-18:25	
10-Jan-11	Total roosting	92		
10-Jan-11	Max No. seen	92		KL
21-Jan-11	17:43- 17:58	47	47 birds were pre-roosted from #18 to #21, individuals were quite activie and moving within those gei wai.	
21-Jan-11	17:58-18:13	0	No new birds join in.	
21-Jan-11	18:13-18:28	4	2 birds join from Deep Bay and 2 from Lut Chau direction.	
21-Jan-11	18:28-18:32	11	Most of the birds head to roost at #16/17/FCA mangrove at 18:28, except a indiviual which from Lut Chau direction and join the group at 18:32.	
21-Jan-11	Total roosting	62		
21-Jan-11	Max No. seen	62		RL
7-Feb-11	17:47- 18:02	10	Birds flew into #16/17/FCA mangrove from both N and S Mai Po.	
7-Feb-11	18:02-18:17	34	More birds join the group in FCA mangrove from Lut Chau, Deep Bay and N Mai Po.	
7-Feb-11	18:17-18:32	-19	All 44 birds in FCA mangrove leave and fly to #18 at 18:26, some birds then re-enter the roost in small groups at 18:29.	
7-Feb-11	18:32-18:43	34	More birds join the group in FCA mangrove from #18, S Mai Po and Deep Bay directions, roosting end at 18:43.	
7-Feb-11	Total roosting	59		
7-Feb-11	Max No. seen	59		KL&TH

Appendix 6 - Faunal Monitoring Surveys : Breeding Black-winged Stilt

FM06. Breeding Black-winged Stilt

(version: October 2013)

FEATURE	Black-winged Stilt *Himantopus himantopus*
PARAMETERS	Abundance, distribution and success of breeding attempts by Black-winged Stilts at MPNR
OBJECTIVE(S)	1. To monitor breeding population size and breeding success of Black-winged Stilts at MPNR; 2. To record the distribution of nesting attempts so that favoured locations can be identified and appropriate management decisions can be made to benefit the species.
BACKGROUND	Black-winged Stilt *Himantopus himantopus* first bred in Hong Kong in 2003 at *Gei wai* #23 at MPNR, and has bred annually at MPNR until 2012 (no birds bred in 2013). Although there have been cases of successful breeding at other sites, MPNR remains the stronghold for this species in Hong Kong. WWF has conducted annual surveys of the breeding population since 2007. The species mostly breeds on islands in shallow water *gei wai* or rain-fed ponds. Nest building starts in most years from April and the first chicks hatch in early May. Surveys provide data not only on the number of nesting attempts but also on the number of juveniles produced, allowing calculation of nesting success/productivity in each year.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicator* Black-winged Stilt

METHODOLOGY

Equipment (essential)	1. Bicycle 2. Binoculars (8x magnification or above) 3. Telescope and tripod 4. Pencil/pen 5. Recording map (Appendix I)
Equipment (optional)	1. Camera
Sampling site(s)	Survey should be carried out at all potential nesting sites within MPNR. Previous nesting locations include: - Pond #8a - Pond #15a and b - *Gei wai* #16/17 - Pond #17b - *Gei wai* #21 - Pond #23 Juveniles leave the nest soon after hatching and can travel from the nesting location to other water bodies, so all *gei wai*/ponds should be checked to count juveniles. See Figure 1 for previous nesting locations and observation locations.

Sampling technique	1. The recorder should station at observation locations (bird hides or along road/foot path) overlooking each *gei wai*/pond. 2. Recorder should count the number of nests within each *gei wai*/pond and mark the location of each nest on the recording maps (Appendix I). 3. Enough observation time should be spent observing sitting adults to determine whether a nest is present. Presence of a nest is confirmed by observation of any of the following: - Presence of eggs; - Parent birds switching nest-sitting responsibility; - Nest building material elevated from ground. 4. The recorder should also take notes of any nest building pairs. 5. Recorder should determine the number of unfledged chicks or juveniles for all *gei wai*/ponds. The total number of unfledged chicks or juveniles at each waterbody should be recorded. 6. All factors likely to significantly influence the data (for example a drained *gei wai*, recent vegetation cutting on islands, disturbance, etc.) should be noted.
Sampling time of year	May. Nest-building may start in April and nesting attempts may continue into June so, at discretion of the recorder, extra surveys can be scheduled in these months if required.
Sampling time of day	Any.
Sampling frequency	Once every half-month. One of the counts should be conducted on or before the 15th May and the other after the 15th May. There should be at least a 7-day interval between the two counts.
No. of samples	Minimum two per year. Extra surveys may be scheduled in April and/or June at the discretion of the recorder if breeding activity is observed in these months.
Repeat interval	Annually.
Weather condition	Heavy rain can make it difficult to assess the presence of eggs or small chicks if these are being sheltered by the adult, and may make observation at a distance difficult. Surveys should therefore avoid periods of heavy rainfall if possible. The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count or if weather deteriorates, the recorder should decide to either continue or reschedule the count by assessing local weather condition and the remaining time duration of the count.

DATA MANAGEMENT

Data format	1. Number and location data - MS Excel Spreadsheet (Appendix I) 2. Mapping location – ArcGIS 10 (Appendix II)
Location of data	All data are stored in the “Research and Monitoring Share” under the Mai Po Server.

Reporting	1. Summary result is presented at the Mai Po Management Committee annually. 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". The report is circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website. <2005-10 Report download link>

Figure 1: Previous Nesting Locations and Observation Locations

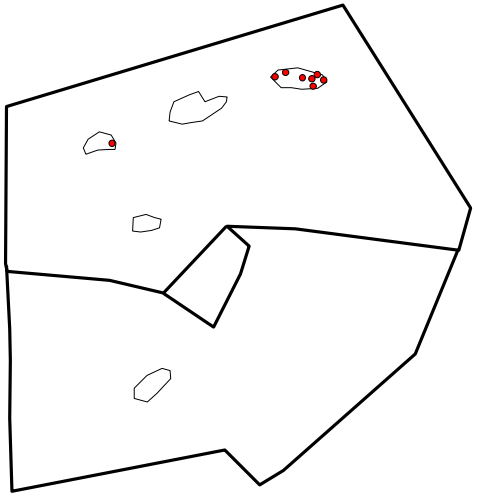
Appendix I : Example of Data SpreadSheet

Mai Po Nature Reserve
Breeding Black-winged Stilt

Date	No. of nest								No. of Juvenile									No. of Nests	No. of Juveniles	Comments	Weather	Recorder
	8	15a	15b	17b	16/17	20	21	23	8	15a	15b	17b	16/17	18	20	21	23					
11-May-07	0	3	0		5			15	0	0	0		0				0	23	0		-	BS
23-May-07	0	1	0		18	0	0	3	0	0	0		7		0	0	0	22	7	Grasses on #23 islands are very tall.	-	BS
8-May-08	0	5	1		8	0	0	0	0	0	0		0		0	0	0	14	0		-	BS
20-May-08	0	2	0		7	0	0	0	0	10	13		2		0	0	0	9	25		Rainy	KL
12-May-09	0	0	0	1	27	0	0	0	0	0	0	0	0		0	0	0	28	0		Clear	KL&RL
25-May-09	0	0	0	1	11	0	0	0	0	0	0	0	18	1	0	0	0	12	19	Possible nesting Pied Avocet on #16/17.	Rainy	KL&RL
12-May-10	0	0	0	0	9	0	0	0	0	0	0	0	11	5	0	0	0	9	16		Clear	KL&RL
27-May-10	0	0	0	0	1	0	1	0	2	0	0	0	19	0	0	0	0	2	21	All 4 individual with HK flags seen on #16/17	Clear	KL
19-Apr-11	0	8	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	9	0	Extra survey.	Clear	KL
4-May-11	0	7	0	0	7	0	16	0	0	4	0	0	0	0	0	0	0	30	4		Cloudy with shower	KL
12-May-11	0	0	0	0	11	0	39	0	0	0	14	0	3	0	0	0	0	50	17	Extra survey.	Clear	KL
20-May-11	0	0	0	0	21	0	32	0	0	0	12	0	14	0	2	2	0	53	30		Clear	KL
27-May-11	0	0	0	0	21	0	28	0	0	4	7	0	15	0	0	7	0	49	33	Extra survey.	Clear	KL
3-Jun-11	3	0	0	0	18	0	14	0	3	0	11	0	34	0	0	24	0	35	72	Extra survey.	Clear	KL

