West Rail

Habitat Creation and Management Plan

(VOLUME A)

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REFERENCES

Ades, G. (1993). Wildlife Windows One. *Porcupine!* 8/9:6.

Annandale, N. (1917). Zoological results of a tour in the Far East, Batrachia, *Memoirs of Asiatic Society Bengal* 6: 121-155.

Bogadek, A and Lau, M W N. (1997). A revised checklist of Hong Kong amphibians and reptiles. *Memoirs of the Hong Kong Natural History Society* 21:173-187.

Boring, A M. (1934). The Amphibia of Hong Kong (1). *Hong Kong Naturalist* 5:8-22.

Brazil, M A. (1991). *The Birds of Japan.* Helm Publications, London.

Chalmers, M L. (1986). *Annotated Checklist of the Birds of Hong Kong.* Hong Kong Bird Watching Society, Hong Kong.

Chalmers, M L. (1989). Significant Breeding Records 1988. *The Hong Kong Bird Report 1988: 36.*

Cheng, T H. (1987). *A Synopsis of the Avifauna of China.* Science Press, Beijing.

Cheung, S-C and Li N-H. (Eds.). (1991). *Chinese Medicinal Herbs of Hong Kong Volumes 1 - 7 (8th Edition).* Commercial Press, Hong Kong.

Cramp, S. and Simmons, K E L.(Eds.). (1983). *Birds of the Western Palearctic, Vol III, Waders to Gulls.* Oxford University Press, London.

del Hoyo, J; Elliot, A. and Sargatal, J. (1996). *Handbook of the Birds of the World, Vol. 3, Hoatzin to Auks.* Links Edicion, Barcelona.

Denton, J S; Hitchings, S P; Beebee, T J C and Gent, A. (1997). A recovery programme for the natterjack toad (*Bufo calamita*) in Britain. *Conservation Biology* 11:1329-1338.

Dudgeon, D and Chan, W C. (1996) *Ecological study of freshwater wetland habitats in Hong Kong.* Department of Ecology & Biodiversity, University of Hong Kong, Hong Kong.

Dudgeon, D and Corlett, R. (1994). *Hills and Streams. An Ecology of Hong Kong.* Hong Kong University Press, Hong Kong.

Duellman, W E and Trueb, L. (1986). *Biology of Amphibians.* Johns Hopkins University Press, Baltimore.

Environmental Resources Management (ERM). (1998a). *West Rail Final Assessment Report.* ERM-Hong Kong.

Environmental Resources Management (ERM). (1998b). Habitat Creation and Management Plan: *Statement of Guiding Principles.* ERM-Hong Kong.

Environmental Resources Management (ERM). (1999). Habitat Creation and Management Plan: *Definition of Habitat Requirements (Discussion Draft).* ERM-Hong Kong.

Fei, L; Ye, C and Huang, Y. (1990). *Key to Chinese Amphibia.* Chongqing Branch, Science & Technology Literature Press, Chongqing (in Chinese).

Garnett, S. (Ed.). (1993). Threatened and Extinct Birds of Australia. *Royal Australasian Ornithologists Union Report No. 82.* RAOU, Victoria.

Goldman, C R and Horne, A J. (1983). *Limnology.* McGraw Hill, Japan.

Grant, C J. (1986). Soils. In *A Geography of Hong Kong*: 110-117. Chiu, T N & So, C L (Eds.). Oxford University Press, Hong Kong.

Hayman, P; Marchant, J and Prater, T. (1986). *Shorebirds: an Identification Guide to the Waders of the World.* Croom Helm, Kent.

Herklots, G A C. (1938). Land snakes of Hong Kong (4). *The Hong Kong Naturalist* 8:189-200.

Hill, D S and Phillipps, K. (1981). *A Colour Guide to Hong Kong Animals.* Government Printer, Hong Kong.

Hodgkiss, I J. (1978). *Hong Kong Freshwater Plants,* Urban Council, Hong Kong.

Inger, R F. (1956). Some amphibians from the lowlands of North Borneo. *Fieldiana: Zoology* 34: 389-424.

Inger, R F. (1966). The Systematics and Zoogeography of the Amphibia of Borneo. *Fieldiana: Zoology* 52:1-401

Inger, R F and Stuebing, R B. (1989). *Frogs of Sabah.* Sabah Parks Trustees, Kota Kinabalu.

Karsen, S J; Lau, M W N; and Bogadek, A. (1986). *Hong Kong Amphibians and Reptiles.* Urban Council, Hong Kong.

Lai, Y -L and Ng, Y -S. (1972). Hong Kong Amphibians. *New Asia College Academic Annual (Hong Kong)* 14:79-111.

Lau, M W N. (1988). *Habitat Use by Hong Kong Amphibians, with Special Reference to the Ecology and Conservation of Philautus romeri.* Unpublished PhD Thesis, the University of Hong Kong, Hong Kong.

Leader, P J. (in press). The status of Painted Snipe in Hong Kong. *Hong Kong Bird Report.*

Lim, K K P and Lim, F L K. (1992). *A Guide to the Amphibians of Singapore.* Singapore Science Centre, Singapore.

Matsui, M; Chan-ard, T and Nabhitabhata, J. (1996). Distinct specific status of *Kalophrynus pleurostigma interlineatus* (Anura, Microhylidae). *Copeia* 1996:561-579.

Marchant, S and Higgins, P J. (Eds.). (1993). *Handbook of the Birds of Australia and New Zealand, Volume 2. Raptors to Lapwings.* Oxford University Press, Melbourne.

Macdonald, J D. (1988). *Birds of Australia - A Summary of Information.* Reed.

Reader's Digest. (1993). *Complete Book of Australian Birds (2nd Edition).* Reader's Digest, Sydney.

Reitinger, F F; Lee, J K S; and Lee, D. (1978). Recording amphibians and reptiles in the New Territories (1973-1977). *Memories of the Hong Kong Natural History Society* 13:39-41.

Roberts, T J. (1991). *The Birds of Pakistan. Volume 1. Non-passerines.* Oxford University Press, Karachi.

Romer, J D. (1966). The frog *Microhyla butleri* Boulenger found in Hong Kong. *Memoirs of the Hong Kong Natural History Society* 7:15

Romer, J D. (1979). Annotated checklist with keys to the amphibians of Hong Kong. *Memoirs of the Hong Kong Natural History Society* 15:1-14.

Scott, D A (Ed). (1982). *Managing Wetlands and Their Birds.* International Waterfowl Research Bureau, Slimbridge.

So, M L. (1994). *Hong Kong Ferns.* Urban Council, Hong Kong.

Thrower, S L. (1971). *Hong Kong Shrubs.* Urban Council, Hong Kong.

Thrower, S L. (1983). *Hong Kong Climbing Plants*, Urban Council, Hong Kong.

Thrower, S L. (1988). *Hong Kong Trees*, Urban Council, Hong Kong.

Tian, W and Jiang, Y (Eds.). (1986). *Identification Manual for Chinese Amphibians and Reptiles.* Science Press, Beijing.

Urban, E K; Fry, C H and Keith, S. (1986). *The Birds of Africa, Volume II.*

Wilson, K D P. (1997) An annotated checklist of the Hong Kong dragonflies with recommendations for their conservation. *Memoirs of the Hong Kong Natural History Society: 21*: 1 - 68

Zhao, E -M and Adler, K. (1993). *Herpetology of China.* Society for the Study of Amphibians and Reptiles, Oxford (Ohio).

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1. INTRODUCTION

1.1 Background

Environmental Resources Management (ERM) has been commissioned by the Kowloon-Canton Railway Corporation (KCRC) to undertake a series of technical studies arising from the West Rail EIA study which was completed in March 1998. This series of studies are collectively known as the Environmental Support Services (KCRC Contract No DD-901) and relate to aspects that were recommended to be the subject of further research, assessment or development following the completion of the EIA Study.

1.2 The Recommendations of the West Rail EIA Study

One of the key recommendations of the West Rail EIA Study committed the Corporation to providing compensatory wetland habitat for the loss of ecologically significant wetland habitat in the Kam Tin valley. The range of habitats that currently exist within the Kam Tin valley represents a mosaic of largely man-made habitats within which the tessarae of wetlands is predominantly comprised of fish ponds, water cress beds and other wet agricultural uses. Other habitats in this area are within pasture, cultivated fields and semi-natural vegetation along water courses and other non-cultivated land.

Much of lowland Hong Kong has been almost completely altered since the advent of human settlement (Dudgeon and Corlett, 1994). However, within the lowlands there exist patches of artificial and semi-natural habitats that retain a high diversity of species. The habitats within the Kam Tin valley support a surprisingly rich assemblage of fauna, especially avifauna, herpetofauna and dragonflies. Several species of high conservation value are known to occur in the Kam Tin valley, including Painted Snipe (*Rostratula benghalensis*, Linnaeus 1758), a range of herpetofauna species (frogs and snakes) and species of dragonflies.

The compensatory wetland habitat recommended by the West Rail EIA Study is required to replace, on a "like-for-like" basis, the ecological functions of the habitat lost to the development of the new railway with particular reference to species of conservation interest recorded in the Kam Tin valley. Based on the West Rail EIA Study report and consultations with the Advisory Council on the Environment (ACE), the compensatory wetland habitat is intended to perform the following functions:

- the re-creation of freshwater wetland habitat;
- the re-provisioning of habitat suitable for dragonflies;
- the re-provisioning of habitat suitable for reptiles and amphibians including the Narrow-mouthed Frog; and
- the re-provisioning of habitat suitable for wetland-dependent birds including the Painted Snipe.

Further studies and surveys will be undertaken, as necessary to successfully implement, maintain and maximise the long term ecological value of the compensatory habitats.

1.3 Objectives of the Plan

This document has been prepared following ongoing consultation with appropriate local conservation groups in order to achieve professional consensus on the intended objectives and provisions of the *Habitat Creation and Management Plan.*

The plan defines the precise range of habitats and ecological functions to be provided within the compensatory area. Whilst the primary focus will be to provide for the ecologically valued wetlands lost to the West Rail scheme, a range of complementary habitats may be created to maximise the ecological diversity and functionality of the resource.

The provision of compensatory habitat is a new concept in Hong Kong and there is no local experience in the construction of new wetland habitats for native wetland species. New information and the application of theoretical principles have been collated and interpreted to provide the basis for the new wetlands to be created within the Kam Tin valley.

The primary objectives of this document include:

- the establishment of guiding principles for the creation and management of the compensatory habitats;
- a review of the habitat requirements of target species that are to be the focus of the compensatory habitat programme;
- to prescribe habitat specifications for compensatory habitat that will used to generate the necessary conditions for the target species;
- to outline a programme for the implementation of the creation and management plan;
- to define and assign responsibilities for the implementation of the plan; and
- to define the mechanisms by which the plan will be implemented.

The target species comprise Painted Snipe (*Rostratula benghalensis*) selected herpetofauna species and a range of dragonfly species.

1.4 Report Structure

The remainder of this document is set out as follows:

- **Section 2** provides the principles that have guided the development of the habitat creation and management plan.
- **Section 3** presents the location of the areas of land made available for the provision of compensatory habitat.

- **Section 4** presents the results of desk-top research and field surveys undertaken to define the habitat requirements of the key "target species" for which habitat is to be provided.
- **Section 5** describes the ecological requirements and characteristics of the compensatory habitat to be created.
- **Section 6** presents a discussion of management actions that will be required to maintain the compensatory habitats in a suitable condition to meet the needs of the target species.
- **Section 7** presents an implementation programme for the habitat creation and management plan.

A list of references is provided at the beginning of the document.

1.5 Rationale for Revisions to the Habitat Creation and Management Plan

The original version of this document was made available in February 1999 further to the completion of the EIA Study and endorsement by the Advisory Council on the Environment. Since the release of the plan KCRC has commissioned a team led by ERM to conduct the detailed design for creating the wetlands.

In conducting the detailed design a number of logistical issues have to be considered, these include:

- availability of good quality water sources;
- ecology of existing land parcels and adjacent habitats;
- drainage and flood protection regime of surrounding lands;
- topography at the time when the wetlands will be constructed;
- availability of land;
- traditional access rights; and,
- interface with committed works projects in the area.

The consideration of the above issues has resulted in some minor changes to both the boundaries of the wetland parcels as well as the mixture of habitats. The revised boundaries of the wetlands parcels are presented in *Figures 1 & 2* and the revised habitat mixture is presented in *Table 6* and *Figures 3 & 4*.

Under Civil Engineering and Developnment Department's ("CEDD") project, namely Site Formation and Infrastructure Works for Development at Kam Tin South, Yuen Long, CEDD agreement number CE34/2014 (CE) (the "Project"), a section of Kam Ho Road between Kam Tin Road and Tung Wui Road will be improved in order to meet the future traffic demand. Kam Ho Road is currently a single 2-lane road and is classified as rural road. It will be widened to a dual 2-lane carriageway. The existing Kam Ho Road will become part of the proposed north bound Kam Ho Road whereas a new elevated road will be formed under the Project as the south bound of Kam Ho Road.

As the proposed road works would encroach upon a significant portion of land Parcels G & H as well as minor portion of Parcel J, the ecological function of the remaining portion of Parcels G & H will be limited. In order to provide a better linkage with other wetlands and enhance the wetland characteristic, the whole Parcels G & H and the minor portion of Parcel J (approximately 135m^2) will be replaced by a new parcel of wetland Parcel M which will be constructed by CEDD at its own costs on a "like-for-like" basis. For the purpose of identification only, the approximate locations of the Parcels G, H and the relevant portion of Parcel J that will be replaced by the new Parcel M are shown and identified in Figure 1.

Upon the completion of the construction of Parcel M as certified by CEDD for the purpose of Habitat Creation and Management Plan ("HCMP"), Parcels G, H and relevant portion of Parcel J will thereupon no longer form part of the wetland habitats under this HCMP and all maintenance, management and/or monitoring obligation and any other liability/obligation in relation to Parcels G, H and the relevant portion of Parcel J under this HCMP shall cease with immediate effect on the date of the confirmation letter of the completion of the construction of Parcel M by CEDD (the "Date"). The Government will undertake the construction at its own costs and will be responsible for the management and maintenance of Parcel M during the 18-month establishment period. Thereafter, the management and maintenance obligations of Parcel M will be undertaken by KCRC.

2. GUIDING PRINCIPLES

2.1 Broad Principles

The overall objective of the habitat creation programme is to compensate for the disruption to the ecology within the Kam Tin valley, whilst maximising the opportunities for the early re-establishment of ecological resources. Within this overall objective, the following broad principles will be applied during the planning and development of the compensatory habitat:

- **Compensatory wetlands will be designed to create a variety of habitat conditions.** In order to maximise the ecological value of the created wetland, a variety of wetland types will be considered to increase the habitat heterogeneity and enhance the diversity of micro-habitats available for different wetland-associated wildlife.
- **Habitat design will incorporate the habitat requirements of key species.** The design of the wetland will consider the general relationship of these habitat elements to the key target species, especially Painted Snipe, a range of herpetofauna species and dragonfly species.
- **Compensatory wetland habitats will be linked as far as practicable to provide maximum opportunities for utilisation by fauna.** The compensatory wetlands will be linked to each other if possible to reduce the edge to area ratio and so minimise undesirable edge effects while maximising opportunities for fauna to disperse across the habitats. Where possible, linkages will also be maintained with habitats off site, such as along river areas, drainage channels and to the vegetation that exists within the adjacent burial area.
- **Habitats will be designed to be self-sustaining as far as practicable.** The water regime of the created wetland will be self-sustainable as far as possible to minimise human intervention and active management needed but without allowing a compromise in the quality of the supply.
- **Wetland design will aim to incorporate key features of the original habitats.** The physical and biological condition of the created wetland will be designed to resemble those to be lost. In some respects, the wetland features can be developed to provide enhanced conditions for wildlife compared to the original conditions.
- **Areas surrounding the wetlands will be managed in a complementary way to enhance the overall ecological functions of the wetlands.** Provision of complementary habitats to fulfil otherwise absent habitat niches and to provide wider community benefit. Examples may include landscape screening and the provision of fruit bearing trees for wildlife.
- **Active management will be needed to maintain the habitats in the long term.** Although the wetlands will be designed for minimal maintenance, it is recognised that there will be a need for ongoing management in the long term. This is because the habitats to be created represent a form of subclimax community that requires

management ("disturbance") to prevent desirable habitat features from being lost through community succession.

- **Monitoring will be required to optimise wetland design and function.** The compensatory wetlands will be designed using the best available ecological information, including data on local species of conservation significance and general ecological design principles. However, there are gaps in the ecological knowledge for habitat creation and management. Therefore the design employed will represent an estimate of the habitat conditions needed for the key species. Monitoring will be required to determine the success of the compensatory wetlands and, if necessary, provide information to allow for future adaptive management.

2.2 Specific Principles

2.2.1 Focus of Habitat Creation

With the limited experience of habitat creation in Hong Kong, the development and implementation of the *Habitat Creation and Management Plan* will provide a vehicle for experimental design and for promoting pioneering work in the understanding of community management in areas affected by the development process.

The focus of the work will be the creation of wetland habitats that are known to support native fauna of conservation significance. The Study Team will seek to increase the wetland habitats' heterogeneity through the incorporation of a variety of wetland types in the design; this would entail the creation of ponds and marshland areas of varying depths and with different vegetation composition and aerial coverage. In certain areas, the length of the shoreline ecocline may be maximised through the adoption of open water areas with outlines of irregular shape or through the inclusion of created islands within the wetland to maximise the habitats available to a wider range of wildlife. Management regimes will be focused on the retention of the sites' heterogeneity so as to maintain the diversity of the created wetland and, thereby, a greater niche capacity and a higher biodiversity.

2.2.2 Habitat Design

On the basis of these considerations, it is considered acceptable and appropriate that the created habitat is to be provided within a series of land "parcels", varying in size and shape. The type and design of habitats for a particular locality will be parcel-specific taking various physical or biological constraints into account, which may include, but should not be limited, to the following:

- **The size and dimension of each particular land parcel:** These factors will determine the sustainability of a particular type of wetland and will affect the rate and extent of the habitat's colonising capacity;
- **Susceptibility to disturbance:** The nature of land use in the immediate vicinity of the created wetland will be considered during the design phase to minimise any possible

sources of disturbance to the habitat and/or associated wildlife. If necessary, different kinds of barriers/buffer will be used to shield off the disturbing factors;

- **Integrity of the surrounding environment:** The type of wetland to be created for a particular land parcel will be designed to maximise the possibility for any ecological linkage to surrounding habitats outside the site boundary so as to enhance the wildlife use of the area; and
- **Available sunlight:** Direct sunlight may be constrained due to the shadowing effect of the overhead viaduct. Plant species selected for planting will be site specific and, if necessary, shade-tolerant. If the habitat creation design includes tree planting, trees of good size will be transplanted as these are likely to become more robustly established than attempts to grow saplings to size under these conditions.

