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Ecological Study of Freshwater Wetland Habitats in Hong Kong

prepared for the
Agriculture & Fisheries Department,
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by

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1. Introduction & preamble

On a world-wide basis, freshwater wetlands are among the most threatened wildlife habitats (e.g. Dugan, 1990, 1993; 1994; Finlayson & Moser, 1991; Prins & Wind 1993). Throughout Asia in particular they have come under extreme pressure from human activities (Scott, 1991; Dugan, 1993). After draining and filling, wetlands provide prime, flat land which is ideal for agriculture or urban development. Unfortunately, infilling, draining and fragmentation all carry known risks of species loss (e.g. Tscharntke, 1992). Increased urbanization and development of the New Territories constitute the greatest threats to freshwater wetlands in Hong Kong. Most of these wetlands lie outside Country Park boundaries and are thus not afforded legal protection by existing legislation. The situation is exacerbated because unmanaged freshwater wetlands in Hong Kong comprise, in the main, abandoned fishponds or flooded fields associated with villages. Most of this land is privately owned and thus vulnerable to pressures arising from the desire to put the land to 'productive use'. The recent (March 1995) designation by Government of the Mai Po Marshes and Inner Deep Bay as a Wetland of 'International Importance' under the Ramsar Convention provides protection for a sizeable area of brackish wetland habitat, but has done little to alleviate the threats to freshwater wetlands. This is important because brackish wetlands support a different flora and fauna from their freshwater equivalents. Freshwater wetlands contain a much wider array of plants and animals, including submerged macrophytes (freshwater plants) and a range of aquatic insects (such as dragonflies and damselflies); in addition, amphibians are confined to fresh water and are not found in brackish wetlands.

Despite the growing recognition that freshwater wetlands are threatened severely by urbanization and development of rural areas in Hong Kong, we have little idea about where the most important wetlands are and what they contain. Such information is vital for the conservation of these habitats. Effective conservation requires that sites can be ranked with respect to their relative importance in supporting biodiversity. This is essential, because limited resources must be deployed most efficiently for the protection of important and representative sites.

A complete species inventory for each site would be a useful conservation objective in this context but, given the seasonal variation in site use by certain elements of the biota (migratory birds, amphibians) and the fact that many invertebrates are represented only by their juvenile stages for much of the year, such a list cannot be exhaustive without many visits to each site throughout (at least) one calendar year. In addition, rare species will be overlooked simply because their rarity reduces the chances of encounters with them. However, a near-complete list including the bulk of the species at each site is a worthwhile objective, particularly if it involves repeated visits to each site that are timed to take account of the wet and dry seasons. Appropriate multivariate analysis of a sufficiently large data set of this type will disclose patterns in species diversity among sites, and reveal those sites which have unusually high species richness or which contain rare species. That is the main objective of the current study. Similar approaches to the evaluation of wetland sites for conservation have been applied with success elsewhere (e.g. Eyre *et al.*, 1990; Matthews *et al.*, 1991; Growns *et al.*, 1992).

Given that most wetlands fall outside Hong Kong's protected-area system, it is unlikely they can all be safeguarded from development. It is thus essential to identify those sites which contain rare species or concentrations of biodiversity so that Government can take steps to protect them. The final selection of wetlands to be protected will depend on non-biological factors: specifically, site 'viability' (Davies & Giesen, 1994). This must take account two main considerations: how feasible is protection (or management) of the site? How long is the site likely to retain its conservation value? The answers to these questions will depend, to a great extent, on land-use changes in localities surrounding the wetland. An extra level of complexity is present because wetlands are transitional habitats (or successional 'seres') and thus their effective conservation cannot be a passive process; it must include some monitoring of the rates of habitat change and, where necessary, involve a degree of active management.

In summary, the main aims of the present report are:

(a) To inventory local wetlands and identify those sites with high biodiversity;

(b) To classify local wetlands into groups or ecotypes and to identify, wherever possible, the environmental variables or conditions that influence their characteristics, biodiversity and conservation value. Such classification provides an essential underpinning for conservation recommendations, since it will be necessary to include at least one wetland of each ecotype in the final list of sites selected.

(c) To rank sites on the basis of their conservation value, and recommend to Government those sites which are particularly worthy of conservation;

(d) To draw attention to any species which are endangered, threatened or of ecological significance, and to identify taxa which may be used as environmental 'indicators' of wetland characteristics.

2. Materials & Methods

2.1 Site selection

Thirty-three wetland sites were chosen throughout the territory on the basis of vegetation maps and suggestions from local naturalists, and included in a preliminary survey (see Figure 1 & Table 1). Sites had to meet pre-defined criteria, that is, they had to be freshwater (with salinity less than 10 ppt: Lewis & Perkins, 1978) and unmanaged, representing a range of habitat types, location and size. Emphasis was placed on sites lying outside Country Park boundaries. A minimum size of 5 m^2 was adopted to eliminate small, temporary rain pools. Managed fish ponds were excluded from this investigation because of their periodic draining and high nutrient loads, although they are the subject of a separate 18-month consultancy study commissioned by Government. Reservoirs were not included in view of their size, artificial nature and protection under existing ordinances. Streams were excluded from the present study also, since these habitats do not constitute what is commonly understood as 'wetland', and because Hong Kongs stream flora and fauna have already been studied and reviewed extensively (Dudgeon, 1992; Dudgeon & Corlett, 1994 and references therein).

After exploratory sampling, five wetland sites were removed from the initial list of 33 sites (Table 1). Three of these sites (So Lo Pun pond, Yung Shue Au reedbed, and Tai O reedbed) had salinities over 10 ppt and were brackish. Two other sites (Tung Chung marsh and Lung Kwu Sheung Tan pond) were omitted because ongoing construction work in the vicinity resulted in disturbances that eventually led to the draining and infilling of parts of these wetlands. In consequence, a total of 28 sites were selected for in-depth study (Table 2 & Figure 1). Detailed descriptions of each site are given below (see **Site Descriptions**), where a general account of their biota is given also. All but one of the sites sampled were close to but outside Country Park boundaries, and were located on private land. Only Tai Lam Country Park marsh was within a Country Park and therefore protected by the Country Parks Ordinance (1996).

Twenty one study sites were marshes or abandoned paddy fields, and seven were open-water ponds. Nineteen sites were located on the mainland New Territories and nine sites were on outlying islands. They ranged in altitude from sea-level (0 m asl) to 680 m asl. Most sites overlay volcanic rock, but a few sites were also located in regions with granitoid and metamorphosed sedimentary rocks (Table 2). The majority of sites sampled were situated in valleys and therefore received water and nutrients from stream run-off. Wetlands were classified into three categories which described their degree of 'wetness (Table 2): permanent wetlands were those that were inundated throughout the year; semi-permanent wetlands were dry during the latter stages of the dry season, although only for one or two months of the year (January-February); and, seasonal wetlands were those that had a distinct dry period, usually lasting throughout the dry season (early October-late March), and were flooded between April and September.

2.2 *Sampling strategy and measurement of environmental variables*

Most sites were visited at least twice during the year, once in the wet season and once during the dry season (Table 2) to account for the seasonality of the freshwater biota (Dudgeon, 1992; Dudgeon & Corlett, 1994). Upon the first visit, a general description was made of the location, noting physical features such as wetland type, area, and dominant vegetation. Permanency or the degree of 'wetness was assessed after at least two visits had been made to the site. Attempts were made to determine the source of the water in the marsh; i.e. whether it was stream-fed or if water was supplied through ground-water discharge. An assessment of ongoing or potential human impact was made also, noting particularly the accessibility of sites, the proximity of villages, any potential or on-going construction, and the discharge of wastes (if any) into the wetland or its feeder streams. Area and altitude of each wetland were estimated from 1:20,000 maps.

Measurements of a number of environmental variables were made at all wetland sites. These included water depth, temperature, salinity, dissolved oxygen (DO), conductivity, and *p*H which, during initial stages of the survey, were made in the field using a calibrated measuring stick, a standard alcohol thermometer, an optical refractometer, and a Checkmate© modular testing meter respectively. Measurements of salinity, DO, conductivity, and *p*H based on water samples taken in the field and measured immediately upon return to the laboratory were compared with measurements taken in the field: they were not different. Consequently, determination of these variables during later stages of the study was based on laboratory measurement of water samples taken in the field.

Water samples were taken from the field to the laboratory in 1-L polyethylene bottles, and immediately vacuum-filtered through Whatman glass microfibre filters (GF/F: pore size 0.7 m) to remove suspended particles. Salinity was measured with an Atago® Salinity Hand Refractometer and determined as parts per thousand (ppt). The instrument was calibrated with distilled water (0 ppt salinity). Electrochemistry was determined by using the Checkmate® Modular Testing System consisting of a meter module and sensor probes for DO, conductivity, and *p*H. DO measurements were taken with the meter after a two-point calibration with zero and hundred percent oxygen solutions. Three measurements were made and averaged to obtain a standardized reading. Corrections for salinity and barometric pressure were made by comparing values to references in standard tables listing the variances. Oxygen levels were determined as a percentage and then converted to mg/l. Conductivity measurements were taken after calibration in air and in a 1413 S standard solution. Three readings were taken from each water sample to obtain a mean conductivity reading. *p*H was measured after a two-point calibration with buffer solutions of *p*H 4 and *p*H 7. Compensation for temperature was made automatically with the thermistor sensing device fitted into the *p*H electrode. Again, three readings were taken for each water sample and the mean value recorded.

Other aspects of water chemistry was determined using a Pharmacia® LKB Biochrom Novaspec II spectrophotometer water analysis system. Nitrate and nitrite concentrations were determined by the titanous chloride method; ammonia determinations used the indophenol blue method, while phosphate was measured by the vanadomolybdate method. All of these analytical procedures are recommended as standard methods by the American Public Health Association (APHA, 1995).

2.3 Faunal sampling

The wetland survey included both plants and animals, but particular attention was paid to the faunal elements which tend to be more diverse than the wetland floral community (e.g. Dugan, 1990; Scott, 1991). Sampling methods for the freshwater fauna are fairly well-established (e.g. Eyre *et al.*, 1990; Spellerberg, 1991; Growns *et al.*, 1992; Kerans *et al.*, 1992; Batzer *et al.*, 1993), and aquatic animals have been used extensively as indicators of habitat conditions and conservation values (see, for example, recent books by Spellerberg [1991] and Rosenberg & Resh [1992]). Moreover, macroinvertebrates have recently been employed in classifying wetland habitats (e.g. Growns *et al.*, 1992) because they provide a better measurement of habitat type than a series of 'spot' measurements of environmental variables (Stewart *et al.*, 1986; Eyre *et al.*, 1990; Matthews *et al.*, 1991). For this reason, elucidation of the community structure of wetland macroinvertebrates was stressed during the present survey.

Macroinvertebrate sampling was undertaken using a D-shaped hand net with a diameter of 30 cm and a mesh size of 1 mm. Qualitative samples were taken in as many microhabitats as possible: flowing and stagnant waters, deep and shallow waters, shaded and unshaded areas, and in and around as many vegetation and substratum types as were represented in the sampled wetland. Two sampling methodologies were adopted. The first was used in wetlands overgrown with vegetation and lacking extensive areas of open waters. It involved vigorously sweeping an undisturbed area with the hand-net as close to the substratum as possible. This method was successful in capturing surface-dwelling macroinvertebrates as well as those in the water column and attached to submerged vegetation. It was quite effective in the capture of fish also. The second approach involved a similar technique but was used after the benthos had been disturbed. This involved trampling the vegetation and 'kicking the surface layers of the substratum to collect organisms that might otherwise be inaccessible by the first technique. Ponds, with extensive areas of open water, were sampled in a slightly different manner. Rather than sweeping the net through open water where few macroinvertebrates are found, samples were taken close to the pond banks, in and around emergent and submerged vegetation., where animals tended to congregate. Duplicate invertebrate samples were taken from each site and placed into plastic bags, filled with 10% formalin as a preservative. They were taken to the laboratory for processing (see below).

Fish captured along with the macroinvertebrates were identified in the field. Methods for sampling fishes in marshland habitats are not well established (Schreck & Moyle, 1990; Streever & Crisman, 1993), but we have no evidence that rare species were overlooked in the present study. Specimens that could not be identified with confidence (particularly immature individuals) were either preserved in 10% formalin or taken back alive to the laboratory for identification; names used herein follow synonymies given in the recent checklist by Chong & Dudgeon (1992). A few small individuals (of *Macropodus* spp.) were reared to adult size in the laboratory in order to confirm their specific identity. Notes were made describing any adult amphibians encountered: determinations were made according to Karsen *et al.*, (1986) and Zhao & Adler (1993). Some amphibian larvae were laboratory-reared to froglet stage in order to confirm species identities. The identification of amphibians was confirmed by Michael W.-N. Lau (Department of Ecology & Biodiversity, The University of Hong Kong). Adult dragonflies were captured using a long-handled net (42 cm diameter and 140 cm circumference), and identified according to Wilson (1995a). Particular efforts were made to collect rare and endemic dragonflies while little attention was paid to those species which Wilson (1995a) considers common and/or widespread (e.g. libellulids such as *Orthetrum sabina sabina* and *Pantala flavescens*).

Macroinvertebrate samples taken from the field were processed in the laboratory by washing them into stacked Endecott's sieves of 2057 and 500 m pore size. Large pieces of vegetation were washed into the sieves and discarded after inspection to remove any macroinvertebrates. The sieved samples were transferred to petri dishes and preserved in 70% alcohol. Samples were sorted under a dissecting microscope at 10x magnification and all macroinvertebrates (>500 m body length) removed for identification and enumeration. Samples with large amounts of detritus were sub-sampled. Identification of macroinvertebrates was based on a number of keys (Merritt & Cummins, 1978; Peckarsky *et al.*, 1990; Clifford, 1991; Morse *et al.*, 1994) and in consultation with local and overseas experts (Dr. M. Jäch and Dr. G. Wewalka, Naturhistorisches Museum, Vienna) and was undertaken to the lowest taxonomic level possible; i.e. species or morphospecies. Morphospecies designation (sometimes using cryptonyms: e.g. *Helochares* complex sp. 1) was employed in instances where the specimens collected were too immature to be identified to species, or in the many cases where the taxonomy of a macroinvertebrate genus or family in Southeast Asia has not yet been fully elucidated by systematists. Rare species - defined as those macroinvertebrates that were found only once across all the sites sampled - were used to calculate a 'rarity index' for each site, where the value of the rarity index for a particular site was obtained by summing the total number of rare species at that site.

Preliminary studies of vegetation suggested a very similar composition at all sites. Field sampling involved an initial general inspection of the dominant vegetation followed by a more detailed investigation using transect lines. This involved laying two 20-m transect lines in the wetland. Each plant morphospecies along the transect was recorded. Transects were laid to cover as many vegetation types as possible. Representatives of each morphospecies were collected and taken back to the laboratory for identification. Identification was undertaken in the laboratory using relevant keys and with the aid of expert opinion (Mr S.T. Chan and Ms Julia Shaw, Department of Ecology & Biodiversity, The University of Hong Kong) and were made down to the lowest taxonomic level possible. Data presented herein represent a summary of the botanical results for all sites, with particular emphasis placed on marshes at Luk Keng, Pui O, Yi O, Shuen Wan and Kuk Po. Where rare or unusual species occur at other wetlands they are mentioned under the individual **Site Descriptions** given below.

2.4 Multivariate analysis of community composition

Data analysis was based upon multivariate gradient analysis techniques (Gauch, 1982; Jongman *et al.*, 1987; Wartenberg *et al.*, 1987; Ter Braak & Prentice, 1988; Ter Braak, 1989; James & McCulloch 1990) employing computer programmes initially developed at Cornell University. Such multivariate ordination analyses have been employed in analysis of wetland communities elsewhere (e.g. Eyre *et al.*, 1990; Matthews *et al.*, 1991; Growns *et al.*, 1992), and are essential because environmental factors covary simultaneously among habitats and may have a variety of influences on wetland characteristics (Brinson, 1993).

An array of methods for multivariate gradient analysis are available, including a variety of direct gradient analyses (which incorporate environmental data in the computations) and indirect analyses (which employ environmental data to explain patterns revealed by ordination of organism data alone). Both indirect and direct gradient analysis may involve either principal components analysis or correspondence analysis (and derivations based on modifications of these techniques). While all of these methods are used by ecologists, they are not equally effective for identifying patterns in ecological data sets (Pielou, 1984; Ludwig & Reynolds, 1988; Matthews *et al.*, 1991). However, only test ordinations after data collection can reveal which techniques will be the most revealing analyses for a particular data set. Thus one result of the present study will be to indicate which ordination technique provides the most informative means of categorising Hong Kong wetlands according to their ecological characteristics. It should also be possible to identify which species (or species combinations) are 'indicators' of particular wetland types (including those wetlands which require protection).

Because it was not obvious which multivariate technique would be most appropriate for analysis of the wetlands data set, a number of indirect gradient analysis techniques were applied, including principal components analysis (PCA), correspondence analysis (CA), and detrended correspondence analysis (DCA). The faunistic data set was analysed at two levels of taxonomic penetration: species and family. The species data set tended to be dominated by rather rare species, which may have reflected sampling error for species occurring at low densities. For this reason those species which occurred only once in all the study sites sampled were deleted from ordination analysis. A large number of rare species will tend to bias the data set by artificially inflating species scores and elevating the weighting given to sites where they appear; hence they distort the subsequent ordination (Jongman *et al.*, 1987).

After initial, exploratory analysis, it was apparent that DCA gave the best ordination results with the greatest spread of species and sites along the first and second ordination axes. The length of the ordination axes (> 4 S.D. units for species-level faunistic data, > 3 S.D. units for family-level faunistic data) indicated that DCA, rather than PCA, was a more appropriate analytical method for the current data set (Jongman *et al.,* 1987). It was employed in all subsequent ordinations. This DCA ordination of species and sites involved detrending by 26 segments. Non-linear rescaling of the axes was done four times with a rescaling threshold of zero. There was no transformation of the faunistic data, which were entered as presence/absence values, and no weights were given to either species, families or sites. Outlying sites (e.g. those which lay > 2.5 S.D. units from their nearest neighbours) were excluded from the ordination (following Jongman *et al.,* 1987) as they distorted the site plot.

The DCA ordination of the species data gave rise to an ordination plot which - upon subjective examination - appeared to represent four groupings of sites (see Section **4.5** and Figure 15). In order to group the sites on a more objective - and robust - basis, they were classified by the application of K-means cluster analysis (Hartigan, 1975; CSS, 1991) to the data set. The faunal data was analysed again in a similar fashion (DCA followed by K-means clustering) using families instead of species in order to classify the apparent site groupings). In this analysis, however, rare families were not deleted. This was because moving up two taxonomic levels (from species through genus to families) reduced the threshold of importance of taxa. That is, groupings at family levels reduced the 'rareness of taxa, thereby minimizing their influence on site scores.

Following DCA and site classification by clustering, mean values for measured environmental parameters (area, altitude, depth, salinity, *p*H, conductivity, DO, ammonia, nitrate, nitrite, and phosphate) were determined for each of the four site clusters (based on species data) and each of the three clusters (using family data), in order to identify which variables differed significantly among site groups. In addition, environmental variables were incorporated into the DCA ordination diagrams using both direct and indirect gradient analyses. Detrended canonical correspondence analysis (DCCA) - the 'direct analytical equivalent of DCA (Jongman *et al.*, 1987) - was employed to integrate the environmental data in the ordination computations. Indirect analysis - whereby environmental variables were added passively into the ordination diagram (i.e. they did not influence site scores or position in the ordination diagram)- was used also.

Indicator species or families for each site group revealed by cluster analysis were identified by three criteria. The simplest method was based upon the significance values for differences in the incidence of each species among site groups indicated by K-means cluster analysis. Those species which had a significantly different (where $P \leq 0.05$) representation among clusters were considered to be suitable potential indicator species. The second approach involved choosing species represented in one cluster and in no others. The third approach depended upon examination of the cluster mean scores of each species across the four clusters. If the mean score in one cluster was more than twice the sum of the mean scores in the other clusters, then that species was considered to be a potential indicator of the cluster in which it had the highest score. Species meeting all three of these criteria were considered indicator species. However, this rather rigorous approach yielded indicator species for only two of the four clusters. Accordingly, indicator species for the other two clusters were identified by relaxing the selection criteria given above, so that species meeting only two (or, in exceptional cases, one) of the three criteria were treated as indicator species. This process was repeated for the family-level data set in order to identify indicator families for the three-cluster site groupings.

Indicator species, as defined here, need not occur at all sites within a cluster group, although this may be the case for some taxa. However, an indicator species (or family) for a particular cluster will be encountered at many of the sites within that cluster, or may be confined to sites in that cluster (or sometimes both). Obviously, a greater number of indicator species in each cluster will tend to increase discriminating power, and *vice versa*. Ideally, therefore, a 'successful' scheme for classifying wetland sites into groups (or clusters) should be accompanied by the identification of several indicator taxa for each group.