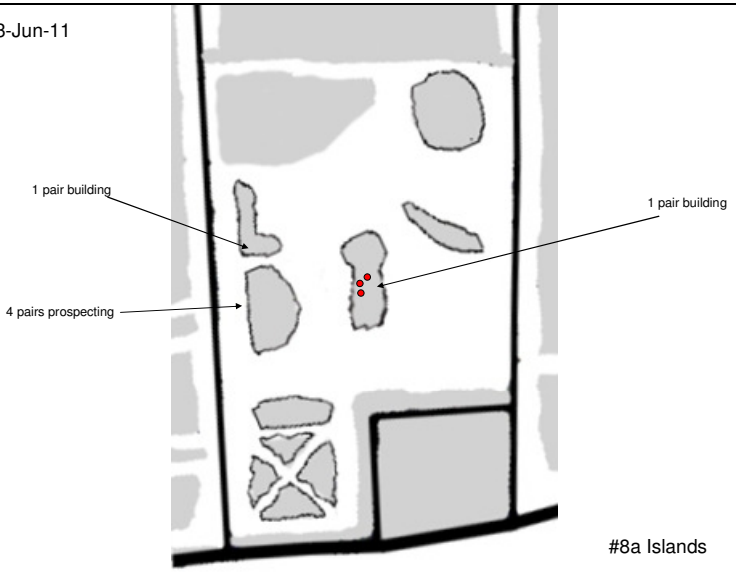
Appendix II : Example of Recording Map

19-Apr-11



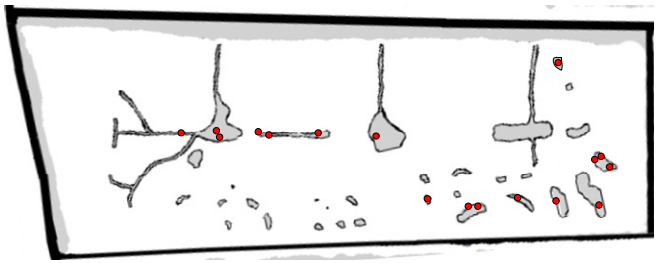
#15 Islands

3-Jun-11



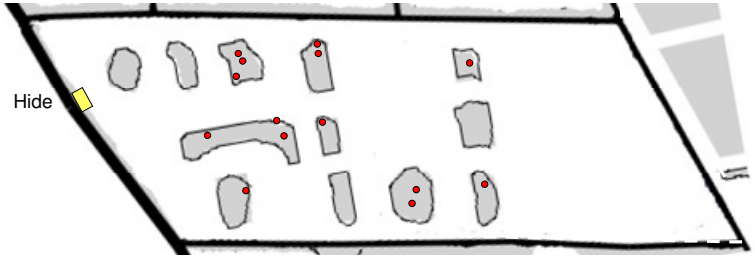
#8a Islands

3-Jun-11



#16/17 Islands

3-Jun-11



#21 Islands

Appendix 7 - Faunal Monitoring Surveys : Ardeid and Spoonbill Use of *Gei Wai* During Drawdown

FM07. Use of *Gei wai* during Drawdown by Ardeids and Spoonbills

(version: October 2013)

FEATURE	Ardeids and spoonbills using draining *gei wai*
PARAMETERS	Abundance of ardeids and spoonbills on *gei wai* during drawdown (including birds foraging and/or roosting).
OBJECTIVE(S)	1. To provide information on the abundance of ardeids and spoonbills attracted into each *gei wai* during drawdown periods. 2. To evaluate the effectiveness of drain-down in each *gei wai* so that management decisions can be made about each *gei wai* if necessary.
BACKGROUND	*Gei wai* at MPNR are drained to attract foraging waterbirds, especially ardeids (herons and egrets) and spoonbills. These species are attracted to feed as falling water levels allow wading and trap fish and shrimp in remaining water. Drawdown is conducted during winter and summer according to a schedule drawn up at the start of the season. Surveys of waterbirds foraging at *Gei wai* #12, #13 & #14 during winter drawdown have been conducted since 2006, and these will be continued to provide a long-term dataset for these *gei wai*. In addition, one other *gei wai* will be surveyed each winter and one will be surveyed each summer. In this way, each of the *gei wai* on the summer and winter draining schedules will be surveyed at least once over the course of the five-year plan (*Gei wai* #22 is not included because this will follow intertidal operation for much of the year, which may affect draining results). Surveys have previously been conducted into waterbird usage of draining *gei wai*, which suggested peak numbers of ardeids and spoonbills occur approximately 30-60 minutes after sunrise, and that on a traditional draining schedule (draining over a period of seven days), the peak numbers on most *gei wai* occur on the third day of draining. To make the results comparable between *gei wai*, all surveyed *gei wai* will be drained to reach the optimal level (about 10-20cm water depth remain in the water channel at 2 sides) on the third day and surveys will be conducted on the third day.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicators* Chinese Pond Heron Grey Heron Great Egret Little Egret Black-faced Spoonbill

METHODOLOGY

Equipment (essential)	1. Binoculars (8x magnification or above). 2. Voice recorder or paper with pen. 3. Bicycle.
Equipment (optional)	1. Telescope and tripod. 2. Hand tally counter.
Sampling site(s)	1. *Gei wai* #12, #13 & #14 to be surveyed each winter during drawdown (November-January). 2. One other *gei wai* to be surveyed each winter during drawdown (tentative schedule:

	2013/14 – #19, 2014/15 – #10, 2015/16 – #18, 2016/17 – #7, 2017/18 – #11). 3. One *gei wai* to be surveyed each summer during drawdown (tentative schedule: 2014 – #21, 2015 – #8b, 2016 – #3/#4, 2017 – #16/17, 2018 – #6.
Sampling technique	1. Any *gei wai* being monitored should be drained to reach the optimal level on the third day. Surveys should be conducted on the morning of the third day of draining. Sluice gate operators should avoid disturbing birds during the count period. 2. Surveyors should arrive at a monitoring location providing a clear view over the open areas of the *gei wai* at least 15 minutes before the count is scheduled to start (i.e. 15 minutes after sunrise), to minimize disturbance to birds during the count. 3. During the count, the number of individuals of each species of spoonbills and ardeids observed using (foraging or roosting) the *gei wai* should be recorded. Birds flying over without using the *gei wai* should not be counted; birds using the bunds, mangroves or other perching locations within the *gei wai* should be recorded. 4. Two counts should be made, one at 30 minutes after sunrise, the other at 60 minutes after sunrise. The count to be recorded is the maximum of each species from these two counts. 5. For most *gei wai*, the entire area of open water will not be visible from a single location. In these cases either two surveyors should co-ordinate the counts from each end of the *gei wai* or one surveyor should move between each end of the *gei wai* between counts. Surveyor should avoid disturbing the birds when moving between locations. 6. If the count requires a single surveyor to move between each end of the *gei wai*, counts should start at the busier end of the *gei wai* at 30 minutes and then the surveyor should count the quieter end of the *gei wai* before start of the second count at 60 minutes. 7. Any sources of disturbance or other factors affecting the count should be recorded.
Sampling time of year	Four *gei wai* in winter (including #12, #13 and #14 in November-January) and one in summer.
Sampling time of day	Surveys should be conducted at 30 and 60 minutes after sunrise.
Sampling frequency	Surveys should be conducted on each *gei wai* on the third day during drawdown.
No. of samples	Total of five surveys per year (four in winter, one in summer).
Repeat interval	Annually
Weather conditions	The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count. When visibility is especially poor (misty or heavy rain), such that the recorder can not see clearly into the central areas of the *gei wai*, the count should be rescheduled. Under any unusual or exceptional circumstances that the count is interrupted for a prolonged period of time, the current count should be abandoned and rescheduled for later the same day or for the following day.

DATA MANAGEMENT

Data format	Species, number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data are stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. A summary of results should be presented at the Mai Po Management Committee on an annual basis. 2. Summary and analysis of the data from 2013-2018 to be presented in a Summary report prepared at the end of the Monitoring Plan.

Appendix 8 - Faunal Monitoring Surveys : Waterbird Use of Inter-tidal Mudflats

FM08. Waterbird use of mudflats cleared of vegetation

(version: October 2013)

FEATURE	Waterbirds using cleared area of mudflats in front of floating hides
PARAMETERS	Total abundance of waterbirds using the area of mudflats cleared of vegetation.
OBJECTIVE(S)	1. To evaluate the effectiveness of the vegetation clearance to maintain habitat for waterbirds.
BACKGROUND	The intertidal mudflats in Inner Deep Bay do not form part of Mai Po Nature Reserve, but are managed on an annual basis by WWF. This management includes the removal of mangrove seedlings and grasses/sedges growing on the mudflats to maintain an open area suitable for foraging waterbirds. Surveys are conducted under contract with AFCD to evaluate the effectiveness of annual mudflat vegetation clearance. Surveys are subject to the continuation of existing annual contracts of Habitat Management Works.
MANAGEMENT PLAN TARGETS / INDICATORS	None.