2.2.3 Freshwater Regime

The freshwater regime of the created area will be self-sustaining and provide a stable series of wetland habitats. The practicality and feasibility of the following design guidelines will be considered:

- The created wetlands should remain submerged or at least suitably supplied at any time of the year;
- Tanks/Ponds for clean water storage that can recharge into the created wetland should be installed;
- The water from the Main Drainage Channel (MDC) may provide a steady supply of freshwater, but the water quality standard should be established in advance to meet specific purposes if any; and
- The silt load of the incoming water to the created wetlands must be minimised so as to reduce the chance of siltation of the site and the subsequent loss of habitat to benthic dwellers.

There are parts of the land area to be provided for the purposes of habitat creation, which are the remnants of a river meander. It is not bound within the designated construction area of the West Rail and thus can be used as a temporary refuge for the wildlife affected by the construction either by active relocation or by passive movement.

2.2.4 Plant Species to be Utilised

Active planting of suitable wetland plant species, including marshy, riparian and emergent species, or relocation of those species from similar habitat in the surrounding area will be undertaken, (if it is appropriate and will not unduly impact the existing conditions in the surrounding area), to enhance the rate of plant colonisation. A list of suitable plants is provided in *Annex B*.

If possible, the substratum of wetlands to be lost to the development of the new railway will be temporarily stored and relocated to the constructed wetland once the construction is complete. As the substrata are usually loaded with nutrients, invertebrates and seeds,

this provides the necessary trophic platform on which the entire wetland community are dependant.

If necessary, a nursery will be established in advance of the construction work to preserve or propagate resident species or suitable pioneering species.

Whilst the primary focus of habitat creation will be the provision of wetland, the planting of trees and shrubs may be recommended on bunds and islands and as screening from potential sources of disturbance. Such planting will be designed so as to provide complementary habitats to serve a variety of ecological functions. Examples include;

- The planting of fruit-bearing species known to be utilised by wildlife could increase or provide alternative food sources and initiate a local increase in species richness and diversity.
- Planting of tree or bamboo species known to be used by egrets could provide potential sites for the initiation of egretries.
- "Greening" the supporting columns of the viaduct by planting epiphyte or climbing plants to attract wildlife and create a natural ambience to an otherwise urbanised habitat.

3. SITE LOCATIONS

3.1 Northern Site Locations

The West Rail EIA Final Assessment Report (FAR) identified two broad areas of land totalling c.12ha (rounded up to the nearest integer), for which Lands Department approval has been received for use in the creation of compensatory habitat. For identification purpose only, the approximate locations of the land parcels are shown and identified in Figures 1 & 2.
The key area is the length of railway easement corridor and adjacent land next to the abandoned Kam Tin river meanders, between Kam Sheung Road Station and the Au Tau Intersection, in large, adjacent parcels of land. These parcels of land will be to some degree constrained by the following factors:

- Approximately half of the compensatory habitat to be recreated will be located underneath the railway viaducts which are independent viaduct structures (both single track viaducts of 6 m width and double track viaducts of 12 m width) with varying heights (ranging from 6 m to 20 m above ground level).
- There are various existing and planned infrastructure that segregates the land parcels including the Kam Tin Road, Kam Tin River Main Drainage Channel, Kam Tin Bypass and West Rail access road.

This key area of land provision comprises ten discrete parcels of land. The current land use, extent of disturbance likely to occur during West Rail works and the dates at which these parcels of land will be made available (according to current works programming) are outlined below.

- **Land Parcel A** is the most northerly of the land parcels made available for compensatory habitat provision and comprises approximately 1.12ha of abandoned agricultural land and former meanders of the Kam Tin River (which has been culverted as the Main Drainage Channel). This area is outside the boundary of the works area for West Rail and will be made available for wetland recreation works in mid 2001.

- **Land Parcel B** comprises approximately 2.12ha of land located adjacent to the Main Drainage Channel and Land Parcel D. The area has been affected by the construction activity associated with the MDC works and includes areas of dumped rubble, broken out concrete and other construction wastes. The area will be made available in mid 2001.

- **Land Parcel C** the approximately 0.61ha of land between the eastern edge of the limits of deviation for the West Rail viaducts and the current course of the Kam Tin River, has been largely undisturbed by the planned West Rail works and will be made available for habitat creation in mid 2002.

- **Land Parcel D** comprises approximately 2.06ha of land next to Parcel B. The parcel has been affected by the works associated with the construction of the West Rail viaducts, the Main Drainage Channel and the Chi Ho Road.

The land includes a Water Services Department Reserve of approximately 0.13ha. This area will be made available in mid 2001.

- **Land Parcel E** is approximately 1.16ha of land between the MDC and the Kam Tin Bypass Roundabout and comprises areas of hardstanding and built structures, an abandoned fish pond and an area of the Old School Marsh. Much of this land parcel has been affected by the works associated with the construction of the West Rail viaducts and Kam Tin Bypass roundabout. The land will be made available for wetland constructed works in mid 2002.

- **Land Parcel F** comprises approximately 0.34ha of land located between the existing Kam Tin Road, the planned Main Drainage Channel and the new Kam Ho Road, which is to be built from the new Kam Tin Bypass roundabout, south and over the Main Drainage Channel. The site is currently occupied by the site office for the civil works contract. This area will be made available for wetland construction works in mid 2002.

- **Land Parcel G*** comprises approximately 0.13ha of land between the planned Main Drainage Channel and Land Parcel J. The parcel is presently affected by the works associated with the construction of the West Rail viaducts, the Main Drainage Channel and the Kam Sheung Road Station Emergency Access. This area will be made available for wetland construction in mid 2002.

- **Land Parcel H*** comprises approximately 0.44ha of land between Kam Ho Road and the planned Main Drainage Channel. This area is presently affected by the works associated with the construction of the Access Road and the Main Drainage Channel. The land will be made available for wetland construction in mid 2002.

- **Land Parcel I** comprises approximately 0.34ha of land to the west of Kam Ho Road. The land is currently abandoned agricultural land that was disturbed during the construction of Route 3. However, the land will be largely undisturbed by the planned works and will be made available for habitat creation in mid 2002.

- **Land Parcel J*** lies to the east of Land Parcel F and comprises approximately 2.93ha of land between the Kam Tin Road, the planned Main Drainage Channel and the current river meander of the Kam Tin River. The parcel has been affected by the works associated with the construction of the West Rail viaducts, the Main Drainage Channel and the Kam Sheung Road Station Emergency Access. This area will be made available for habitat construction in mid 2002.

As is indicated above, the land parcels for compensatory habitat creation will be made available in two broad tranches. The most northerly of the land, Land Parcel A, B and D (approximately 5.3ha), will be made available in mid 2001. The remaining works areas (approximately 6.0ha) will be made available from mid to late 2002 following the completion of the major civil works.

3.2 Southern Site Location

In addition to the parcels of land in the vicinity of the Kam Tin Road, there are additional parcels of land totalling approximately 0.6ha in size at the top of the Kam Tin valley

* Parcels G, H and the relevant portion of Parcel J (the approximate locations of which are for identification only as shown and identified in Figure 1) will be replaced by Parcel M to be constructed by CEDD on the Date so that Parcels G, H and the relevant portion of Parcel J will thereupon no longer form part of the wetland habitats under this HCMP and all maintenance, management and/or monitoring obligation and any other liability/obligation in relation to Parcels G, H and relevant portion of Parcel J under this HCMP shall cease with immediate effect on the Date. The management, maintenance and monitoring of Parcel M will be undertaken by KCRC in accordance with Volume B. The total area of the land parcels to be maintained, managed and monitored under Volume A of the HCMP shall be reduced to approximately 11.3ha.

adjacent to the Tai Lam tunnel northern portal. The location of the land parcels is shown in *Figure 2*.

- **Land Parcel K** comprises approximately 0.49ha of land between the Tai Lam tunnel northern portal and the planned Main Drainage Channel. This area of land is presently affected by the works associated with the construction of the tunnel portal and the Main Drainage Channel. It is envisaged that this land will be made available for habitat creation in mid 2002.

- **Land Parcel L** comprises approximately 0.15ha of land located to the west of the planned Main Drainage Channel. This area of land is presently affected by the works associated with the construction of the tunnel portal and the planned Main Drainage Channel. The land will be made available for habitat creation in mid 2002.

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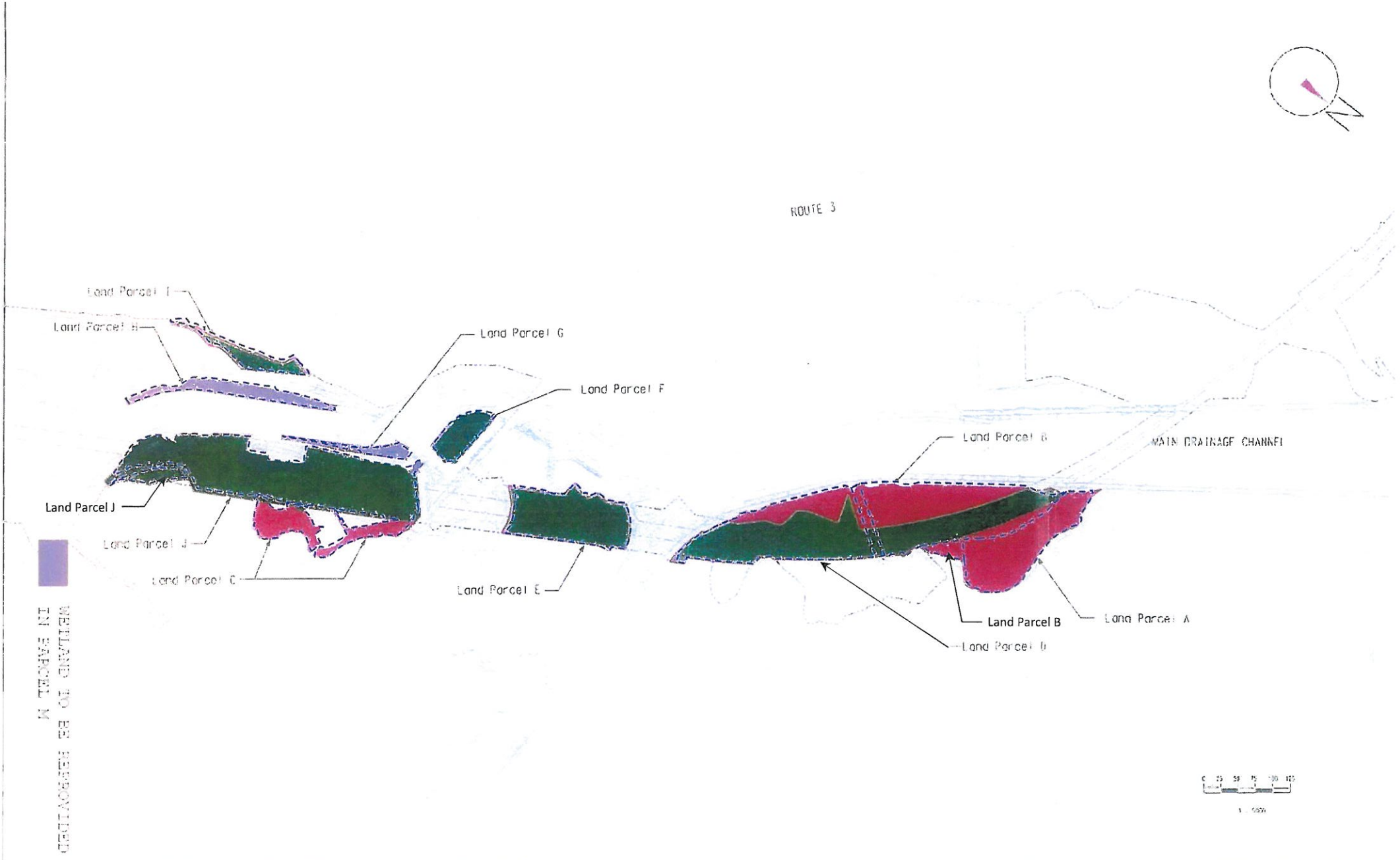

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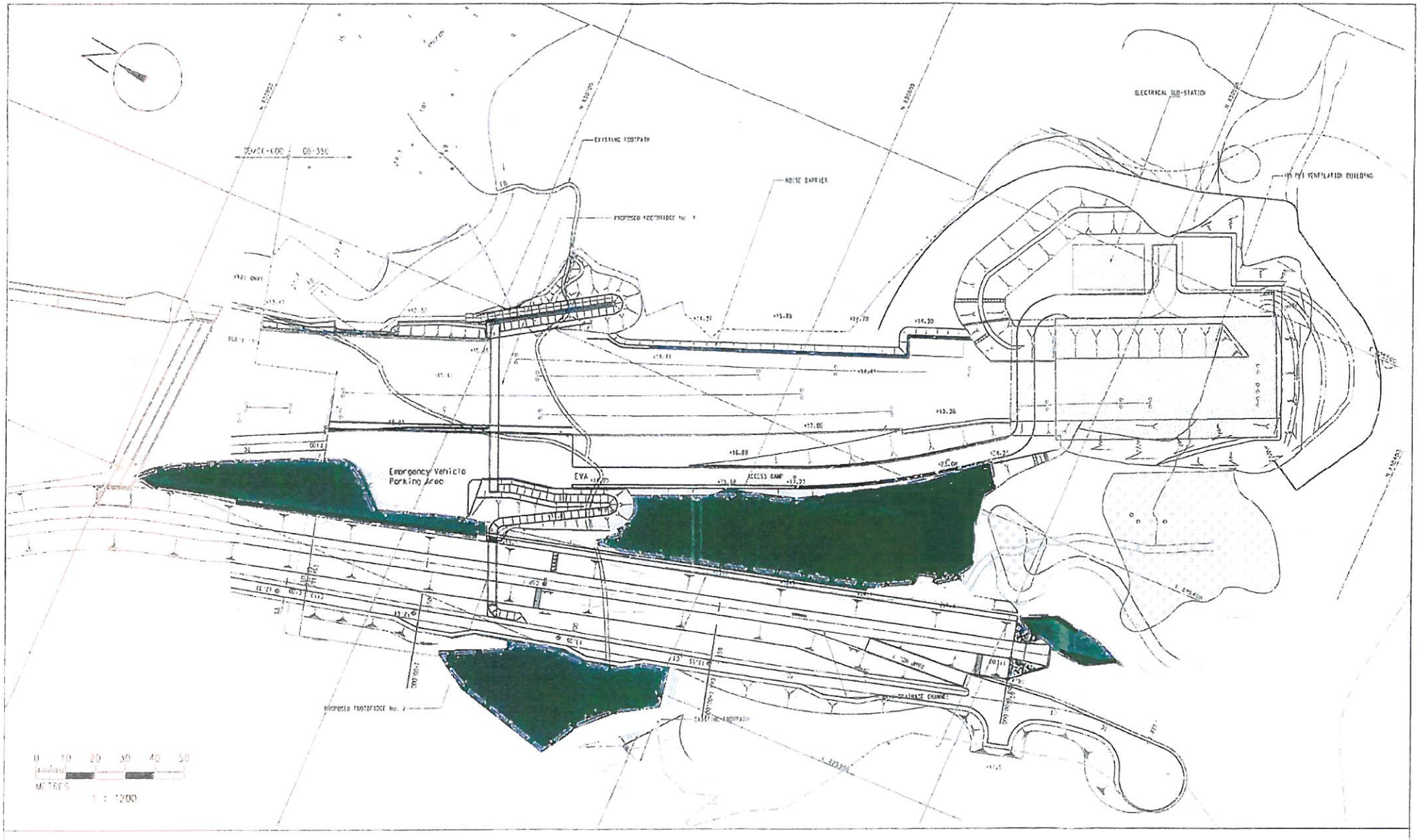

LEGEND

HABITAT COMPENSATION AREA AT PAT HEUNG

FIGURE 2

ERM

KOWLOON - CANTON RAILWAY CORPORATION

WEST RAIL: DD-901 ENVIRONMENTAL SUPPORT SERVICES

4. TARGET SPECIES FOR HABITAT CREATION

4.1 Habitat Requirements of Wetland Fauna

A wide range of fauna is known to use the existing wetland habitats of the Kam Tin valley. Each fauna species has its own optimum habitat or habitats with specific requirements for breeding, feeding and shelter. Furthermore, various species will use wetlands in different ways. For example, certain frog species will live entirely within wetlands and use them for feeding, shelter and reproduction. Other species, including many wetland birds may only use them for feeding.

The specific elements to be included in the wetland design shall consider the habitat requirements, ecological functions and pattern of usage of the principal wildlife groups discussed below.

- **INVERTEBRATES** - The created wetlands will be designed to incorporate areas and features that are predicted to encourage use by two insect groups of conservation significance: Dragonflies (Odonata) and Butterflies (Lepidoptera). The design shall recognise the relationship between wetland structure and function and the habitats and ecology of these insects at different stages of their life cycle. In order that the utilisation of the created wetlands by rarer species of dragonflies is encouraged, ponds and slow flowing ditches with good quality water will be constructed and maintained. Riparian vegetation will be maintained for the adult stage in these areas. To encourage utilisation of created wetland areas by rarer butterflies, (which typically rely on the secondary vegetation of abandoned paddies) marsh areas will be provided; artificial marsh is expected to provide similar habitat conditions to those which occur in abandoned paddies. The common species of butterflies will benefit from the creation of general wetlands and complementary terrestrial habitats.

- **HERPETOFAUNA (REPTILES AND AMPHIBIANS)** - The general relationship between wetland structure and function and the habitat requirements of frogs, snakes and lizards will be considered in the habitat creation design, with a particular focus on the habitat needs of uncommon species. Only limited information is available regarding the specific habitat requirements of these species at present. For this reason, research undertaken into the ecology of the target herpetofauna species will inform appropriate habitat design for the different life cycle stages of selected species.

- **AVIFAUNA** - The created wetlands will provide habitats for a variety of bird species. However, the habitat requirements of two types of birds will be used to guide the design of the wetland areas: Egrets and Painted Snipe. Egrets have come under increasing pressure in recent years as egretries are lost and existing wetland feeding habitats are drained; such developments limit the reproductive capacity of the local population. The created wetland shall provide a range of feeding sites with ponds and shallow marshes serving as habitats for aquatic and terrestrial prey; bunds and islands with low vegetation may also provide for their roosting needs. Planting of trees and/or bamboo may also be considered in suitable locations to provide future potential sites as egretries. Although the

habitat to be created will provide suitable opportunities for exploitation by egrets, their specific requirements will not form the basis of the detailed habitat design. The Painted Snipe is a species with close links to freshwater wetland in Hong Kong, and is currently known to roost and breed on freshwater marshland with sparse vegetation next to Kam Tin School. The marshland created for this species shall be similar to that known to be used by these species; i.e. that which varies in water depth to a maximum of 100 mm and covered by a mix of vegetation with various levels of coverage. The shape of the marsh for Painted Snipe will be built to minimise the edge effect wherever possible. The design of the wetlands will aim to create foraging and breeding habitat for this species.