We refined the indicator-species analysis, and furthered the site classification so that it could be used to predict the cluster membership of any new sites from which invertebrate community data became available, by analysing the cluster mean scores determined for each species and each family across the site groups. Because the faunal data were included in the ordination and clustering as presence/absence, the occurrence of a particular species in only one site group (cluster) would give rise to a one hundred percent probability score for occurrence at sites in that cluster (or at any other sites with similar environmental characteristics to the site-group members). Likewise, absence of a species for all sites in a cluster would give rise to a zero percent probability of occurring at sites in that cluster (or at sites with similar characteristics). However, a one hundred percent probability score for a species confined to a given cluster can arise if that species is confined to a single site within the cluster or if it occurs at several sites within the cluster. The data can be refined, and used to predict the probability of a species occurrence at any one site in a cluster group, by dividing the number of occurrences at sites in each group by the total number of sites in that group; when multiplied by 100 this figure indicates the chance of encountering a particular species or family at a site in a particular cluster group. The usefulness of this information is that - given a knowledge of their species composition - it can be used to place other, new wetland sites (which may need to be evaluated at a later date) into the clusters identified during the present study.

3. Site Descriptions

3.1 Marshes

Cheung Sheung marsh

Cheung Sheung, situated in the eastern New Territories within the Sai Kung West Country Park district but on private land, was situated on a mid-elevation plateau rising 280 m asl (Figures 1 & 2). It was bordered by Shek Uk Shan in the north and Wa Mei Shan in the south. Cheung Sheung marsh (50Q KV 2290 8286) was a semi-permanent marsh fringed on all sides by secondary forest; a pond was situated approximately 300 m to the west of the marsh. The vegetation within the marsh, like all the other freshwater marshes sampled in this study, was dominated in terms of species richness and individuals by emergent sedges (Cyperaceae) and grasses (Gramineae or Poaceae) (Table 5 & Appendix 1). Macroinvertebrate diversity was well above average (39 species: Table 6), ranking sixth among the study sites in terms of species richness. Note that 'average' species richness as used here applies to those sites where approximately 30 macroinvertebrate species were recorded. Rare species found only at this site were mainly beetles including larvae of *Ilybius* sp. (Dytiscidae) and an Elmidae (possibly an undescribed genus), as well as one rare adult beetle, *Hydrovatus ferrugatus* (Dytiscidae). The elmid larva was an unexpected find since most members of this family inhabit fast-flowing streams. Although the marsh is stream-fed, and water does run through it, flow is usually slow with no riffles. The Black Paradise Fish, *Macropodus concolor* (Belontiidae), was found at Cheung Sheung. Paradise Fishes are relatively common in certain parts of Hong Kong but, until this survey, it was supposed that there was only one species - the Chinese Paradise Fish, *Macropodus opercularis* - in the territory (Chong & Dudgeon, 1992). The 'new species was found at Cheung Sheung and in a few other sites located in the northeastern part of the New Territories, but has not been recorded from anywhere else in southern China. A fuller account of this poorly-known species is given below (see ***Macropodus concolor*: the Black Paradise Fish**).

Yung Shue O marshes 1 & 2

Yung Shue O wetland, located on the eastern border of Three Fathoms Cove into which it drained, yielded two sampling sites (Figures 1 & 2). The wetland was bordered by the village of Yung Shue O along its eastern edge, by Three Fathoms Cove in the west, and by secondary forest in the north and south. Both sample sites were at sea level and were approximately equidistant (500 m) from the coastline. Drainages flowed into the marshland from three mountains: Wong Tei Tung in the north, Kai Kung Shan in the south, and Wa Mei Shan in the east. Yung Shue O site 1 (50 Q KV 2130 8256) was a semi-permanent marsh of approximately 0.1 ha. The vegetation in the area, dominated by grasses, was low-lying and grazed by feral cattle (*Bos taurus*). This site had above-average species richness (35 species: Table 6) but lacked rare macroinvertebrates, although it should be noted that a single individual of the Black Paradise Fish (*Macropodus concolor*) was found.

Yung Shue O site 2 (50 Q KV 2130 8262) was a small (0.01 ha) permanent wetland but more varied in microhabitat than the Yung Shue O site 1. The presence of a stream flowing slowly through the site, in combination with the presence of emergent vegetation such as *Ammannia baccifera* (Lythraceae) and *Colocasia esculenta* (Araceae), sustained a rich assemblage (50 species) of macroinvertebrates. As a result, this marsh ranked second (to Luk Keng marsh) in terms of species richness among all sites sampled. It also contained four rare species. Because Yung Shue O site 2 was only a fraction of the size of Luk Keng marsh (the latter being over 70 times the area of the former), it merits strong consideration as a site for conservation on the basis of its diverse macroinvertebrate fauna. K.D.P. Wilson (Agricultural & Fisheries Department, Hong Kong Government) has recently discovered a possible new species of bog orchid of the genus *Liparis* (Orchidaceae) from the Yung Shue O marshland (Wilson, 1996). In addition to providing habitat for the damselfly, *Pseudagrion rubriceps rubriceps* (Coenagrionidae), which is uncommon in Hong Kong, this site is one of only three known breeding sites for *Nannophya pygmaea* (Libellulidae) - the worlds smallest dragonfly - in the territory (see Wilson, 1995a).

Sham Chung marsh

Sham Chung marsh (50 Q KV 2080 8424) was situated at sea level behind Sham Wan Chung, to the east of the mouth of Three Fathoms Cove (Figures 1 & 2). The village of Sham Chung bordered the eastern side of the marsh which was semi-permanent and fairly large (9.3 ha). This wetland was stream-fed from Shek Nga Tan hill in the north, Wong Tei Tung hill in the south, and Shek Uk Shan in the southeast. A large stream divided the marsh into two approximately-equal parts, and the habitat was traversed by a number of cement walkways. Sampling was carried out both in the marsh habitat and in the slow-moving, low-gradient stream. Sham Chung stood out as an outstanding site for fish with more than half (six) of the total wetland species recorded (10) found here. *Macropodus concolor, Gambusia affinis* (Poeciliidae), *Capoeta semifasciolatus* and *Parazacco spilurus* (Cyprinidae), *Misgurnus* sp. (Cobitidae), and the catfish, *Silurus cochinchinensis* (Siluridae), were present (Table 7). Invertebrate richness was above average (37 species), and eight rare species were recorded making Sham Chung marsh the second-ranked wetland in this regard (Table 6). The rarities included stream specialists such as the mayfly *Choroterpes* sp. (Leptophlebiidae) and the dytiscid beetle, *Neptosternus* sp., as well as a number of larval dragonflies: *Orthetrum* sp. 2 (Libellulidae), *Somatochlora* sp. (Corduliidae) and *Aeschnophlebia* sp. (Aeshnidae).

Yung Shue Au reedbed

Yung Shue Au reedbed (Figures 1 & 3) was situated in the northeast New Territories at sea-level (50 Q KV 1690 9570). Although quite large (4 ha), this wetland was not included in the present study due to its high salinity (26 ppt).

Luk Keng marsh

Luk Keng marsh (50 Q KV 1390 9310) was located in the northeastern part of the New Territories close to the Pat Sin Leng Country Park but outside its boundaries (Figures 1 & 3). It was the largest marsh sampled (approximately 32 ha) and was stream-fed from numerous small hills surrounding the site. The marsh was bordered by two villages, Luk Keng Wong Uk to the west and Luk Keng Chan Uk to the south. Brides Pool Road effectively impounded the wetland along the northern seaward end, creating a barrier between the marsh and Starling Inlet and thereby reducing salt-water intrusion. Three managed fishponds where situated along the northern boundary of the marsh also. Luk Keng was a permanent marsh, but water levels declined dramatically during the dry season and the marsh shrunk to half its wet-season extent. Vegetation was low-lying and dominated by grasses and sedges, but there were distinct patches of reeds, *Phragmites australis*, and large floating grass islands ('sudd') were found here and in no other site. The aquatic fern *Ceratopteris thalictroides* (Parkeraceae) and the Wooly 'Grass' *Philydrum langinosum* (Philydraceae) - which are in decline elsewhere in Hong Kong - were present, together with a high proportion of the territory's total wetland flora. Movements of a resident population of feral cattle created deep channels of open water in the marsh adding to the habitat complexity of the site. In addition, Pitcher Plants (*Nepenthes mirabilis*) occurred along the banks of streams draining into the wetland.

Because of its large size and diverse habitats it was not surprising that Luk Keng supported the greatest number of macroinvertebrate species (62: Table 6), and this array constituted approximately one-third of the total number of species (all sites combined) recorded during the survey. There were seven rare macroinvertebrate species, including beetles - the larvae of *Hydrophilus* sp. (Dytiscidae) and *Hydroporus* sp. (Dytiscidae), and an undescribed species of *Helochares* (Hydrophilidae) - hemipterans (two veliids including *Angilia* sp.) and dipterans (sciomyzids and *Probezzia* sp.: Ceratopogonidae). In addition to invertebrates taken during sampling, adults of two internationally-important species of Odonata occur at Luk Keng: *Mortonagrion hirosei* (Coenagrionidae), previously thought to be endemic to Japan and where it is now endangered, and *Nannophyosis clara* (Libellulidae), a rare dragonfly recorded in only a few locations in southern China (Wilson, 1995a). *Rhyothemis triangularis* (Libellulidae) and *Diplacodes nebulosa* (Libellulidae), although not rare in the region, were uncommon local species found at this site. Interestingly, *R. triangularis* does not appear to have been recorded from China (Wilson, 1995a). Four fish species and two frogs were recorded from Luk Keng marsh (Tables 7 & 8), although none was rare. This site is of importance as a breeding site for

Banded Rails (*Gallirallus striatus*), and is the only local breeding site of Watercock (*Gallicrex cinerea*) which has been declining due to habitat destruction (Viney *et al.*, 1994). Breeding by Painted Snipe (*Rostratula benghalensis*) is suspected also. Luk Keng is an important feeding site for Cattle Egrets (*Bubulcus ibis*), as well as migrants (especially grassland specialists) which use this site, including Schrenck's Bittern (*Ixobrychus eurhythmus*), Chestnut Bittern (*I. cinnamomeous*), Grasshopper Warblers (*Locustella* spp.) and the Grey-headed Bunting (*Emberiza fucata*). The majority of these birds are on the decline or are threatened locally because of habitat loss (Viney *et al.*, 1994).

Kuk Po marsh

Kuk Po marsh (50 Q KV 1560 9420) was situated at sea level in the northwestern part of the territory beyond the boundaries of the Plover Cove Country Park (Figures 1 & 3). It was approximately 9 ha in area. The marsh drained into Tai Wan in Starling Inlet, and was bordered by Kuk Po village to the south. A bed of *Phragmites* was situated between the marsh and the coast in the north. The marsh was stream-fed from a range of hills (Shek Nga Tau and Tsim Kong Tung) to the east. The wetland was semi-permanent, and was wet throughout much of the year (apart from January-March). This site was the most saline of all the freshwater sites studied (Tables 3 & 4) and, although readings varied among visits, values reached 6 ppt in October 1995. Despite the salinity, the emergent vegetation at Kuk Po marsh was relatively tall and dense; dominant species included *Wedelia chinensis* (Compositae), *Fimbristylis dichotoma* (Cyperaceae), *Ischane* sp. (Gramineae) and the asiatic pennywort, *Hydrocotyle sibthorpioides* (Umbelliferae). Diptera were particulary rich at this site with 18 species (out of a total of 40 macroinvertebrates: Table 6) representing 6 families recorded. The Tipulidae comprised seven species including one occurring here and at no other site. In terms of macroinvertebrate species richness, this site ranked equal fourth (with Shuen Wan marsh) among the sites sampled. Adult odonata of interest at Kuk Po included *Onychargia atrocyana* (Coenagrionidae), *Prodasineura croconota* (Protoneuridae) and *Lyriothemis elagantissima* (Libellulidae).

Sheung Miu Tin marsh

Sheung Miu Tin marsh (50 Q KV 1770 9112) was a mid-sized (approximately 1 ha) permanent marsh situated 100 m asl (Figures 1 & 4). This upland site received its water from streams flowing off Tiu Tang Lung hill, and was drained by a number of streams that eventually made their way into Double Haven. Vegetation was consistent with most marshy areas, being of low stature and dominated by grasses and sedges. Sheung Miu Tin marsh had average species richness (31 species: Table 6) and supported four rare macroinvertebrate species. Of note was the first (and only) record of the beetle family Hydrochidae from Hong Kong: specimens are now with Dr. Manfred A. Jäch (Naturhistorisches Museum, Vienna) for identification but, should the species be new, then a scientific description will need to await a taxonomic revision of the Southeast Asian *Hydrochus* (M.A. Jäch, pers. comm.). Hydrochids are confined to shallow, stagnant eutrophic freshwaters and are associated with clayey soils (Chikun, 1994). Two fish species were found at Sheung Miu Tin (Table 7): the Black Paradise Fish, *Macropodus concolor,* and the loach *Misgurnus* sp. (probably *M. anguillicaudatus*: Cobitidae).

Sam A Tsuen marsh

Sam A Tsuen marsh (50 Q KV 1920 9260) was situated at sea level on private land near the boundaries of the Plover Cove Country Park (Figures 1 & 4). It was relatively large (approximately 14 ha), and was bisected by cement walkways and narrow channels that drained the area. Run-off from nearby Ngau Shi Wu Shan to the north and Tiu Tang Lung to the southwest ensured that the marsh was wet year-round. Sam A Tsuen village lay north of the sampling site and channels from the marsh flowed eastward into Sam A Wan. Macroinvertebrate biomass in this marsh was dominated by gastropods (6 species), especially *Melanoides tuberculata* (Thiaridae) and *Segmentina* sp. (Planorbidae). Significantly, Sam A Tsuen had the highest nitrate levels of the 28 sampled wetlands (Tables 3 & 4). Macroinvertebrate species richness was high (43 species), ranking third in this respect among the sites sampled (Table 6), although only one rare invertebrate (*Limnogonus* sp.: Gerridae) was recorded. The numerous open water channels in the marsh provided good habitat for fishes (Table 7) including *Macropodus opercularis*, *Clarius fuscus* (Clariidae) and, notably, the Rice Fish, *Oryzias curvinotus* (Oryziidae). Sam A Tsuen marsh is one of few remaining sites in Hong Kong where this native fish can still be found in quite large numbers (Chong & Dudgeon, 1992), and this site was the only wetland where *O. curvinotus* was found during the present survey (Table 7). This fish must now be considered as endangered locally. Its decline has been attributed to the introduction and subsequent spread of the exotic Mosquito Fish, *Gambusia affinis* (Poeciliidae), which is known to predate smaller fish and amphibian larvae (Dudgeon & Corlett, 1994).

Siu Tan marsh

Siu Tan marsh (50 Q KV 1860 9310), situated at sea level northwest of Sam A Tsuen (Figures 1 & 4), was approximately 3 ha in extent. It was bordered by secondary forest to the east and west, by the abandoned village of Siu Tan to the south, and by coastline to the north. Streams from Shan Mei Au (in the south) flowed into this marsh and subsequently drained into Crooked Harbour. The marsh was semi-permanent, remaining wet for all but two or three months of the year (January-March). Macroinvertebrate species richness was above average (37 species: Table 6) with two rare species of Diptera: *Tipula* (*Tipulodina*) sp. (Tipulidae) and *Culiseta* sp. (Culicidae). Vegetation was consistent with that of other marshy habitats, and was grazed by feral cattle.

Shuen Wan marsh

Shuen Wan marsh was situated at sea-level west of Ting Kok Road in the northeastern New Territories (Figures 1 & 5). The Pat Sin Leng mountain range was north of the site, the closest peaks being Ping Fung Shan and Lai Pek Shan. The marsh was permanently flooded, and drained by a man-made channel which discharged into Shuen Wan Hoi in Tolo Harbour. The sampled site (at Wai Ha: 50 Q KV 1230 8750) was separated from a larger area of saline wetland by a road which served as a barrier to salt-water intrusion. The freshwater marsh was approximately 12 ha in extent and dominated by emergent grasses (mainly *Ischane* spp.). Forty macroinvertebrate species were recorded from this wetland, ranking equal fourth (with Kuk Po marsh) in species richness among all sites sampled (Table 6). Three rare species - including a larval damselfly (Coenagrionidae U3) and two Tipulidae - were recorded.

Sha Lo Tung marsh and pool

Sha Lo Tung Valley, situated in the northeastern New Territories (Figures 1 & 5), was bordered by Cloudy Hill (Kau Lung Hang Shan) to the east and Shek Lau Shan to the north. There were two villages in the vicinity, Cheung Uk village to the west and Lei Uk village to the east. Two study sites were chosen from this area; a mid-sized (8 ha) semi-permanent marsh and a permanent pool formed by the impoundment of a slow-moving stream. Although Sha Lo Tung is an excellent site for dragonflies, with over half of Hong Kongs known species found in and around the streams and abandoned paddy fields (Wilson, 1995a), the wetlands were not exceptional for other macroinvertebrates. The marsh site (50 Q KV 1030 8860; 220 m asl) was located close to the village of Lei Uk. It had average macroinvertebrate richness (32 species: Table 6), and two rare dipteran species: *Tipula* (*Angarotipula*) sp. (Tipulidae) and *Hemerodromia* sp. (Empididae). The Paradise Fishes *Macropodus opercularis* and *Macropodus concolor* were both found in this marsh (Table 7), the only known locality where they are sympatric. The pool site (50 Q KV 1034 8836; 220 m asl) was relatively small (0.003 ha) with low macroinvertebrate species richness (9 species; Table 6). Two stream snails, *Brotia hainanensis* (Thiaridae) and *Radix* sp. (Lymnaeidae), were the only rare species.

Although the macroinvertebrates and vegetation were unexceptional, the amphibian and dragonfly fauna were of great interest. Five amphibians were recorded in and around the villages. Four, including Günthers Frog (*Rana guentheri*: Ranidae), the Paddy Frog (*Rana limnocharis*: Ranidae), the Three-striped Grass Frog (*Rana macrodactyla*: Ranidae), and the Brown Tree Frog (*Polypedates megacephalus*: Rhacophoridae) are fairly common locally. However, the relatively rare Narrow-mouthed Frog (*Kalophrynus pleurostigma*: Microhylidae) - which has a more restricted distribution - was also found in this area. Dragonflies were probably the most important feature of the Sha Lo Tung basin, and one expert view is that it is one of the best, if not the best, dragonfly site in the territory (Wilson, 1995a). Sha Lo Tung is host to three endemic species: *Lamelligomphus hongkongensis* (Gomphidae), *Macromidia ellenae* (Corduliidae), and *Macromia katae* (Corduliide). It is the type locality for *Macromia katae* and *Macromidia ellanae,* and this fact alone warrants designation as an SSSI (Site of Special Scientific Interest). It is the only site in the world known to support two *Macromidia* species (Wilson, 1995a). Sha Lo Tung also contains six internationally rare species: *Polycanthagynă erythromelas* (Aeshnidae), *Megalogomphus sommeri* (Gomphidae), *Gomphidia kellogi* (Gomphidae), *Macromia berlandi* (Corduliidae), *Idionyx victor* (Corduliidae) and *Prodasineura croconota* (Protoneuridae). It must be stressed that these species (especially the larvae) are stream inhabitants and not strictly 'wetland species' as defined in the context of this study, although the adults may forage over wetlands. However, maintenance of the riparian environment and marshland of the Sha Lo Tung Valley will be essential if the stream community is to remain intact.

Liu Pok marsh

Two sites were located within the Frontier Closed Area in the northern New Territories (Figure 1). The first site (50 Q KV 0180 9450: Figure 6), at Lo Wu near the village of Liu Pok, was a seasonal marsh approximately 1 ha in extent, situated at sea level. It was bordered by secondary forest to the east and west, the village of Liu Pok to the south, and by fish ponds to the north. The marsh was fed by Tai Shek Mo from the south. The marshland was situated on the floodplains of the heavily-polluted Sham Chun River (in the north) and its tributary - the Ng Tung River (in the east). Proximity to these rivers had a bearing on the ecology of the marsh because their high loads of organic pollution affected ground-water supplies. Water analysis revealed that the marsh had poor water quality (Tables 3 & 4), with low dissolved oxygen (3.6 mg/l) and high nitrites (0.014 mg/l) and ammonia (0.37 mg/l). The site had a depauperate macroinvertebrate fauna of only 9 species (Table 6) and no rarities. The macroinvertebrates encountered were indicative of poor water quality: oligochaetes, *Pseudolimnophila* sp. (Tipulidae), *Pericoma* sp. (Psychodidae) and (Chironomidae: Chironominae) are all adapted to low levels of oxygen. For example, *Pseudolimnophila* has elongate, membranous anal gills (Gelhaus & Byers, 1994), while *Pericoma* possess amphineustic spiracles at the apex of short conical siphons allowing it to utilize atmospheric oxygen (Courtney, 1994). The Chironominae ('bloodworms') includes a number of species (especially in the genus *Chironomus*) that are well-adapted to oxygen-poor conditions because the haemoglobin-filled haemocoel gives them a high affinity for oxygen (Oliver, 1971).