METHODOLOGY

Equipment (essential)	1. Binoculars (8x magnification or above). 2. Telescope and tripod. 3. Voice recorder or paper with pen.
Equipment (optional)	1. Hand tally counter.
Sampling site(s)	1. Floating Boardwalk Hide (Northernmost hide)
Sampling technique	1. Observers should conduct all counts from the northernmost floating hide overlooking Deep Bay. 2. Counts should be conducted on a rising tide when the tide is predicted to be around 1.9m. 3. All waterbirds observed on the mudflats from the hide should be counted and recorded into the following groups: - Cormorants (all members of Phalacrocoracidae); - Ardeids, etc. (all members of Ardeidae or Threskiornithidae); - Ducks, grebes, pelicans (all members of Anatidae, Podicipedidae or Pelecanidae); - Rails, coots, etc. (all members of Rallidae); - Shorebirds (all members of Recurvirostridae, Charadriidae or Scolopacidae); - Gulls and Terns (all members of Laridae). 4. Total counts for each group should be recorded; separate counts for each species are not required. 5. Any significant disturbance potentially affecting the count (for example mudskipper collectors or raptors disturbing birds) should be recorded.
Sampling time of year	November – March

Sampling time of day	Any time of day during high tide, but preference should be given to tides peaking before noon (when light conditions are more suitable for viewing from the hide).
Sampling frequency	Once per month. Survey dates should be selected when the tide reaches a level of about 1.9m during high tide, preferably in the morning.
No. of samples	Five surveys per year.
Repeat interval	Annually
Weather conditions	The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count. When visibility is especially poor (misty or heavy rain), such that the recorder cannot see clearly onto the mudflat, the count should be rescheduled. Under any unusual or exceptional circumstances that the count is interrupted for a prolonged period of time, the current count should be abandoned and rescheduled the following day with suitable tide condition.

DATA MANAGEMENT

Data format	Species, number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data are stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. A summary of results to be reported to AFCD and District Lands Office- Yuen Long (DLO) as part of the annual reporting on the contract of Habitat Management Works as long as annual contracts for this work continue.

Appendix 9 - Faunal Monitoring Surveys : Amphibians

FM09. Amphibians

(version: October 2013)

FEATURE	Amphibians
PARAMETERS	Abundance and distribution of amphibians in rain-fed ponds
OBJECTIVE(S)	1. To provide data on breeding amphibians in rain-fed habitats at MPNR to inform management practices.
BACKGROUND	Amphibians are largely absent from the brackish *gei wai* at MPNR but are present in the rain-fed habitats. Although all species present at MPNR are common and widespread in Hong Kong, these species contribute to the overall biodiversity of the reserve and may provide food for other species, including some wetland bird species. Amphibians are also easy to survey as an indicator for the overall quality of freshwater habitats. Amphibians can easily be surveyed by listening for the breeding calls of males during the wet season. Such surveys are best conducted in the evening, preferably during or after rainfall.
MANAGEMENT PLAN TARGETS / INDICATORS	None

METHODOLOGY

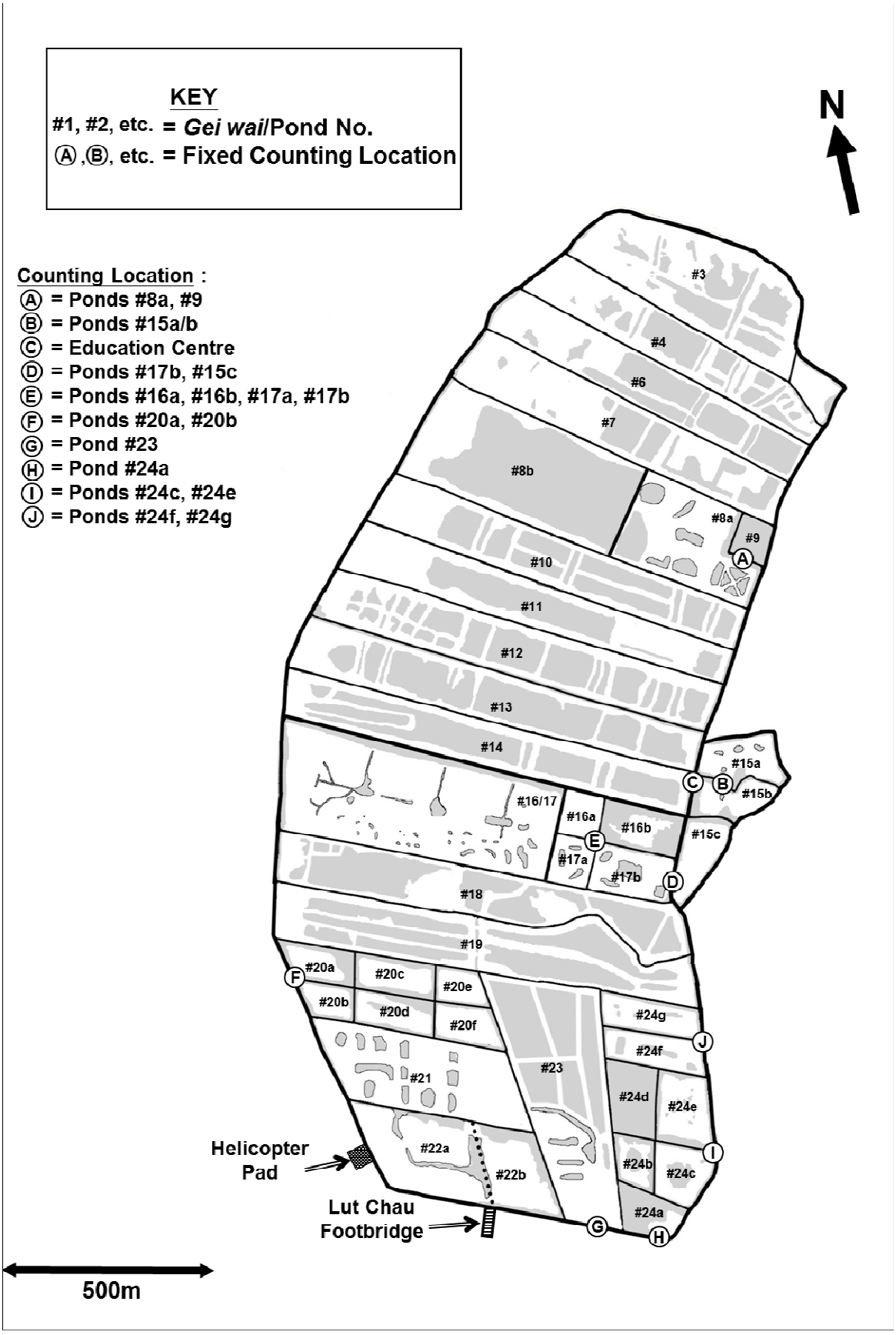
Equipment (essential)	For each recorder: 1. Voice recorder or paper with pen 2. Watch 3. Bicycle 4. Torch
Equipment (optional)	1. Hand tally counter
Sampling site(s)	Rain-fed ponds around Mai Po including Ponds #8a, #9, #15a/b/c, #16a, #16b, #17b, #20a/b, #23, #24a/c/e/f/g and the small pond at the front of Education Center (other ponds may need to be added if *gei wai* are converted to rain-fed ponds). See Figure 1
Survey Technique	1. Surveyor should visit all rain-fed ponds adjacent to major footpaths around the reserve (16 ponds, as listed above). For safety reasons, access is not required to ponds which are not easily accessible along major paths (#20c/d/e/f and #24b/d). Use of bicycle will be required to travel rapidly between survey locations. 2. At each waterbody, the surveyor should stop for a between three and five minutes and listen for vocalizing amphibians. The duration of the stop will depend upon the number of amphibians present, with more time needed at ponds with more amphibian activity. The number of individuals of each species heard calling should be recorded. 3. Weather during the period of the count should be recorded, particular the presence of any rain and the prevailing temperature (recorded from the HKO website for the Hong Kong Wetland Park monitoring station). 4. Tadpoles and eggs of amphibians will not be surveyed, due to the difficulty of finding these in most ponds.

Sampling time of year	From 1st April to 31st August.
Sampling time of day	Surveys should start at sunset and should last for approximately 1-2 hours.
Sampling frequency	Surveys should be conducted every two months (in April, June and August). Preferred date of survey is weather-dependent and may require some flexibility in date, as detailed under weather conditions below.
No. of samples	Three per year
Repeat interval	Once in 5-year period: scheduled in 2016
Weather conditions	Preference should be given where possible to periods of light rain, or immediately after a rainfall event in the previous afternoon. If weather on the proposed survey date is dry, preference should be given to surveying another date with predicted rainfall if possible. Warm, still evenings are also preferred. Despite preference for rainy weather, the survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey. Under any unusual or exceptional circumstances that the survey is interrupted for a prolonged period of time, the current survey should be abandoned and rescheduled.