- MAMMALS - Bat species and the Javan Mongoose (*Herpestes javanicus*) have potential to benefit from the construction of wetlands in the Kam Tin valley. Records suggest that all except one of Hong Kong's resident bat species utilises the Kam Tin valley for foraging purposes. The insectivorous bat species will utilise marsh and pond areas to feed on emerging insects. The frugivorous bat species may benefit if wetland associated fruit bearing trees and shrubs are grown or if such trees and shrubs are planted within terrestrial areas bordering the created wetlands. The Javan Mongoose, which has been recorded in the area, is likely to be attracted by the omnivorous opportunities provided by the open water, shoreline and marsh interfaces.

However, it is not possible to design wetlands that are optimal for the requirements of all species. Therefore wetland design will focus on species of high conservation value that are likely to derive significant benefit from the compensatory habitat. The aim will be to create habitat conditions that are suitable for the key impacted species, identified during the West Rail EIA Study. The impacted "target" species comprise:

- Painted Snipe;
- Uncommon herpetofauna species; and
- Dragonflies.

As the target species represent a variety of fauna with differing habitat requirements, the resultant habitats will provide a mosaic of ecological conditions that may satisfy a wider range of fauna. The ongoing management and monitoring of the created habitats will enable adaptations to be made which can seek to maximise opportunities for additional target species.

The following sections examine the specific habitat requirements of the target species and identify possible candidates for inclusion in any future expansion of the target species following the creation of the compensatory habitat areas.

4.2 Painted Snipe

4.2.1 Introduction

This subsection examines the interim findings of an ongoing field survey of Painted Snipe (*Rostratula benghalensis*) in the Kam Tin area and presents a review of known habitat requirements for the species.

Painted Snipe is considered unusual among waders (*Charadriiformes*) as a result of the species' sex-role reversal, its social behaviour and its polyandrous breeding strategy. The female Painted Snipe pairs successively with at least two (and often three or four) males each year and, following egg-laying, the male builds the nest, incubates the eggs and rears the young to fledging stage, typically unaided by the female. Painted Snipe are sexually dimorphic in both plumage and size, with the females being larger and brighter (Cramp and Simmons 1983, del Hoyo *et al.* 1996). Although the species is mainly silent, the female is known to growl and hiss when threatened and to emit a sharp repeated alarm call (*"cuck..cuck"*), whilst the males near the nest give a soft *click-click* call.

There is comparatively little information available on the species, not least because its behaviour is difficult to study as it is unobtrusive, at roost during the day and forages at night. It is thought to be local and uncommon throughout its range (Cramp and Simmons 1983), although in Hong Kong it is considered local and rare (Leader pers. com.). The Painted Snipe is one of the few wetland dependant bird species that does not regularly occur within the Mai Po and Inner Deep Bay RAMSAR site and, as a consequence, the species is considered to be locally at risk due to the ongoing and cumulative loss of wetland habitat elsewhere in Hong Kong.

4.2.2 Distribution and Habitat

4.2.2.1 World-wide Distribution and Habitat

The nominate race *R. benghalensis benghalensis* breeds in Africa, the Middle East and throughout Asia as far east as Japan and including southern China, the Philippines and Indonesia. The race *R. benghalensis australis* is confined to the eastern half of Australia (Cramp and Simmons 1983, del Hoyo *et al.* 1996).

In China, it is resident from Sichuan and Yunnan eastwards to the coast and Taiwan; it is a summer visitor from Shaanxi to the southern part of Liaoning province (Cheng 1987). The Chinese population is the only one known to undertake regular migrations; the movements of all other populations are considered nomadic (Hayman *et al.* 1986). However this may reflect the limited amount of work undertaken on the species, and it is likely that some African populations are regular intra-African migrants (Urban *et al.* 1986).

Painted Snipe is an entirely wetland dependant species; it inhabits a range of wetland areas including freshwater lakes with grassy islets for nesting, overgrown mudflats and dam-lakes, abandoned wet agricultural land, swamps and marshes interspersed with pools

up to 30-50 cm deep, soft muddy areas, and dense shrubbery and reed-beds (del Hoyo *et al.* 1996). In Japan it occurs and breeds in wet rice and lotus fields, reed beds, marshes and ponds (Brazil 1991), whilst the Australian race is known to favour shallow, vegetated, temporary or infrequently filled freshwater wetlands (Garnett, 1993).

Painted Snipe feed on a range of freshwater aquatic insects and invertebrates as well as plant seeds, earthworms and aquatic vegetation. In the southern part of the range of the Australian race the species is known to feed on samphire, a succulent herb which grows in salt marshes (Reader's Digest 1993). The bill of the Painted Snipe is well adapted for probing into soft mud and evidence of probing during feeding has been observed in Hong Kong (Leader, pers. com.).

4.2.2.2 Status in Hong Kong

In Hong Kong, Painted Snipe was initially considered a passage migrant and winter visitor (Chalmers 1986). The first record of proven breeding was in 1988 (Chalmers 1989) and, since 1993, Painted Snipe have been recorded in high numbers at both Kam Tin and Long Valley and breeding has been recorded annually. Prior to the survey work in Kam Tin and Long Valley, the species was considered to be declining in Hong Kong, although this may well have been due to a lack of coverage of what have been assumed to be day time roost sites (Leader in press).

In Hong Kong, Painted Snipe is dependent upon freshwater wetlands and is largely confined to abandoned wet agricultural areas, overgrown marshy areas and grazed seasonally-wet grassland. Although recorded breeding elsewhere within its range in habitats such as reedbeds, it is absent from such habitats in Hong Kong; this would appear to be due to its aversion to brackish water habitats. Not surprisingly, given the scarcity of freshwater habitat in Hong Kong, breeding locations are very localised and appear to be confined to just two areas: Kam Tin and Long Valley (ERM 1998a).

However, it is possible that Painted Snipe may breed, very occasionally, in temporarily suitable areas, although records of non-breeding birds are almost exclusively from Kam Tin and Long Valley. During the period from 1993 to 1997, the peak count per year at Kam Tin varied from 12 to 45, the latter being the highest count ever in Hong Kong at a single site. During the same period, peak numbers at Long Valley varied from 8 to 33 (Leader in press).

The Kam Tin and Long Valley Painted Snipe habitats appear to comprise relatively large areas of inactive or abandoned wet agricultural land and seasonal/permanent marsh. Both areas include actively farmed land, but there are extensive areas of inactive or abandoned wet agricultural land, which are characterised by dense aquatic and emergent vegetation. These latter areas tend to be subjected to low levels of human disturbance and are favoured by Painted Snipe, especially as daytime roost sites. From 1993 to 1997, the only records away from these two areas concerned single birds at three sites on four dates, illustrating the high degree of importance of the Kam Tin and Long Valley areas for Painted Snipe.

The first confirmed Hong Kong breeding record for Painted Snipe was in 1988 (Chalmers 1989). The species is very secretive during the breeding season and can be difficult to detect; however between 1988-98, there were ten confirmed cases of breeding in Hong Kong:

- **1988**: A male accompanying three juveniles, recorded at Lok Ma Chau on 4 July.
- **1992**: A pair with three juveniles, recorded at Tin Shui Wai on 9-23 August.
- **1993**: A male with four juveniles, recorded at Long Valley on 8 July.
- **1996**: An abandoned nest with four eggs was found at the Old School Marsh, Kam Tin on 10 October. A male was seen giving a broken-wing distraction display at Long Valley on 16 May.
- **1997**: A male with four large juveniles, recorded at the Buffalo Fields, Kam Tin on 2 April, and a different male with four very young chicks on 7 April. A long-predated nest was found at the Old School Marsh, Kam Tin in October.
- **1998**: Two single nests were recorded at the Buffalo Fields, Kam Tin (in April and May) both with four eggs and both being incubated by males.

The 1992 breeding site at Tin Shui Wai was a filled-in fishpond with extensive low aquatic vegetation and shallow water. However, this site dried up in 1993 and became unsuitable for the species.

The only current location in Hong Kong where annual breeding is confirmed is the Old School Marsh/Buffalo Fields in Kam Tin where a preliminary investigation in 1998 put the breeding population at approximately 10-15 birds. It is likely that breeding also occurs annually at Long Valley. It is not yet known whether the breeding population in Hong Kong is resident or comprised of summer visitors (Leader in press). In Hong Kong, the usual clutch size would appear to be four, which is typical of the species elsewhere (Cramp and Simmons 1983, Roberts 1991, del Hoyo *et al.* 1996, Macdonald 1988).

4.2.3 Detailed Habitat Requirements

A four-season field survey of Painted Snipe at Kam Tin has been completed and whilst field survey work continues, a preliminary review of the data collected to date has been undertaken.

The review of Painted Snipe habitat requirements has been complicated by events at the Old School Marsh site, where much of the previous field work on Painted Snipe had been undertaken. During early March 1998, the marsh was bulldozed, much of the vegetation was destroyed, a high fence was erected and a security guard was installed. Although the site recovered sufficiently to attract similar numbers of Painted Snipe, access to the site was not secured until early November 1998. As a consequence, the fieldwork carried out during April-November 1998 focused on an area of grazed abandoned agricultural land to the north of the Old School Marsh ('the Buffalo Fields'). During November and December 1998, two visits were made to the Old School Marsh site and the survey data from these visits have been included together with data for the Old School Marsh

collected during 1997. In addition, radio telemetry data has been collected from ten birds which were tagged on the Old School Marsh in mid-December (see below).

4.2.3.1 Habitat Conditions

4.2.3.1.1 Overview

During the course of the surveys, Painted Snipe utilised the following habitat types in the Kam Tin area:

- Permanent and Seasonal Marshes comprising abandoned wet agricultural land with extensive emergent vegetation;
- Permanent/ Seasonal Marshes and pastureland comprising grazed abandoned agricultural land with limited emergent vegetation; and
- Inactive wet agricultural land.

Each of these habitat types is discussed separately below. The significance to Painted Snipe of these different habitat types for breeding, foraging and roosting is discussed in *Section 2.3.2.*

4.2.3.1.2 Permanent and Seasonal Marshes

The Old School Marsh comprises *c.*4 ha of former agricultural land that has been abandoned since the late 1980s. Prior to being bulldozed, the marsh was seasonal and tended to dry out following the end of the wet season; in 1997 the site was almost totally dry by early November. However, the bulldozing of the site has altered the drainage on the site such that an area in the centre of the site now appears to be permanently wet.

The existing plant community of the Old School Marsh has a species composition which is typical of marshy habitat in Hong Kong. In general, both of the seasonal and permanent marsh areas are dominated by herbaceous plant such as the grasses *Eragrotis atrovirens* and *Paspalum distichum*, as well as the herbs *Polygonum hydropiper* and *Ranunculus sceleratus*. However, several common weedy plant species such *as Lantana cacmara* and *Mikania micrantha*, as well as the herb *Alocasia eculenta* and *Coix lacrymajobi* are found in considerable densities in the permanent marsh at the centre of the site.

Numbers of Painted Snipe on the Old School Marsh site were at their highest during 1996; the decline in numbers in 1997 was attributed to over grazing by water buffalo that had previously been absent from the site (Leader in press). The numbers present on the site at the end of 1998 appear to have returned toward the 1996 levels.

4.2.3.1.3 Permanent/Seasonal Marshes and Pastureland

The Buffalo Fields comprise a relatively large area (*c.*25-30 ha) of predominantly abandoned wet and dry agricultural land interspersed with small areas of actively managed wet and dry agricultural land, active and abandoned fishponds. Abandonment appears to have occurred progressively over the 1980s and 1990s and the area is heavily grazed by a herd of feral Asian Water Buffalo (*Bubalus bubalis*) which by early 1999 numbered some 180 animals. Levels of human disturbance are very low, largely due to the deterrent provided by the water buffalo, which are sometimes aggressive towards humans. Water levels drop following the end of the wet season, with limited areas of permanent marsh remaining wet year round.

4.2.3.1.4 Recently Abandoned/Inactive Wet Agricultural Land

The areas surrounding the Old School Marsh include areas of wet agricultural land that are currently inactive, apparently for the short-term, or which have recently been abandoned. These are characterised by there being limited control over water levels with increasing abundance of emergent vegetation. These areas experience low levels of human disturbance during daylight hours.

4.2.3.2 Breeding Season Habitat Requirements

During the 1998 breeding season, surveys were conducted at the Buffalo Fields only. At this site, birds showed a preference for areas with a water depth of 5-20 cm and low herbaceous vegetation, 10-30cm high. Most birds were located in areas grazed by water buffalo, but it is suspected that this is out of necessity, rather than selection, given that over-grazed areas (height of vegetation <5cm) were largely avoided.

Two nests were located in the Buffalo Fields during 1998. Both were in dry areas of rough grass 20cm high. The outcome of both nests is unknown, although it is suspected that one was trampled by buffalo and the other was in an area that was subsequently flooded. That both nests were in dry grass is surprising. However, single nests were found in the Old School Marsh in both 1996 and 1997 (Paul Leader unpublished data). These nests were in wet, mixed emergent vegetation. Thus, it seems that nest site location (although the sample is small) is not dictated by complex requirements, and is likely dependant more on availability of nearby foraging areas and low levels of human disturbance.

The number of Painted Snipe in the Old School Marsh during the summer months is largely unknown as previous studies have focused on the autumn and winter periods. However, the high numbers recorded there during the autumn by Leader (in press) are considered to include migrants and winter visitors from further north.

Whilst it is not possible to determine if either of these areas are preferred by Painted Snipe, the available information indicates that the species is to a degree opportunistic in terms of nest site location. That the species breeds in seasonal wetlands may explain this

strategy. Leader (in press) details at least one example of the species breeding in a temporarily available area in Hong Kong.

In terms of providing suitable breeding habitat for the species, the main habitat limitations are considered to be a fresh-water regime, with well-vegetated areas dominated by low herbaceous vegetation and with low levels of human disturbance. Grazing by large herbivores, such as water buffalo, may help to maintain such low herbaceous vegetation. However, if such grazing is to be incorporated into the management regime of the created wetlands, it should be closely monitored to prevent trampling of nests and over-grazing of vegetation.

4.2.3.3 Foraging and Roosting Habitat Requirements

While considerable data have been collected in recent years on the numbers and turnover of Painted Snipe present at the Old School Marsh (Leader in press), these data were considered limited in terms of indicating habitat preferences for the species. The continuing uncertainty was a function of the foraging behaviour of the species as Painted Snipe is considered to be nocturnal or crepuscular in its foraging habits (Cramp and Simmons 1983, del Hoyo *et al.* 1996), whilst the Old School Marsh could only be confirmed as a daytime roost for the species (Leader in press).

In order to investigate the broader foraging requirements of Painted Snipe, ten birds were trapped on the Old School Marsh in December 1998 and were fitted with radio transmitters before being released. From field observations during the flushing and capture of the birds, suggest that the tagged birds represented between 25% and 35% of the birds present on the Old School Marsh. The ten tagged birds were then radio tracked during both daylight and night-time hours for a period of ten days to elucidate the difference in diurnal and nocturnal habitat requirements.

It must be stressed that the data derived from the radio tracking of Painted Snipe was gathered over a relatively short period of time and as such the results should be considered indicative rather than definitive.

The results of the radio tracking programme are presented in *Table 1* below.

Table 1 Summary of diurnal and nocturnal locations by habitat

	Diurnal (%)	Nocturnal (%)
Old School Marsh	92	64
Buffalo Fields	7	6
Inactive/Abandoned Agricultural	0	19
Unknown	1	11

The findings of the radio tracking indicate that there are considerable differences between diurnal and nocturnal habitat requirements of Painted Snipe. It shows that while 92% were located on marshland (the Old School Marsh) during the day, this figure fell to 64%

at night. At night, 19% of the birds were present in inactive or abandoned agricultural land, but each of these birds returned to the Old School Marsh before dawn. The 11% of unknown locations refer mainly to a single bird that frequently left the Old School Marsh during the night for an unknown destination, whilst the records from the Buffalo Fields relate to an individual bird that left the Old School Marsh shortly after tagging and remained within the Buffalo Fields for the remainder of the survey.

From the radio transmitting data, it can be concluded that, although the Old School Marsh provided the main night and daytime roosting and foraging requirements, there is a strong indication that up to a third of the birds present on the Old School Marsh utilise additional areas for night-time foraging purposes.

During night-time foraging the tagged birds travelled a maximum of 800m, although the single bird that departed to an unknown destination is likely to have moved to foraging areas further than 800m from the Old School Marsh, as wide sweeps of areas within 100-1,000m from the Marsh failed to locate this individual.

4.3 Herpetofauna

This subsection covers the findings of a literature review of the habitat requirements of Narrow-mouthed Frog (*Kalophrynus interlineatus*) and other herpetofauna species of high conservation value in the Kam Tin Valley.

Previously unpublished observations by Dr Michael Lau have been used to provide a comprehensive overview of the herpetofauna in the Kam Tin area and their status in Hong Kong.

4.3.1 Herpetofauna in the Kam Tin Valley

The Kam Tin valley is located in the north-western part of the New Territories and includes the Kam Tin, Ho Pui and Pat Heung districts. The main habitats present are fish ponds, abandoned and actively cultivated agricultural land (involving both wet and dry cultivation) and associated permanent and seasonal marshes and pools. Ten species of amphibians and ten species of reptiles were reported in the West Rail EIA based on first-hand records and other published materials (ERM, 1998a). Two additional snake species have been reported in the literature and a further two species (a snake and a lizard) were recorded in the 1990's (Lau, unpublished).

A full list of the amphibian and reptilian species recorded from the Kam Tin area, using the most up-to-date scientific names according to Bogadek & Lau (1997), is presented in *Table 2* below.

Table 2 List of Amphibian and Reptilian Species Recorded in the Kam Tin Area

Species	Common Name	Local Status	Source
Bufo melanostictus	Asian Common Toad	Abundant	1, 2
Rana guentheri	Gunther's Frog	Abundant	1, 2
Rana limnocharis	Paddy Frog	Abundant	1, 2
Rana rugulosa	Chinese Bullfrog	Uncommon	1, 2
Polypedates megacephalus	Brown Tree Frog	Abundant	1, 2
Kalophrynus interlineatus	Narrow-mouthed Frog	Uncommon	1, 2
Kaloula pulchra	Asiatic Painted Frog	Common	1, 2
Microhyla butleri	Butler's Pigmy Frog	Uncommon	1, 2
Microhyla ornata	Ornate Pigmy Frog	Abundant	1, 2
Microhyla pulchra	Marbled Pigmy Frog	Common	1, 2
Gekko chinensis	Chinese Gecko	Common	1, 2
Hemidactylus bowringi	Bowring's Gecko	Abundant	1, 2
Calotes versicolor	Changeable Lizard	Common	1
Eumeces chinensis	Chinese Shrink	Common	2
Scincella reevesi	Reeves' Smooth Skink	Common	1
*Trachemys scripta elegans**	Red-eared Terrapin	Common	1, 2
Cyclophiops major	Greater Green Snake	Uncommon	1
Enhydris chinensis	Chinese Water Snake	Uncommon	1, 3
Enhydris plumbea	Plumbeous Water Snake	Uncommon	1, 2, 3
Lycodon subcinctus	Banded Wolf Snake	Rare	2
Ptyas korros	Indo-chinese Rat Snake	Common	1, 2
Bungarus fasciatus	Banded Krait	Rare	3, 4
Naja atra	Chinese Cobra	Common	1
Ophiophagus hannah	King Cobra	Rare	5

Notes:

1. ERM (1998a)
2. Lau, M W N (Personal Records)
3. Romer (1970)
4. Ades (1993)
5. Herklots (1938)

* Introduced exotic

The status of amphibians and reptiles in Hong Kong has never been studied in detail and hence there is no quantitative ranking system for local herpetofauna. However, it is essential to prioritise the species for conservation in a study such as this and a simple ranking system has been employed in which each of the local amphibian and reptilian species have been allocated to one of five categories - Abundant, Common, Uncommon, Rare, and Very Rare. The ranking has been determined by Dr Michael Lau and is based on over 15 years of first-hand herpetofauna experience in Hong Kong supplemented by reference to all available published materials. Although the system is crude and at times may seem arbitrary, it is believed to be adequate for selecting species for active conservation.