Ma Tso Lung marsh

Like Liu Pok marsh, Ma Tso Lung marsh (50 Q KV 0130 9360) was situated in the Frontier Closed Area (Figures 1 & 6). It was seasonal and was bordered by Shun Yee Shan Tsuen in the north and Ma Tso Lung San Tsuen in the southeast. The close proximity of these villages had a significant influence on the site since wastes were discharged directly into the marsh. There was a distinct putrid odour and the water was black. Water analysis confirmed the apparent poor quality of the water (Tables 4 & 5). This site had the lowest dissolved-oxygen levels (2.14 mg/l), and the highest concentrations of nitrite (0.043 mg/l) and ammonia (10 mg/l) among all sites sampled. The macroinvertebrate fauna was extremely depauperate (8 species: Table 6) and - as in Liu Pok marsh - the species encountered were adapted to oxygen-poor conditions. It should be stressed that K.D.P. Wilson (Agriculture & Fisheries Department, Hong Kong Government) has sighted significant populations of the dragonflies *Rhodothemis rufa* and *Urothemis signata* in the Ma Tso Lung area, but these insects were not seen during the present survey despite visits to Ma Tso Lung in both the wet and dry seasons. This probably reflects insect phenology as well as the localised nature of suitable breeding sites.

Lung Tsai marsh

Lung Tsai marsh was situated at sea level in the western New Territories (Figure 1) near Lung Kwu Tang (49 Q HQ 0060 7870: Figure 7). It was one of three western-most sites on the mainland. The marsh was small (0.02 ha) and seasonal, reflecting the low annual rainfall in this part of the territory (1600 mm per annum, compared with 2800 mm on Tai Mo Shan: Royal Observatory, 1994). The highest peak in the area was Tsing Shan (Castle Peak), streams from the west of which drained into this marsh. Lung Tsai marsh was particularly acidic and had the lowest *p*H (5.15) of all sites visited (Tables 3 & 4). The emergent vegetation was dense and dominated by tall sedges, but macroinvertebrate richness was barely average (28 species: Table 6), perhaps reflecting the acidic conditions. Two rare species, an aquatic lepidopteran (Pyralidae) and a dytiscid beetle larva (*Bidessus* sp.) were recorded. Lung Tsai marsh was only one of two sites where members of the Corethrellidae - a family of Diptera previously unrecorded in Hong Kong - were found.

Pak Long marsh

Pak Long marsh was situated at sea level immediately north of Lung Tsai marsh (Figures 1 & 7). The study site (49 Q HQ 0060 7920) was a small (0.01 ha) seasonal marsh with similar attributes - in terms of vegetation and faunal species composition - to Lung Tsai. Macroinvertebrate species richness was below average (25 species: Table 6) and two rare species - a dytiscid beetle (*Laccophilus pumilus*) and a soldier fly (Stratiomyidae) - were recorded.

Tai Lam Country Park marsh

Tai Lam Country Park marsh was the only surveyed wetland site situated within a Country Park (Figures 1 & 8) and thus the only site surveyed that currently has legal protection. Macroinvertebrate collections from this site indicated that it was the least diverse of the marshland sites visited, and only six species found (Table 6). However, two rare species were recorded: the larvae of *Megalogomphus sommeri* (Gomphidae) - a dragonfly which is usually found in streams rather than marshes, but which appears to be restricted to southern China (Wilson, 1995a, 1995b) - and the cranefly *Hexatoma* sp. (Tipulidae).

Pui O marsh & taro bed

Pui O on southern Lantau Island yielded two study sites (Figure 1). The entire Pui O wetland was quite extensive, stretching from the coastline of Pui O Wan to South Lantau Road. The area was cris-crossed by cement walkways that divided the marsh into patches. The first sampling site (49 Q HQ 0690 6290: Figure 9) was a patch of seasonal marshland approximately 2 ha in extent located at sea level close to the coast. Emergent vegetation in the marsh was short due to grazing by a resident population of Water Buffaloes (*Bubalis bubalis*). Macroinvertebrate diversity was below average (22 species: Table 6) and there were no rare taxa. The Chinese Paradise Fish (*Macropodus opercularis*) was collected at this site, as were the frogs *Rana guentheri*, *Rana macrodactyla*, *Polypedates megacephalus* and the Marbled Pygmy Frog (*Microhyla pulchra*: Microhylidae) (Tables 7 & 8). All of these vertebrates are widely distributed in the territory. Pui O marsh is the site of the only known record of the *Tramea transmarina euryale* (Libellulidae) in Hong Kong (Wilson, 1995a) but, as this is a migratory Southeast Asian dragonfly, the record should perhaps be treated as a vagrant specimen rather than being indicative of a resident population. The second site at Pui O (49 Q HQ 069 631: Figure 9) consisted of a 0.1 ha taro (*Colocasia esculenta*) bed located further inland and to the north of the marshland sampling site. It was permanently-flooded, and contained much decaying organic matter which was reflected in low dissolved-oxygen concentrations (3.3 mg/l: Table 3). Macroinvertebrate species richness at this site was above average (39 species: Table 6), and the community included species with specialized adaptations for breathing atmospheric air: *Eristalis* (Syrphidae) and ephydrids (Diptera). Leeches made up an important part of the invertebrate fauna at this site also, including sanguivorous *Limnatis*, *Erpobdella* (both which were found only at this site) and *Helobdella stagnalis*. Among the six rare macroinvertebrates recorded (Table 6) were *Macrodiplax* larvae (Libellulidae), hydrophilid beetles (including *Sternolophus* sp.) and *Sphaeromias* sp. (Ceratopogonidae). *Macropodus opercularis* was the only fish encountered at this site (Table 7) during the survey, however, subsequent visits by A.F.D. officials encountered *Gambusia affinis* at Pui O marsh; two common frogs were reported also (Table 8).

Tai O reedbed

Two sites, in close proximity, were sampled at Tai O on western Lantau island (Figure 1). Both were part of the same wetland. One site - Tai O reedbed (49 Q GQ 9510 6330; Figure 10) - consisted of a large, inundated bed of reed grass (*Phragmites australis*) that was almost completely surrounded by fishponds; the second (Leung Uk marsh; see below) was an extension of the same reedbed but separated from it by a cement walkway. The division was significant because it restricted the extent of saltwater intrusion into these sea-level sites. Tai O reedbed was extremely saline (25 ppt), and thus was not included as a sampling site in the present survey. It is, however, one of the largest *Phragmites* beds in the territory (G. Reels, Department of Ecology & Biodiversity, The University of Hong Kong, pers. comm.).

Leung Uk marsh

A second site at Tai O (Figure 1) was near Leung Uk village (49 Q GQ 9510 6340; Figure 10) covering 3.5 ha. It was freshwater (i.e. 0 ppt salinity: Table 3) and dominated by grasses and other low-lying emergent vegetation (as well as floating Duck-weed, *Lemna minor*) of a composition consistent with freshwater marshes elsewhere in the territory (Table 5). The village of Nam Chung lay south of the site and the village of Leung Uk lay east of the site. Macroinvertebrate richness was below average (24 species; Table 6), and only one rare species (a culicid fly) was recorded. However, the rare Rough-skinned Floating frog (*Occidozyga lima*: Ranidae), which was thought to be extinct in Hong Kong (Dudgeon & Corlett, 1994), was found at this site (Table 8). At present, this is the only known locality record for this frog in the territory (M. W.-N. Lau, Department of Ecology & Biodiversity, The University of Hong Kong, pers. comm.). Two widely-distributed frog species were found at Leung Uk marsh also (Table 8).

Yi O marsh

Yi O, located on southwestern Lantau Island (Figure 1), near the Lantau South Country Park but outside its boundaries, was the site of a semi-permanent marsh (49 Q GQ 9360 6080; Figure 10) situated at sea level and approximately 2.6 ha in extent. Streams from three mountains - Kai Kung Shan to the west, Tai Hom Shan to the southeast, and Sham Hang Lek to the south-southeast - drained into the marsh. The area was quite remote, and the nearby village of Yi O San Tsuen had been abandoned. The emergent wetland vegetation was dense and quite high, dominated by grasses, sedges and the aquatic fern *Marsilea quadrifolia* (Marsileaceae). Macroinvertebrate community composition was above average (35 species; Table 6), and rare species included a beraeid caddisfly (Trichoptera) and a hydrophilid beetle (*Enochrus*). *Macropodus opercularis* was the only fish collected (Table 7). The endemic and protected Romers tree frog (*Philautus romeri*) was found in a small temporary pool close to the study site.

Tung Chung marsh

Tung Chung was the site of a large (49 Q HQ 0240 6700: Figures 1 & 11) semi-permanent marsh, approximately 30 ha and located at sea-level. Although this site was visited during the preliminary stages of this investigation, it could not be included in the detailed study because it was drained and partially infilled during work related to the on-going Chek Lap Kok Airport project. Tung Chung marsh was formerly the habitat of *Macropodus opercularis*.

Lamma Island marsh

Lamma Island was the location of a small permanent marsh at 50 m asl (50 Q KV 0340 5960; Figures 1 & 12). It was approximately 1 ha in area and drained by a small stream. The vegetation was mostly of low stature and dominated by grasses and sedges. Macroinvertebrates species richness was well below average (15 species: Table 6), and only one rare species (a simuliid fly) was recorded. *Simulium* spp. are typically confined to running water, and its occurrence in the marsh reflected proximity to the stream outflow.

3.2 Ponds

Cheung Sheung pond

Cheung Sheung pond (50 Q KV 2262 8280: Figures 1 & 2) was a natural, permanent pond that reached an area of 0.25 ha during the wet season, shrinking to about half this in the dry season. Maximum water depths varied from 1.0 (dry season) to 1.5 m (wet season), and the substratum was muddy. The pond was fringed mostly by shrubs and a few small trees. Dominant vegetation consisted of emergent grasses along the edges, and submerged *Bacopa floribunda* (Scrophulariaceae). Macroinvertebrate community composition at this site was quite outstanding with the highest species richness (38 species) of all ponds (Table 6), and the greatest number of rare species (9) also. Rare species of note included the water scorpion, *Ranatra* (Nepidae), and two genera of whirligig beetles (Gyrinidae: *Gyrinus orientalis* and *Dineutus* sp.). The latter have declined in distribution and abundance throughout the territory during recent years.

So Lo Pun pond

So Lo Pun pond, situated at sea level in the northeastern New Territories (50 Q KV 1730 9460; Figures 1 & 3), was relatively large (5 ha) and fringed by *Phragmites australis* on the seaward side. Although this site was included in the initial stages of the survey, it was not sampled intensively because of high salinity (28 ppt).

Hung Shek Mun pond

Hung Shek Mun pond (50 Q KV 2134 9060; Figures 1 & 4) was a permanent, man-made pond of approximately 0.36 ha situated 80 m asl. The pond received water from two streams flowing off Kwun Yam Tung to the west, and was drained by another stream flowing into Tai Shui Wu to the north. The margins were fringed by emergent grasses which were restricted in extent by the depth of the pond (up to 1.5 m). Macroinvertebrates species richness was low (seven species; Table 6) and only one rare species (an unidentified coenagrionid damselfly larvae) was recorded.

Lung Kwu Sheung Tan pond

Lung Kwu Sheung Tan pond (49 Q GQ 9950 8060: Figure 7) was small (0.006 ha), and situated at 10 m asl in the western New Territories (Figure 1). The site could not be studied in detail after initial inspection, because it was drained and infilled during construction of a new road.

Luk Tei Tong pond

Luk Tei Tong (49 Q HE 0872 6500; Figures 1 & 9), situated at sea level on the eastern side of Lantau Island near Mui Wo, was the site of an abandoned fish pond bordered by elevated bunds. The pond was large (approximately 0.3 ha) and permanent with a mud substratum. Water depths were approximately 2 m during the wet season, but fell to about half this in the dry season. Submerged vegetation consisted of the macrophytic algae (the Stonewort, *Chara* sp.: Characeae), with sparse growths of emergent grasses along the pond fringes. Secondary forest bordered the eastern end of the pond. The pond was quite alkaline with the highest *p*H (7.51) of all sites sampled (Tables 3 & 4). This is typical of *Chara* habitats as the cells contain lime deposits, and this alga cannot tolerate strongly acidic conditions. Macroinvertebrates species richness was quite low (12 species; Table 6), as was typical of most ponds sampled. A single 'rare' species (*Ischnura senegalensis*: Coenagrionidae) was found in the larval stage at this site only during the survey, although this damselfly is quite common elsewhere in the territory. The endemic Romers tree frog, *Philautus romeri*, was recorded close to Luk Tei Pond - at Tai Tei Tong - but there was no evidence that it bred in the pond.

Sunset Peak pond

Sunset Peak on Lantau Island (49 Q HQ 0484 6442; Figures 1 & 9) was the location of the highest of all wetland sites surveyed (680 m asl). While the Sunset Peak area is part of the Lantau Country Park, the sampled pond lies in a small patch of private land topographically within - but legally outside - the Country Park boundaries. It was a small (0.08 ha) man-made stream impoundment, with depths varying from 2 m (during the wet season) to only 10 cm in late March. The substrate was rocky and vegetation was sparse, consisting mostly of emergent *Juncus* sp. (Juncaceae). Because it was stream-fed, lotic invertebrates - such as mayflies (*Cinygmina*: Heptageniidae), caddisflies (*Anisocentropus maculatus*: Calamoceratidae) and shrimps (*Neocaridina serrata:* Atyidae) - made up a large part of the total macroinvertebrate fauna, although species richness (11 species) was quite low (Table 6). The three 'rare' species (for example, the Backswimmer, *Enithares* sp.: Notonectidae) were taxa typical of upland stream pools. The endemic - and protected - Hong Kong newt, *Paramesotriton hongkongensis* (Salamandridae) was present in Sunset Peak pond. Adult dragonflies of interest included two species of *Anax*: *Anax immaculifrons* and *Anax* sp. (probably *A. guttatus*).

Lamma Island pond

A permanent pond, resulting from the impoundment of a stream, of 0.25 ha, was located approximately 70 m asl, on Lamma Island (50 Q KV 0350 5960: Figures 1 & 12) was sampled as part of the survey. It was the deepest of all the sites visited: over 2.5 m (Tables 3 & 4). Water levels were quite stable. The pond was fringed by emergent sedges and grasses, but contained no submerged macrophytes. The substratum was coarse sand. Macroinvertebrate richness species was consistent with other ponds, being quite poor relative to marshes (15 species: Table 6) although it was ranked second among pond sites. This pond supported large populations of the dytiscid beetle *Cybister tripunctatus orientalis*. Morover, the submerged stems of the plentiful emergent vegetation provided good habitat for assorted odonates and the larvae of *Rhyothemis* (Libellulidae) and *Crocothemis* (Libellulidae) were found here and nowhere else. Caddisfly larvae of the genus *Polycentropus* (Polycentropodidae) were likewise confined to this site. The pond was easily accessible, and human impacts in the form of released aquarium fish (such as the Swordtail, *Xiphophorus helleri*: Poeciliidae) and Common Carp (*Cyprinus carpio*) were apparent. K.D.P. Wilson (Agriculture & Fisheries Department, Hong Kong Government, pers. comm.) has reported 'a thriving population' of the locally-rare dragonfly *Diplacodes nebulosa* (Libellulidae) from this site.

Kau Sai Chau pond

A single, small (0.009 ha) man-made pond was sampled on Kau Sai Chau at the northeastern tip of the island (50 Q KV 2340 7660; Figures 1 & 13). This man-made pond, impounded at the seaward end, was situated 20 m asl and varied in depth from 1.0 - 1.5 m according to season. The substratum was muddy, and emergent vegetation was dominated by grasses and sedges. Submerged Bladderwort (*Utricularia* sp.: Lentibulariaceae) was quite abundant also. Kau Sai Chau pond yielded the lowest numbers of macroinvertebrate species of any wetland (4 species: Table 6), and there were no rare species. Vertebrates likewise consisted of common species: *Macropodus opercularis* and *Rana guentheri* (Tables 7 & 8). Nevertheless, this site is the first known breeding locality of *Nannophya pygmaea* (Libellulidae) in Hong Kong (Wilson, 1995a), and *Rhyothemis triangularis* (Libellulidae) occurs here also.

4. Results

4.1 General results

A total of 33 wetlands have been sampled; of these, nine were ponds and 24 were marshland. Twenty-two were situated on the mainland New Territories; the remainder were on outlying islands. Only one lay within Country Park boundaries. Five sites were excluded from detailed study because of high salinity or subsequent disturbance and destruction. Because attention was focused primarily upon those freshwater wetlands which lay outside Country Park boundaries, the majority of sites were low-lying. For example, although the range of altitudes sampled was quite considerable (0 - 680 m asl: Table 1); 22 sites were situated at sea level and the mean altitude overall was only 74 m asl (Table 4). The wetlands ranged in area from 0.003 to 32 ha (Luk Keng marsh), with a mean of 4.8 ha. As would be expected, marshes (mean 6.2 ha) were generally larger than ponds (mean 0.5 ha). All of the nine ponds sampled were permanent (Table 2); 11 of the marshes were permanent, nine were semi-permanent and five were seasonal. A summary of the water chemistry of the sampled wetlands is given in Table 4 and the raw data are summarised on Table 3. Apart from the remarks made on organic pollution under the relevant sections of the **Site Descriptions**, the water chemistry of the sites sampled lacked outstanding or notable features. The 'average' wetland (Table 4) was acidic (*p*H 6.25) and reasonably well-oxygenated (5.45 mg/l) with low conductivity (100 μS); however, slight increases in salinity caused marked rises in conductivity resulting in considerable inter-site variation in this parameter.

4.2 Biological results: vegetation

A total of 73 species of macrophytes in 28 families were recorded during the survey (Table 5). Despite the range of families reported, the wetland flora was dominated by sedges (Cyperaceae: 27 species) while grasses (Gramineae: at least 9 species) were of secondary importance. Note that the name of the reed grass *Phragmites australis* as used herein has precedence over the widely-used *Phragmites communis*, and the identity of the local species has been confirmed by comparison with specimens at Kew Gardens, London (G.T. Reels, Department of Ecology & Biodiversity, The University of Hong Kong, pers. comm.).

Submerged aquatic macrophytes were rather poorly represented, and no endangered species were found. Larger marshes, with varied topography, areas of open water and a greater range of microhabitats, tend to support more species so - in the absence of rare or endangered plants - it is suggested that the goal of wetland plant conservation would be best served by protecting the most extensive among the sites sampled. The recent discovery of a new bog orchid (*Liparis* sp.) in Hong Kong is noted above (see **Yung Shue O marshes 1 & 2**) and may necessitate the designation of an SSSI. Although this orchid was not recorded at Yung Shue O during the present investigation (although subsequent visits found many flowering individuals at both sites), one specimen was found in November 1996 near Hoi Ha Wan (between Pak Sha O and Nam Shan Tung: 50 Q KK 234849) in a dry area of abandoned paddy within Country Park boundaries. This site may be flooded during the wet season.

4.3 Biological results: macroinvertebrates

A total of 194 species (or morphospecies) in 76 families (within 16 higher taxa) were recorded during the study (Table 9; Appendix 2). The order Diptera was notably diverse with 59 species in 16 families. Macroinvertebrate species richness across all wetlands (Table 6) ranged from 4 (Kau Sai Chau pond) to 62 (Luk Keng marsh), with a mean ($\pm$ S.D.) of 27.0 $\pm$ 15.2. Ponds supported a narrower range (4 -38) and a generally lower number (mean 13.7 $\pm$ 11.3) of species relative to marshes (mean 31.4 $\pm$ 13.9; range 6 - 62). The mean richness of macroinvertebrate families (Table 6) across all sites ranged from 2 (Kau Sai Chau pond) to 34 (Luk Keng marsh), with a mean of 18.1 $\pm$ 8.7. Again, ponds supported fewer families (mean 10.4 $\pm$ 7.2; range 2 - 25) than marshes (mean 20.6 $\pm$ 7.7; range 6 - 34).

Seventy-two rare species (i.e. macroinvertebrates found in samples from only one site) were recorded from all sites combined (Table 6). Fifteen rare families were encountered, including the first Hong Kong records for the Corethrellidae (Diptera) and Hydrochidae (Coleoptera). The mean number of rare species per wetland site ranged from 0 (at five sites) to 9 (Cheung Sheung pond), with a mean of 2.6 $\pm$ 2.4. The range for marshes and ponds was similar (0 - 8 and 0 - 9 respectively), as were the mean values 2.5 $\pm$ 2.3 and 2.7 $\pm$ 3.0. In addition to these data, additional information on the incidence of rare adult odonates in the study wetlands is given under the relevant **Site Descriptions**.