DATA MANAGEMENT

Data format	Species, number and location data - MS Excel Spreadsheet (Appendix I)
Location of data	All data should be stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. Summary graphs are presented at the Mai Po Management Committee. 2. Summary and analysis of the data are presented in the "Research & Monitoring Work Five-year Report". The report is circulated and adopted by the Mai Po Management Committee and thereafter uploaded to WWF-HK website.

Figure 1: Fixed Count Locations and Transect Route



Appendix 10 - Faunal Monitoring Surveys : Adult Odonata

FM10. Adult Odonata

(version: October 2013)

FEATURE	Adult odonata
PARAMETERS	Abundance and diversity of all odonata species around rain-fed ponds.
OBJECTIVE(S)	1. To provide data on adult odonata abundance to inform habitat management decisions; 2. To provide data on the overall species diversity of odonata around rain-fed ponds at MPNR.
BACKGROUND	Over 40% of Hong Kong's odonata (dragonfly and damselfly) species have been recorded in the MPNR and/or the close vicinity. All odonata have an aquatic larval stage, but an easily-observed adult stage, and the observation of adults is an easily-surveyed indicator to the health of aquatic ecosystem, particularly in freshwater habitats. WWF has conducted regular surveys of adult odonata since March 2006 at the majority of the rain-fed ponds inside MPNR. This provides information on the abundance of adults along this fixed transect, so that the number and diversity of odonata using the rain-fed ponds can be monitored in the long term. Changes in species abundance or diversity allow a rapid assessment to identify whether habitat management is required so that this can be implemented promptly. Given the high diversity of odonata present at MPNR and their importance as an indicator, the diversity of adult odonata is included as a target for the management of rain-fed ponds at the reserve.
MANAGEMENT PLAN TARGETS / INDICATORS	*Indicator* Diversity of adult odonata

METHODOLOGY

Equipment (essential)	1. Binoculars (8x magnification or above) 2. Voice recorder 3. Watch
Equipment (optional)	1. Odonata field guide 2. Hand tally counter 3. Pencil/pen and paper 4. Camera
Sampling site(s)	A 2.68km transect running along pond bund of 11 rain-fed ponds (Pond #16b, Pond #17b, Pond #24a,c,e-g and Pond #20c-f) divided into three sections. Data is not collected between these sections. See Figure 1 Section A – Pond #16b and Pond #17b - Start of section: northern end of boardwalk at Pond #16b - End of section: south-east corner of Pond #17b Section B – Pond #24 * - Start of section: north-east corner of Pond #24g - End of section: south-west corner of Pond #24a Section C – Pond #20 - Start of section: north-east corner of Pond #20f - End of section: south-east corner of Pond #20e Direction of the transect should be rotated each month.

	(* Pond #24 is now buffalo-grazed and care will be required to minimize the safety risks of carrying out surveys in some parts of this enclosure; this may involve retaining buffalo behind an electric fence at certain times. Sections along the perimeter path at #24c and #24a will not be affected by buffalo grazing).
Sampling technique	1. The entire transect (Fig 1) should be walked from start to finish at a speed slow enough to enable positive identification of all adult odonata. Surveys should not exceed a total of 2.5 hours with equal effort upon each sub-pond. 2. All odonate adults within 3m on the specified side of the transect should be recorded for each bund along the transect. Care should be taken to avoid double-counting of individuals moving during the course of the survey. 3. All factors likely to significantly influence the data (for example any drained pond, recent vegetation cutting on bund, etc.) should be noted. 4. Additional notes should be recorded of species seen ovipositing or as a tandem or copulating pair.
Sampling time of year	From 16th March to 15th October (Section C which should only be surveyed from 16th April onwards to avoid disturbance to wintering Anatidae.)
Sampling time of day	Morning count: 10:00-13:00 Afternoon count: 15:00-18:00 The timeslot should be alternated between surveys, so that one morning survey and one afternoon survey are conducted in each month.
Sampling frequency	Two samples should be collected each month (one morning count and one afternoon count). One of the counts should be conducted on or before the 15th day of each month and the other after the 15th day. There should be at least a 7-day interval between successive counts.
No. of samples	14 per year (12 per year for Section C)
Repeat interval	Twice every five years. Surveys are scheduled for 2014 and 2017.
Weather condition	The count should not be carried out during heavy rainfall and should be abandoned if persistent rain occurs before completion. The count should not be started when temperatures are below 15 °C or when winds are strong. Preference should be given to days with less than 50% cloud cover. The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count. If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable.

DATA MANAGEMENT AND REPORTING

Data format	1. Number of individuals of each species along each bund to be entered into MS Excel Spreadsheet (Appendix I)
Location of data	All data to be stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. A summary of results, including achievement of the species diversity target, to be presented at the Mai Po Management Committee. 2. Summary and analysis of the data from 2013-2018 to be presented in a Summary report prepared at the end of the Monitoring Plan.

Figure 1: Transect Route

Pond	Transect Length (m)
#16b	249.0
#17b	185.0
#20c	294.0
#20d	294.0
#20e	175.5
#20f	273.0
#24a	182.5
#24c	213.5
#24e	249.0
#24f	283.0
#24g	283.0
TOTAL	2681.5

Appendix I : Example of Data SpreadSheet

Mai Po Nature Reserve Odonate Count 2009

		COENAGRIONIDAE					P	A	GOMP	C	LIBELLULIDAE								
Gei wai / Pond	Section	*Agriocnemis pygmea*	*Ceriagrion auranticum*	*Ischnura senegalensis*	*Mortonagrion hirosei*	*Pseudagrion microcephalum*	PLATYCNEMIDIDAE	AESHNIDAE	*Sinictinogomphus clavatus*	CORDULIIDAE	*Acisoma panorpoides*	*Brachydiplax chalybea*	*Brachythemis contaminata*	*Neurothemis tullia*	*Orthetrum sabina*	*Pantala flavescens*	*Rhyothemis variegata*	*Tholymis tillarga*	Comments
16b	**16b / 14**		1	5	1														The M. hirosei is green morph.
16b	**16b 16a**		4	3	1						1		2						The M. hirosei is orange morph.
16b	**16b / 17b**		1																
17b	**17b / 16b**																		
17b	**17b / 15c**																		
20c	**20c / d**			19															Partly submerged
20c	**20c / e**			7															
20d	**20d / 21**			169															
20d	**20d / b**			27															
20e	**20e / 19**			7															
20e	**20e / 23**			12									2						
20f	**20f / 21**			97		1													
20f	**20f / 23**			23									2						
24a	**24a / E**		6														3		
24a	**24a / S**																		
24c	**24c / e**		1	3					1			6	6						
24c	**24c / path**		18	9							1	1	7	2					
24e	**24e / path**		39	5							11	2	5	2	1		2		
24e	**24e / c**		4	4							5	1		7					
24f	**24f / 23**	1		5															
24f	**24f / d/e**			4												1			
24g	**24g / 19**	1		75									12		1			1	
24g	**24g / 23**		1	6															
	Species Total	2	75	480	2	1	0	0	1	0	18	10	36	11	2	1	5	1	

Survey Date : 28-Apr-09
Survey Time : 15:10 - 17:34
Weather : 27oC, Sunny, Breezy
Starting Location : Pond #20e
General Comments : Windy condition might have prevent odonata from flying around.
: Fist survey of the year at Pond #20.
Recorder : Katherine Leung, Roger Lee

Gei wai / Pond	16b	17b	20c	20d	20e	20f	24a	24c	24e	24f	24g	TOTAL
No. of individuals	19	0	26	196	21	123	9	55	88	11	97	**645**
No. of species	5	0	1	1	2	3	2	7	8	3	6	**14**

Appendix 11 - Environmental Monitoring Surveys : Water Quality

EM01. Water Quality

(version: October 2013)