Three uncommon amphibians and six uncommon or rare snakes have been reported from the Kam Tin area. The three frog species (*Rana rugulosa, Kalophrynus interlineatus* and *Microhyla butleri*) are known to breed in the Kam Tin valley and these will be targeted in West Rail Habitat Creation and Management Plan. Four of the uncommon or rare snakes (*Cyclophiops major, Lycodon subcinctus, Bungarus fasciatus* and *Ophiophagus hannah*) are terrestrial and are not suitable species for this study. However, *Bungarus fasciatus* quite often occurs around water (Karsen *et al.*, 1986) and might benefit from the future expansion of the target species to be provided for in the creation and management of new wetland habitats. The other two species, *Enhydris chinensis* and *E. plumbea,* are aquatic and will be considered as target species for the current study.

The five herpetofauna species selected as target species are typical lowland lentic species. Although quite widespread regionally, they are uncommon or rare in Hong Kong and are increasingly threatened by urbanisation. Hence, incorporating these species in the West Rail Habitat Management and Creation Plan will be a positive step towards their conservation in Hong Kong.

4.3.2 Target Herpetofauna Species

4.3.2.1 Narrow-Mouthed Frog

Kalophrynus interlineatus (Blyth, 1854)

This species was once considered to be a subspecies of *K. pleurostigma* - *K. pleurostigma interlineatus* - but has recently been elevated to a full species (Matsui *et al.*, 1996). The sonagram of the mating call of the Hong Kong populations confirms this view (Lau, 1998). Further supporting evidence comes from the observation that tadpoles of *K. pleurostigma* do not feed, but rely upon the yolk sac for sustenance during development (Inger, 1956, 1966; Inger & Stuebing, 1989; Lim & Lim, 1992), while tadpoles of the Narrow-mouth Frog raised in captivity, actively feed on suspended organic particles (Lau, 1998). Narrow-mouth Frog occurs in South China (Yunnan, Guangdong, Hainan and Guangxi Provinces), Burma, Thailand, Vietnam, Cambodia and possibly Java (Matsui *et al.*, 1996).

The Narrow-mouth Frog was once considered to be rare in Hong Kong (Lai & Ng, 1972) and was recorded from a limited number of locations: Kam Tin, Fanling, Shek Fong and Lam Tsuen (Romer, 1979). However, more recent studies have indicated that this species is widely distributed in lowland, basins and hills in the north-western, north-eastern and central New Territories (Lau, 1998); as a consequence, the status of the species in Hong Kong is now considered to be uncommon (Lau pers. com.).

A recent study on the breeding habitat requirements of the Narrow-mouth Frog (Lau, 1998) has indicated that this species breeds in marshland areas with the following characteristics:

- Breeding sites ranged from sea level to 410 m (mean 85 m). Nearly all the sites were seasonal lentic habitats with no surface flow and ranged from less than 1 m^2 to over 1,000 m^2 in area (most are between 10 and 100 m^2), with depths of less than 1 m and sloping banks.

- Canopy cover (i.e. overhanging vegetation) was sparse but there was usually medium to dense marginal macrophtye cover. Breeding sites were surrounded by abandoned agricultural land, forest and/or grassland, and the majority had mud/silt as substrates and variable amounts of submerged leaf litter. Dense emergent hydrophytes (over 75%) were present at most sites. Trailing plant roots and algal blooms were absent while filamentous algae and iron bacteria were rare. Aquatic predators were never recorded.

- The water quality of identified habitats seemed variable. Dissolved oxygen levels ranged from 0.2 to 8.6 mg/l and BOD_5 was between 1.9 to 5.5 mg/l. Conductivity was high (135 - 408 S/cm) while total nitrogen (0.03 - 7.50 mg/l), phosphates (0.71 - 26 mg/l), suspended solids (5.9 - 21.3 mg/l) and volatile suspended solids (1.6 - 15.3 mg/l) were variable. The sites were slightly acidic (pH from 6.3 to 6.7).

Outside the breeding seasons, the Narrow-mouthed Frog utilised a range of terrestrial habitats including cultivated fields, abandoned fields, shrubland, plantation and forest (Lau, 1998).

4.3.2.2 Chinese Bull Frog

Rana rugulosa Wiegmann, 1834

The Chinese populations of this species have been mistakenly referred to as *Rana tigerina rugulosa* or *R. tigrina rugulosa* (Lai & Ng, 1972; Romer, 1979; Hill & Phillipps, 1981; Karsen *et al.*, 1986; and Tian & Jiang, 1986); the Chinese Bull Frog is actually distinct from *R. tigerina* (see comparisons in Annandale, 1971). It is widely distributed in Central and South China (Henan, Yunnan, Guizhou, Hubei, Anhui, Jiangsu, Zhejiang, Jiangxi, Hunan, Fujian, Guangdong, Hainan and Guangxi Provinces) including Taiwan; and extends into Burma and Thailand (Fei *et al.*, 1990; Zhao & Adler, 1993). The type locality is Cape Syng-more (= Kap Shui Mun), an old port at the north-eastern tip of Lantau Island which has been seriously degraded in the 1990's by the Port and Airport Development project.

The Chinese Bull Frog was once considered to be the most common amphibian in Hong Kong (Boring, 1934) but has since become less common (Romer, 1979; Karsen *et al.*, 1986). The Frog has been reported from Shatin, Tai Po, Sai Kung (Lai & Ng, 1972); Ha Tsuen, Ping Shan (Romer, 1979) and Shek Kong (Reitinger *et al.*, 1978) in the New Territories; and Happy Valley (doubtful record, see Romer, 1979). A territory-wide survey carried out in the 1990's (Lau, 1998) indicated that whilst this species still occurs in low-lying areas of the New Territories and Lantau Island, revisited localities on Hong Kong Island failed to yield evidence of this species (Lau, 1998). Apparently, the Chinese Bull Frog has disappeared from Hong Kong Island. Similarly, much of its former range in the New Territories (for example Shatin) has undergone drastic change and can no longer support this frog.

A recent study on the breeding habitat requirements of the Chinese Bull Frog indicated that this species bred in both pools and marshes (Lau, 1998). According to the data presented by Lau (1998), characteristics of Chinese Bull Frog breeding sites are summarised as follows:

- Breeding sites occurred in lowlands from sea level to 110 m (mean 19 m). The vast majority were permanent or seasonally inundated lentic habitats although a small number of sites had slow flows. The sites ranged greatly in extent (from less than 1 m^2 to over 1000 m^2, which were of variable depths and usually with sloping banks).

- Most identified sites had little or no canopy cover and had variable marginal macrophyte cover. Sites were usually surrounded by abandoned and/or actively cultivated agricultural land. The most common substrate was mud/silt and submerged litter was scarce. Hydrophytes ranged from absent to dense and emergent forms were most common. Trailing roots were seldom present. Filamentous algae sometimes occurred while algal blooms and iron bacteria were never observed. A substantial number of sites had predatory fish (*Capoeta semifasciolanta*, *Gambusia affinis* and *Oreochromis* spp.) and/or invertebrates.

- The breeding sites had rather varied water quality. Dissolved oxygen levels were between 1.3 and 9.1 mg/l while BOD_5 varied from 1.8 to 6.1 mg/l. Conductivity (55.0 - 306 S/cm), total nitrogen (0.12 - 9.30 mg/l), phosphates (1.02 - 24 mg/l), suspended solids (4.2 - 143.3 mg/l) and volatile suspended solids (1.6 - 62.6 mg/l) were variable. The sites ranged from slightly acidic to alkaline (pH from 6.3 to 8.1).

- The Chinese Bull Frog often occurs in wetlands when not breeding and can be found in wells, pools, fish ponds, marshes, drainage ditches, flooded fields and abandoned fields (Lau, 1998).

4.3.2.3 Butler's Pygmy Frog

Microhyla butleri Boulenger, 1990

This species was first reported from Hong Kong in 1966 (Romer, 1966). It is widely distributed in Central and South China (Sichuan, Yunnan, Guizhou, Hubei, Zhejiang, Jiangxi, Hunan, Fujian, Guangdong, Hainan and Guangxi Provinces), including Taiwan,

and extends south to Burma, Thailand, Vietnam and the Malay Peninsula (Zhao & Adler, 1993).

Butler's Pygmy Frog has been reported from Tai Mo Shan, Lam Tsuen (Romer, 1979) and between Shek Kong and Ho Pui (Karsen *et al.*, 1986) in the New Territories, and Sharp Island (Romer, 1966). It is uncommon in Hong Kong (Karsen *et al.*, 1986). A territory-wide survey in the 1990's showed that this species is scattered throughout the New Territories except the Clearwater Bay Peninsula.

A recent study of the breeding habitat requirements indicated that Butler's Pygmy Frog bred in both pools and marshes (Lau, 1998). According to the data presented by Lau (1998), characteristics of Butler's Pygmy Frog breeding sites may be summarised as follows:

- Breeding sites of Butler's Pygmy Frog occurred from near sea level to moderate altitudes (10 - 420 m, mean 101 m). Most of the sites were seasonal lentic habitats with no surface flow although one site was a pool left in a small, intermittent stream with a gentle gradient (less than 10°). Lentic sites ranged from less than 1 m^2 to over 1,000 m^2 in area (most were between 10 and 1000 m^2), and were of variable depths and often with sloping banks.

- Most sites had little or no canopy cover and moderate to dense marginal macrophyte cover. They were surrounded by fields, plantation and/or forest. Grassland was also present in the vicinity of a considerable number of sites. Most sites had mud/silt substrates but some were lined with concrete. The amounts of submerged leaf litter and emergent hydrophytes were variable. Filamentous algae and algal blooms seldom occurred and iron bacteria were never recorded. Predatory invertebrates, exotic fish (*Gambusia affinis* and *Oreochromis* spp.) and reptiles (*Pseudemys scripta elegans*) sometimes occurred.

- Butler's Pygmy Frog breeding sites usually had high levels of dissolved oxygen (7.2 - 12.6 mg/l) and moderate BOD_5 (3.4 to 5.5 mg/l). Conductivity (68.5 - 268 S/cm), total nitrogen (3.20 - 5.95 mg/l) and phosphates (4 - 17 mg/l) were all quite high. Varying amounts of suspended solids (3.7 - 189.4 mg/l) and volatile suspended solids (2.8 - 98.2 mg/l) were present. The sites ranged from slightly acidic to fairly alkaline (pH from 6.4 to 9.2).

Non-breeding habitat of Butler's Pygmy Frog includes active agricultural land, shrubland, plantation, forest and fish ponds (Lau, 1998).

4.3.2.4 Chinese Water Snake

Enhydris chinensis (Gray, 1842)

The Chinese Water Snake is widely distributed in southern China (Hubei, Anhui, Jiangsu, Zhejjiang, Jiangxi, Fujian, Guangdong, Hainan and Guangxi) and Taiwan. In Hong Kong, there are records for the Chinese Water Snake from the northern, central and eastern New Territories (Romer, 1970, 1979, Hill & Phillipps, 1981; Karsen *et al., 1986*),

Lantau Island (Karsen *et al.*, 1986) and Hong Kong Island (M W N Lau, unpublished data). In the Kam Tin area, it is found in suitable habitats within the low-lying valley floor and, in particular, the area around Ho Pui.

The Chinese Water Snake is pale brownish and may grow up to 70-80 cm in length. Largely aquatic, it inhabits active and abandoned wet agricultural land, slow-flowing streams and, in particular, fish ponds (Romer, 1979; Karsen *et al.*, 1986) where it feeds on small fish and occasionally frogs. It appears active in wetland areas during the day, but its forays on to land appear to be largely nocturnal (Hill & Phillipps, 1981).

Detailed information on its breeding habitat requirements is not available, although the Chinese Water Snake is known to reproduce by ovoviviparity (bearing live young) and up to 18 young snakes may be born at a time.

4.3.2.5 Plumbeous Water Snake

Enhydris plumbea (Boie, 1827)

The Plumbeous Water Snake is widespread in southern China (Yunnan, Jiangsu, Zhejiang, Jiangxi, Fujian, Guangdong, Hainan and Guangxi), Taiwan and South East Asia (Zhao & Adler, 1993). In Hong Kong, it seems to be restricted to the Kam Tin Valley (Romer, 1979) and Tsing Fai Tong (M W N Lau, unpublished data) in the New Territories but is fairly widespread on islands including Cheung Chau (Romer, 1979), Lantau, Lamma, Shek Kwu Chau, Ping Chau and Peng Chau (M W N Lau, unpublished data).

The Plumbeous Water Snake is usually 30-40 cm in length, but lengths of up to 60 cm have been recorded. The upper body is uniformly dark grey to dark olive and the belly is whitish to pale yellow. This aquatic snake inhabits active and abandoned wet agricultural land, slow-flowing streams and ponds (Romer, 1979; Karsen *et al.*, 1986) where it feeds on small frogs and tadpoles, insect larvae and occasionally small fish.

The wider habitat requirements of the Plumbeous Water Snake, including its breeding habitat requirements, are unknown. However, the species is known to reproduce by ovoviviparity (bearing live young) with up to 9 young snakes being born at a time.

4.4 Dragonflies

4.4.1 Target Species of Dragonflies

Over 100 species of dragonflies (*Odonata*) have been recorded in Hong Kong (Wilson 1997) and these species occur in a wide range of habitats from relatively natural upland streams to highly artificial lowland ponds (Dudgeon and Corlett 1994; Wilson 1997).

During the ecological field surveys undertaken as part of the West Rail EIA Study, twenty-two species of dragonfly were identified from the Kam Tin valley area (ERM

1998); summary descriptions of the species identified are presented in *Annex A* and the habitat requirements and current status of each is presented in *Table 3*.

Table 3 Habitat Requirements and Status of Dragonflies recorded from Kam Tin

Species	Local Status	Habitat
ZYGOPTERA		
Neurobasis chinensis	Fairly Common	Shallow gradient streams.
Agriocnemis femina	Abundant	Abandoned wet agricultural land; marshes; ditches and weedy margins of ponds.
Ceriagrion auranticum	Common	Salt tolerant species occurring in ponds, marshes and abandoned wet agricultural land.
Ischnura senegalensis	Abundant	Ponds, marshes and sluggish rivers; ornamental ponds in urban areas.
Rhinocypha perforata	Common	Well wooded mountain ravines; forest streams; fast hill streams; stream with shallow gradient
Copera ciliata	Common	Streams with shallow gradient; lowland streams with silty margins; ditches; weedy margins of ponds.
ANISOPTERA		
Sinictinogomphus clavatus	Fairly Common	Still water habitats such as ponds, marshes and reservoirs.
Anax guttatus	Common	Ponds and reservoirs
Orthetrum chrysis	Common	Pools; marshy areas adjacent to streams.
Orthetrum luzonicum	Common	Marshes, abandoned wet agricultural land and swampy areas.
Orthetrum pruinosum	Abundant	Streams with shallow gradient; fish ponds; slow streams; rain puddles; and irrigation conduits.
Rhyothemis variegata	Common	Marshes; ponds; and tanks.
Pantala flavescens	Abundant	Ponds; marshes; swampy areas; abandoned wet agricultural land; reservoirs and tanks.
Brachythemis contaminata	Abundant	Weedy ponds; banks of sluggish rivers.
Crocothemis servilia	Common	Breeds in static waters favouring ponds, tanks, sluggish sections of irrigation feeder streams and shallow pools.
Brachydiplax chalybea	Common	Marshes and weedy ponds
Tholymis tillarga	Common	Marshes, weedy ponds and tanks.
Orthetrum glaucum	Abundant	Streams, conduits, drainage channels, seepage and even road gutters, if wet.
Orthetrum sabina	Abundant	Salt tolerant species occurring at coastal, marshy, riverine and mountainous locations.
Neurothemis tullia	Fairly Common	Marshes, swampy areas and abandoned wet agricultural land.
Neurothemis fulvia	Common	Active and abandoned wet agricultural land and streams.
Trithemis aurora	Abundant	Ravine stream; streams with shallow gradients; lowland streams; marshes; ponds; tanks; irrigation feeders; and ornamental ponds.

Each of the species identified during the field surveys is considered Abundant or Common apart from three species that are considered Fairly Common: *Sinictinogomphus clavatus* (Fabricius, 1775), *Neurobasis chinensis* (Linnaeus, 1758) and *Neurothemis tullia* (Drury, 1773).

The dragonfly *Sinictinogomphus clavatus* is a large and robust species that, in Hong Kong, is on the wing from late April through to October. *S. clavatus* is known to prefer still water habitats, such as ponds, reservoirs and permanent freshwater marshland, where the males perch on stems and overhanging branches (Wilson, 1995).

The dragonfly *Neurothemis tullia* is an attractive, small and distinctive species that is on the wing from mid April until late Autumn. The flight is weak and usually only short distances are covered. *N. tullia* is known to prefer abandoned wet agricultural land and permanent freshwater marshland (Wilson, 1995).

The damselfly *Neurobasis chinensis* is on the wing from April with some individuals still in-flight in late December (Wilson, 1995). *N. chinensis* is present alongside relatively remote, clean streams with shallow gradients and in the Kam Tin valley is found along the upper reaches of the Kam Tin River; the lower reaches are heavily polluted and do not support Odonata larvae (Wilson, 1995). Part of upper reaches of the Kam Tin River will not be disturbed by either the Main Drainage Channel or the West Rail works and these areas will continue to provide habitat for this species.

As indicated in *Table 4.1a*, the majority of the species recorded from Kam Tin (including two of the three less common species) have a requirement for still water habitats such as permanent and seasonal marshes, ponds and pools. The more detailed requirements within these habitat types are presented below.