4.4 Biological results: fishes

Ten fish species were collected from the study wetlands. Of these, only the Black Paradise Fish (*Macropodus concolor*) was of significant local and regional conservation interest. It was found at five sites in the northeastern New Territories (Table 7), and is considered in more detail below (section 5). *Oryzias curvinotus* - recorded at only one site - has been declining throughout the territory and should be considered locally endangered although it is widely-distributed in China. The commonest species was the Chinese Paradise Fish (*M. opercularis*), occurring at eight of the 28 sampled wetlands (Table 7). Sham Chung marsh was the richest site in terms of fish biodiversity, supporting half of the total number of species recorded. Luk Keng ranked second with four species, but did not support any rare fishes.

4.5 Biological results: amphibians

Ten amphibian species were recorded from the study wetlands (Table 8), including an endemic newt (*Paramesotriton hongkongensis*) and nine anurans of which one (*Philautus romeri*: Romer's Tree Frog) is endemic. Another is extremely threatened locally (*Occidozyga lima*: the Floating Frog), and was present at only one locality (Leung Uk marsh). An additional species (*Kalophyrnus pleurostigma*: the Narrow-mouthed Frog) is rather rare locally, occurring at a few sites in central and northern New Territories only.

4.6 Multivariate statistical analyses: overall trends

Exploratory multivariate analysis of the macroinvertebrate species *versus* sites data set confirmed the applicability of detrended correspondence analysis (DCA), because the ordination diagram (Figure 14) spread over 4 standard-deviation units on axes 1 & 2 indicating an underlying unimodal (non-linear) response of the fauna to environmental gradients. As Figure 14 shows, Tai Lam Chung Country Park marsh (TLCPM) was an obvious outlier on the site plot, being more than two standard-deviation units from its nearest neighbour and therefore tending to distort the ordination. Accordingly, it was omitted from subsequent analyses, as were the severely-polluted Ma Tso Lung marsh (MTLM) and Liu Pok marsh (LPM) where conditions deviated markedly from those at other sites (Tables 3 & 4). Subsequent re-ordination of the species *versus* sites data produced what appeared to be four groupings of sites (Figure 15); these were tested for robustness and classified objectively using K-means cluster analysis.

An initial attempt to classify the sites into four groups by constraining the K-means cluster analysis to a four-cluster solution produced grouping which bore no relation to those on the DCA ordination plot (Figure 16). By contrast, clustering constrained to a three-cluster solution yielded site groups which were similar to those on the DCA ordination plot (Figure 17) although one of the site groupings was rather large. The match was greatly improved by further clustering of the largest site group in the three-cluster solution - a technique we called 'two-level clustering. This site classification produced a total of four clusters (Figure 18) that closely matched the site groupings implied by DCA of the species data set (Figure 15) and which, more importantly, made biological sense. The site-group membership of each wetland based on species complement is given in Table 10. When DCA was repeated on the faunal data set based of family composition, an ordination plot that implied three site groups resulted (Figure 19). K-means clustering constrained to a three-cluster solution confirmed that this classification was robust (Figure 20), and the site-group membership of each wetland based on family complement is given in Table 11.

Examination of the community characteristics of the site groups classified by macroinvertebrate species complement revealed that the five marshland sites comprising cluster 1 had the greatest species richness and the second highest rarity index of any cluster. Clusters 2, 3 and 4 had successively decreasing mean species richness, although Cluster 3 had the highest rarity index despite no more than 'average' species richness. Cluster 4 was particularly species-poor, and none of the sites in this group had more than 15 species. Significantly, all of these sites were ponds (Table 10). Cheung Sheung pond was the only pond site that lay outside cluster 4. When the sites were reclassified on the basis of macroinvertebrate family complement, cluster-1 sites had the greatest richness and rarity index (Table 12), but were only slightly higher than the scores of these variables for cluster 2. Cluster 3 was again notably depauperate, and made up of pond sites (Table 11); once more, Cheung Sheung pond was classified separately from other ponds - in this case within cluster 1. The composition of clusters classified by macroinvertebrate species or family complement were identical with respect to group 4, but were otherwise rather dissimilar, although Luk Keng, Sam A Tsuen, Siu Tan and Pui O marshes were consistently placed in cluster 1 (Tables 10 & 11).

4.7 Multivariate statistical analyses: environmental variables

When the 11 environmental variables measured at each wetland site (Table 3) were incorporated directly into ordination computations using detrended canonical correspondence analysis (DCCA), the results were confusing and failed to uncover any significant patterns in the data set. Accordingly, this approach was abandoned and, as an alternative, the environmental variables were incorporated passively onto the ordination diagrams (i.e. by indirect ordination). This approach produced more concise and interpretable diagrams than DCCA and these are the results presented in Figures 21 & 22. When the environmental variables were included in the DCA ordination plot of the macroinvertebrate species data (Figure 21), the direction and lengths of the components showed that cluster-1 sites were characterised by the wetland area, nitrate, ammonia and *p*H components. Cluster-2 sites were associated with the nitrite, PO_4, salinity and conductivity components on the ordination plot, while dissolved oxygen, depth and altitude were important for clusters 3 and weakly associated with cluster 4. Examination of the mean values of the environmental variables for each cluster (Table 13) revealed that (relative to the other clusters) cluster-1 sites were large marshes at sea level with slightly elevated phosphate and ammonia levels; cluster-2 sites were smaller marshes characterised by high conductivity, salinity (although the mean value was only 1 ppt), nitrates, nitrites and the least acidic conditions; cluster 3 sites had generally low levels of nutrients and conductivity, and were the most acidic wetlands; while cluster 4 sites were small, deep, 'upland' (mean 178 m asl) ponds. There was no obvious relationship between cluster characteristics and the degree of permanence of the wetland (Table 2), although all the sites in group 4 were permanent. However, it may be significant that (with the exception of Sam A Tsuen marsh) those sites in clusters 1 & 2 overlay volcanic rocks, while clusters 3 & 4 comprised a mixture of sites on volcanic, metamorphosed sedimentary and granitiod rock.

When the environmental variables were incorporated passively onto ordination diagram resulting from DCA of the macroinvertebrate family data, the results were rather inconclusive (Figure 22). For example, some sites within cluster 2 were associated with the nitrite component, while others were associated with the salinity component which pointed in the opposite direction. Cluster 3 sites were not closely linked to any environmental components in this analysis. Nevertheless, examination of the mean values for the environmental variables in each cluster (Table 14) indicated that cluster 1 sites were, on average, relatively large and acidic, with high phosphates and ammonia. Cluster 2 sites were the most low-lying (mean 25 m asl) and had high conductivity and salinity (0.55 ppt) with slightly elevated nitrite concentrations. Cluster 3 sites were relatively small, deep, upland ponds with intermediate water-chemistry characteristics (as seen for cluster 4 in Table 13).

<u>*4.8 Multivariate statistical analyses: indicator species*</u>

Indicator species that could typify each cluster of sites were identified by three criteria. Thirty-six species met the criterion of differing significantly ($P < 0.05$) in their representation among clusters; 16 species were represented in one cluster and in no others; and, 39 species had a mean score in one cluster that was more than twice the sum of the mean scores in the other clusters. Those species which met two of these three criteria were designated indicator species (Table 15). As a result, 28 indicator species were identified (Table 16): eight species in cluster 1; 18 in cluster 2; and, two in cluster 3. In order to designate indicator species for cluster 4, the procedure was relaxed to take in those species in cluster 4 which met any one of the selection criteria. This was necessary because cluster-4 sites were rather species poor, and the majority of the species found in this cluster occurred in all cluster groups were therefore unlikely to serve as indicators. By means of this 'relaxed procedure', a further three species that indicated cluster 4 sites were identified (Table 16). Diptera and Coleoptera were the main (but not the only) indicators of clusters 1 & 2, the greater number of indicator species for these two clusters reflecting the relatively high species richness of sites in these groups. All clusters had at least one odonate as an indicator species, but the relative importance of odonates as indicators increased (in clusters 3 & 4) as the number of indicator species per cluster declined (Table 16).

4.9 Multivariate statistical analyses: indicator families

Identification of indicator taxa (using the criteria set out above) was repeated by analysis of the family-level faunal database. Twenty-two families met the criterion of differing significantly in representation among clusters; 20 families were represented in one cluster and in no others; and, 30 families had a mean score in one cluster that was more than twice the sum of the mean scores in the other clusters (Table 17). Those families which met two of these three criteria were designated indicator families. Twenty-two were identified: one family in cluster 1; 18 in cluster 2; and, three in cluster 3 (Table 18). In contrast to the results of indicator species analysis, the indicator families included no Coleoptera or Odonata (Table 18), and cluster 1 had only a single indicator family, despite having the highest mean richness and rarity of the three clusters(Table 12). Relative to the indicator species list (Table 16), the inventory of indicator families was less useful because almost all were indicative of cluster 2. Moreover, the exclusion of important and diverse wetland taxa such as Odonata and Coleoptera seems rather unsatisfactory, particularly in view of the importance of members of these taxa as indicator species.

4.10 Multivariate statistical analyses: probability of occurrence

Data arising from K-means clustering allowed calculation of the mean probability (in percentage terms) of encountering a particular species or family at a site in a particular cluster group. This is useful information if data become available from other wetland sites because it will be possible to classify them into the cluster groups identified herein. Alternatively, or if the same wetland sites are sampled after an environmental change (e.g. habitat management) it will be possible to determine whether site-group membership has shifted. When the species data set was considered (Table 19), certain taxa had a high probability of occurrence in three or all clusters: for example, *Orthetrum* sp. 1 was common (> 80% occurrence) clusters 1, 2 & 3; Chironominae had > 80% occurrence in all clusters, while incidence of Tanypodinae and Orthocladiinae was > 50%. Other species were invariably found (i.e. they had 100% occurrence) at all sites in particular clusters (Table 19): *Segmentina* sp., *Agriocnemis* sp. 1, *Ceriagrion melanurum*, *Orthetrum* sp. 1, *cf. Hyphydrus* 1L, *Cyphon* sp. L, *Hydrovatus bonvouloiri*, Chironominae and Tanypodinae were present at all sites in Cluster 1. *Orthetrum* sp. 1, *Cyphon* sp. L, Tipulidae U1 were present at all Cluster-2 sites, while *Ceriagrion melanurum* and Chironominae occurred at all Cluster-3 sites. Interestingly, no species were invariably associated with cluster-4 sites and, apart from the Chironominae, no species had a > 50% chance of occurring at any site in this cluster.

Examination of the incidence of families across the clusters (Table 20) reveals that Planorbidae, Baetidae and Coenagrionidae had > 50 % probability of occurrence in all clusters, while Chironomidae were present (i.e. 100% probability) at all sites in all clusters. Few families (relative to the number of species) were always present at sites a particular cluster. Coenagrionidae and Ceratopogonidae were found at all sites in cluster 1, and Helodidae in cluster 2. Chironomids were invariably found in cluster-3 sites but, because these dipterans were present at all sites, their occurrence at a site could not be used to predict cluster membership. As was the case with identification of indicator taxa (sections **4.8** & **4.9**), it appeared that species- or morphospecies-level identifications were more useful than family-level identifications for categorising wetland sites.

4.11 Multivariate statistical analyses: summary of site-group characteristics

4.11.1 Species

The present study has shown that Hong Kong wetlands can be classified into four robust site groups (or clusters) according to macroinvertebrate community composition. These groupings make biological sense in that the characteristics of sites within each cluster are rather similar, and concord with what is known about wetland ecotypes. Although the main biological results and the cluster characteristics have been described in some detail above, this section integrates all of these findings under a single heading for convenience and ease of interpretation.

Cluster 1 consisted of five large marshland sites situated at sea level. They had relatively high phosphate and ammonia levels, and most overlay volcanic rock. In terms of macroinvertebrates, this was the richest site group, and it ranked second in terms of the rarity index. Indicator species were *Eriocheir japonicus*, *Agriocnemis* sp. 2, Noteridae L1, *Hydrophilus* sp., Hydrophilidae L2, *Limonia* sp., *Chrysops* sp. and *Forcipomyia* sp. 1. Mean fish richness was 2.0 $\pm$ 1.4 species per site in the cluster; mean amphibian richness was 1.6 $\pm$ 1.7 species. These were the highest cluster values for both vertebrate groups.

Cluster 2 comprised seven shallow marshes overlying volcanic rock. They were the least acidic sites, and had high conductivity, nitrate and nitrate, but relatively low dissolved oxygen. This cluster ranked second in terms of macroinvertebrate species richness, but was not outstanding in terms of rare species. Indicator taxa included *Sommanniathelphusa zanklon*, *Habrophlebiodes gilliesi*, *cf. Ceriagrion*, *Pelocoris* sp., *Eubrianax* L1, *Hydaticus rhantoides*, *Hydrobiomorpha* sp., Hydrophilidae sp. 1, and Noteridae sp. 3, as well various dipterans (Anthomyiidae, Dolichopodidae, *Forcipomyia* sp. 2, Phoridae) - particularly Tipulidae (Table 16). Mean fish and amphibian richness were 1.0 $\pm$ 1.2 and 1.1 $\pm$ 1.8 species respectively.

Cluster 3 consisted of seven sites (six marshes and one pond overlying volcanic or granitoid rock) which had the lowest nutrients (ammonia, nitrates, nitrites, phosphates), conductivity and *p*H among the four clusters. Macroinvertebrate species richness was unremarkable (ranking third among the clusters), but these sites had ranked highest in terms of the rarity index. Only two indicator species were identified: *Agriocnemis lacteola* and *Canthydrus weisei*. Fish and amphibian richness were 1.7 $\pm$ 2.2 and 1.3 $\pm$ 1.2 respectively, ranking second for both groups among the clusters.

Cluster 4 included 6 pool sites with the lowest values of macroinvertebrate species richness and rarity among the clusters. They were the smallest, deepest and most upland of the wetlands sampled, and overlay volcanic, granitoid or metamorphosed sedimentary rock. All were well oxygenated. Indicator species were *Macrobrachium hainanense, Anax immaculifrons* and *Copera ciliata*. These pools were poor in fish (mean 0.5 $\pm$ 0.5 species) and amphibians (0.5 $\pm$ 0.8).

4.11.2 Family

Classification of wetland sites according to their macroinvertebrate composition identified to the family level produced three rather robust clusters of sites. The advantage of using a family-level classification is that it reduces taxonomic difficulties and reduces the complexity (and some redundancy) in the data set. Unfortunately, the resulting groupings were less informative and offered with less discriminating power than a classification based on species-level identifications. There were, for example, very few rare families and so the rarity index conveyed little useful information. An additional problem was that most indicator families were associated with cluster 2, and only one family with cluster 1. As indicated in the **Materials and Methods** (section **2.4**), this is rather unsatisfactory. The characteristics of the three clusters are summarised below.

Cluster 1 included seven marshes and a pond overlying (with one exception) volcanic rock. They supported the greatest number of families and rare families. This group included the largest sites: they were relatively acidic, with high ammonia and phosphate - but low nitrate and nitrite - concentrations. A single indicator family (Caenidae) was identified.

Cluster 2 was a group of 11 shallow marshes overlaying a variety of igneous rock types, with relatively high conductivity and elevated nitrite levels, but low ammonia. Family richness and rarity was similar to - but less than - cluster 1. A number of indicator taxa were identified (Ostracoda, Dugesiidae, Isopoda, Hydrobiidae, Sesarmidae, Lepidostomatidae, Glossiphoniidae, Erpbodellidae, Hirudinidae, Beraeidae, Psephenidae, Limnichidae, Syrphidae, Anthomyiidae, Stratiomyidae, Simuliidae, Empididae and Corethrellidae) but many of them were rather uncommon and confined to one or a few sites within the cluster.

Cluster 3 consisted of six pools, and comprised the same sites (with the same characteristics) as those in cluster 4 of the species data set. Relative to the other two family cluster groups, these pools had low phosphate concentrations. Indicator families for cluster 3 were Palaemonidae, Heptageniidae and Polycentropodidae.

5. *Macropodus concolor*: the Black Paradise Fish

Only three species of Paradise Fishes are known to science; two of them occur in Hong Kong. The Chinese Paradise Fish (*Macropodus opercularis*) was the first tropical aquarium fish to be maintained in Europe (in 1869), and appears to be quite widespread in freshwater habitats in the territory. It now exists as a highly-modified strain in the aquarium trade, and is of some economic value. However, there has been no research on this species in its natural habitat. The Black Paradise Fish (*Macropodus concolor*) is a rare aquarium fish, and only highly selectively-bred individuals are known to aquarists. The domestic strain is in-bred, as it has been derived from a few founder individuals. Recent reports (Topfer, 1990) that the sex ratios of aquarium populations are highly skewed (> 95% male) suggest that this strain may soon become extinct. Wild populations of the Black Paradise Fish have been discovered at five sites during the present survey. This is of great biological interest because they are the only known wild population of this species on the planet. In fact, the geographical range and origins of *M. concolor* are obscure (Topfer, 1990): it has not been recorded from China (e.g. Nichols, 1943; Pan, 1991; Ding, 1994), and nothing is known of its biology in the wild.

A recent survey of streams in Hong Kong (Chong & Dudgeon, 1992) yielded a total of 96 species of native stream fishes. Thirty-five of these species were marine vagrants, but the remainder are true freshwater fishes. Ten species are threatened with extinction or may be extinct already, and one of them is an endemic species known only from Hong Kong. The Chinese Paradise Fish (*Macropodus opercularis*) is widespread in the territory, and was the commonest wetland fish recorded during the present survey. It occurs in marshlands, pools and also in streams. *Macropodus opercularis* is well known to aquarists but, paradoxically, the biology of this or any Paradise Fish has never been investigated in the natural habitat. Many facets of its ecology are unknown (Topfer, 1990; Gerlai, 1993). Since Chong & Dudgeon's (1992) survey, the present investigation of local wetlands has uncovered another species of Paradise Fish, the Black Paradise Fish (*M. concolor*). The rarity of the Black Paradise Fish <u>in a global context</u> cannot be overstated. There are no accurate records of location data for this species - in Hong Kong or anywhere else. The original type specimens from which the species was described (Ahl, 1937) were found in the Berlin Museum, and the original collecting locality is obscure. Until now, there was a complete absence of ecological information on *M. concolor* in the scientific literature, and no data are available on its natural history (breeding, diet, etc). As far as is known, the recently-located Hong Kong population represent the only wild individuals of the Black Paradise Fish. There is thus an urgent need to ensure that the habitats where it occurs are adequately protected.

Macropodus concolor has been recorded from five sites during the present survey and, since belontiids are 'marshland specialists' and rather uncommon in streams, this may be a representative picture of its distribution in the territory. The fish was confined to marshlands and generally occurred in allopatry with *M. opercularis* except at Sha Lo Tung Marsh where both species were sympatric (although *M. concolor* was very scarce). When the incidence of Paradise Fishes across sites was examined in relation to the species composition of macroinvertebrate communities at each site, it appeared that *M. concolor* was confined to sites classified into cluster groups 2 & 3, whereas *M. opercularis* was found at least one site in each of clusters 1 - 4, but was most commonly encountered at cluster-1 sites. Although it is not obvious what the causal factors underlying the differences in cluster occupancy might be, information on the environmental and biological characteristics of sites occupied by the two Paradise Fishes have been summarised in Table 21.

In view of the fact that the Black Paradise Fish has potential for the aquarium trade, protection of breeding sites from amateur and professional collectors will be essential (Andrews, 1990). Nothing is known of the Hong Kong Paradise Fishes in an evolutionary context - in particular the possible isolating mechanisms that exist between the two *Macropodus* species (Koref-Santibanez *et al.*, 1991) - and this is of interest because the prevailing view of these two species was that they existed in allopatry and not (as in Hong Kong) in sympatry (Topfer, 1990).

6. Conservation recommendations

6.1 Overall strategy

The classification of wetland sites according to their macroinvertebrate fauna has allowed the identification of several site groups which differ with respect to their environmental and biological characteristics. As discussed above (section **4.11**), classification on the basis of macroinvertebrate species (rather than families) produced the most informative results, and thus these results will provide the main (but not the only) basis for our conservation recommendations. Two alternative approaches can be taken to the selection of sites for conservation. One possibility would be conservation of all five sites making up cluster 1 because they have the highest macroinvertebrate species richness and the greatest area, as well as the highest fish and amphibian richness. In effect this would result in protection for large, low-lying marshlands that support the greatest number of species. However this schema is rather rigid and it would leave out sites which - despite being small and relatively species-poor - support rare or unusual species that do not occur in large marshes.

An alternative would be conserve (for example) the best sites from each cluster). 'Best in this case would mean greatest species numbers, although other factors (such as rarity and 'viability' - see Davies & Giesen, 1994) would influence site selection. This approach permits a broader coverage of wetland types and might provide a buffer against environmental impacts confined to particular types of habitats. For instance, low-lying sites (as in cluster 1) are especially vulnerable to sea level changes, and are particularly attractive locations for residential or recreational developments.