FEATURE	Water quality
PARAMETERS	Temperature Salinity pH Dissolved Oxygen (DO) Nitrates Phosphates
OBJECTIVE(S)	1. To monitor water quality in all waterbodies. 2. To collect data relating to target levels in waterbodies where targets for water quality have been set and to assist with setting of target levels in other waterbodies.
BACKGROUND	Water quality has a significant impact upon the life living within a waterbody, including plants and aquatic fauna, which can have further knock-on impacts to other species relying on a wetland. Regular testing of water quality is therefore beneficial in wetland management so that any changes can be identified early which may affect the ecology of the wetland, and action can be taken if this is considered necessary. Regular monitoring of water quality will help to inform management practices in each waterbody, including identifying any need for water exchange or pumping of water between rain-fed ponds. Water quality has not been routinely monitored in most of MPNR in recent years, so no baseline is available for most *gei wai* or rain-fed ponds. The baseline monitoring proposed here is expected to form a baseline which can be used for future study of the interaction between water quality and site ecology.
MANAGEMENT PLAN TARGETS / INDICATORS	None

METHODOLOGY

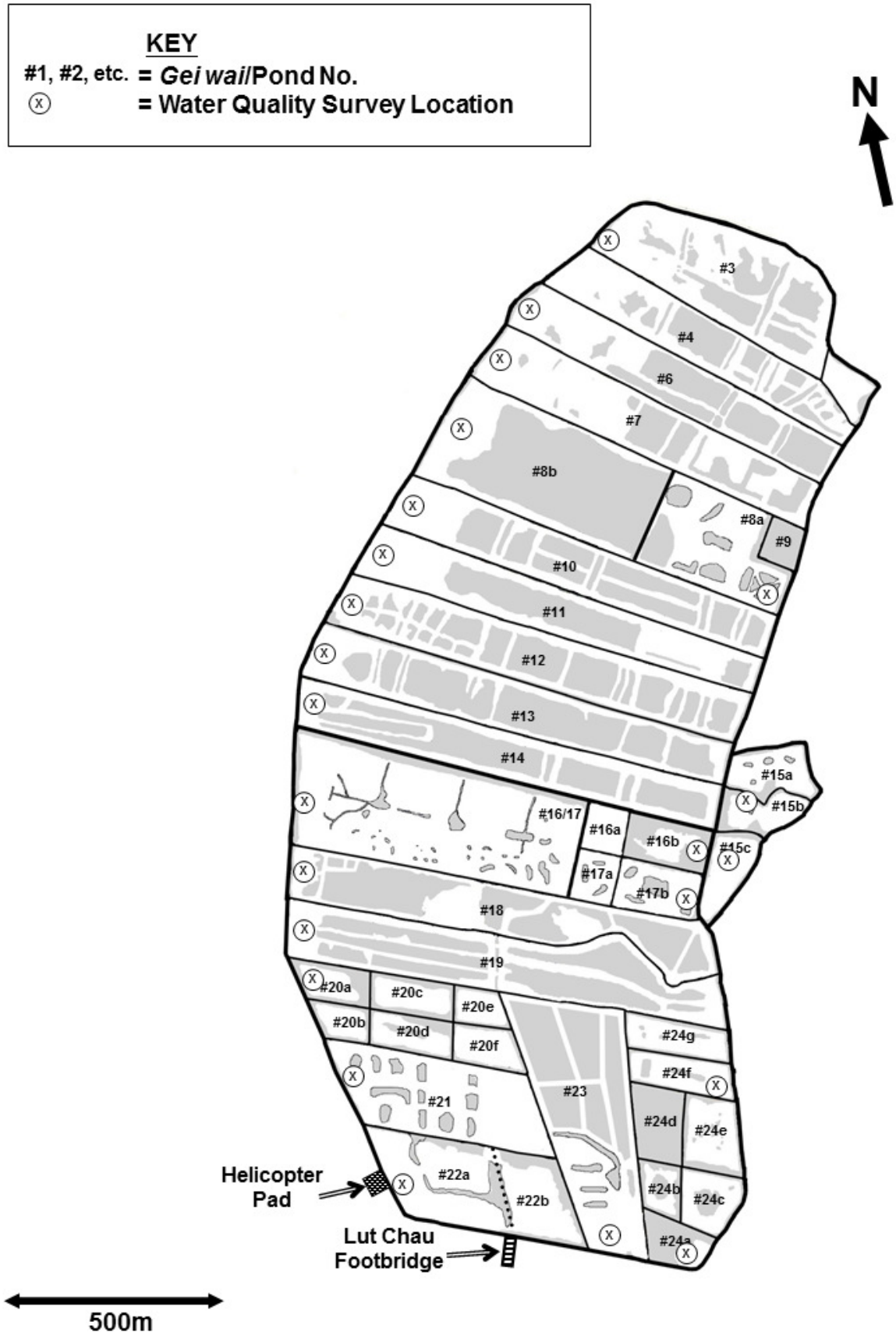
Equipment (essential)	1. Water quality testing kit capable of measuring temperature, salinity, pH and DO and storage of data for later analysis. 2. Water quality test kit for nitrates and phosphates. 3. Clean 1 litre plastic bottles for collection of water samples.
Equipment (optional)	
Sampling site(s)	Water quality locations distributed across the reserve to represent brackish *gei wai*, brackish waterbird roosts and rain-fed ponds. See Figure 1 for details of sampling locations.
Sampling technique	Before any water quality sampling, the test machinery should be checked and calibrated according to manufacturer's instructions. Samples (for monitoring of nitrates and phosphates) should be collected in a clean 1 litre plastic bottle, which should be rinsed with water from the *gei wai*/pond prior to sample collection. After sample collection, bottles should be allowed to stand for 1 minute to allow the release of trapped air. Three replicate samples should be collected from each sampling location and should be either tested immediately *in situ* or stored in a cool box until returned to the lab for analysis.

	Temperature, Salinity, pH, DO 1. At each sampling point, the probe of the meter should be fully submerged and gently stirred in a circular motion for 30-seconds while data is collected on the relevant parameters (temperature, salinity, pH and DO). 2. Data should be collected from three replicate sampling points in each location. 3. Upon returning to the lab, all data from the water quality meter should be downloaded to computer for analysis. 4. The value to be recorded for each sample should be the average of the middle 20 seconds (6^{th} to 25^{th} second) of the 30-second sampling period (the first five seconds are excluded as parameters stabilize, and the last five seconds are excluded as the DO level falls). 5. The value for each *gei wai*/pond should be the mean of the values collected from each of the three replicates. *Nitrates, Phosphates* 1. Three water samples should be collected from each *gei wai*/pond to act as replicates. 2. From each replicate, concentrations of nitrates and phosphates should be calculated according to the manufacturer's instruction for the test machine. 3. The value for each *gei wai*/pond should be the mean of the values collected from each of the three replicate samples. Any factors which might affect the measurement should be noted (e.g. draining, recent heavy rain)
Sampling time of year	Throughout the year
Sampling time of day	Surveys should be conducted in the morning before 10 am.
Sampling frequency	Every second month (January, March, May, July, September, November)
No. of samples	Three replicate samples per waterbody
Repeat interval	Annual
Weather condition	The survey should not be carried out during periods of heavy rainfall, when conditions may affect the water quality readings or may be unsafe for staff carrying out measurements. The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the survey, the recorder should decide to either continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey. If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed in the same timeslot on the first available date.

DATA MANAGEMENT AND REPORTING

Data format	1. Water quality parameters in each waterbody to be entered into MS Excel Spreadsheet.
Location of data	All data to be stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. A summary of results to be presented at the Mai Po Management Committee at least annually, or more often if requested. 2. Summary and analysis of the data from 2013-2018 to be presented in a Summary report prepared at the end of the Management Plan.

Figure 1: Water Quality Sampling Locations



Appendix 12 - Environmental Monitoring Surveys : Water Level

EM02. Water Levels

(version: October 2013)

FEATURE	Water level
PARAMETERS	Water level in all water bodies relative to target level
OBJECTIVE(S)	1. To monitor water level in all water bodies to ensure that this follows targets set out in Management Plan.
BACKGROUND	Control of water levels is essential in the management of a wetland site, in order to ensure that suitable conditions are provided for the species to be attracted to the site. Each species of wetland flora and fauna will have a tolerable or preferred range of water depths, and it is essential that the water level is kept within the appropriate range in each waterbody. The Habitat Management Plan (Section A) specifies operational water levels for all water bodies over the course of the year. These have been determined according to the intended function of each waterbody, so that suitable water levels are provided for target species and for management of vegetation encroachment into the waterbody.
TARGETS	Target is for 90% compliance with recommended operational water levels.