4.4.2 Habitat Requirements

Dragonflies spend the majority of their life cycles at an aquatic, larval stage when they are known as *nymphs*. Nymphs hatch from eggs laid by the mature, winged adults on emergent aquatic plants, dead wood or are dropped freely onto the waters' surface. When the eggs hatch, the newly emerged nymphs grow through a series of changes, known as *instars*, until they emerge as terrestrial winged adults. The majority of Hong Kong's dragonfly species overwinter in the larval stage and it is the larvae that provide the continuity for these species to the next season rather than the adults which entirely die out during the colder weather of January/February[1].

The nymphs are predators that prey upon smaller aquatic life including small aquatic invertebrates and fish.

[1] There are exceptions. For example, the rare *Lestes nodalis*, which is known from just one site in Hong Kong, overwinters in the adult stage and the larval stage will develop and emerge in one season if the eggs are laid early enough.

A wide variety of dragonfly species is known to occur in ponds, marshes and other bodies of non-flowing water in lowland areas of Hong Kong. The habitat requirements of species all differ slightly and there is currently inadequate information available regarding the precise requirements of particular species. However, many of the lentic (i.e. still water or lake dwelling) species share a number of key habitat requirements.

- Emergent water plants are generally required for egg laying sites and as feeding and sheltering areas for nymphs.
- Both emergent and aquatic plants are used as areas for feeding and shelter, depending upon the species of dragonfly, though some species feed by burying themselves in the bottom sediments and ambushing their prey.
- Water should be of adequate quality to support both the dragonfly nymphs and their prey. Highly polluted waters generally support few or no dragonflies.
- Permanent ponds are required to enable dragonfly species to overwinter in the larval stage.

The lentic habitats of lowland Hong Kong that support high diversity of dragonflies tend to have broad areas of relatively shallow water habitat in which occur extensive areas of emergent water plants. Diversity of water depths and water plant species will afford opportunities for a wider array of dragonfly species; in particular, water depth of 3.5 metres or above (if practicable) will ensure minimum temperature fluctuations and will enable the overwintering of nymph of a wider range of species.

4.5 Possible Future Expansion of the Target Species

In the longer term, the possibility and feasibility of establishing (through reintroduction or translocation) additional rare and locally threatened wetland species within the areas of created habitats will be investigated. Prior to the intentional introduction of additional species into the compensatory habitat areas, an ecological impact assessment will be undertaken to ensure that the introduced species will not disrupt the stability of the created habitat and its ability to provide the necessary resources to the target species.

Rare or threatened herpetofauna species for establishment might include the following frog species:

- the (Rough-Skinned) Floating Frog (*Occidozyga lima*) was previously widely distributed in Hong Kong, but has declined as the rice paddies within which it was found have been abandoned or converted into other uses. The Floating Frog is now restricted to a small number of sites in the Tai O area of Lantau Island and its scarcity is such that translocation would need to rely upon specimens from southern China.
- the Three-Striped Grass Frog (*Rana macrodactyla*) is known from areas of the Kam Tin valley not currently under threat of development and, historically, was recorded in the Au Tau and Tung Shing Lei areas east of Yuen Long before habitat loss associated with the Route 3 construction. The collection of adult specimens and tadpoles would be undertaken within the Kam Tin valley.

- the Two-Striped Grass Frog (*Rana taipehensis*) has been recorded from the reservoir above Ho Pui village and, therefore, locally sourced specimens for translocation would be readily available.
- the Banded Krait (*Bungarus fasciatus*) quite often occurs around water (Karsen *et al.*, 1986) and might benefit from the future expansion of the target species to be provided for in the creation and management of new wetland habitats.

It may also be possible to introduce significant numbers of nymphs of the dragonflies, *Rhodothemis rufa* and *Urothemis signata* from their stronghold at Ma Tso Lung. Both of these species are considered rare (Wilson, 1997) and have limited distribution in Hong Kong. The establishment of these species would require the transferral of a number of dustbin loads of vegetation and organic debris from the breeding site (Wilson, pers. com.). The nymphs of these species require weed-choked water bodies with a depth of metre or more.

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5. HABITATS TO BE CREATED

5.1 Overview

The ecology of the identified target species has been summarised through a combination of literature review, field survey and discussion with relevant local ecologists. The focus of study has been the determination of the key habitat requirements of each of the target species during feeding or foraging, refuge or shelter and breeding activity.

There are complementary elements in the habitat requirements of each of the target species that enables some broad elements to be readily identified; for example, the majority of the target species have a requirement for:

- emergent and submerged aquatic vegetation;
- medium to high water quality;
- variable water depths;
- seasonal and permanent marsh;
- permanent ponds; and
- surrounding terrestrial vegetation.

The existing wetlands of the Kam Tin Valley have these characteristics. They include a mosaic of different aquatic, semi-aquatic and terrestrial habitats. These include deep permanent fish ponds, shallow temporarily wet agricultural land, abandoned wet agricultural and freshwater marshes.

The existing wetlands are also interconnected by a variety of terrestrial areas with different types and mixes of vegetation including grassland, shrubland and secondary woodland.

The proposed compensatory habitats will be designed and constructed to reflect those elements of the existing wetland habitats in the Kam Tin Valley which are critical to the breeding, foraging and refuge needs of the defined target species. Wherever possible, opportunities will be pursued for improving the ecological function and utility of a particular habitat in order to maximise the conservation value of the compensatory habitat areas.

The recommendations for the creation of compensatory habitat are presented below and are based upon the guiding principles established at the commencement of the current study, the habitat requirements of the target species, survey information on the existing features of habitat within the Kam Tin Valley and through reference to general guidelines on wetlands creation (Weller, 1981).

Some of the target species are known to utilise abandoned wet agricultural land both within the Kam Tin area and within their wider range of distribution. It is considered that

these areas may be characterised by reference to naturally occurring seasonal and permanent marshland areas to which long-abandoned wet agricultural land often reverts. For the purposes of defining the habitat requirements of the target species, it is assumed that the conditions found within abandoned wet agricultural land will be provided within recreated seasonal and permanent marsh.

To further identify the characteristics to be accommodated within created habitats, the habitat requirements of each of the target species have been analysed in terms of feeding, refuge and breeding requirements; where insufficient information exists the professional judgement of specialists in the ecology of the target species has been employed. The outcome of this analysis is summarised in *Table 4* below.

Table 4 Summary of Habitat Requirements for Target Species

	Target Species	Painted Snipe	Narrow-mouthed Frog	Chinese Bull Frog	Butler's Pygmy Frog	Chinese Water Snake	Plumbeous Water Snake	Dragonfly Species
Microhabitat requirements	shallow water (1)	f	b	b, f	b	f	f	f, b, r
	deep water (2)			b, r		f, r	f, r	f, b, r
	emergent aquatic plants	f, r, b	r	r	r	r	r	f, r
	submerged aquatic plants	f	r	r	r	f, r	f, r	f, r
	high or moderate water quality	f	b	b	b	f	b	b, f
	permanent ponds	f,	f, b	f, b, r	f	f, r	f, r	f, b
	seasonal / permanent marshes	f, r, b	b	f, b	b	f	f	f, r, b
	terrestrial vegetation	f, r, b	f, r	f	f, r	b	b	r

f = feeding/foraging habitat; r = refuge/shelter habitat; b = breeding habitat

Notes: (1) "shallow water" is defined as up to a depth of 1.5 metres: (2) "deep water" is defined as a depth of 3.5 metres or above.

On the basis of the habitat requirements of the target species, four broad habitat "types" have been identified: seasonal marsh, permanent marsh, permanent ponds and terrestrial vegetation. *Table 5* provides an indication of the extent to which the identified habitat types (i.e. seasonal and permanent marsh, pond, terrestrial vegetation) satisfy the identified microhabitat requirements identified in *Table 4*.

Table 5 Occurrence of Desirable Microhabitat Features in Proposed Habitats

	Proposed Habitats			
Microhabitat Features	Seasonal Marshes	Permanent Marshes	Permanent Ponds	Terrestrial Vegetation
shallow water areas	***	**	*	
deep water areas		*	**	
emergent aquatic plants	***	*	*	
submerged aquatic plants	*	***	**	
dense cover of water-edge plants	**	**	*	**
high or moderate water quality	**	**	**	
terrestrial foraging habitats				**
terrestrial refuges				**
fish habitat (for prey)	*	**	***	

* = potential for occurrence of desirable microhabitat characteristic

The ecological function of each of the identified habitat types is discussed in greater detail in the subsections that follow.

5.2 Seasonal Marshes

Small seasonal marshes that will be flooded during the wet season form ideal breeding habitat for the Narrow-mouthed Frog, the Chinese Bullfrog and some species of dragonfly. The frogs and tadpoles in this habitat will also provide food for the Plumbeous Water Snake and, to a lesser extent, the Chinese Water Snake. It is also likely that they will provide foraging and roosting habitat and possibly nesting sites for Painted Snipe.

Small seasonal pools should also be incorporated into the wetland design as they are favoured by many lowland amphibians including Butler's Pygmy Frog. The presence of many small frogs and tadpoles will support predators such as Chinese Bullfrog and Chinese Water Snake. Seasonal pools are also likely to provide feeding areas for Painted Snipe, particularly during the breeding season when the larger areas may also be suitable nesting locations. For maximum productivity, these pools should be less than 10 m^2 in size and shallow, reaching a maximum of 1.5 m in depth.

The marshes should be of variable size (from over 10 m^2 up to 1000 m^2) and should be of irregular shape to increase the amount of cover and water edge and have gradually deepening shorelines to encourage the growth of emergent hydrophytes. The surroundings of the marshes should be well vegetated by terrestrial vegetation, including patches of grasses and shrubs.

If the physical condition of the seasonal marsh reflects that of marshland in the surrounding area, a similar plant species mix could be expected to become established

through natural colonisation, as many typical wetland plant species (such as *Paspalum dischitum*, *Eragrotis atrovirens* and *Polygonum hydropiper*) are dispersed either by birds or by wind. On the other hand, some rare wetland plant species (such as *Blyxa albertii* and *Junus effusus*) could be actively planted if appropriate propogule are available. While terrestrial plants, such as the grasses *Paincum maxima* and *Miscanthus spp.*, are quite common in the vicinity of marshes, seasonal marsh areas could also be planted with other native plants species which could attract butterflies; appropriate species would include *Celtis sinensis* and *Aristolochia tagala*. A full list of suitable wetland plants is presented in *Annex B*.

5.3 Permanent Marshes

Permanent marsh areas will provide many of the attributes of seasonal marshes, but much larger areas will be required in order to ensure that the marsh does not dry out during the dry season. Large permanent marshes (over 1000 m^2) will be created to provide freshwater habitat for the larval stage of some dragon-fly species as well as for the Chinese Bull Frog, the Chinese Water Snake and the Plumbeous Water Snake, especially during the dry season. Fish in these permanent water bodies will provide food for the Chinese Water Snake and, to a lesser extent, the Plumbeous Water Snake. The permanent marsh areas would also provide suitable feeding areas for the Painted Snipe, especially during the dry season, as well as providing suitable habitat for breeding and daytime roosting for this species.

The permanent marsh areas will include limited areas of shallow open water (no more than 1.5 m deep) which should be of irregular shape, with gentle banks.

The plant species mix within the permanent marsh areas would be similar to that of the seasonal marsh, with large patches of *Cyperaceae*, reed beds (*Phragmites*) and floating grass islands (referred to as "sudd") and with the additional introduction to the permanently wet areas of *Hedychium coronarium, Polygonum hydropiper* and *Saururus chinensis*.

5.4 Permanent Ponds

Relatively small, permanent ponds should also be incorporated into the wetland design as these are favoured by many lowland amphibians and the presence of many small frogs and tadpoles will support predators such as the Chinese Bullfrog and Chinese Water Snake. Permanent ponds are also required to support the overwintering larval stages of a wide range of dragonfly species and to provide habitat for species of fish upon which dragonfly larvae, the Chinese Bullfrog and the Chinese Water Snake prey.

For maximum productivity, the permanent ponds should be of irregular shape, greater than 400 m^2 in size with sloping sides and a maximum depth of 4 metres. The vegetation expected to be established in association with permanent ponds is mainly found on the pond bund which is characterised by mainly grassy vegetation such as *Apulda mutica* and *Paspalum spp.*. Planting of *Nelumbo nucifera* within the ponds would provide emergent

platforms for Amphibia and dragonfly species. Further species of plant suitable for establishment within permanent ponds are presented in *Annex B*.

5.5 Terrestrial Habitats

Each of the target species breeds, feeds, disperses or shelters in terrestrial vegetation for at least part of their life cycle. It is important, therefore, that the wetland habitats are interconnected or linked by appropriate forms of terrestrial vegetation.

The frogs, snakes and Painted Snipe tend to seek refuge in grassland and among low shrubs bordering wet areas, whilst some species of frog and dragonfly require overhanging vegetation to maximise the suitability of aquatic habitats for breeding. Similarly raised areas or islands will be provided as undisturbed refuges for all target species; these would be maintained as primarily grassland/low shrub.

Frogs and snakes would also benefit from the emplacement of large rocks, rubble, etc. that can be used for shelter from predators. Such materials will be put in and around the wetland areas to increase habitat complexity.

The required terrestrial vegetation will be maintained at subclimax levels to avoid succession to taller, woodier vegetation in the absence of disturbance. Although some areas of dense vegetation will be retained, to provide, for example, suitable daytime roosts for Painted Snipe, much of the vegetation surrounding the wetland habitats, as well as the aquatic vegetation within the wetlands, will need active management. This management of the defined habitats is discussed in greater detail in *Section 6* below.

5.6 Habitat Mixture

The proposed range of wetland habitats will be intermingled and connected by continuous patches of terrestrial and semi-aquatic vegetation.

Of the habitats that are proposed for construction, the most productive are likely to be the seasonal and permanent marshes and the permanent ponds. For this reason, most of the available land for the compensatory habitat will be devoted to these habitats. The recommended mixture of habitats is provided in *Table 6* below and is based upon the promotion of biodiversity and the provision of maximum ecological utility for the target species.

Table 6 Habitat Mixture

Habitat Type	Percentage of Total Area
Permanent Marsh	38%
Seasonal Marsh	33%
Permanent Ponds	18%
Terrestrial Habitats - edge areas and islands	11%

Edge areas of marshes will be maximised by making edges irregular and also through the provision of islands within the ponds or raised areas within the marshes. Islands may also serve as areas that are relatively predator free for some species and are also potential refuges for Painted Snipe during the breeding season when rapid increases in water levels can be problematic for birds with young chicks.

The number of individual marshes and ponds will be maximised as this will serve to increase the area of shallow, productive edge habitat and will also create a diversity of water quality and aquatic conditions, as every marsh or pond created will differ at least slightly in this respect. However, one continuous area of permanent/seasonal marsh will be provided to maximise the attractiveness to Painted Snipe and to provide maximum carrying capacity for herpetofauna.

5.7 Recommendations for the Allocation of Land

5.7.1 Rationale

In the subsections above, the characteristics of the habitats required to support the target species have been defined and a broad indication of the percentage mix to be achieved has been provided. It is appropriate, therefore, that the latest indication is provided as to how the compensatory habitat requirements will be accommodated within the specific land parcels made available for this purpose by the Kowloon-Canton Railway Corporation. The latest allocation of the land parcels is indicated in *Table 7* below.Parcel M refers to Volume B.

Table 7 Habitat to be Created within each of the Land Parcels

	Proposed Habitats			
Land Parcel	Seasonal Marshes	Permanent Marshes	Permanent Ponds	Terrestrial Vegetation
Land Parcel A	**		***	*
Land Parcel B	***		**	*
Land Parcel C			***	**
Land Parcel D	***		**	*
Land Parcel E		***		*
Land Parcel F			***	*
Land Parcel G#	**			***
Land Parcel H#	**			***
Land Parcel I	**			***
Land Parcel J#		***		**
Land Parcel K	***	***		**
Land Parcel L		***		**

* - *** = presence and relative landtake of the proposed habitat, whereby *** denotes principal habitat to be provided.

Parcels G, H and the relevant portion of Parcel J (the approximate locations of which are for identification only as shown and identified in Figure 1) will be replaced by Parcel M to be constructed by CEDD on the Date so that Parcels G, H and the relevant portion of Parcel J will thereupon no longer form part of the wetland habitats under this HCMP and all maintenance, management and/or monitoring obligation and any other liability/obligation in relation to Parcels G, H and relevant portion of Parcel J under this HCMP shall cease with immediate effect on the Date. The management, maintenance and monitoring of Parcel M will be undertaken by KCRC in accordance with Volume B. The total area of the land parcels to be maintained, managed and monitored under Volume A of the HCMP shall be reduced to approximately 11.3ha.

The final, detailed allocation and layout of the compensatory habitat areas will be determined following the development of the detailed design for the construction and provisioning of the habitats. However, the design process will be governed by broad guidelines for land allocation and habitat mix derived from the definition of habitat requirements of the target species, the existing ecological resources and linkages of the land parcels available and the size and location of each individual parcel of land and its relationship to the habitats in the immediate vicinity.

The recommendations for the allocation of land, on the basis of the factors indicated above and as indicated in *Table 7* and illustrated in *Figures 3* and *4* (the locations of the land parcels shown therein are approximate locations and for identification purpose only) are discussed in greater detail in the subsections that follow with separate discussion for the parcels of land in the area north of the proposed Kam Sheung Road Station (the "Northern Site") and the area to the west of the Tai Lam Tunnel Portal (the "Southern Site") respectively.

5.7.2 The Northern Sites

These sites comprise ten* discrete parcels of land. The current landuse, extent of disturbance likely to occur during West Rail works and the dates at which these parcels of land will be made available (according to current works programming) are provided in *Section 3* above and their approximate locations are shown in *Figure 1* for identification purpose only.

The preliminary recommendations for the utilisation of these parcels of land in the provision of compensatory habitat are provided below:

- **Land Parcel A:** ***Permanent Pond and Seasonal Marsh.*** This site is recommended for use as the primary focus for the provision of the habitat characteristics identified as being required by Painted Snipe for roosting, foraging and breeding habitat. The site is in close proximity (less than 100 metres) to the existing habitat on the Old School Marsh and 200-300 metres from known roosting/foraging areas within the Buffalo Fields to the east. The comparatively large area available, comprising an area of former river meander which will not be physically disturbed by the West Rail works, provides the most likely conditions favourable for this species and the early availability of parts of this site provides an opportunity for the early establishment of attractive seasonal marsh areas which Painted Snipe may colonise. The site is bordered to the west by the Main Drainage Channel which would aid the establishment of an area relatively free from human disturbance.

- **Land Parcel B:** ***Seasonal Marsh.*** This site is recommended for use as the primary focus for the provision of the habitat characteristics identified as being required by Painted Snipe for roosting, foraging and breeding habitat. The site is in close proximity (less than 100 metres) to the existing habitat on the Old School Marsh and 200-300 metres from known roosting/foraging areas within the Buffalo Fields to the east. The comparatively large area available provides the most likely conditions favourable for this species and the early availability of parts of this site provides an opportunity for the early establishment of attractive seasonal marsh areas which Painted Snipe may colonise. The site is bordered to the west by the Main Drainage Channel which would aid the establishment of an area relatively free from human disturbance.