The second approach offers greater promise because, by selecting only cluster-1 sites, rare species which are not represented in that cluster (since they require environmental conditions that prevail in the other cluster groups) are excluded. Moreover, protection of all sites within a cluster may lead to redundancy if all have a similar species composition, and if the species complement of smaller marshes are simply nested subsets of those in larger marshlands. For example, Luk Keng marsh - the richest site - may support all of the species found in the four smaller marshes within cluster 1; thus a greater protection of biodiversity would be achieved by protecting some sites from other clusters (in addition to some from cluster 1) rather than selecting all sites in cluster 1. For these reasons we recommend giving priority to cluster 1 sites, with the addition of selected sites (with rare species or with distinctive characteristics) from each of the other three clusters. **We believe that most - if not all - of the sites selected from clusters 1, 2 & 3 (and listed below) could be protected by extension of the existing Country Park boundaries to include the valley bottoms in which these wetlands are situated.**

6.2 Sites selected

6.2.1 Cluster 1

Luk Keng marsh is an obvious choice because it supported the greatest number of macroinvertebrate species, approximately one third of the total species recorded from all wetlands, with a good representation of rare macroinvertebrates. It is the largest freshwater marsh in the territory, and has diverse microhabitats including patches of Cyperaceae, a reed bed (*Phragmites*) floating grass islands, and numerous deep-water channels. This diversity of habitat supports the majority of the territory's wetland flora. In addition, two internationally-rare dragonflies have been reported (*Mortonagrion hirosei* and *Nannophyosis clara*) as well as two species which are locally-rare (*Rhyothemis triangularis* and *Diplacodes nebulosa*). The marsh is an important breeding site for certain wetland birds also.

Sam A Tsuen marsh - ranking fourth in terms of area among the sites sampled - should be protected also. It was the third richest site with respect to macroinvertebrates, and the composition of the community was distinctive because of the importance of gastropods. This was the only wetland where the Rice Fish (*Oryzias curvinotus*) was found. The remoteness of this area should make legal protection viable.

6.2.2 Cluster 2

Yung Shue O marsh 2 had the second highest species richness of all wetlands despite being only a fraction of the size of the richest site (Luk Keng marsh). Rare species were quite well represented, and the Black Paradise Fish (*Macropodus concolor*) was present. A possible new species of bog orchid, *Liparis* sp. has been found here also, and this is one of three sites where *Nannophya pygmaea* - the worlds smallest dragonfly - breeds locally. Because of their proximity, it is recommended that protection of this locality extend to cover nearby Yung Shue O marsh 1 since populations in a larger area will be less vulnerable to extinction as a result of unusual weather conditions (e.g. a lengthy drought) or unforseen human impacts.

Shuen Wan marsh could represent a second choice from this cluster as it was ranked fourth in macroinvertebrate species richness, and fifth in terms of wetland area. However, development in the vicinity has been proceeding rapidly, and protection of this site may not be practicable. As an alternative, **Sheung Miu Tin marsh** - which is unlikely to be impacted by development in the immediate future - could be considered. This is a breeding site for *Macropodus concolor* and has moderate macroinvertebrate richness and species rarity (being the only Hong Kong locality for hydrochid beetles).

6.2.3 Cluster 3

Cheung Sheung pond was the most biodiverse pond site sampled (ranking eighth among sampled wetlands), and had the highest number of rare macroinvertebrates (including two species of whirligig beetles). It had well established growths of submerged macrophytes. The site is rather small and is closely associated with **Cheung Sheung marsh** where **Macropodus concolor** (in addition to other fish) is abundant. Accordingly we recommend that the combined wetland be protected. Cheung Sheung marsh was ranked sixth in terms of macroinvertebrate species richness and fifth in terms of rarity among all sites sampled. The remoteness of Cheung Sheung should facilitate the designation of this locality as a protected area.

Sham Chung marsh was fairly diverse in terms of macroinvertebrate species richness, and ranked second with respect to rarity. It was an important locality for fish, including more than half of the total number of species collected, and was the richest site in this respect. It was the eighth largest wetland sampled; a stream flowing through the middle created habitat conditions which were rather different from those prevailing at other sites. The lack of road access to this coastal site should contribute to the protection of this site.

6.2.4 Cluster 4

Lamma Island pond had plentiful emergent vegetation, provide good habitat for numerous macroinvertebrates, including dragonflies such as *Diplacodes nebulosa* and *Rhyothemis triangularis*. This site ranked second among ponds in richness and rarity of invertebrates which may reflect its size, depth and relatively stable water levels. This site should be considered for SSSI status since protection by extension of the existing Country Park boundaries may not be practical.

6.2.5 Other sites with rare species or significant attributes

Sunset Peak pond - the highest wetland in the territory - deserves protection because of the presence of the Hong Kong newt (*Paramesotriton hongkongensis*) which is listed under the Wild Animals Protection Ordinance. This site is used as a swimming pool by campers on Sunset Peak. Water levels decline dramatically during the dry season this may reflect extraction of water for human consumption or deliberate draining. Consideration should be given to adjusting the Country Park boundaries to include this locality within the Lantau Country Park.

Yi O marsh on Lantau Island is remote with no current human impact. The endemic and protected Romers Tree Frog is found in the vicinity, but breeding within the marsh has not been confirmed.

Sha Lo Tung marsh was not exceptionally diverse but was quite rich in terms of amphibians and fishes. It was the only site where *Macropodus opercularis* and *Macropodus concolor* were sympatric. The basin has a unique dragonfly fauna with many rare and endemic species and, while most of these are stream specialists, protection of the wetland from draining or infilling will be necessary to minimize detrimental impacts on the stream fauna. This site undoubtedly justifies SSSI status on the basis of its stream dragonfly fauna. However, extension of the Country Park boundaries, if practical, would give more effective protection to this important site.

Leung Uk marsh was unexceptional in terms of plant or macroinvertebrate biodiversity. However, this is the only remaining habitat of the locally-endangered Rough-skinned Floating frog (*Occidozyga lima*) and merits protection on this basis alone.

Pui O marsh and taro bed comprised part of an extensive, low-lying wetland. The taro bed contained a number of rare macroinvertebrates (ranking fourth in this respect), and several (albeit rather common) frogs. The area is distinctive because of the presence of a resident population of water buffaloes, one of few remaining areas where they still occur in the territory.

7. Concluding remarks

Much basic ecological knowledge of the ecosystems and their components in Southeast Asia is still virtually non-existent, and has yet to be collected (Prins & Wind, 1993). Emphasis is needed especially on the study of wetlands (Dugan, 1990, 1993, 1994; Scott, 1991; Prins & Wind 1993), but the rate of destruction of wetland habitats is so great that it is certain to mean the loss of many sites before information on their ecologies has been gathered. It is therefore essential that we employ all available information, however fragmentary, to conserve the remaining sites or to ameliorate human impacts upon them. The vast majority (perhaps all) of the freshwater wetlands in Hong Kong have already been significantly altered by human influence; indeed, many of them are abandoned fishponds, rice paddies and flooded fields. These habitats are now under threat because the land which they occupy is needed for development, and many sites have already been drained and filled in. Proposals have already been put forward to develop many of those remaining such as, for example, the Luk Keng marshland. Most of the remaining Hong Kong wetlands are small on a global scale, but this does not mean that they lack conservation value. Some small wetlands have an importance out of all proportion to their size. This applies especially if they are used as breeding, feeding or roosting sites where large numbers of a widely-distributed species become concentrated during certain periods (Davies & Giesen, 1994). In addition, some rare or endemic species (e.g. *Philautus romeri* in Hong Kong) are confined to small wetlands where predators or potential competitors are absent. Moreover, Gibbs (1993) has shown clearly that local populations of turtles small birds and small mammals (which are stable under conditions of no wetland loss) face a significant risk of extinction after loss of small wetlands. Apparently small wetlands play a greater role in the metapopulation dynamics of wetland animals than their modest area might imply (Gibbs 1993). This observation has particular relevance for Hong Kong. The territory supports at least three species of endemic amphibians (two - possibly three - frogs and a newt) and one endemic fish as well as the rare *Macropodus concolor*. In addition, Hong Kong is host to many species of freshwater invertebrates that have been described as new to science and which are (as yet) known from nowhere else (Barnard & Dudgeon, 1984; Asahina & Dudgeon, 1987; Polhemus & Polhemus, 1988; Wells & Dudgeon, 1991; Ng & Dudgeon, 1992; Schönmann, 1994; Jäch, 1995; Jäch & Boukal, 1995; Wilson, 1995a, 1995b). Freshwater species are especially vulnerable because many of them have a rather restricted distribution and diversity tends to be concentrated in a few sites. For example, two streams on North Lantau contain almost half of the territory's freshwater fish fauna, including some species not found elsewhere in Hong Kong (Chong & Dudgeon, 1992).

While many of Hong Kong's rare or endemic freshwater animals are confined to streams, they indicate the richness of the territory's freshwater biodiversity. Moreover, the risk of extinction of elements of the local wetland fauna is relatively high compared to those living in streams. The latter receives protection because of the important role of streams in local water supplies. Wetlands are not thus used, and their perceived value hinges upon a potential to serve as sites for development. We expect that the final selection by Government of sites to be protected (from among those sites of potential conservation value which have been identified in this report) will enable limited resources and manpower to be focused on sites of high ecological and conservation value which have the potential to be protected (and, if need be, managed) successfully.

We stress that extension of Country Park boundaries - rather than designation of the wetlands as SSSIs - will provide more effective protection for the sites identified herein (section **6.2**). While SSSI designation may be the only practical option for some wetlands, current SSSI legislation (covered under the Town Planning Ordinance) requires merely that developers take note of the presence of SSSIs in Outline Zoning Plans. Enforcement procedures against developments which have a detrimental impact on SSSIs seem complex and weak, and their effectiveness has yet to be demonstrated. SSSI designation is therefore less likely to ensure the long-term persistence and conservation of Hong Kong's endangered wetlands than would limited extension of Country Park boundaries to include ecologically-important sites within their boundaries. We recommend this course of action to the relevant Government authorities most strongly.

8. Acknowledgements

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Figure 1 Sampled Wetland Sites in Hong Kong

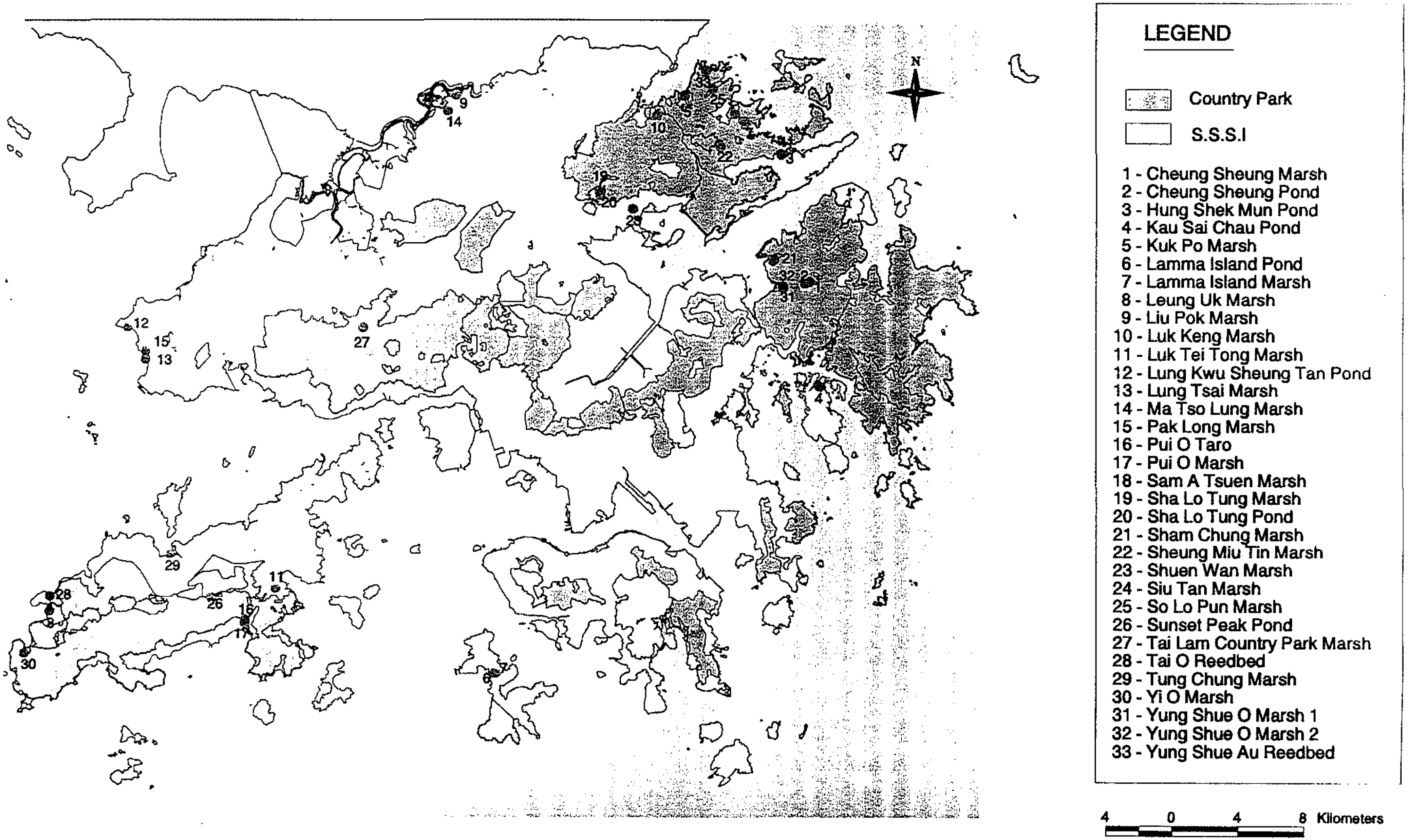
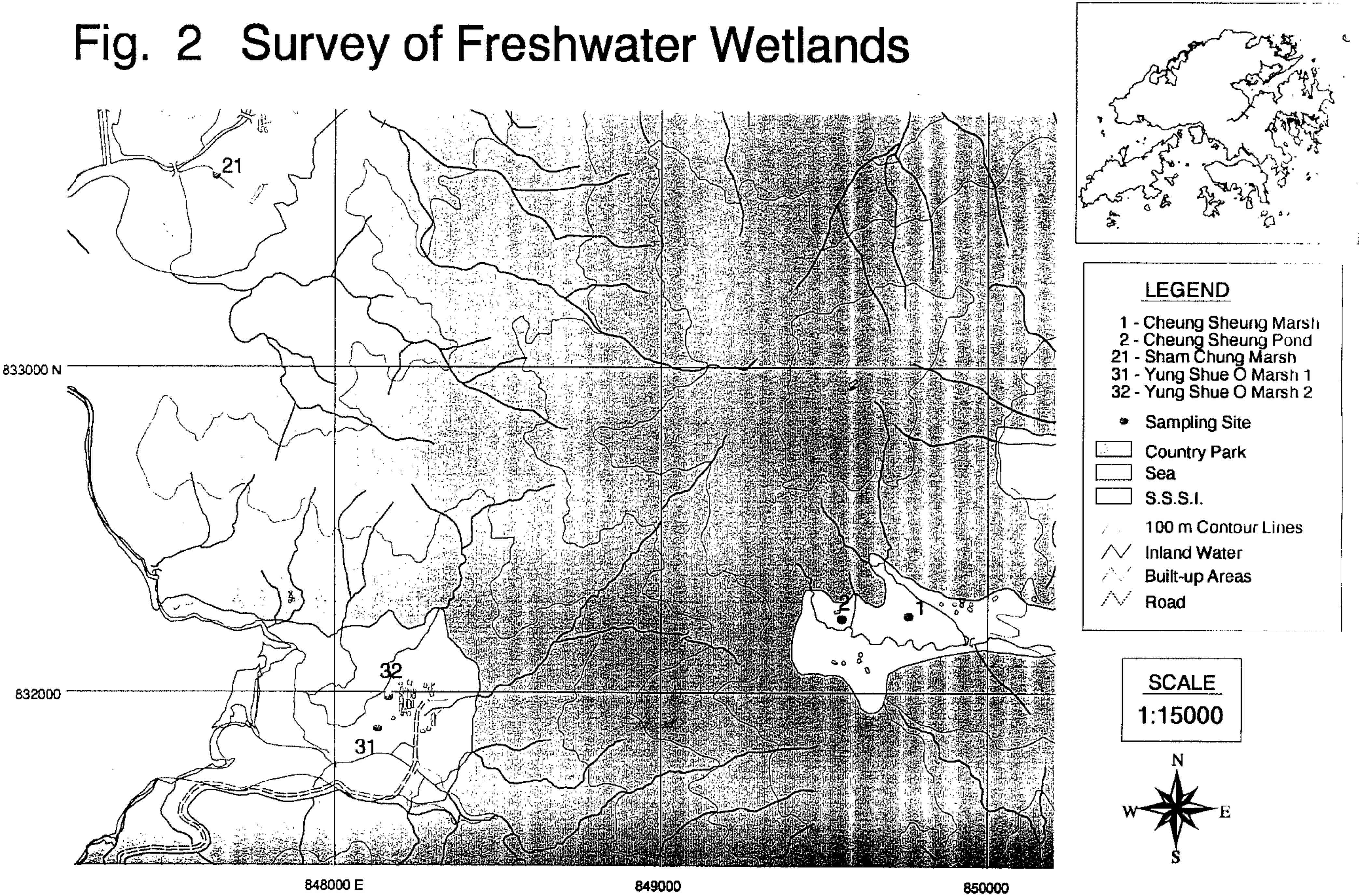


Fig. 2 Survey of Freshwater Wetlands



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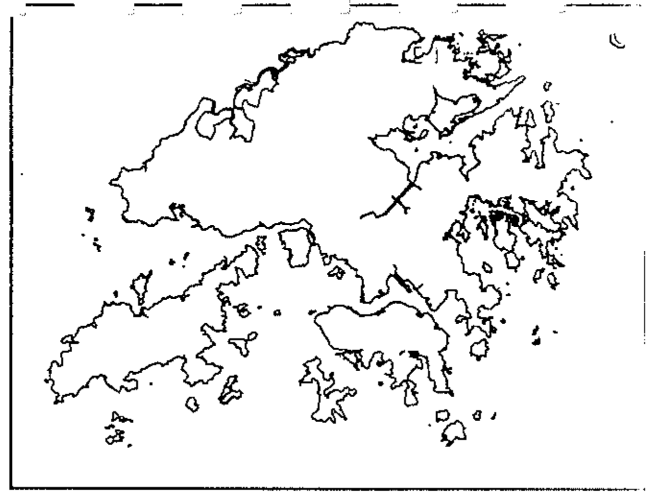

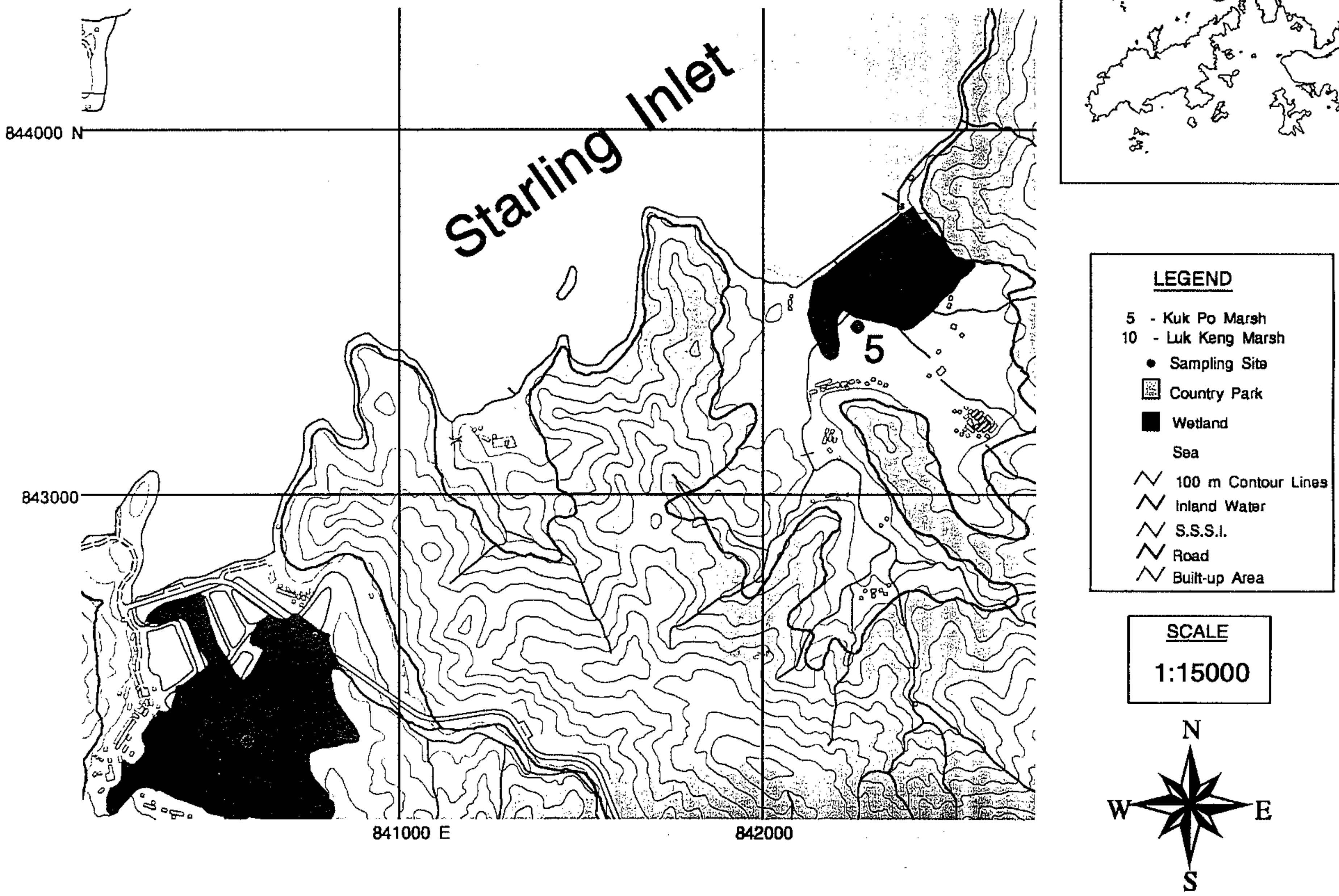

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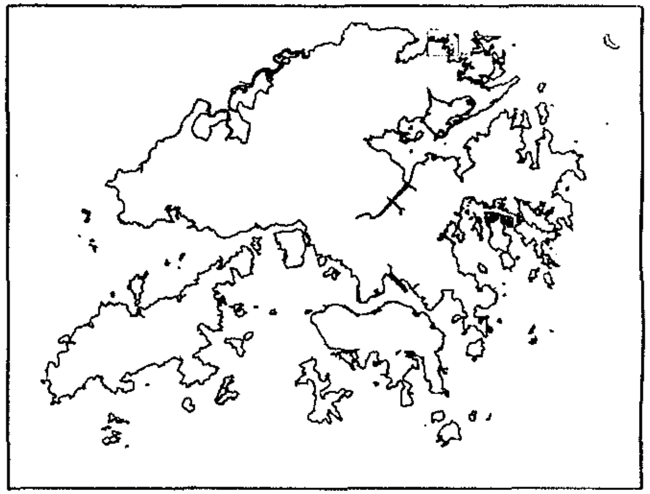