METHODOLOGY

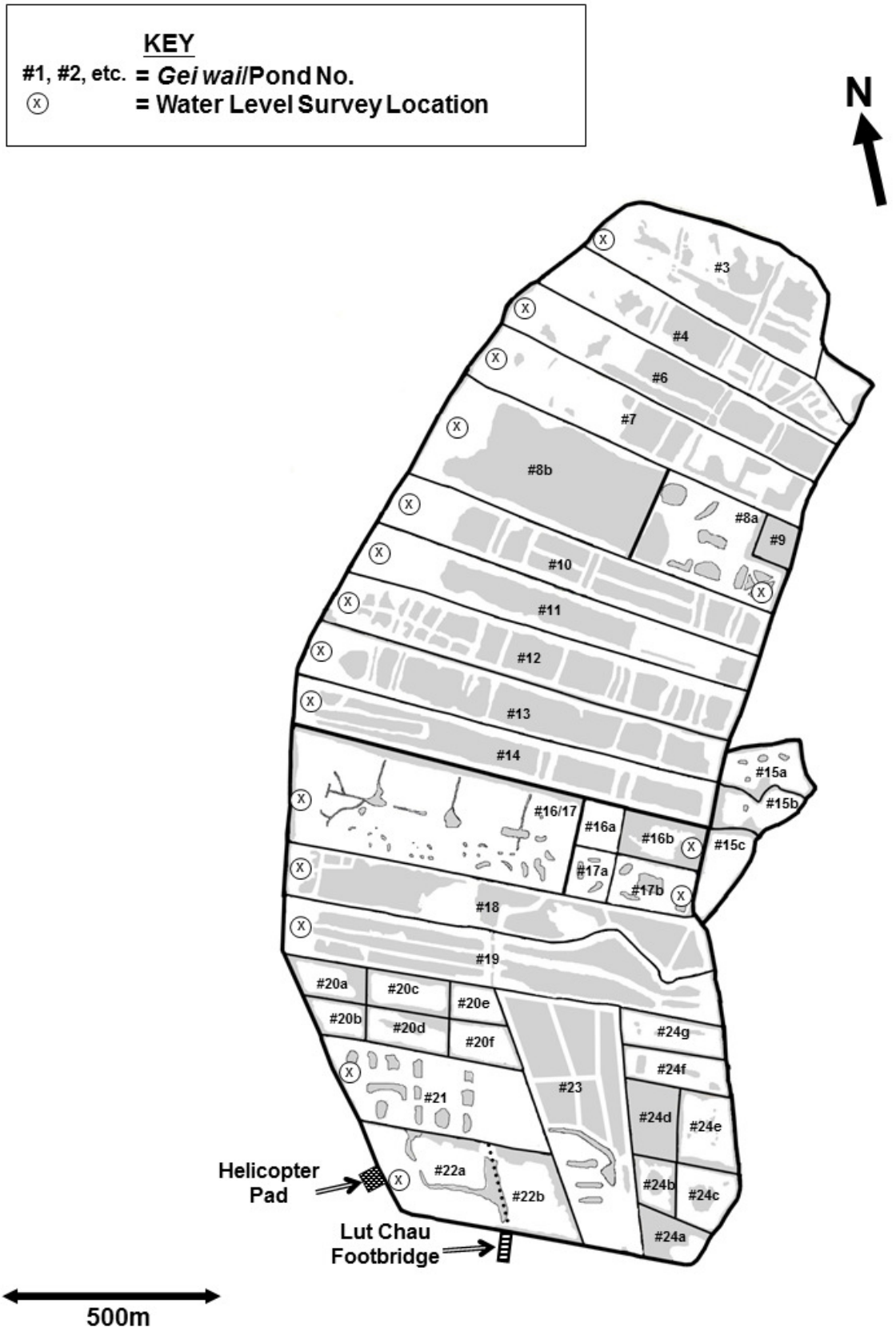
Equipment (essential)	1. Water level markers set up in each waterbody, marked with an operational water level for that particular water body. 2. Pen and recording sheet
Equipment (optional)	-
Sampling site(s)	Water level locations distributed across the reserve to represent brackish *gei wai*, brackish waterbird roosts and rain-fed ponds. See Figure 1 for location of depth markers.
Sampling technique	Water level markers on each waterbody should be checked and the level of the water in each water body should be recorded relative to the operational water level shown on the marker.
Sampling time of year	Throughout the year
Sampling time of day	Any time of day.
Sampling frequency	Once per week.
No. of samples	One sample per waterbody per week.
Repeat interval	Annual
Weather condition	The survey should not be carried out when conditions prevent the water level being read accurately against the marker (for example torrential rain or dense fog). The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the survey, the recorder should decide to either

	continue or abandon the survey by assessing local weather condition and the remaining time duration of the survey. If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed in the same timeslot on the first available date.

DATA MANAGEMENT AND REPORTING

Data format	1. Water level in each waterbody to be entered into MS Excel Spreadsheet.
Location of data	All data to be stored in the "Mai Po Management Share" under the Mai Po Server.
Reporting	1. A summary of the achievement of targets to be reported to the Mai Po Management Committee. 2. A summary of results to be presented at the Mai Po Management Committee each year. 3. Summary and analysis of the data from 2013-2018 to be presented in a Summary report prepared at the end of the Monitoring Plan (for the Review of the 2013-2018 management period).

Figure 1: Water Level Measurement Locations



Appendix 13 - Environmental Monitoring Surveys : Water Depth

EM03. Water Depth

(version: October 2013)

FEATURE	Water depth
PARAMETERS	Water depth in *gei wai* channels
OBJECTIVE(S)	1. To monitor water depth in *gei wai* channels so that channels requiring dredging can be identified as early as possible.
BACKGROUND	Sediment is imported into the *gei wai* on a regular basis, resulting in the gradual siltation of the channels within the *gei wai*. As the channels become shallower, this affects the rate of water exchange and leads to problems with water quality and shrimp productivity within the *gei wai*. *Gei wai* channels require dredging approximately every 10-15 years to maintain a suitable depth. Monitoring of water depth in these channels will help to identify which are becoming shallow and are most in need to dredging, so that this can be planned accordingly. The target level is set as 60cm, and the aim of the monitoring is to identify areas shallower than this depth, therefore the survey methodology identifies water less than 60cm, rather than measuring actual depth throughout the *gei wai*.
MANAGEMENT PLAN TARGETS / INDICATORS	Water depth of greater than 60 cm is included as a target in the Habitat Management Plan to identify when *gei wai* are in need of dredging.