* Parcels G, H and the relevant portion of Parcel J (the approximate locations of which are for identification only as shown and identified in Figure 1) will be replaced by Parcel M to be constructed by CEDD on the Date so that Parcels G, H and the relevant portion of Parcel J will thereupon no longer form part of the wetland habitats under this HCMP and all maintenance, management and/or monitoring obligation and any other liability/obligation in relation to Parcels G, H and relevant portion of Parcel J under this HCMP shall cease with immediate effect on the Date. The management, maintenance and monitoring of Parcel M will be undertaken by KCRC in accordance with Volume B. The total area of the land parcels to be maintained, managed and monitored under Volume A of the HCMP shall be reduced to approximately 11.3ha.

- **Land Parcel C:** ***Permanent Pond.*** This parcel includes the current course of the Kam Tin River, which will be largely undisturbed by the planned works and will be made available for habitat creation in mid 2002. It is recommended that the river meander is retained as an ponded area of permanent open water.

- **Land Parcel D:** ***Seasonal Marsh.*** This site is recommended for use as the primary focus for the provision of the habitat characteristics identified as being required by Painted Snipe for roosting, foraging and breeding habitat. The site is in close proximity (less than 100 metres) to the existing habitat on the Old School Marsh and 200-300 metres from known roosting/foraging areas within the Buffalo Fields to the east. The comparatively large area available provides the most likely conditions favourable for this species and the early availability of parts of this site provides an opportunity for the early establishment of attractive seasonal marsh areas which Painted Snipe may colonise. The site is bordered to the west by the Main Drainage Channel which would aid the establishment of an area relatively free from human disturbance.

- **Land Parcel E:** ***Permanent Marsh.*** This area currently comprises a portion of the Old School Marsh together with a temporary storage area. It is recommended that this site be the focus of general provision of permanent marshland habitats for herpetofauna, dragonflies and, possible, nocturnal foraging by Painted Snipe.

- **Land Parcel F:** ***Permanent Pond.*** This ponded area will be located between the existing Kam Tin Road, the planned Main Drainage Channel and the new Kam Ho Road.

- **Land Parcel G*:** ***Terrestrial Habitat and Seasonal Marsh.*** This area is located between the Land Parcel J and the planned Main Drainage Channel. Given the extreme constraints associated with the site, it is recommended that a small area of seasonal marsh bounded by terrestrial screening vegetation is established.

- **Land Parcel H*:** ***Terrestrial Habitat and Seasonal Marsh.*** This area is located between the Kam Ho Road and the planned Main Drainage Channel and will be isolated from other land parcels by the Main Drainage Channel and the Kam Ho Road. Given the extreme constraints associated with the site, it is recommended that a small area of seasonal marsh is established and bounded by terrestrial screening vegetation.

- **Land Parcel I:** ***Terrestrial Habitat and Seasonal Marsh.*** This area is somewhat less constrained than Land Parcel H and abuts the heavily wooded hill immediately to the west as well as areas of grassland bordering Route 3. It is recommended that a small area of seasonal marsh is established within this area and that the linkages to the wooded hillside and adjacent grassland are maximised.

- **Land Parcel J*:** ***Permanent Marsh.*** This parcel includes an area of land, between the eastern edge of the limits of deviation for the West Rail viaducts and the Land Parcel C.

* Parcels G, H and the relevant portion of Parcel J (the approximate locations of which are for identification only as shown and identified in Figure 1) will be replaced by Parcel M to be constructed by CEDD on the Date so that Parcels G, H and the relevant portion of Parcel J will thereupon no longer form part of the wetland habitats under this HCMP and all maintenance, management and/or monitoring obligation and any other liability/obligation in relation to Parcels G, H and relevant portion of Parcel J under this HCMP shall cease with immediate effect on the Date. The management, maintenance and monitoring of Parcel M will be undertaken by KCRC in accordance with Volume B. The total area of the land parcels to be maintained, managed and monitored under Volume A of the HCMP shall be reduced to approximately 11.3ha.

5.7.3 The Southern Site

In addition to the parcels of land in the vicinity of the Kam Tin Road, there are additional parcels of land approximately 0.7ha in size at the top of the Kam Tin valley adjacent to the Tai Lam tunnel northern portal. The location of the land parcels is shown in *Figure 2*.

Land Parcel K: ***Seasonal and Permanent Marsh.*** This area is located between the Tai Lam tunnel northern portal and the planned Main Drainage Channel. It is recommended that the focus of habitat creation at the Southern Site is on the requirements of herpetofauna which are currently present in the immediate vicinity of the site.

Land Parcel L: ***Permanent Marsh.*** This area is located to the west of the planned Main Drainage Channel. It is recommended that the focus of habitat creation at the Southern Site is on the requirements of herpetofauna which are currently present in the immediate vicinity of the site.

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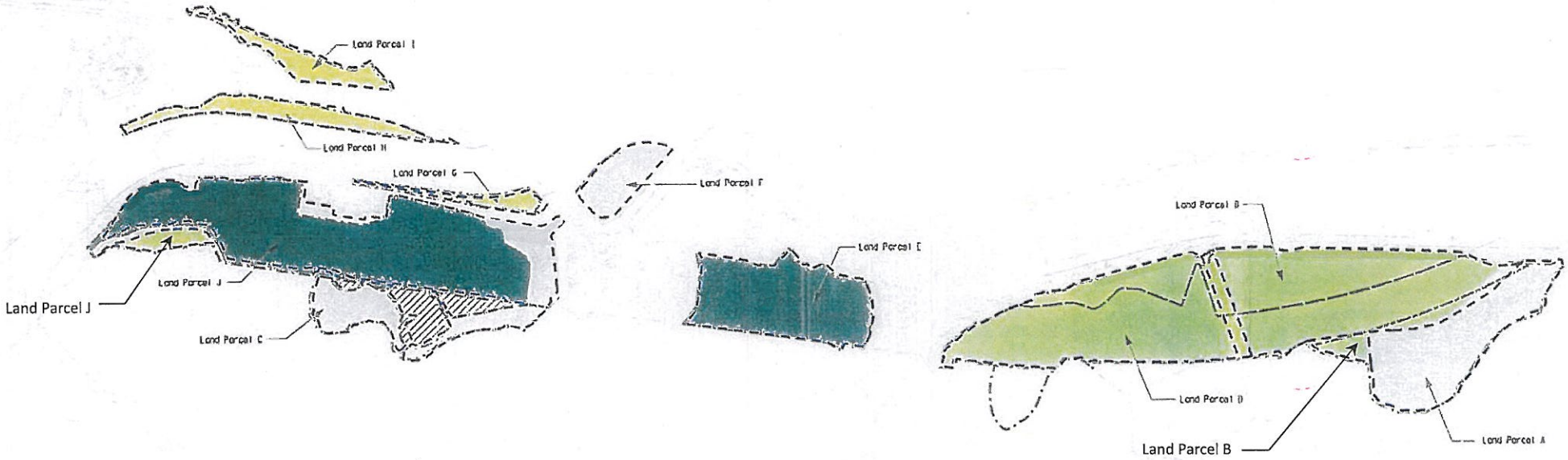
ROUTE 3



LEGEND:
- KCRC Boundaries
- Habitat Compensation Site Boundaries
- Private Lots
- Permanent Marshes
- Seasonal Marshes
- Terrestrial Habitats
- Permanent Ponds

The locations of wetland parcels shown on this Figure are approximate locations and for identification purpose only.

HABITAT MIXTURES PARCELS A TO J

FIGURE 3

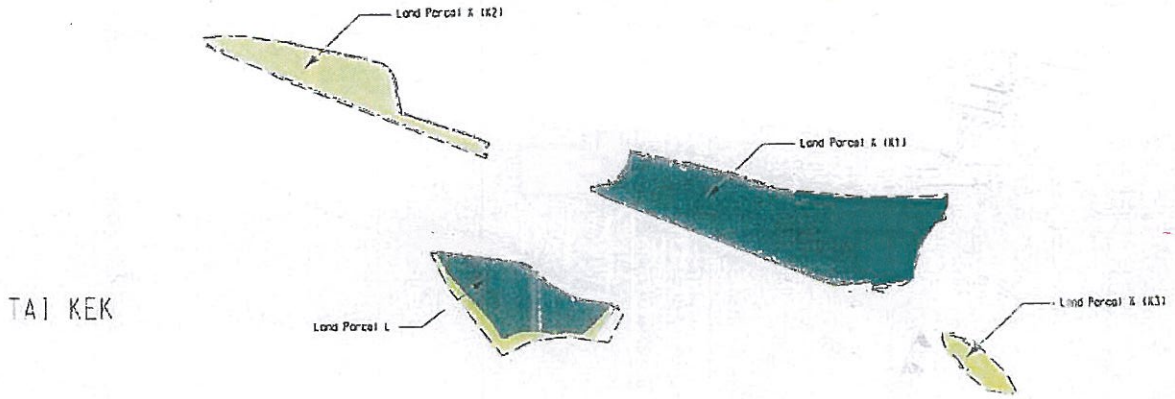
ERM

KOWLOON - CANTON RAILWAY CORPORATION

WEST RAIL: 00931 ENVIRONMENTAL SUPPORT SERVICES

Remark: Parcel G, Parcel H and portion of Parcel J will be replaced by Parcel M, details refer to Volume B

CHEUNG PO



LEGEND:

- KCRC Boundaries
- Habitat Compensation Site Boundaries
- Private Lots
- Permanent Marshes
- Seasonal Marshes
- Terrestrial Habitats
- Permanent Ponds

The locations of wetland parcels shown on this Figure are approximate locations and for identification purpose only.

HABITAT MIXTURES PARCELS K & L

FIGURE 4

ERM

KOWLOON - CANTON RAILWAY CORPORATION

WEST RAIL: 00501 ENVIRONMENTAL SUPPORT SERVICES

6. IMPLEMENTATION PRINCIPLES

6.1 Introduction

In the preceding sections, the habitat requirements of the target species have been reviewed as the basis for defining the range and proportions of habitats to be created and a preliminary indication of how these requirements might be provided for within the parcels of land available has been presented.

In this section, the broad principles to be adopted in the implementation of the habitat creation and management recommendations are examined.

6.2 Implementation Principles for Habitat Creation

6.2.1 Design Principles

The created habitats will be designed to be self-sustaining as far as practicable (particularly in relation to water regime management) to minimise human intervention and active management but without allowing a compromise in the quality of the habitat created. Considerable water is lost by evaporation and plant transpiration and may exceed annual rainfall, causing difficulties in creating permanent marshes. This can be solved by directing seepages, streams or overflows to these permanent wetlands, provided that these sources are not polluted.

Existing areas of wetland that are not to be encroached by the West Rail works will be surveyed and an inventory of species supported within these areas will be compiled. If the existing areas support a diverse flora and fauna, an interim management plan will be prepared and implemented to ensure that these resources are preserved and, where possible, maximised.

The preferred approach to the creation of new areas of wetland habitat will be through the excavation of basins or the construction of impoundments in poorly-drained soils. Former paddy soils in the Kam Tin Valley are impervious (Grant, 1986) and will be retained whenever possible. However, if the impervious hardpan is disrupted, artificial liners such as Butyl 'rubber' sheeting can also be used with top soil removed from the site added to provide an 8 cm deep mud on the bottom.

Eight centimetres of mud is considered sufficient to promote the growth of aquatic plants and to support a range of invertebrates (Goldman and Horne, 1983). This is for a number of reasons:

- Most aquatic plants tend to be shallow rooted, as mud on the bottom of ponds and lakes quickly becomes anoxic (deprived of free oxygen) below the upper few centimetres.

- Additional sediment will be accumulated within the created habitats as materials wash into the ponds and organic matter decomposes. Therefore, the sediment layer can be expected to thicken naturally.

- Most species of aquatic invertebrates are found in the top few centimetres of mud as deeper layers are anoxic. Eight centimetres would, therefore, provide more than adequate mud depths for burrowing invertebrate larvae such as dragonfly nymphs (Odonata), midges (Chironomidae), etc.

- Bacteria, algae and protozoans exist in abundance in layers of pond mud and 8 cm of mud would furnish an abundant supply of these organisms.

The various types of wetlands will be designed to provide the greatest heterogeneity to meet the needs of a multitude of wildlife with a particular focus on the identified target species. Wetland areas will be linked by terrestrial habitats such as grassland and, in addition, opportunities will be pursued to enable created habitats to linked to other habitats (both terrestrial and aquatic) in the area to increase the effective size and diversity of wildlife habitats. This is important for species with complex life cycles such as amphibians. For example, Narrow-mouth Frog has an aquatic tadpole stage and breeds in marshes, whilst the adults are terrestrial and dwell in a variety of shrub and wooded environments.

6.2.2 The Introduction and Establishment of Ecological Resources

The retention, wherever practicable, of existing areas of wetland will ensure that newly created habitats are located in close proximity to areas from which natural colonisation may take place. However, the specific objective of providing habitats for the identified target species requires an active programme of introducing and establishing ecological resources to a programme that enables the habitats to be established and largely stabilised within a relatively tight five year timescale.

The introduction of soils and organic debris from marshes and mud from ponds will provide a variety of seeds and invertebrate cysts and larvae that will provide the basis for establishing a diverse and representative biota in the newly created habitat areas (Weller, 1981). Although such an approach will also reduce or even eliminate the need for artificial seeding and planting, if sufficient material is unavailable or regeneration of emergent hydrophytes is too slow, active seeding or planting of native grasses, sedges, rushes and herbs will be needed. The dominant physical factor influencing the establishment of hydrophytes is water depth and the idea is to create different strata in a marsh of varying depths. It is difficult to predict which species will become established as ecological information on local hydrophytes is scarce. Hence some experimentation will be necessary.

Trial planting and experimentation will also be required to establish the constraints to vegetation (if any) of the "shadowing" effect of the railway viaducts. Desk-top research, supplemented by selective field surveys, will seek to establish a list of appropriate shade-tolerant wetland plants; trial planting of these species underneath the viaducts will be

closely monitored to identify suitable species for wider planting in shade constrained areas. The listing of wetland plants provided in *Annex B* includes an indication of the shade tolerance of identified plant species.

Exotic plant species will not be planted or encouraged in and around the wetlands. One species in particular that occurs in and dominates some of the Kam Tin wetlands is the Water Hyacinth; this species is of limited ecological value to the target species and appears to be actively avoided by Painted Snipe. Other native species such as the water lettuce (*Pistia stratioides,* Araceae) will be used in preference.

The wetland habitats to be created, and the maintenance regime to be implemented, will seek to maximise macroinvertebrate biomass. Dudgeon and Chan (1996) are of the general view that those sites where macroinvertebrate biomass is high generally have a high conservation value. This relationship is primarily due to macroinvertebrates acting as reliable bio-indictaors for good water quality and the high abundance and diversity of emergent and submergent vegetation. High macroinvertebrate biomass will provided abundant food supply for higher trophic levels of the wetland system including amphibians, fish and birds.

A range of macroinvertebrate species will be encouraged or introduced into the created wetland areas through the provision of suitable aquatic and semi-aquatic vegetation. Whilst the aim will be to maximise biodiversity key species may include midge larvae (*Chirinomids*), various freshwater snails and a range of winged insect larvae including mayflies, dragonflies and stoneflies.

Once stable wetlands, supporting healthy plant and invertebrate communities, have been created, and providing that there are healthy and expanding populations of the target species in the surrounding area, natural colonisation should occur from neighbouring areas. If still present in the Kam Tin area, Painted Snipe are likely to utilise suitable foraging, roosting or breeding habitats, particularly if these are subjected to low levels of human disturbance. Young frogs are known to disperse considerable distances through favourable habitats (Duellman & Trueb, 1986), whilst aquatic snakes, such as the Chinese Water Snake and the Plumbeous Water Snake, may travel considerable distances over land on damp nights. Dragonflies will generally locate and utilise suitable habitat within a relatively short period of time (Wilson, pers. com.).

Natural colonisation is the preferable means of introducing species to the newly created habitats as there are no genetic implications and such an approach is clearly less demanding in terms of time and effort. However, if natural colonisation does not occur, or if it is unlikely, active introduction (translocation) will be undertaken.

The herpetofauna target species all occur naturally in the immediate area surrounding the land allocated for habitat creation in Ho Pui. It is expected that this area will be readily colonised within a year or so of the habitat being established. However, those habitat creation areas to the north of the Kam Tin valley are some considerable distance from the sites known to support these species. The utilisation of the Ho Pui habitat creation area as

a possible reservoir for translocation to other areas of newly created habitats will be considered as will the possible capture of specimens for direct translocation to the lower Kam Tin valley habitat areas. The frog species will be translocated as adults or tadpoles, whilst adult snake specimens will be sought for translocation.

In order to establish a geographically separated population outside the current known distribution of a particular species, it will be necessary to ensure that sufficient numbers are translocated such that both genetic diversity and population stability are achieved, whilst the carrying capacity of the individual land parcels is not compromised. By way of illustration: to establish a stable population of the herpetofauna species would require the translocation of between 20 and 50 adults (M W N Lau, pers. com.).

As has been stressed, the translocated animals will be sourced from within the general area of the Kam Tin valley to prevent unnatural mixing of genetic makeup and the translocated species should be monitored regularly for at least five years to determine the success or failure of translocation

6.3 Implementation Principles for Habitat Management

6.3.1 Active Management

Following the successful creation of the defined habitat types and the colonisation or translocation of stable, self-sustaining populations of the target species, a detailed, ongoing management plan will be prepared and implemented. The management plan will be focused on the maintenance of the desired habitat characteristics necessary for the preservation and maximisation of conservation interest within the newly created habitat areas.

Although the engineering design for the compensatory habitat will seek to establish a self-sustaining water regime which requires minimum ongoing management, the habitats to be created will be essentially early successional or subclimax habitats which will require continued input or disturbance to prevent colonisation and/or succession to shrubs and trees that may detract from the desirable habitat values. Also, other threats in the form of weed invasion and decline in water quality could reduce habitat values.

For example, in order to maintain open-water habitats (i.e. ponds and shallow areas of open water within marshland), emergent and aquatic vegetation will need to be controlled either through physical clearance or through the judicious use of herbivores. Physical clearing of hydrophytes will need to be carried out regularly and eventually new pools will need to be dug as old ones become silted. Alternatively, water buffalo can be used to keep hydrophytes in check and to open up small parts of the marshes through grazing and wallowing. Management of herbivores is a valuable but difficult management tool since it depends on the efficiency of population management (Weller, 1981). The relatively small size of the separate areas that comprise the approximately 12 ha (rounded up to the nearest integer) of land available for habitat creation is such that two water buffaloes (probably a mother and a female calf) could be rotated between the relevant marshland areas as the vegetation becomes well established.

in the newly created wetlands. However, the impact of the water buffalo will be closely monitored to ensure that the vegetation management objectives are met and that the extent of grazing is not detrimental to the ecological value of the sites. It should be noted that Leader (in press) cites the introduction of water buffalo on to the Old School Marsh during 1997 as a contributory factor to the subsequent drop in Painted Snipe numbers on the site.