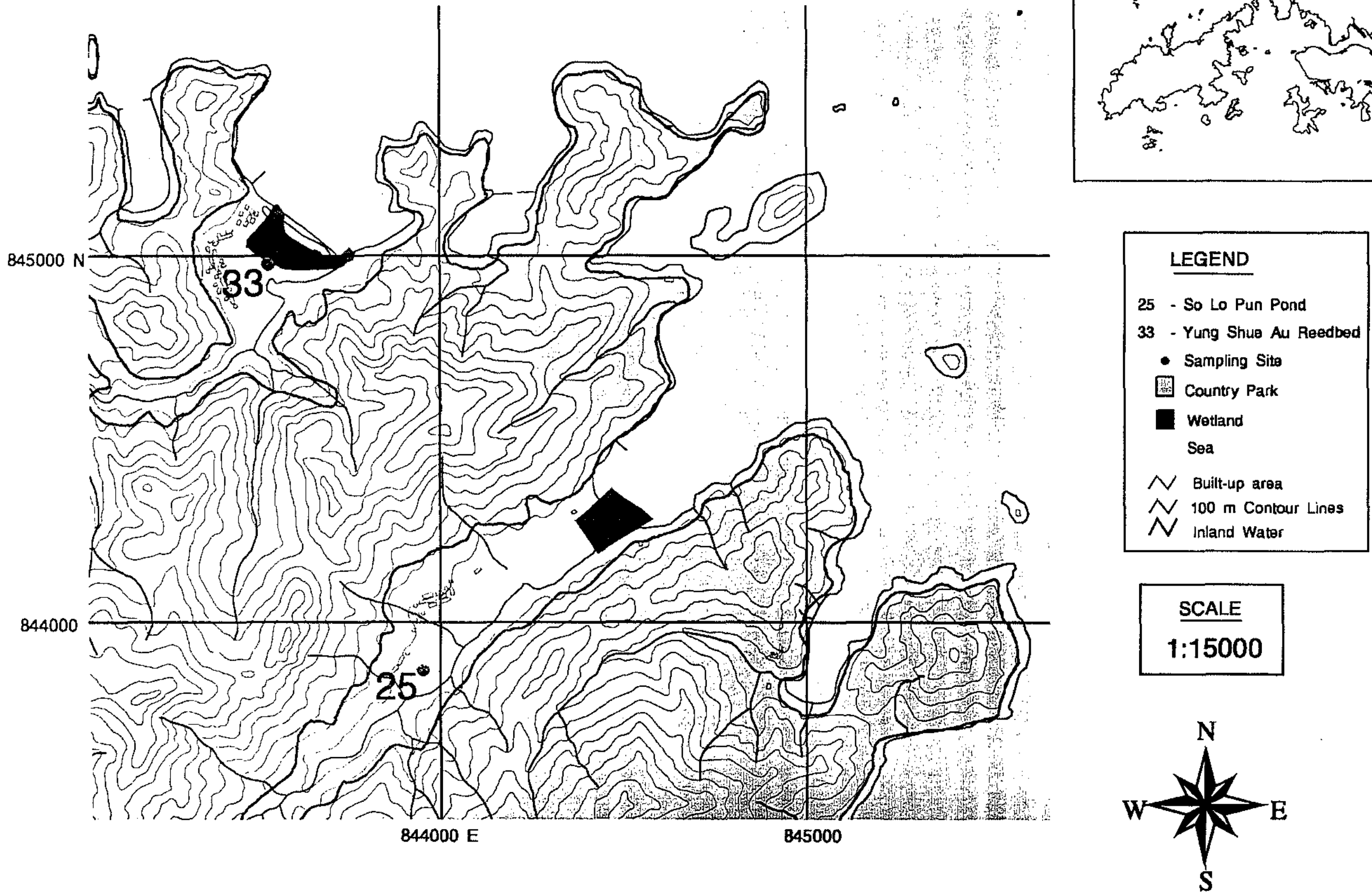

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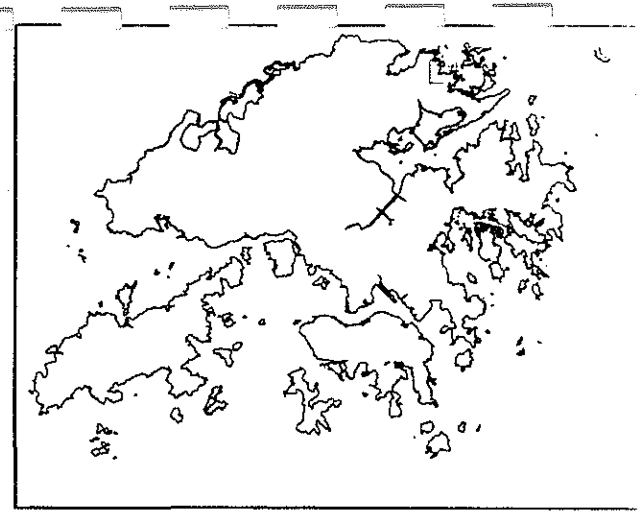

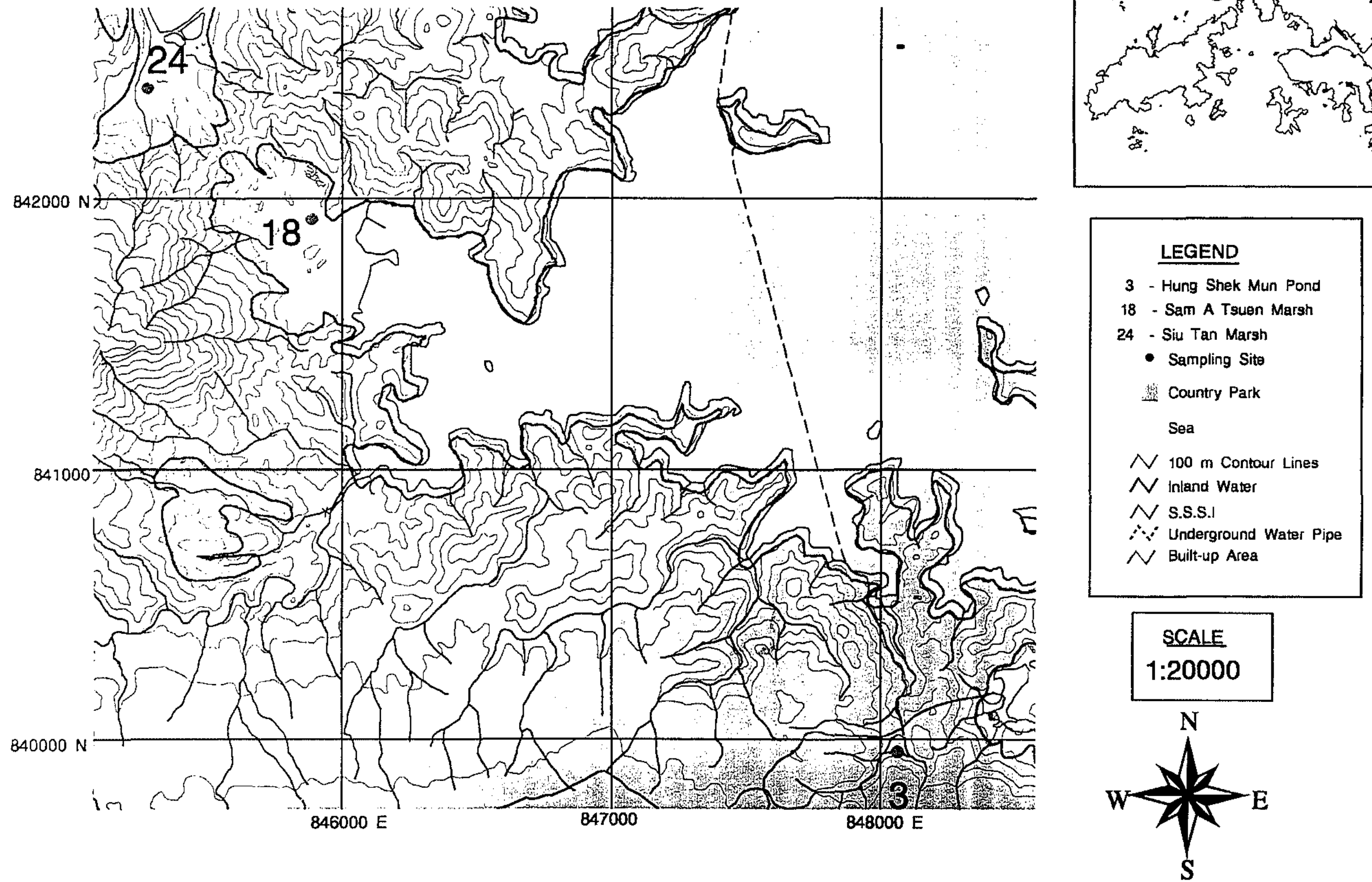

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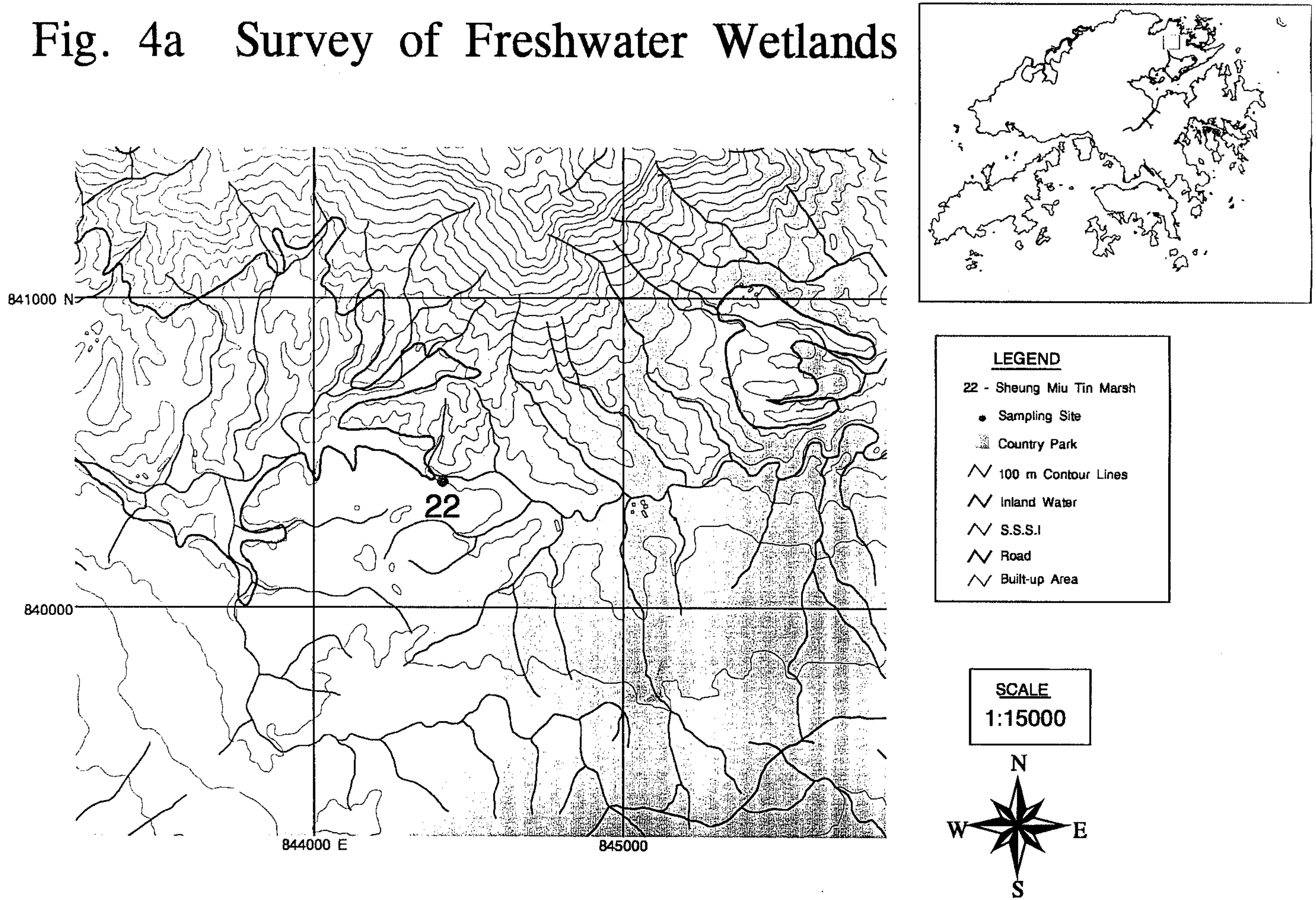

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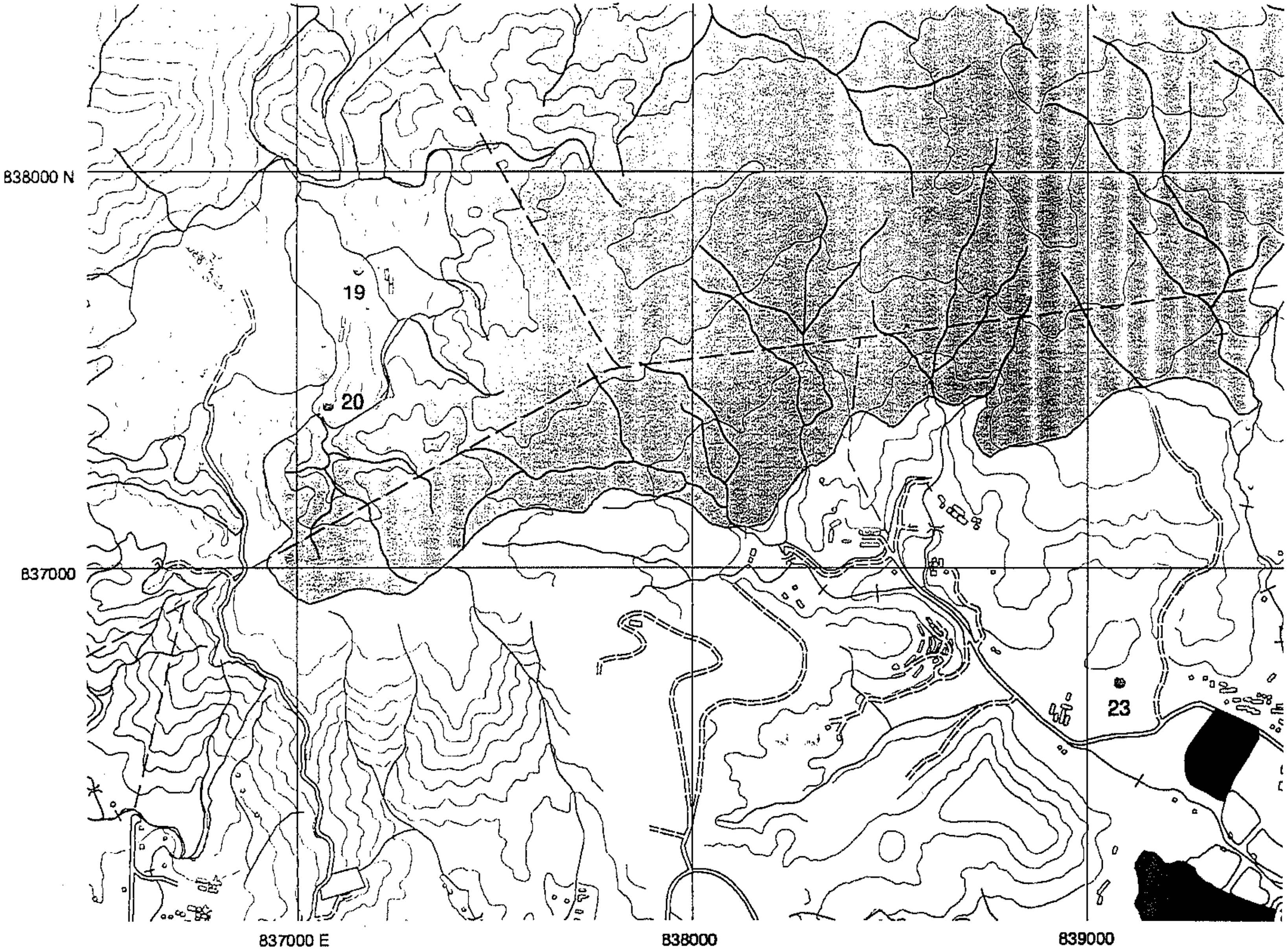
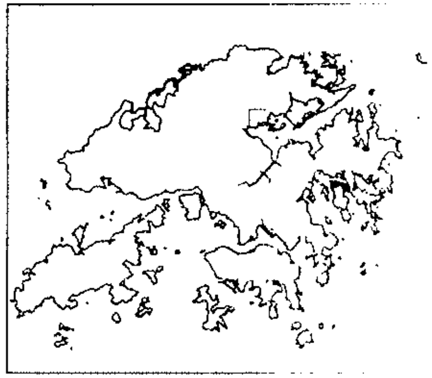