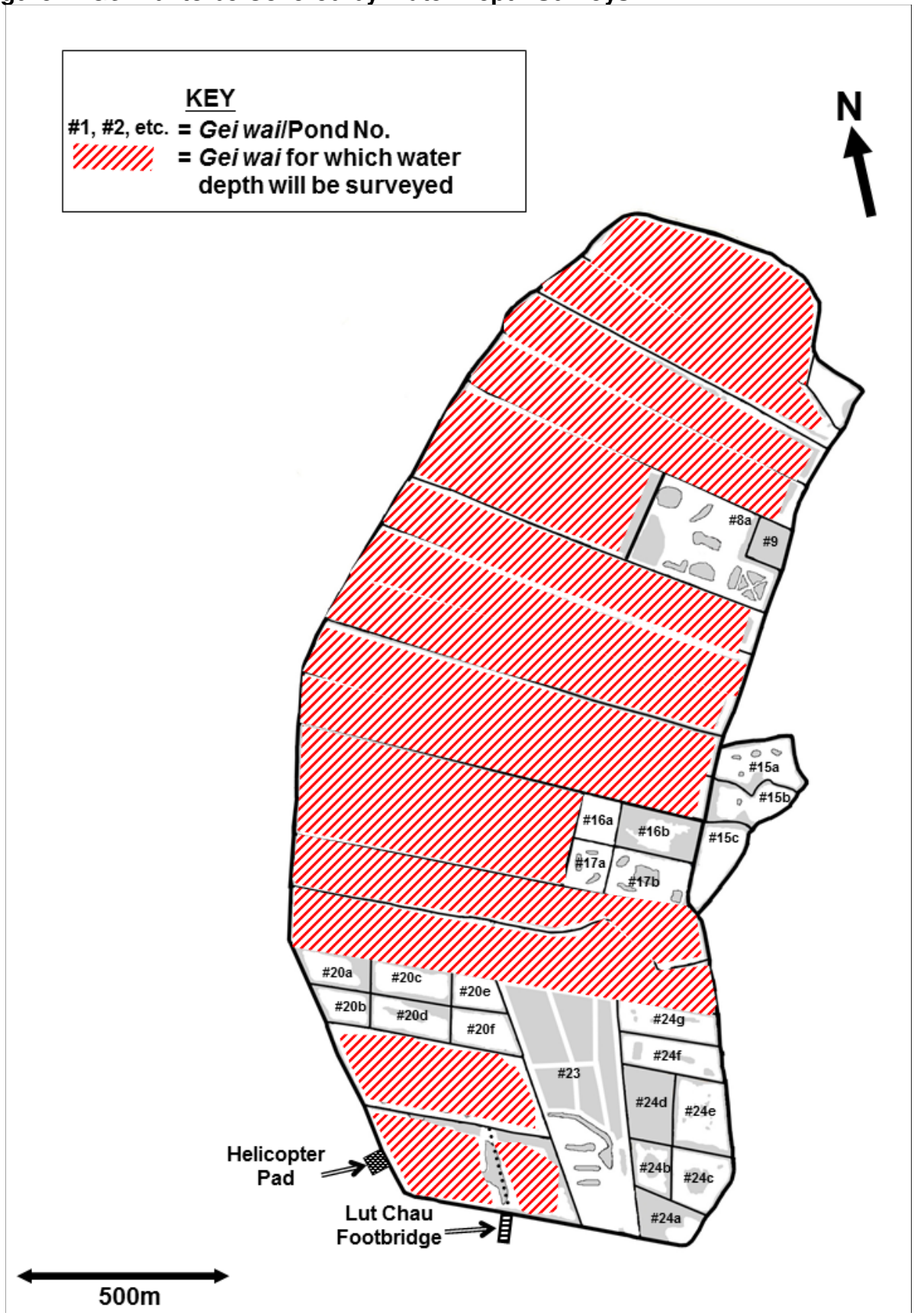
METHODOLOGY

Equipment (essential)	1. Base map of each *gei wai*.
Equipment (optional)	
Sampling site(s)	All brackish *gei wai* and brackish waterbird roosts at MPNR (*Gei wai* #3, #4, #6, #7, #8b, #10, #11, #12, #13, #14, #16/17, #18, #19, #21, #22).
Sampling technique	Water level should be lowered to -60 cm below normal operation level and allowed to stabilize over the course of 24 hours. Area covered by water should be mapped for entire *gei wai*.
Sampling time of year	Conducted during May-July to minimize disturbance to wintering waterbirds.
Sampling time of day	Survey should be conducted in late morning/early afternoon to minimize disturbance to waterbirds feeding in *gei wai* during early morning and evening.
Sampling frequency	Each *gei wai* to be surveyed once during 2013-17 (surveys scheduled to be conducted before end of 2015).
No. of samples	One survey of each *gei wai* during 2013-17.
Repeat interval	Every five years
Weather condition	Surveys should avoid periods of rainfall when possible to avoid potential influence of heavy rain on survey methodology. The survey should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions. If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining

	time duration of the count. If weather forces the cancellation of any survey, that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed in the same timeslot on the first available date.

DATA MANAGEMENT AND REPORTING	
Data format	1. A map of areas shallower than 60cm to be entered in GIS format (ArcGIS shapefile).
Location of data	Data to be entered into GIS program and stored in the "Research and Monitoring Share" under the Mai Po Server.
Reporting	1. A summary of the results to be reported to the Mai Po Management Committee. 2. Summary and analysis of the data to be presented in a Summary report prepared at the end of the Management Plan, to help identify *gei wai* requiring desilting over course of next Management Plan.

Figure 1: *Gei wai* to be Covered by Water Depth Surveys



Appendix 14 - Environmental Monitoring Surveys : Habitat Mapping

EM04. Habitat Monitoring

(version: October 2013)

FEATURE	Habitat
PARAMETERS	1. Distribution of habitats at MPNR. 2. Area of habitats at MPNR.
OBJECTIVE(S)	1. To provide information on the distribution and total area of each habitat type at MPNR for assessment of targets and to inform habitat management decisions.
BACKGROUND	Mapping of MPNR is essential to calculate the total area of each habitat type present in each *gei wai*/pond and on the reserve. This information is important for habitat management decisions, to determine whether a particular habitat is increasing or decreasing and to decide what changes should be made to maximise the ecological value of the reserve. Mapping also visualises the long-term changes of the habitats on the reserve, so that differences between years can be identified and management measures can be taken if required. Such long-term and gradual changes may not be readily visible by relying upon visual observation. GIS software permits the mapping of the reserve in detail so that habitat areas can be easily calculated and compared between years. A GIS map has been prepared of the habitats present at MPNR in October 2013, and this will be updated at the mid-point (2016) and end (2018) of the current Management Plan to track progress of the habitat management work conducted.
TARGETS	The Habitat Management Plan (Section A) sets out targets for the total area of each habitat to be provided in each *gei wai* / pond by the end of the plan.

METHODOLOGY

Equipment (essential)	1. ArcGIS 10 mapping software 2. Up-to-date aerial photos covering the reserve
Sampling site(s)	Entire Reserve

Sampling technique	1. Habitat mapping should initially be conducted from aerial photos by marking all discreet habitat patches using GIS software. Mapping should be carried out as accurately as possible using the aerial photographs available. Wherever possible, habitats should be assigned to a category (some categories may require ground-truthing). 2. Habitat categories to be mapped include: - Open brackish water - Open fresh water - Trees/shrubs - Other bund vegetation - Low island (<20cm above water level) - Wet *Phragmites* Reedbed - Dry *Phragmites* Reedbed - Dry *Phragmites* Reedbed with a high proportion of climbers - Mature mangroves, good quality - Mature mangroves with a high proportion of climbers - *Acanthus*-dominated mangrove stands

	- Poor-quality mangrove stands containing terrestrial vegetation and/or dry reed - Mangrove Fern *Acrostichum aureum* - Emergent sedges - Waterlilies *Nymphaea* spp. - Emergent Grasses - Other emergent vegetation 3. Once desk-top mapping has been completed, printed maps should be taken into the field for ground-truthing of existing conditions. Ground-truthing should cover the entire reserve. During ground-truthing all habitats should be checked to see whether the desk-top mapping is correct, and any habitat patches which could not be identified from the aerial photographs should be checked to confirm the appropriate habitat category. 4. Desk-top GIS maps should be updated to reflect the findings of the ground-truthing surveys. 5. Areas of each habitat patch should be calculated using GIS software, and areas for each habitat should be summed for individual *gei wai* / ponds, and for the reserve as a whole.
Sampling time of year	Will depend upon availability of aerial photos. Ground-truthing to be conducted during May – July to minimize disturbance to wintering waterbirds.
Sampling time of day	Any time, but ground-truthing should avoid high tide periods to minimize disturbance to roosting waterbirds.
Sampling frequency	Mapping to be conducted twice over the course of the Management Plan.
No. of samples	Twice during Management Plan.
Repeat interval	Twice every 5 years.
Weather condition	Aerial photos to be used should be clear from cloud. Ground-truthing can be conducted in any weather provided that visibility is suitable to see all habitats within each waterbody (periods of heavy rain and dense fog should be avoided).

DATA MANAGEMENT AND REPORTING	
Data format	1. Habitat maps will be prepared in ArcGIS.
Location of data	All data to be stored in the “Mai Po Management Share” under the Mai Po Server.
Reporting	1. Updated maps of the reserve to be presented at the Mai Po Management Committee and in a Summary report prepared at the end of the Management Plan.

Appendix 15 - Environmental Monitoring Surveys : Fixed-point Photography

EM05. Habitat Fixed Point Photography

(version: October 2013)

FEATURE	Habitat
PARAMETERS	Habitat quality.
OBJECTIVE(S)	1. To monitor changes in habitat coverage and quality over time by generating a time series of photographs at the same locations in successive years; 2. To facilitate habitat management decisions by comparing changes in habitat quality over time.
BACKGROUND	Changes to habitat distribution and quality generally take place over a time period of several years. Such gradual changes can be difficult to assess through visual inspection, as direct comparison between years is not possible. Fixed point photography creates a time series of photographs from the same location in each year, so that changes in habitats at that location can be monitored over a longer time period and habitat condition can be evaluated