Periodic draw down of the large permanent marshes might be necessary to rejuvenate the marsh and to speed up decomposition of dead vegetation and recycling of nutrients (Scott *ed.*, 1982) when hydrophytes are disappearing or in serious decline. This can be carried out during an extensive dry spell by partial draining. Similarly, permanent ponds would benefit from periodic draining and clearance in order to maintain water depths and as a means of control aquatic and emergent vegetation. The implications for the target species would be assessed prior to the implementation of this active management measure, but a basic principle to be applied would be that such draw down would be undertaken outside the breeding season of the target species. It is envisaged that draw down would be a relatively infrequent event, occurring every few years rather than annually, and that rotational draw down would ensure that only discrete areas of the wetland were effected at any one time.

6.3.2 Monitoring

Wetlands will have to be regularly monitored to ensure that the key features of habitats are maintained in the long term. The specific range of management activities will be kept under constant review and, as necessary, adaptive management measures will be introduced on the basis of an ongoing monitoring programme.

There is a lack of comprehensive empirical data on the creation and management of wetland habitats, particularly in an east Asian context. Therefore the design employed will represent an estimate of the optimum habitat requirements of the key "indicator" fauna of Painted Snipe, the herpetofauna species and dragonflies. Monitoring is required to determine the success of the compensatory wetlands and, if necessary, to provide information to allow for future adaptive management.

A monitoring programme will be required for several years following the construction of the compensatory habitats. The programme will need to be cost effective, well designed and focus on those critical features of the wetland habitats that provide accurate means of assessing the success, or otherwise, of the habitat creation process. An outline of the possible key features required for the monitoring programme are summarised in *Table 8.*

Table 8 Features of Monitoring Programme

Elements	Comment
Purposes	Checking that habitats have been created and are being maintained;
	Checking that the target species are utilising habitats;
	Detecting problems such as declining water quality, weed encroachment, etc.;
	The provision of information that can be used for adaptive management to rectify or improve the design or management strategy.
Measurements	The occurrence and/or relative abundance of key target species (Painted Snipe, herpetofauna and dragonflies);
	General species diversity of avifauna;
	General species diversity of herpetofauna;
	Water quality (pH, turbidity, conductivity and dissolved oxygen);
	Floristics and structure of wetland vegetation.
Timing	Monitoring will be conducted four times annually during optimum weather conditions when there is typically the highest probability for the detection of the key species
Duration	Monitoring will be conducted for at least five years following construction of the wetlands to ensure that the wetlands are colonised by key species of wetland plants and animals and that such populations are maintained.
Reporting	Data collected from the monitoring programme will be analysed and presented in a series of quarterly and annual written reports.

7. IMPLEMENTATION PROGRAMME

7.1 Timing of Habitat Creation

The programme for the implementation of the *Habitat Creation and Management Plan* will be determined by the following factors:

- **The Drafting of Contract Documentation**. The design specification for the compensatory habitat provision will be drafted and incorporated into tender documents during April-June 2001.

- **The Award of Contract**. The civil works contract for the creation of the specified habitats will be tendered and awarded by August-September 2001.

- **The Availability of Land**. Much of the land identified for compensatory habitat provision will become available following the completion of the major civil and structural engineering works associated with the construction of the railway viaducts. A review of the current indicative works programme suggests that these works will be largely complete by mid 2002 with discrete areas becoming available as early as mid 2001. As the works programmes are finalised (following the award of the construction contracts), the availability dates for land to be provided for habitat creation will be determined.

As a consequence, the first tranche of habitat creation (or modification to maximise ecological functionality within those areas undisturbed by the West Rail works) will commence in the Autumn of 2001 and will progressively advance as further land parcels become available. In the interim, contract clauses have been inserted into the civil and structural works contracts to ensure that areas outside the limits of deviation are securely fenced to avoid encroachment.

7.2 Responsibility for Habitat Creation

As indicated above, the creation of compensatory habitat will be undertaken by a Specialist Contractor under the contract management of the West Rail Environmental Manager.

The Contractor's proposed methodology will be independently assessed by specialist ecologists and the progress and completion of the works will be independently checked as being compliant with the requirements of the design specification.

7.3 Responsibility for Habitat Management

The Specialist Contractor will be retained to undertake modifications to the created areas and to implement any changes in drainage identified as being required through the ongoing monitoring programme.

In parallel, it is the Corporation's intention to appoint a locally based conservation organisation to undertake the day-to-day management and monitoring of the created

habitat areas. In this respect, the Corporation commits to fully fund the costs associated with the management and maintenance of the compensatory habitat for an initial period of ten years (following the opening of the railway) and thereafter to provide a one-off capital grant to the conservation organisation for the purpose of establishing a permanent management regime.

7.4 Ongoing Consultation.

The implementation of the *Habitat Creation and Management Plan* will be undertaken in close liaison with the Hong Kong conservation community. A Working Group has been established as a vehicle for the building of consensus on the form and range of habitats to be created on the land available; this Working Group comprises representatives of the following organisations:

- KCRC;
- ERM-Hong Kong, Ltd;
- The Conservancy Association;
- Friends of the Earth;
- Green Power;
- The Hong Kong Bird Watching Society; and
- World Wide Fund for Nature Hong Kong (WWF)

ANNEX A

Annex A: Summary Information on Odonata species recorded from the Kam Tin Valley (ERM, 1998a)

Species	Local Status	Habitat	Description	Distribution in Hong Kong
ZYGOPTERA				
Neurobasis chinensis	FC	Shallow gradient streams.	This is an extremely beautiful species that is widely distributed throughout Indo-China and Southeast Asia. According to Dr D Dudgeon in Asahina (1987) it has declined in recent years due to environmental destruction. It is however present in a number of clean remote streams and is still on the wing in good numbers at some sites in late autumn. It has a long season; emerging in April with some individuals still in flight in late December.	Lam Tsuen Valley, Tai Lam reservoir, Sai Kung.
Agriocnemis femina	A	Disused paddy fields or marshy ground; ditches and weedy margins of ponds.	A very common and widespread damselfly of tiny proportions and easily overlooked. This species emerges in late March and is present in large numbers by mid April. Still on the wing in late autumn.	Lam Tsuen Valley, Sam A Chung, Pak Kong, Pui O, Hoi Ha, Ping Yeung, Wu Kau Tang, Luk Keng, Sha Lo Tung and Mai Po.
Ceriagrion auranticum	C	Salt tolerant species occurring in ponds, marshes and abandoned rice paddies.	Ceriagrion species are large stout bodied damselflies with thick abdomens and short legs. Ceriagrion auranticum is quite aggressive and will consume smaller damselflies. The short-bodied larvae are found amongst submerged aquatic weeds in ponds and marshes. It has a long flight period from late March until December.	Common and widespread throughout Hong Kong Island and the New Territories.
Ischnura senegalensis	A	Ponds, marshes and sluggish rivers; ornamental ponds in urban areas.	An extremely common species that can tolerate fairly brackish water conditions at Mai Po Marshes. It is quick to colonise and is often found in ornamental ponds in urban areas. Is on the wing from March until January.	Common and widespread throughout Hong Kong and the New Territories.

Species	Local Status	Habitat	Description	Distribution in Hong Kong
Rhinocypha perforata	C	Well-wooded mountain ravines; forest streams; fast hill streams; stream with shallow gradient	A small colourful stream species. On the wing from early Spring until early January although numbers of adults fall markedly in autumn. Even on sunny December days courtship displays can be observed. Does not occur at high elevations.	Widespread and common in Hong Kong and the New Territories.
Copera ciliata	C	Streams with shallow gradient; lowland streams with silty margins; ditches; weedy margins of lakes and ponds.	Fairly common species. Appears on the wing in mid April until late Autumn.	Common and widespread throughout Hong Kong and the New Territories.
ANISOPTERA				
Sinictogomphus clavatus	FC	Still water habitats such as ponds, marshes and reservoirs.	On the wing from as early as late April through summer to October. The larvae are broad and very large.	Mai Po, Tai Tong, Ho Pui, Au Tau, Luk Keng and Ping Yeung.
Anax guttatus	C	Ponds and reservoirs	This is a very large and powerfully built dragonfly. The male is an impressive sight as it patrols streams and bodies of water aggressively defending its territory. Occurs on the wing as early as February and continues until late autumn.	A widespread and common species. Records from Hong Kong and numerous locations in the New Territories.

Species	Local Status	Habitat	Description	Distribution in Hong Kong
Orthetrum chrysis	C	Pools; marshy areas adjacent to streams.	A medium-sized species that has a local distribution but is common where found. Found on the wing from mid April until late autumn.	Common but with local distribution. Records from Tai Po Kau, Ho Chung, Ping Yeung, Sha Lo Tung, Tai Tong, Ma On Shan, Hoi Ha, Luk Keng, Sam A Chung, Lamma Island, Sham Tseng and Lai Chi Wo.
Orthetrum luzonicum	C	Marshes, abandoned rice paddies and swampy areas.	A medium-sized libellulid found in high numbers at suitable habitats.	Widely distributed and common at suitable locations. Records from Shuen Wan, Tai Mo Shan, Pak Kong, Lam Tsuen Valley, Pak Tam Au, Sha Lo Tung, Tai Tong, Luk Keng, Pui O, Ho Chung, Sam A Chung.
Orthetrum pruinosum	A	Streams with shallow gradient; fish ponds; slow streams; rain puddles; and irrigation conduits.	A common medium-sized libellulid. It is the most frequently encountered medium-sized libellulid. The larvae can occur in huge numbers in the feeder ditches and irrigation tanks of cultivated areas. Appears on the wing from late March until late Autumn.	Widespread and abundant.
Rhyothemis variegata	C	Marshes; ponds; and tanks.	A fairly large and extremely attractive libellulid which is immediately recognised by the fully coloured wings with their distinctive amber and dark brown variegated pattern. Occurs in groups of soaring and gliding individuals which hover at low altitude over wind-sheltered locations close to the breeding sites. Many thousands of individuals can occur in these swarming groups at Mai Po Marshes during late summer. Breeding sites include marshes, ponds and tanks. Although only abundant in late summer it is seen on the wing from mid April.	A common and widespread species which favours the pond and marsh areas in the north-western part of Hong Kong but is also found throughout the New Territories.

Species	Local Status	Habitat	Description	Distribution in Hong Kong
Pantala flavescens	A	Ponds; marshes; swampy areas; abandoned rice paddies; reservoirs and tanks.	Undoubtedly the commonest dragonfly in Hong Kong. It is known as the Wandering Glider, Typhoon Dragonfly or Orange Glider. This species is extremely migratory and will seek out moisture-laden air. Numbers build up in Hong Kong at times of high humidity during the summer. This leads to huge aggregation of thousands of individuals in a single swarm and these often occur as a typhoon approaches. It is found on the wing all year round and on warm sunny days small groups can be seen flying over wind-sheltered woodland even in January, the coldest month. Larvae have extremely rapid development.	Abundant throughout Hong Kong and the New Territories.
Brachytemis contaminata	A	Weedy ponds; banks of sluggish rivers.	A very common smallish libellulid of stout build. It is able to survive in the semi-intensive polyculture fish ponds centred in the northwest New Territories. Not usually found far from ponds or the borders of streams. Emerges early in the year and is seen on the wing during late March until December.	Abundant and widespread throughout Hong Kong and the New Territories.
Crocothemis servilia	C	Breeds in static waters favouring ponds, tanks, sluggish sections of irrigation feeder streams and shallow pools.	A medium-sized, brilliant red species which favours cultivated areas, ponds and marshes in the New Territories.	Common and widespread. Records from Lam Tsuen Valley, Ping Yeung, Luk Keng, Sha Lo Tung, Mai Po Marshes, Tai Po Kau, Castle Peak, Fanling, Tai Tong, Tai Lam Country Park, Au Tau, Tin Fu Tsai.
Brachydiplax chalybea	C	Marshes and weedy ponds	Salt tolerant species. A widespread, common pond and marsh species of small medium size. In addition to the inland ponds and marshes it occurs in coastal areas and appears to tolerate brackish water. Where trees overhang the breeding sites, many adults and sub-adults, both male and female, can be found perching on twigs. The adults do not wander far from the breeding sites. It appears on the wing from early April until late autumn.	Common and widespread. Records from Mai Po Marshes, Luk Keng, Au Tau, Pui O, Sai Kung Peninsular, Ho Chung, Shuen Wan, Tai Tong, Ping Yeung, Sam A Chung, Lamma Island.

Species	Local Status	Habitat	Description	Distribution in Hong Kong
Tholymis tillarga	C	Marshes, weedy ponds and tanks.	Moderately large dragonflies with predominantly crepuscular habits, appearing towards the end of the day and flying long after dusk. At Mai Po Marshes it tolerates brackish water conditions and will also occur in moderately polluted water. It has a very wide distribution and migratory habits.	Common and widespread throughout the New Territories. Records from Mai Po Marshes, Au Tau, Shuen Wan, Luk Keng, Tai Tong and Sha Lo Tung.
Orthetrum glaucum	A	Streams, conduits, drainage channels, seepage and even road gutters if wet.	One of the most familiar of the territory's dragonflies. Seen on the wing during all months of the year though numbers during the winter are greatly reduced. The males with bright powder blue abdomens perch, often on the ground, adjacent to preferred habitat.	Abundant and widespread.
Orthetrum sabina	A	Salt tolerant species occurring at coastal, marshy, riverine and mountainous locations.	This species has an enormous range and is immediately distinguished from other Hong Kong libellulids by the shape of the abdomen and the yellowish green and black coloration. It is an extremely aggressive species and often predates on other dragonflies. Many of the prey items are species that are nearly as large as sabina itself. Observed on the wing from late March until December.	Abundant and widespread.
Neurothemis tullia	FC	Marshes, swampy areas and abandoned rice paddies.	A very attractive, small and distinctive dragonfly. The male's wings are predominantly black. The flight is weak and usually only short distances are covered. It favours disused rice paddies and swampy areas. Occurs on the wing from as early as mid April until late autumn.	Locally common and widespread. Records from Castle Peak, Tai Mong Tsai, Tai Tong, Ping Yeung, Ho Chung, Pak Kong, Fanling, Hok Tai Wai, Luk Keng, Shuen Wan, Kau Sai Chau. High population numbers at Pui O Marsh, Lantau.

Species	Local Status	Habitat	Description	Distribution in Hong Kong
Neurothemis fulvia	C	Cultivated areas and streams.	An extremely attractive medium-sized dragonfly with very distinctive reddish brown wings. Usually found in higher numbers later in the year during summer. Well established in streams, tanks and irrigation feeders in Lam Tsuen Valley.	Common and widespread. Records from Sam A Chung, Hoi Ha, Lam Tsuen Valley, Tai Po Kau, Tai Mong Tsai, Ho Chung, Tai Po Market and Sha Lo Tung.
Trithemis aurora	A	Mountain, ravine and lowland streams; marshes; ponds; tanks; irrigation feeders; and ornamental ponds.	An extremely common and brightly coloured scarlet red species. It is a smallish libellulid which is even found in ornamental ponds in urban areas such as Hong Kong Park and Kowloon Park. Emergence occurs in early spring and continues into late autumn. Males often seen on hot sunny days with abdomen raised vertically towards the sun to reduce heat uptake.	Abundant and widespread throughout Hong Kong and the New Territories.

A = Abundant; C = Common; FC = Fairly Common.

Extracted from Wilson 1995 and 1997.

ANNEX B

Annex B: Possible Wetland Species for the Compensatory Habitat Areas

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Acorus gramineus	Streamside, margin of ponds	*	***	SS	Moderately widespread: S & SE Asia.	Common along most streams	Erect herb 0.2-0.5m, semi-submerged		HKFWP	
Alocasia marcrorrhiza	Lowland forest, streamside, FW marsh	*		S	Moderately widespread: S China, SE Asia, India.	Common	Herb, 0.8-2.5m	Bright orange berry eaten by birds	CMHHK 3	May be originally cultivated but naturalized now
Apluda mutica	FW marsh, streamside, hillside grassland	*		S	Widespread: S China, SE Asia, India, Australia, Africa.	Common	Grass 0.5-2.0m, may be semi-submerged.		Flora of China 10:2, Grass & Sedges of HK	
Azolla pinnata	Paddy field	*		F	Moderately widespread: E Asia.	Common in most FW marsh: Hau Tok	Floating herb		HKFP, HKF	
Bacopa monnieri	FW/Brackish marsh, abandoned paddy field, beach	**		S	Widespread: Pantropical.	Rare: Sam A Chung	Prostrate herb (semi-submerged), 5-10cm		Flora of China 67:2, Photo:2:12	
Blyxa albertii	FW pond/ marsh, paddy field	*		Sub	Moderately widespread: S China, Japan, SE Asia.	Rare:Sai Keng (Sai Kung)	Submerged herb, 10-20cm		Flora of China 8	
Ceratopteris thalictroides	FW marsh, abandoned paddy field	**		SSS	Widespread: Pantropical.	Moderately common: Sam A Chung (NENT), Lai Chi Woo (Sai Kung)	Semi-submerged herb, 20-50cm		HKFP, HKF, Photo:2:9,10	
Cleistocalyx operculatum	Streamside, paddy field, FW marsh	**		SSS	Widespread: S China, India, SE Asia, Australia.	Common along streams	Tree, 4-15m	Fruit fleshy	HKT, Flora of China 53:1	Fruit edible to humans
Coix lacryma-jobi	FW marsh, abandoned paddy field	*		SSS	Widespread: China & Pantropical.	Common near old villages	Tall grass 1.5-2.5m, mainly cultivated		Flora of China 10:2, Grass & Sedges of HK	
Colocassia esculenta	FW marsh, abandoned paddy field	*		SS	China & India.	Common in most old villages	Erect herb 1-1.5m, semi-submerged		HKFWP	Widely cultivated for its edible stem tuber