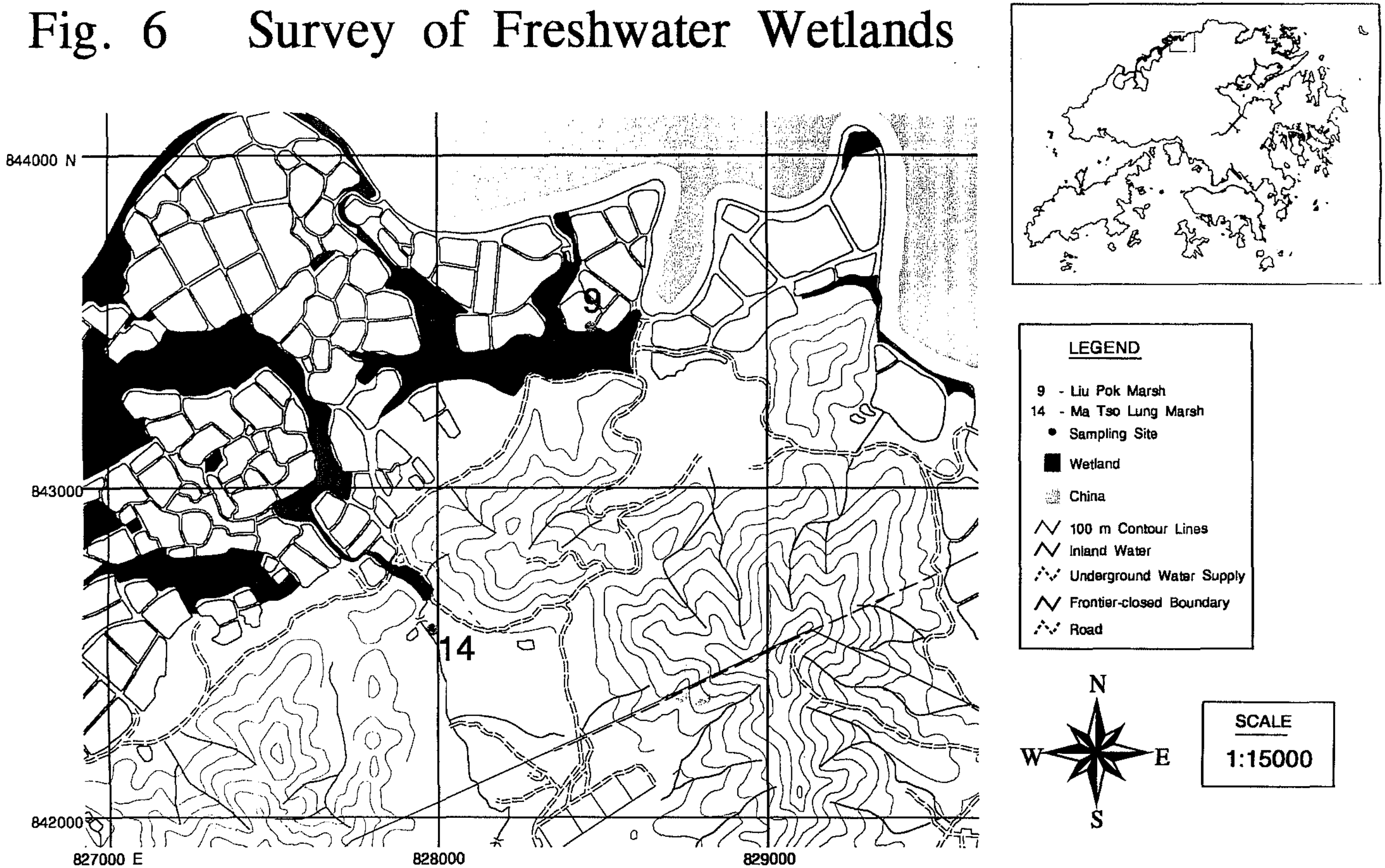


LEGEND

19 - Sha Lo Tung Marsh
20 - Sha Lo Tung Pool
23 - Shuen Wan Marsh
Sampling Site
Wetland
Country Park
Sea
S.S.S.I.
100 m Contour Lines
Inland Water
Built-up Areas
Road

SCALE
1:15000

Fig. 6 Survey of Freshwater Wetlands



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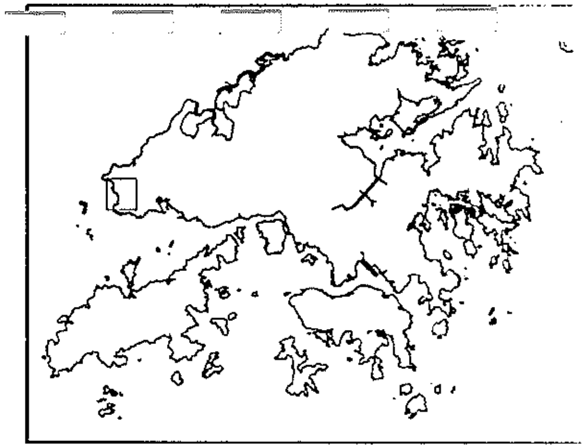

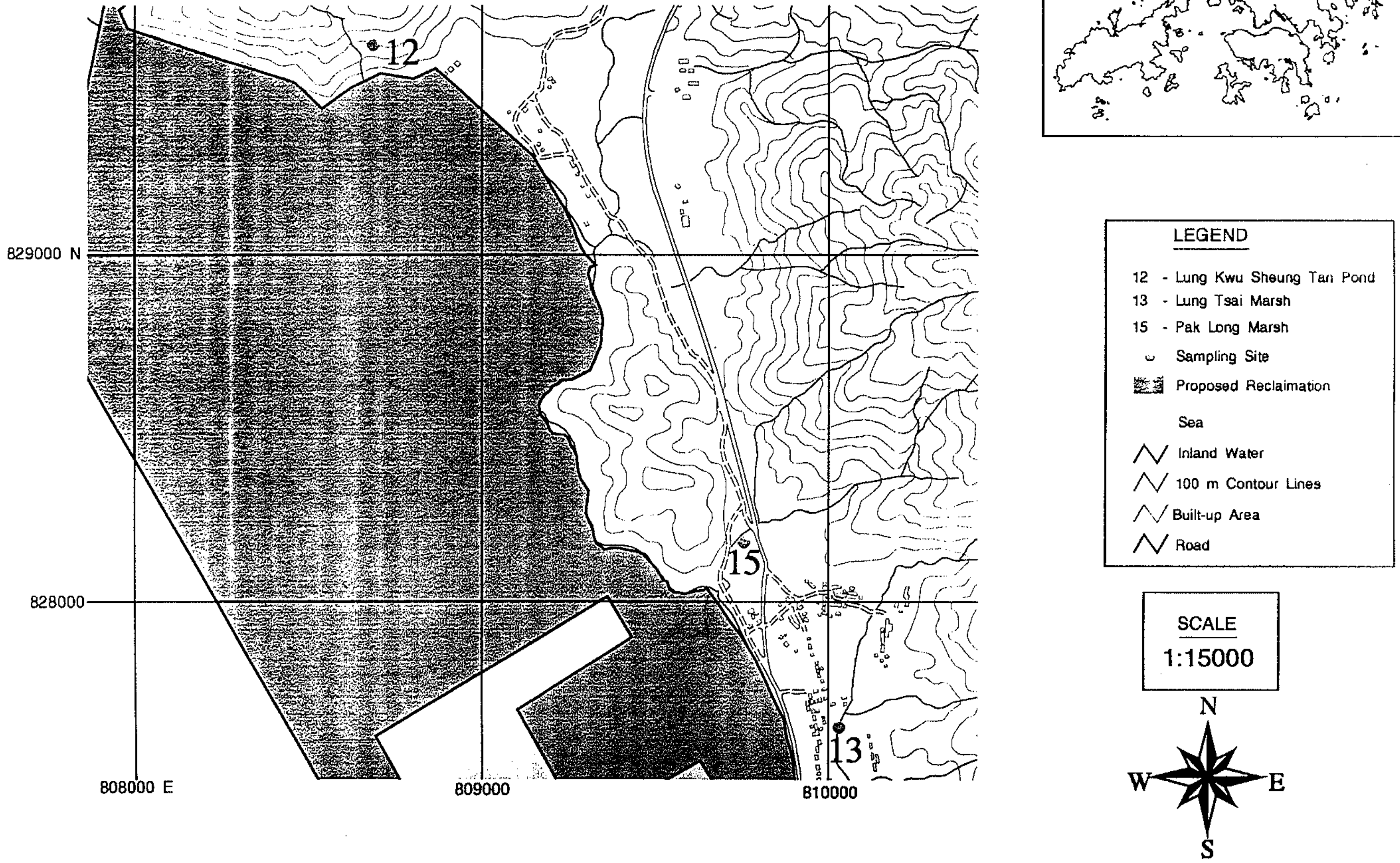

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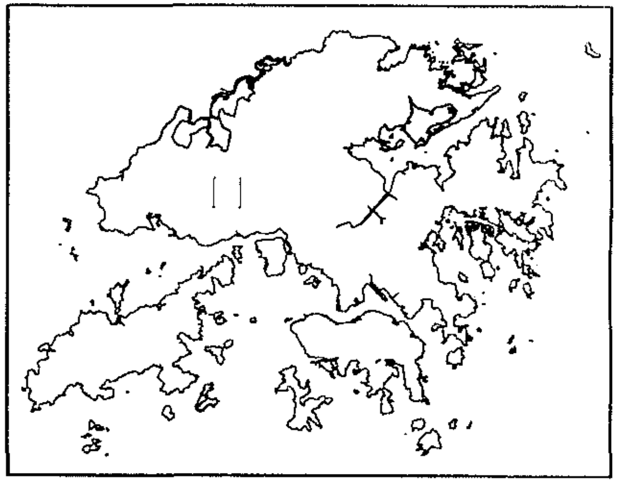


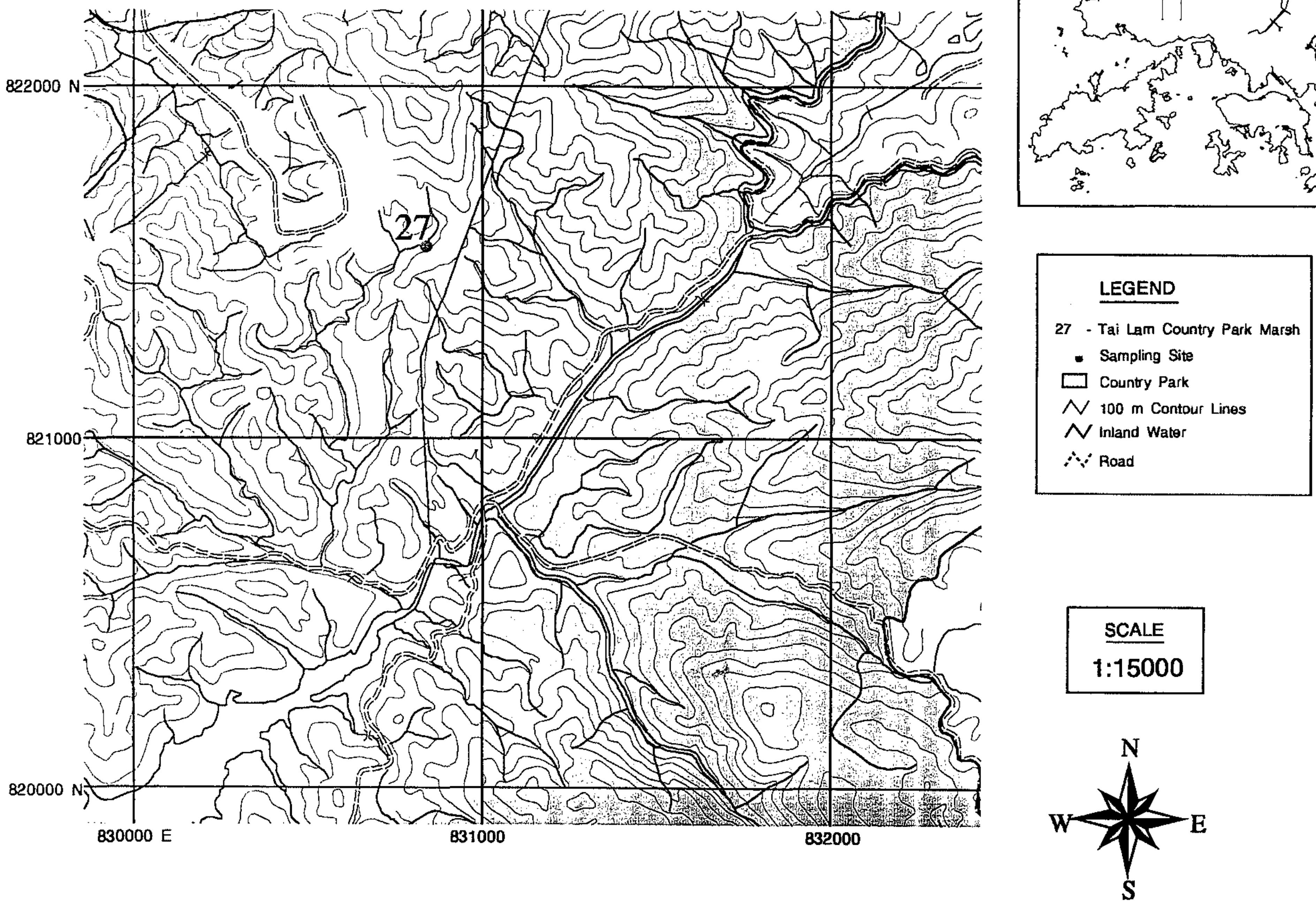
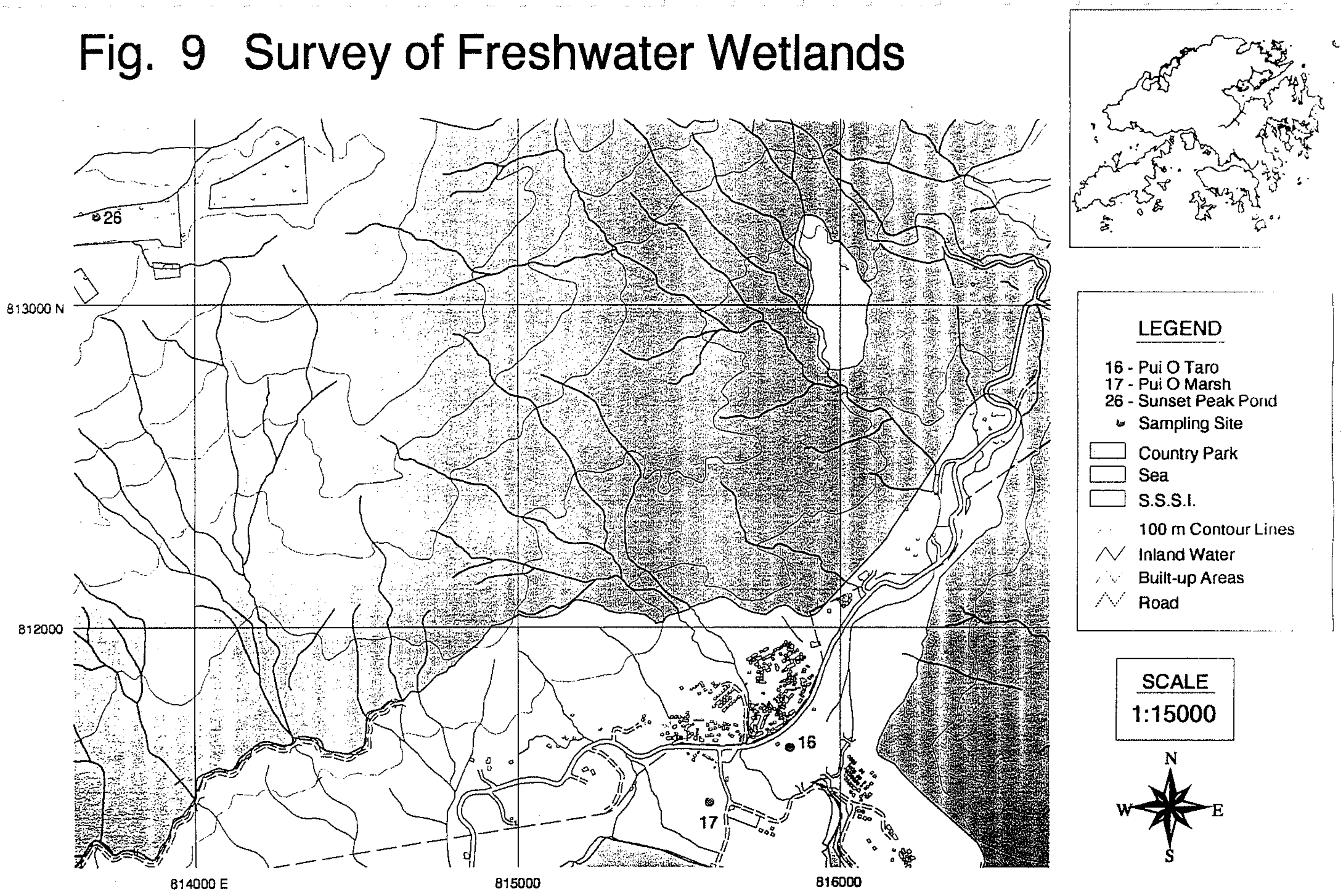


Fig. 9 Survey of Freshwater Wetlands



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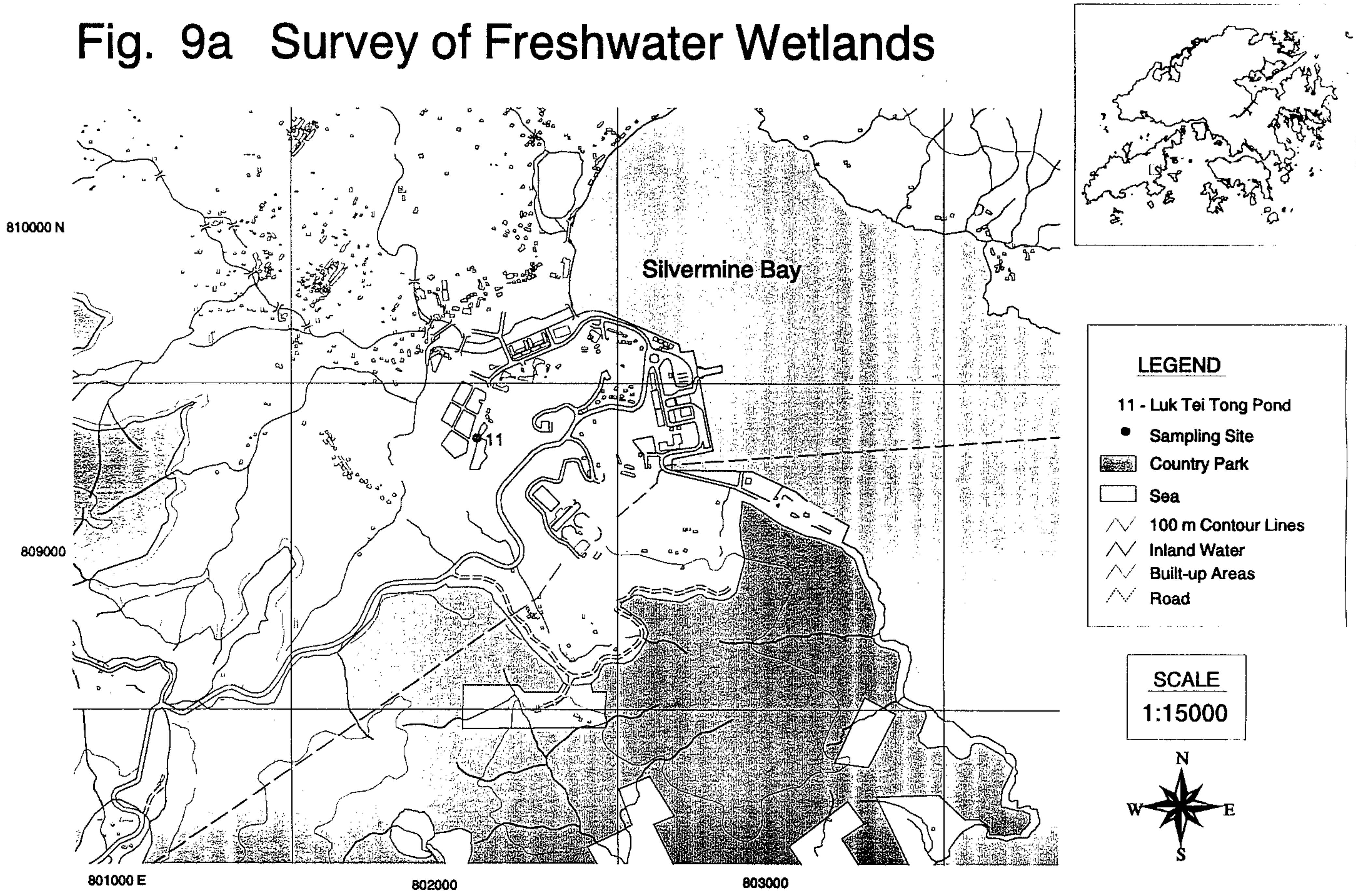
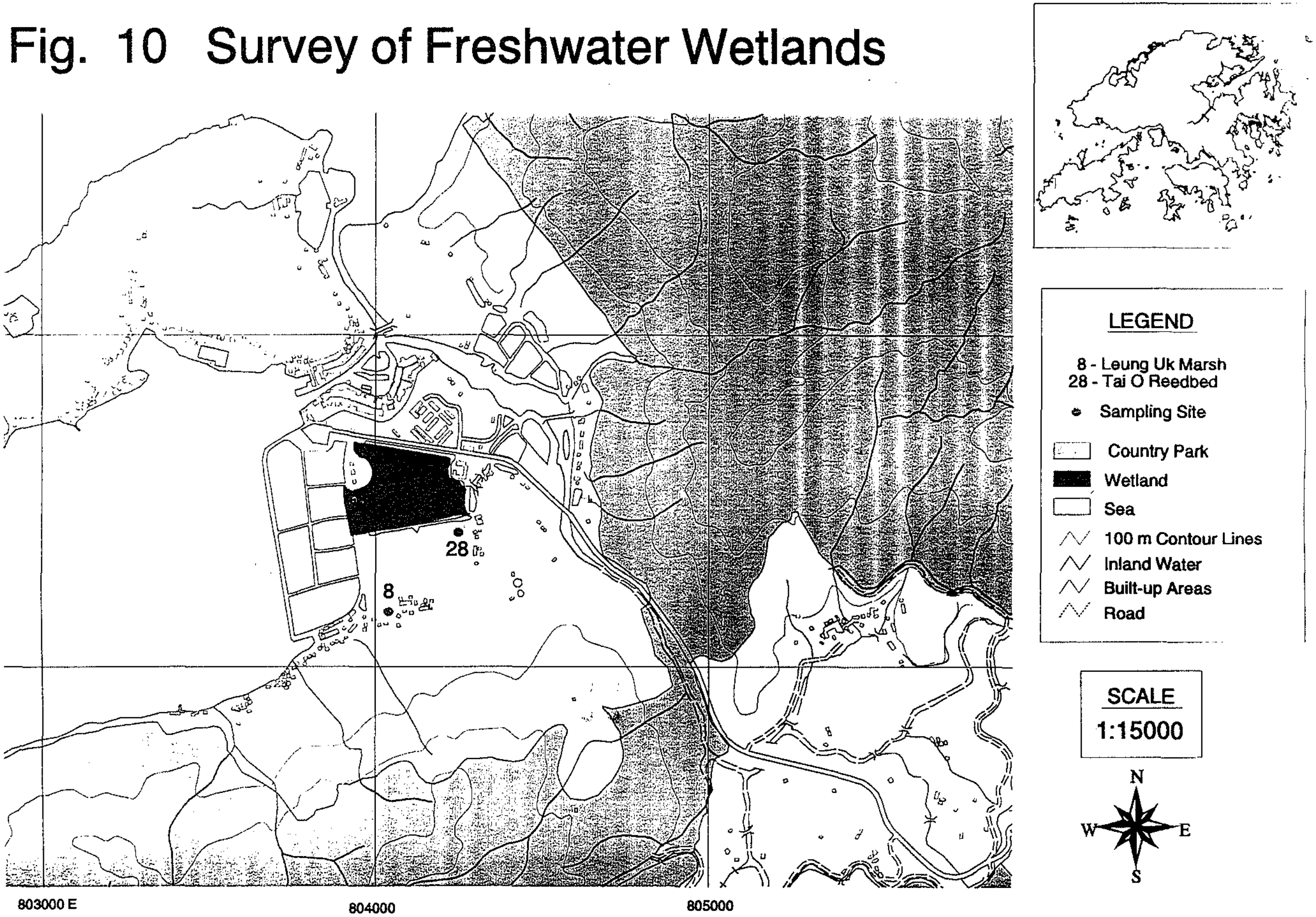