METHODOLOGY

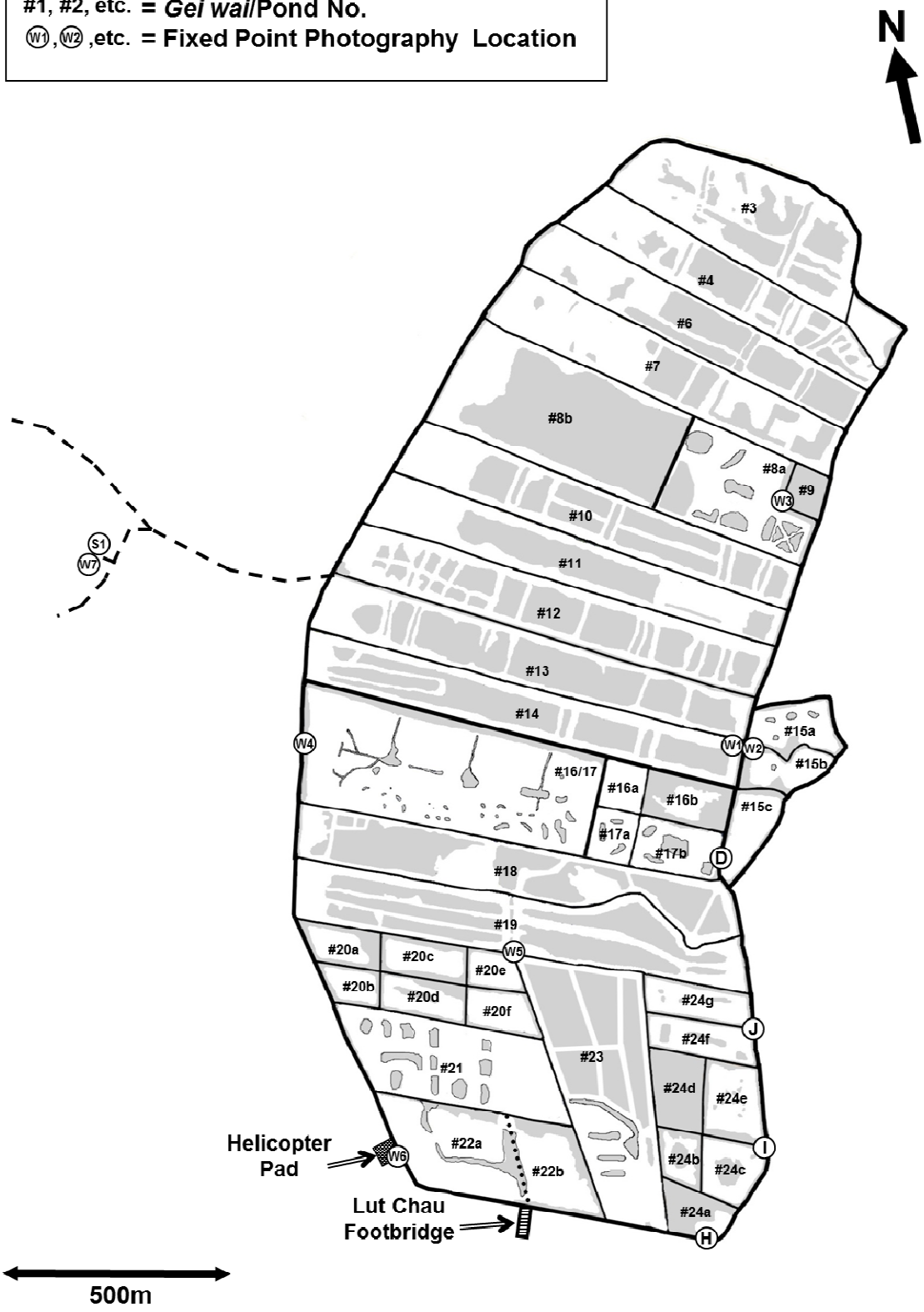
Equipment (essential)	1. Digital camera
Equipment (optional)	
Sampling site(s)	See Figure 1 for all Fixed Point Photography locations. Winter set (reserve and mudflat): 1. South-west corner at the roof of the Education Center - *Gei wai* #14 2. South-east corner at the roof of the Education Center - Pond #15 3. Middle of the 1st window on the left at the top floor of the Tower Hide - Pond #8a 4. In front, at the middle of Hide #7 - *Gei wai* #16/17 5. Top of the Canvas Hide at *Gei wai* #19/20e bund * - Pond #20 - *Gei wai* #23 6. From the Tower at the helicopter pad at the southern end of MPNR - *Gei wai* #22 7. In front at the middle of the Rotary Floating Bird Hide - Intertidal mudflat Summer set (mudflat only): S1. In front, at the middle of the 3rd window on the right at the Jockey Club Floating Bird Hide - Intertidal mudflat (* Fixed photography point W5 was previously located on the canvas tower hide at *Gei wai* #19/20e bund. This hide has subsequently been removed. During the first fixed-point photography of the current Monitoring Plan an alternative location will be sought to ensure consistency of photographs).
Sampling technique	1. All sampling sites listed should be visited and a panoramic photograph should be taken at each, facing in the direction specified for each sampling site.

	2. In most locations a clear view is already present. If vegetation obscures the view, some may be removed, but this should be kept to a minimum, and should be confined to essential clearance in the immediate surroundings of the photographer only to provide a view of the location being photographed, 3. Care should be taken to minimize disturbance to waterbirds and to visitors to the reserve. 4. Panoramic photographs should be joined using appropriate formatting software.
Sampling time of year	Winter set: first or second week of December Summer set: second or third week of July
Sampling time of day	Photographs should not be taken early or late in the day, when the sun is not low to the horizon. Mudflat photographs should be taken at low tide (<1.6m) to minimize disturbance to waterbirds and to ensure that vegetation on the mudflat is visible. Photographs at roost sites (especially W4 at *Gei wai #*16/17) should also be taken at low tide, to minimize disturbance to roosting waterbirds.
Sampling frequency	Every second year.
No. of samples	One photograph from each of the survey locations.
Repeat interval	Every second year.
Weather condition	Surveys should be carried out on clear, sunny days when possible. On no account should the survey be carried out when visibility is poor (for example torrential rain or dense fog). If weather forces the cancellation of any survey (for example, onset of heavy rain), that survey should be rescheduled for the first available date when weather conditions are suitable. If the survey has been partially completed but is abandoned, the remainder of the survey should be completed on the first available date. The count should not be started if Typhoon Signal 3 (T3) or higher and/or any rainstorm warning (Amber, Red or Black) is in effect. If any signal/warning is issued during the count, the recorder should decide to either continue or abandon the count by assessing local weather condition and the remaining time duration of the count. In case of thunderstorm warning, the recorder should decide whether to proceed with the survey according to the prevailing local conditions.

DATA MANAGEMENT

Data format	1. Digital photographs in JPEG format.
Location of data	All photographs are stored in the “Research and Monitoring Share” under the Mai Po Server.
Reporting	No specific reporting.

Figure 1: Sampling Locations



Appendix 16 - Previous research projects conducted by WWF at the MPNR

2006 **Trial on Improvements to the High-tide Roosting Habitat for Migratory Waterbirds at *Gei wai* #16/17 Mai Po Nature Reserve 2005-06 : Final Report**. Report by World Wide Fund For Nature Hong Kong to the Agriculture, Fisheries and Conservation Department, Hong Kong Special Administrative Region Government.

2006 **Trials to Improve the Roosting Habitat for Wintering Waterfowl in Ponds #20 and #24 at Mai Po Nature Reserve 2005-06 : Final Report**. Report by World Wide Fund for Nature Hong Kong to the Agriculture, Fisheries and Conservation Department, Hong Kong Special Administrative Region Government.

2008 **Study into the Avian Value of Different Aged Stands of *Phragmites australis* at Mai Po Nature Reserve**. Joint report by the World Wide Fund for Nature Hong Kong and the Hong Kong Bird Ringing Group.

2008 **Study upon the Wildlife Impact and Potential Economic Habitat Management Benefits of Introducing Asian Water Buffalo *Bubalus bubalis* into the Freshwater Ponds at Mai Po Nature Reserve – Final Project Report 2008.** Report to the Environmental Conservation Fund by the World Wide Fund For Nature Hong Kong, Hong Kong.

2008 **A Short Study on the Butterfly Hotspots in Mai Po Nature Reserve – Summer 2007.** Report by World Wide Fund for Nature Hong Kong.

2008 **Brief Report on the Survival of Shrub Species Planted between 1996-2007 at Mai Po Nature Reserve.** Report by World Wide Fund for Nature Hong Kong.

2010 **Baseline survey on the usage of MPNR by roosting Barn Swallow *Hirundo rustica* and Yellow Wagtail *Moticilla flava*.** Report by World Wide Fund for Nature Hong Kong.

2012 **Freshwater Pond Vegetation Management Trial using Asian Water Buffalo *Bubalus bubalis* at Mai Po Nature Reserve. Phase II (2009-10): Project Report**. Report by World Wide Fund for Nature Hong Kong.

2013 **Waterbird Usage of *Gei wai* #22 Following Conversion to Intertidal Operation**. (in prep).

2013 **Waterbird Usage of a Newly Created Brackish Shallow Water High-tide Roost in *Gei wai* #21 at the Mai Po Nature Reserve**. (in prep).

2013 **Waterbird Usage of *Gei wai* #23 Following Conversion from Brackish Water to Freshwater.** (in prep).

2013 **Waterbird Usage of Draining *Gei wai* at the Mai Po Nature Reserve.** (in prep).

Appendix 17 - Habitat Distribution at the Mai Po Nature Reserve in 2013.