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Cyclosorus interruptus	FW marsh, abandoned paddy field	**		SSS	Widespread: SE Asia, India, Africa.	Common in most marshland areas	Semi-submerged herb, 20-50cm		HKFP, HKF, Photo:1:1	
Cyperus difformis	FW/Brackish marsh	**		SS	World-wide.	Common: Tin Shui Wai, Mai Po, Sai Kung.	Sedge 0.3-0.5m		Flora of China 11, Grass & Sedges of HK, Photo:1:3	
Cyperus distans	FW marsh, abandoned paddy field, grassland, roadside.	*		SS	World-wide.	Common: Tin Shui Wai	Sedge 0.4-0.7m, annuals		Flora of China 11, Grass & Sedges of HK, Photo:1:7	
Cyperus haspan	FW marsh, abandoned paddy field, grassland, Streamside.	*		SSS	World-wide.	Common: Wu Kau Tang, Sai Kung, Ngong Ping (Ma On Shan), Lantau	Sedge 0.2-1.0m, semi-submerged.		Flora of China 11, Grass & Sedges of HK, Photo:1:13,14	
Cyperus imbricatus	FW marsh, abandoned paddy field	*		SS	Widespread: SE Asia.	Common: Tin Shui Wai, Lai Chi Woo (Sai Kung)	Sedge 0.5-1.2m, semi-submerged, annual?.		Flora of China 11, Photo:1:8,9	
Cyperus iria	FW marsh, abandoned paddy field	*		SS	World-wide.	Common: Tin Shui Wai	Sedge 0.2-1.0m, semi-submerged, annual.		Flora of China 11, Photo:1:10	
Cyperus pilosa	FW, Brackish marsh, abandoned paddy field	**		SS	Widespread: SE Asia, Australia, Africa.	Moderately common: Wu Kau Tang, Sam A Chung, Sai Kung, Tin Shui Wai	Sedge 0.5-1.2m, Semi-submerged.		Flora of China 11	
Diplazium esculantum	FW marsh, abandoned paddy field	**	**	SSS	Moderately widespread: India, SE Asia to Japan.	Moderately common: Chek King (Sai Kung), Liu Pok (Lok Ma Chau), Hok Tau, So Lo Pun (NENT)	Semi-submerged herb, 50-100cm		HKF	
Eleocharis dulcis	FW marsh & abandoned paddy field	**		SSS	Moderately widespread: China, Indochina, India, Japan.	Rare: Shui Hau, Luk Keng,	Sedge 0.5-1.2m, mainly cultivated or naturalised, semi-submerged		Flora of China 11, Grass & Sedges of HK	"Water Chestnuts"

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Eleocharis fistulosa	FW marsh & abandoned paddy field	*		SSS	Moderately widespread: S China, SE Asia, India.	Moderately common: Shui Hau (Lantau) & Cheung Sheung (Sai Kung)	Sedge 0.2-0.6m, semi-submerged		Flora of China 11, Photo:3:15,17,26 ,27	
Eleocharis oshrostachys (*E. varigata* in HK checklist)	FW/ Brackish marsh & abandoned paddy field	**		SS	Moderately widespread: S China, SE Asia, India	Rare: Lai Chi Woo (NENT), Shui Hau (Lantau)	Sedge 0.2-0.6m, semi-submerged		Flora of China 11, Photo:3:15,16	
Eleocharis plantaginei-formis	FW/ Brackish marsh & abandoned paddy field	**		SS	Moderately widespread: S China, Japan, SE Asia, India..	Rare: Lai Chi Woo, Sam A Chung (NENT), Tin Shui Wai	Sedge 0.2-0.6m, semi-submerged		Flora of China 11, Photo:2:8	
Eleocharis retroflexa (*E. chaetaria* in Flora of China)	abandoned paddy field	*		SS	Moderately widespread: S China, Indochina, India.	Rare: Hoi Ha, Cheung Sheung (Sai Kung), Shui Hau (Lantau)	Sedge 0.1-0.2m		Flora of China 11, Photo:3:23-25	
Eleocharis tetraquetra	FW marsh, streamside,	*		SSSS	Widespread: South China to Australia	Very Rare: Tai O	Sedge 0.4m , nearly completely submerged		Flora of China 11	
Equisetum debile	Lowland streamside	*		SS	Moderately widespread: S & E China, SE Asia, India.	Moderately common: Tai Po, Wu Kau Tang, Brides Pool, Sha Lo Tung	Herb, 0.5-1.0m		HKFP, CMHHK 2, HKF	
Eriocaulon setaceum	Streamside	*		SS	Moderately widespread: S China, Indochina, India.	Rare: Kau Sai Chau (Sai Kung)	Erect Herb, 10-30cm, semi-submerged			
Eriocaulon sexangulare	FW marsh, abandoned paddy field, streamside	*	*	S	Moderately widespread: S China, Indochina, India.	Common: Shui Hau (Lantau), Cheung Sheung (Sai Kung)	Erect Herb 10-50cm, semi-submerged		Flora of Zhejiang 7, CMHHK 5	
Eucalyptus robusta	Sandy marshy heath	*		S	Australia.				Flora of New South Wales 2	fast growing tree but is an exotic
Fimbristylis acuminata	abandoned paddy field	*		SS	Moderately widespread: S China, SE Asia.	Moderately common: Lai Chi Chong, Hoi Ha (Sai Kung), Sam A Chung, Lai Chi Woo (NENT)	Sedge 0.2m		Flora of China 11	

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Fimbristylis aestivalis	FW marsh & abandoned paddy field	*		SS	Moderately widespread: S China, Japan, India, Australia.	Moderately common: Sai Kung, Lai Chi Woo, Tin Shui Wai.	Sedge 0.1-0.2m		Flora of China 11, Grass & Sedges of HK	
Fimbristylis complanata	FW marsh & abandoned paddy field	*		S	Moderately widespread: S China, Japan, SE Asia, India.	Moderately common : Cheung Sheung, Ngong Ping (Sai Kung), Wu Kau Tang,, Lai Chi Woo (NENT)	Sedge 0.2-0.4m		Flora of China 11, Photo:3:12	
Fimbristylis miliacea	FW marsh & abandoned paddy field	*		S	Moderately widespread: S China, Japan, SE Asia, India.	Moderately common: Sai Kung, Lai Chi Woo, Tin Shui Wai.	Sedges 0.2-0.4m		Flora of China 11, Grass & Sedges of HK	
Fimbristylis nutans	FW marsh & abandoned paddy field	*		SS	Moderately widespread: S China, Japan, SE Asia, India.	Very Rare: Cheung Sheung (Sai Kung)	Sedges 0.4-0.6m, semi-submerged		Flora of China 11	
Fimbristylis tetragona	FW/Brackish marsh, abandoned paddy field	**		S	Widespread: E Asia, Australia	Very Rare: Shui Hau (Lantau)	Sedge 0.4-0.6m, semi-submerged		Flora of China 11	
Floscopa scandens	Streamside, FW marsh	*	***	SS	Moderately widespread: E Asia & Australia	Common: Sai Kung, NENT	Creeping herb 20-30cm, semi-submerged.		HKFWP, Photo:3:2,3	
Fuirena ciliaris	FW/Brackish marsh, abandoned paddy field	*		SSS	Widespread: Tropics of Asia & Australia.	Very Rare: Shek Pek (Lantau)	Sedge 0.2-0.3m		Flora of China 11, Photo:3:4,5	
Fuirena umbellata	FW/Brackish marsh, abandoned paddy field	*		SS	Widespread: Pantropical.	Common: Yung Shu O, Sum Chung, Cheung Sheung, Ko Tong (Sai Kung), Wu Kau Tang, Lai Chi Woo (NENT), Shek Pek, Shui Hau (Lantau), HK Is.	Sedge 0.6-1.2m, semi-submerged		Flora of China 11, Grass & Sedges of HK	

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Glochidion hirsutum (=*G. dasyphyllum*)	Lowland forest, FW marsh, abandoned paddy field	**	*	SS	Moderately widespread: S China, India, Indochina.	Common: Sai Kung, Wu Kau Tang	Tree, 3-15m		HKS	
Hedychium coronarium	FW marsh, abandoned paddy field, streamside	*		SS	Moderately widespread: S China to Australia.	Common in most old villages	Erect herb 1.0-2.0m, semi-submerged		HKFWP, CMHHK 6	Widely cultivated for its large, fragrant flowers
Hygrophila salicifolia	FW marsh, abandoned paddy field	*		SS	Moderately widespread: S & SE Asia.	Common: Lai Chi Woo	Semi-submerged herb, 40-60cm		CMHHK 6	
Impatiens chinensis	Streamside, FW marsh, abandoned paddy field	*		SSS	Moderately Widespread: S China, India, Indochina.	Common: Wu Kau Tang, Ngong Ping (Sai Kung)	Herb, 0.2-0.5m, semi-submerged		CMHHK 4, Photo:1:15-18	Red flower, large & attractive
Isachne globosa	FW marsh, abandoned paddy field	*		SS	Widespread: China, SE Asia, India, Australia, Pacific Islands.	Common	Grass 0.2-0.3m, semi-submerged		Flora of China 10:1, Grass & Sedges of HK, HKFWP	
Junus effusus	FW marsh, abandoned paddy field	*	*	SSS	World-wide.	Rare: Luk Keng, Cheung Sheung (Sai Kung), Tai Mo Shan	Grass 0.8-1.0m, semi-submerged		Flora of Zhejiang 7, Photo:3:29,30	
Junus primatocarpus	FW marsh, abandoned paddy field	*		SS	Widespread: S & Central China and Japan.	Moderately common: Lai Chi Woo (NE NT), Lai Chi Chong, Cheung Sheung (Sai Kung), Shui Hau (Lantau),	grass 0.1-0.3m		Flora of Zhejiang 7, HKFP	
Lemna minor	Paddy field	*		F	Widespread: Pantropical	Common in most FW marsh: Yuen Long	Floating herb		HKFP	
Lepidosperma chinensis	Sandy Streamside, hillside grassland.	*		S	Restricted to S China & Malaysia.	Very Common: on local hillside and along stream.	Sedges 0.5-1.2m		Flora of China 11, Flora of Zhejiang 7	

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Limnophila aromatica	FW marsh, abandoned paddy field, stream	**		SS	Moderately widespread: S & SE Asia, Australia.	Common: NENT	Semi-submerged herb, 20-30cm		CMHHK 4, Flora of China 67:2	
Limnophila chinensis	FW marsh, abandoned paddy field, stream	*		SS	Moderately widespread: S & SE Asia, Australia.	Common: Sai Kung	Semi-submerged herb, 20-30cm		Flora of China 67:2	
Linderna antipoda	FW marsh, abandoned paddy field, stream, roadside	**		S	Moderately widespread: S & SE Asia, Australia.	Common: Sam A Chung, Tin Shui Wai	Prostrate herb, 5-15cm		CMHHK 6	
Linderna crustacea	abandoned paddy field, stream, roadside	*		S	Widespread: S & SE Asia , Japan.	Common: Lai Chi Woo, Tin Shui Wai	Prostrate herb, 5-10cm			
Lipocarpha senegalensis	FW marsh, abandoned paddy field	*		SS	Moderately widespread: S China, SE Asia, India.	Moderately common: Wu Kau Tang, (NENT), Cheung Sheung (Sai Kung)	Sedge 0.4-0.6m, semi-submerged		Flora of China 11, Photo:3:10,11 & 2:1	
Ludwigia adscendens	Lowland stream, FW marsh, paddy field	*		SSS/F	Widespread: Tropical and subtropical Asia.	Common: Tai Po	Herb, semi-submerged, floating.		HKFP	
Mapania sinensis	FW Forest sandy streamside & marsh	*	***	S	Moderately widespread: S China, SE Asia.	Rare: Sha Tok Kok.	Sedge 0.5-0.8m		Flora of China 11	
Melastoma sanguineum	Hillside shrubland, FW marsh, abandoned paddy field, stream	*		SS	S China, India, SE Asia.	Common locally in shrubland & paddy field	Shrub, 1.5-3m	Fruit with flesh pulp, eaten by bird.	CMHHK 1, Flora of China 53:1	Large pink flower
Microstegium ciliatum	FW marsh, abandoned paddy field, streamside, roadside.	*		SS	Moderately widespread: S China , Indochina, India.	Common: Tin Shui Wai, Fung Lok Wai	Creeping grass 10-30cm, can be semi-submerged		Flora of China 10:2,	
Nepenthes mirabilis	FW sandy marsh & streamside	*	**	S	Widespread.	Restricted	Creeping herb; Insectivorous	Insectivorous		Protected
Nelumbo nucifera	abandoned paddy field	*		SSS	Widespread: E & S Asia to Australia.	Rather Rare	Submerged herb, 1m		HKFP, CMHHK 5	Widely cultivated for its seed & rhizome

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Ottelia alismoides	FW pond/ marsh, paddy field, stream	*		Sub	Widespread: S & SE Asia to Australia, Africa.	Not seen	Submerged herb, 20cm		Flora of China 8	
Pandanus forceps	Forested Bogs or sandy marshes	*	***	S/T	Widespread: S Asia to Australia.	Common in hillside forests	Large spiny herb 1.5-2.5m		Flora of China 8	Has spines on leaves
Panicum repens	FW marsh, abandoned paddy field, streamside, roadside	*		SSS	Widespread: Pantropical & Pansubtropical.	Common	Creeping grass 0.5-1.0m, semi-submerged		Flora of China 10:1, Grass & Sedges of HK, HKFWP	
Paspalum orbiculare	Grassland, wasteland, FW marsh, abandoned paddy field	**		S	Widespread: S China to Australia.	Common: Yuen Long	Grass 0.3-0.5m		Flora of China 10:1, Grass & Sedges of HK	
Philydrum lanuginosum	FW marsh, abandoned paddy field, streamside	*		SS	Widespread: S Asia to Australia.	Common: Sai Kung, NENT	Erect herb 0.5-1.0m, can be semi-submerged		CMHHK 6, HKFWP	
Polygonum glabrum	Streamside, FW marsh, abandoned paddy field	*		SS	Widespread: Pantropical.	Common: Ngon Ping	Herb, 0.2-0.5m, semi-submerged		Flora of Hainan 1, Flora of Fujian 1, Photo:1:11,12	
Polygonum hydropiper	Streamside, FW marsh, abandoned paddy field	**		SS	Widespread: Tropical & subtropical Asia.	Common: Sam A Chung (NENT)	Erect herb, 0.5-1.0m, semi-submerged		Flora of Hainan 1, Flora of Fujian 1, Photo: 2:15,16	
Polygonum jucundum	Streamside, FW marsh, abandoned paddy field	*		SS	Moderately widespread: S.& E China, India, Japan.	Common : Yung Shu Au (NENT)	Herb, 0.2-0.5m,		Flora of Hainan 1, Flora of Fujian 1,	
Pycreus flavidus (=*Cyperus f.* in H.K checklist)	FW marsh, abandoned paddy field	*		SS	Widespread: E Asia, Australia, Africa.	Common: Wu Kau Tang, Sam A Chung (NENT), Yung Shu O (Sai Kung)	Sedge 0.6-1.0m		Flora of China 11, Photo:2:7 & 3:7,8	

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Pycreus polystachyos (=*Cyperus p.* in HK checklist & HK Grass & Sedges)	Brackish/FW marsh, abandoned paddy field, Seashore	**		S	Moderately widespread: SE China, Japan, India, Indochina.	Very Common: on most seashores, paddy fields and marshes. Tin Shui Wai	Sedge 0.6-1.0m		Flora of China 11, Grass & Sedges of HK	
Pycreus sanguinolentus (= *Cyperus s.* in HK checklist)	FW marsh, abandoned paddy field	*		S	Restricted to S China & Indochina.	Moderately common: Wu Kau Tang, Sam A Chung (NENT), Yung Shu O (Sai Kung)	Sedge 0.2-0.4m		Flora of China 11, Photo: 2:13	
Rhynchospora chinensis	FW marsh, abandoned paddy field	*		SS	Moderately widespread: S & E China, Japan, India, Indochina, Madagascar.	Moderately common: Cheung Sheung (Sai Kung), Wang Shan Keuk (NENT)	Sedge 0.2-0.8m, may be semi-submerged.		Flora of China 11	
Rhynchospora corymbosa	FW marsh, abandoned paddy field	*		SS	Moderately widespread: S & E China, Japan, India, Indochina, Madagascar.	Restricted: Sha Lo Tung, Tai O (Lantau)	Sedge 0.8-1.5m, may be semi-submerged.		Flora of China 11	
Rotala rotundifolia	Lowland stream, FW marsh, abandoned paddy field	*		SSS	Widespread: China, India, SE Asia, Japan.	Common: Sai Kung,	Prostrate Herb, semi-submerged, 5-10cm		CMHHK 6, Flora of Guangdong 3, Photo:3:31	With pink inflorence
Sagittaria trifolia	FW marsh, abandoned paddy field	*		SSS	Moderately widespread in Asia.	Kadoorie Farm	Semi-submerged herb, 0.2-0.7cm		HKFWP	
Saurauia tristyla	Streamside, FW marsh	*		S	Moderately Widespread: S China, India, SE Asia.	Common: Sai Kung, Shing Mun	Tree, 3-5m	Fruit fleshy.	Flora of Guangdong 3	
Saururus chinensis	FW Forest marsh, abandoned paddy field	*	*	SS	Moderately widespread: S & E China, Japan, SE Asia.	Rare: Ngoon Ping (Sai Kung), Sha Lo Tung (Tai Po)	Herb, 0.2-0.5m, semi-submerged		CMHHK 4, HKFP	

Species	Habitat	Salt tol.	Shade	Sub.	Regional distn	Local distn	Description	Fruit	Ref.	Notes
Scheonoplectus mucronatus (*Scripus subulatus*)	FW-brackish marsh	*		SSS	Widespread.	Restricted: Mai Po	Herb, 1-1.5m, semi-submerged			
Scleria sumatrensis	Forest Streamside, FW marsh, shrubland	*	**	S	Moderately widespread: S China, SE Asia, India, Indochina.	Common	Sedge 0.5-2.0m		Flora of China 11	
Sphaerocaryum malaccense	FW marsh, abandoned paddy field	*	*	SS	Moderately widespread: S China, SE Asia, India.	Rare: Lai Chi Woo (NENT), Cheung Sheung (Sai Kung)	Prostrate grass 5-20 cm , semi-submerged		Flora of China 10:1	
Symploccos laurina	Lowland forest, near paddy field	*	**	SS	S China, Indochina, India.	Common in lowland forest & shrubland	Tree, 4-8m	black fleshy fruit	HKT, HKS	
Viburnum odoratissimum	Streamside forest, abandoned paddy field	**	**	SS	Moderately widespread: S China, India, SE Asia.	Common: in Lowland forest	Tree, 4-8m	Red Fleshy berry	HKT, CMHHK 7	
Xyris indica	Streamside, FW marsh	*	*	SS	Moderately widespread: Tropical Asia & Australia.	Rare: Tung Chung, Pokfulam, Lai Chi Woo	Erect herb, 20-30cm.		Photo:2:19-21	

Abbreviations: **CMHHK** = Cheung and Li, 1991; **HKF** = So, 1994; **HKFP** = Hodgkiss, 1978; **HKS** = Thrower, 1971; **HKT** = Thrower, 1988; **HKCP** = Thrower, 1983.

Salt Tol. = Salt Tolerance: *** : can survive in very saline soil, e.g. intertidal zone
* : cannot survive in saline soil

Sub. = Submersibility
T: can be partly submerged or terrestrial,
S: Can be partly submerged by freshwater, about 1cm depth
SS: Can be partly submerged by freshwater, about 10cm depth
SSS: Can be partly submerged by freshwater, about 20cm depth,
SSSS: Can be partly submerged by freshwater, about 30cm depth or more,
Sub: Submerged under water
F: Floating plant.

Source: Derived from research undertaken by NG Sai-chit, Department of Ecology & Biodiversity, University of Hong Kong.