Fig. 10 Survey of Freshwater Wetlands



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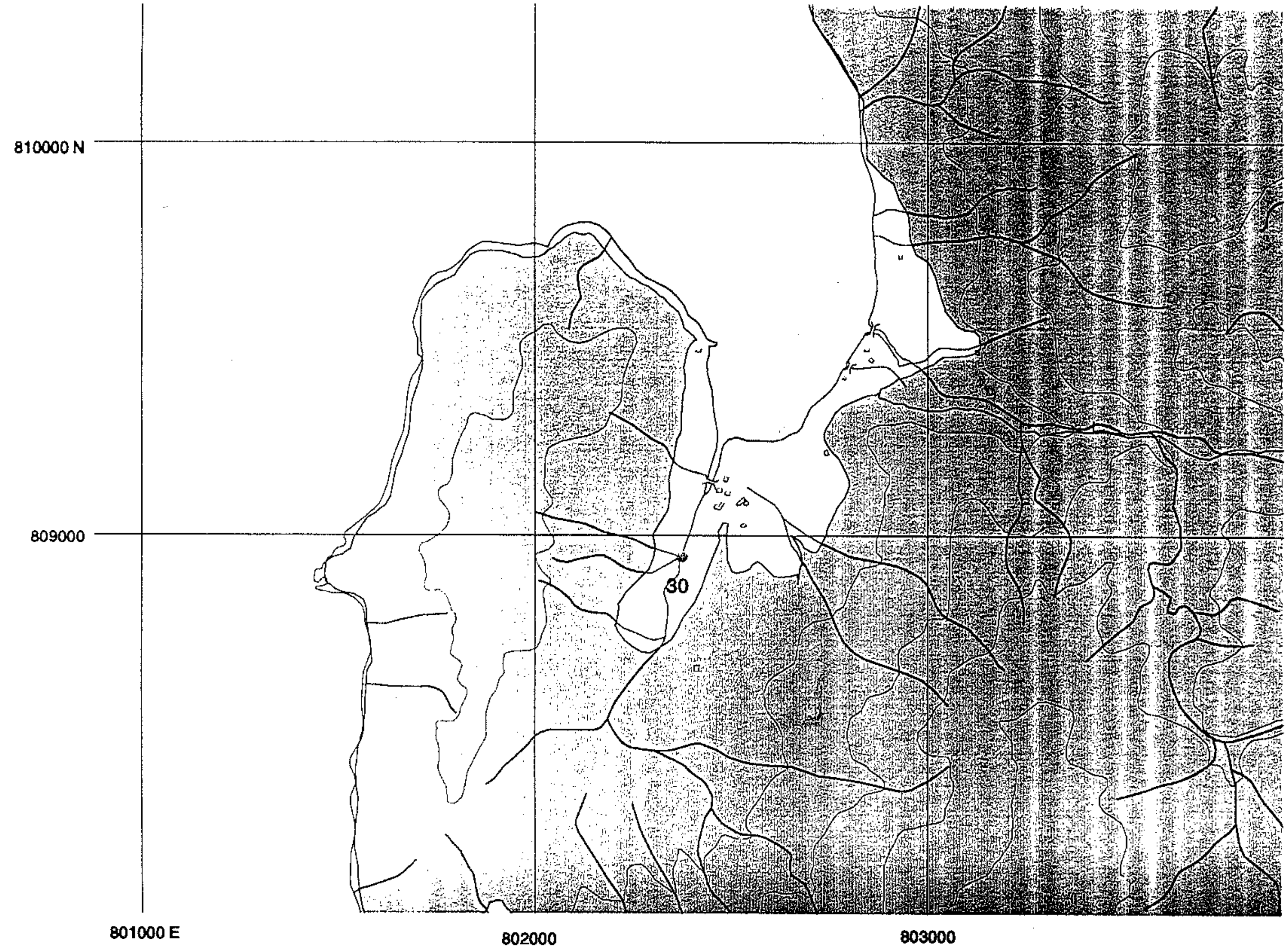

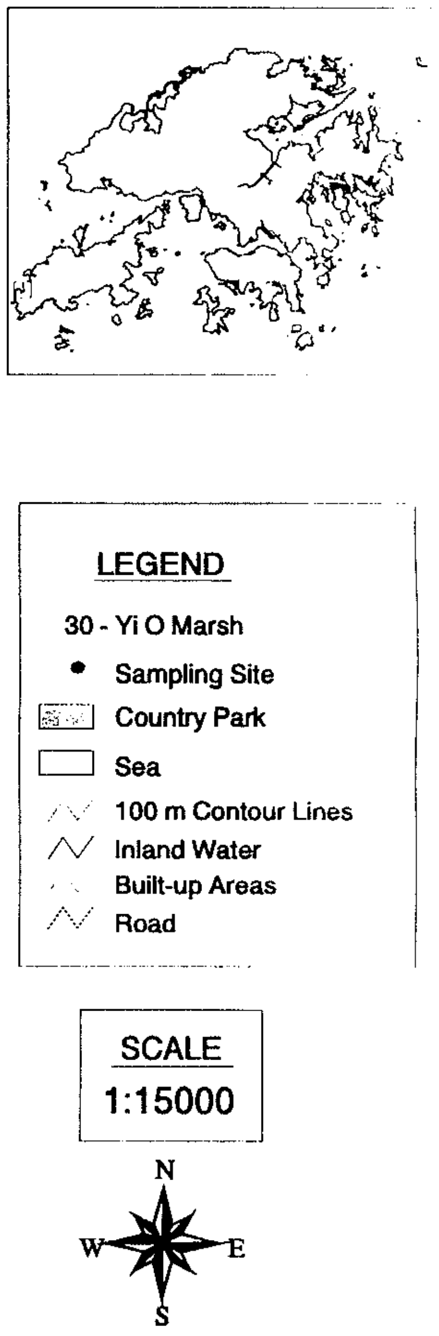

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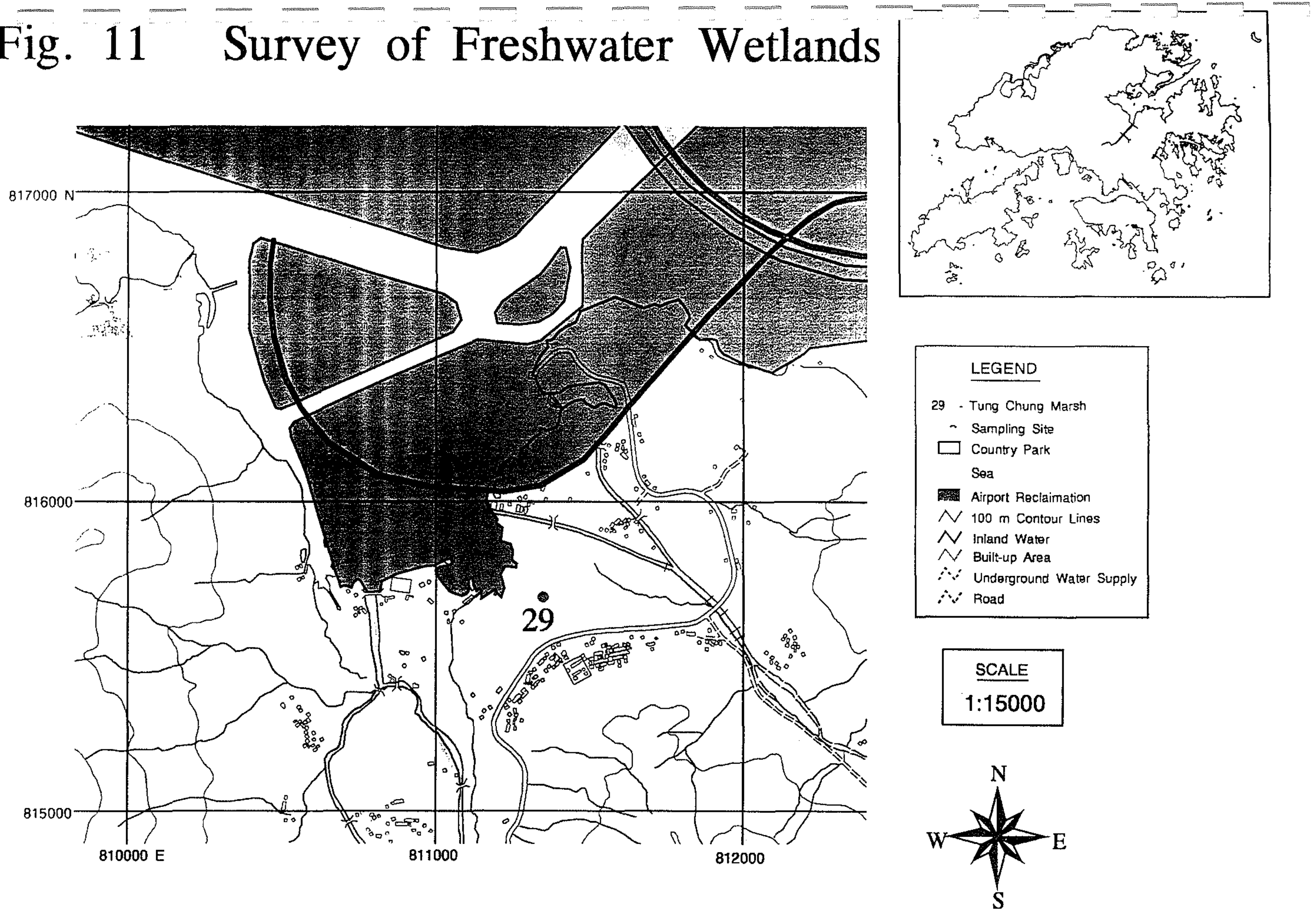

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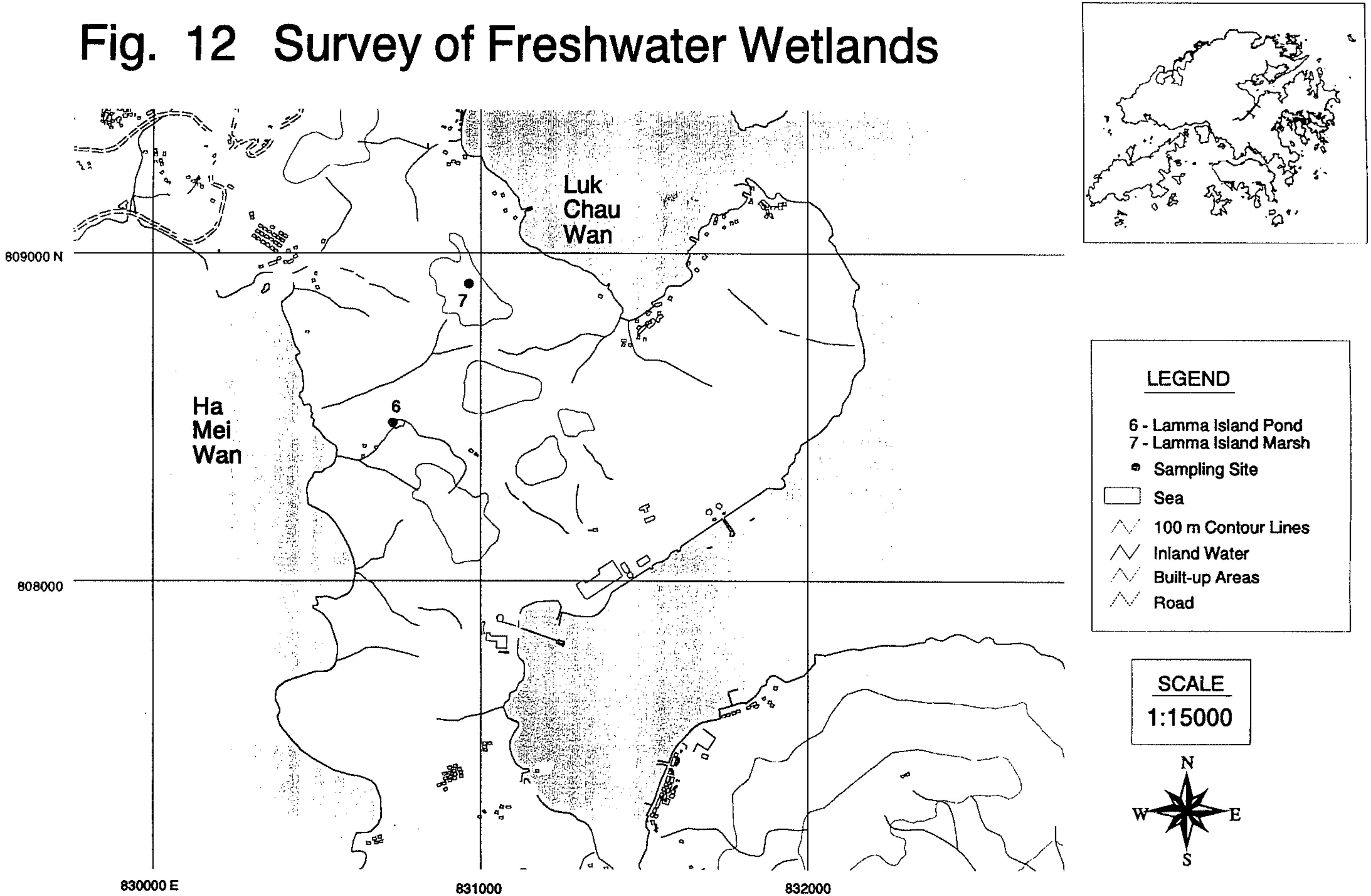
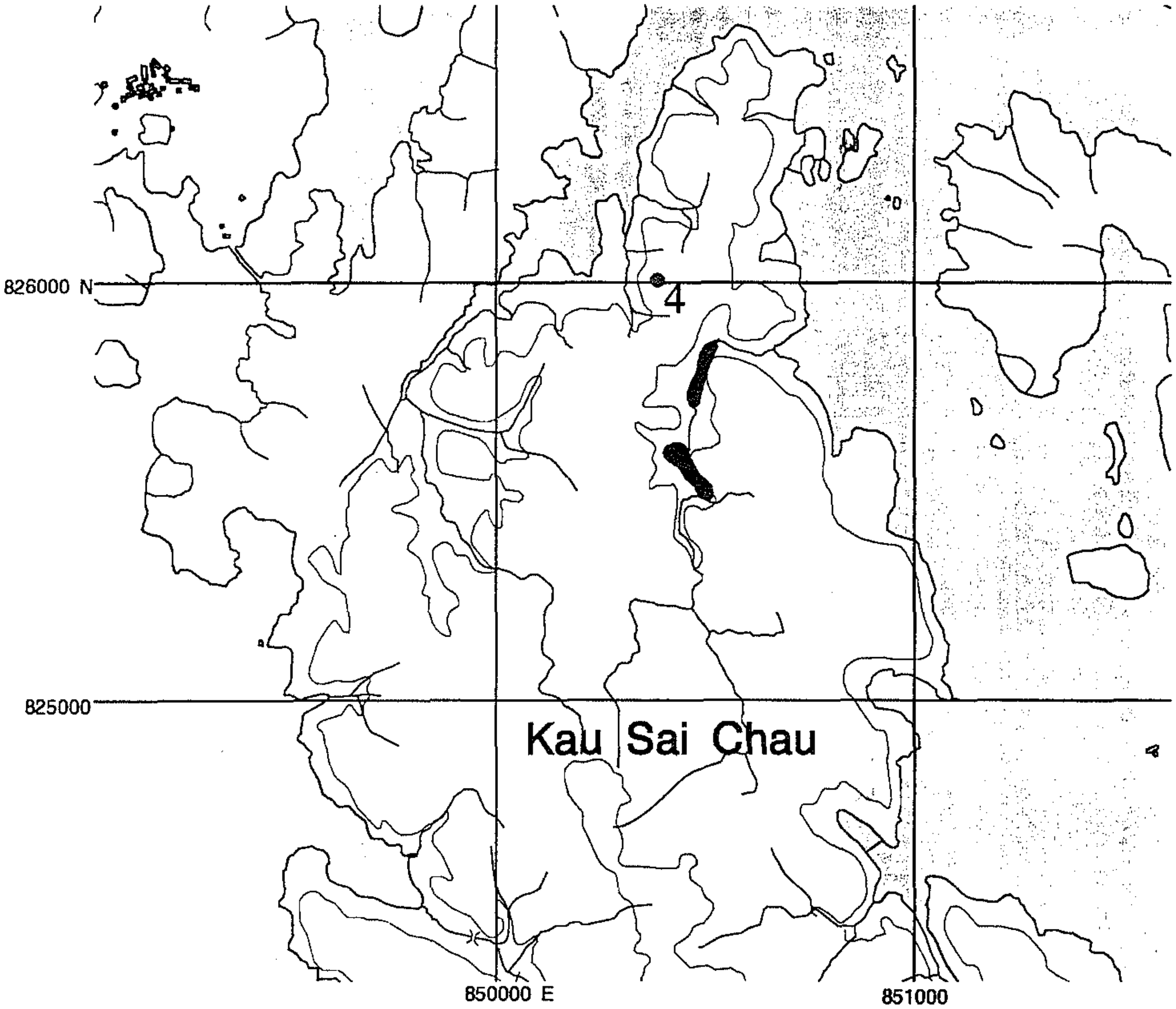
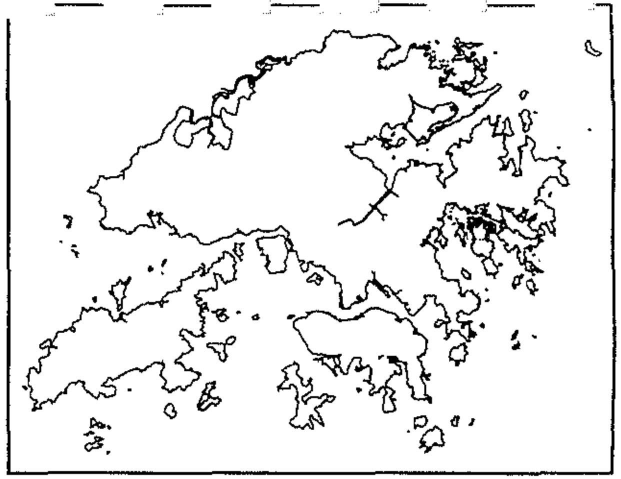


Fig. 13 Survey of Freshwater Wetlands





LEGEND

- 4 - Kau Sai Chau Pond
- Sampling Site
- Country Park
- Sea
- Wetland
- 100 m Contour Lines
- Inland Water
- Built-up Area

SCALE

1:15000

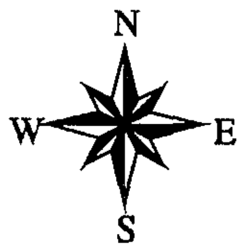


Figure 14. DCA Ordination of macroinvertebrate species data showing TLCPM as an outlying site. Abbreviations as in Table 1.

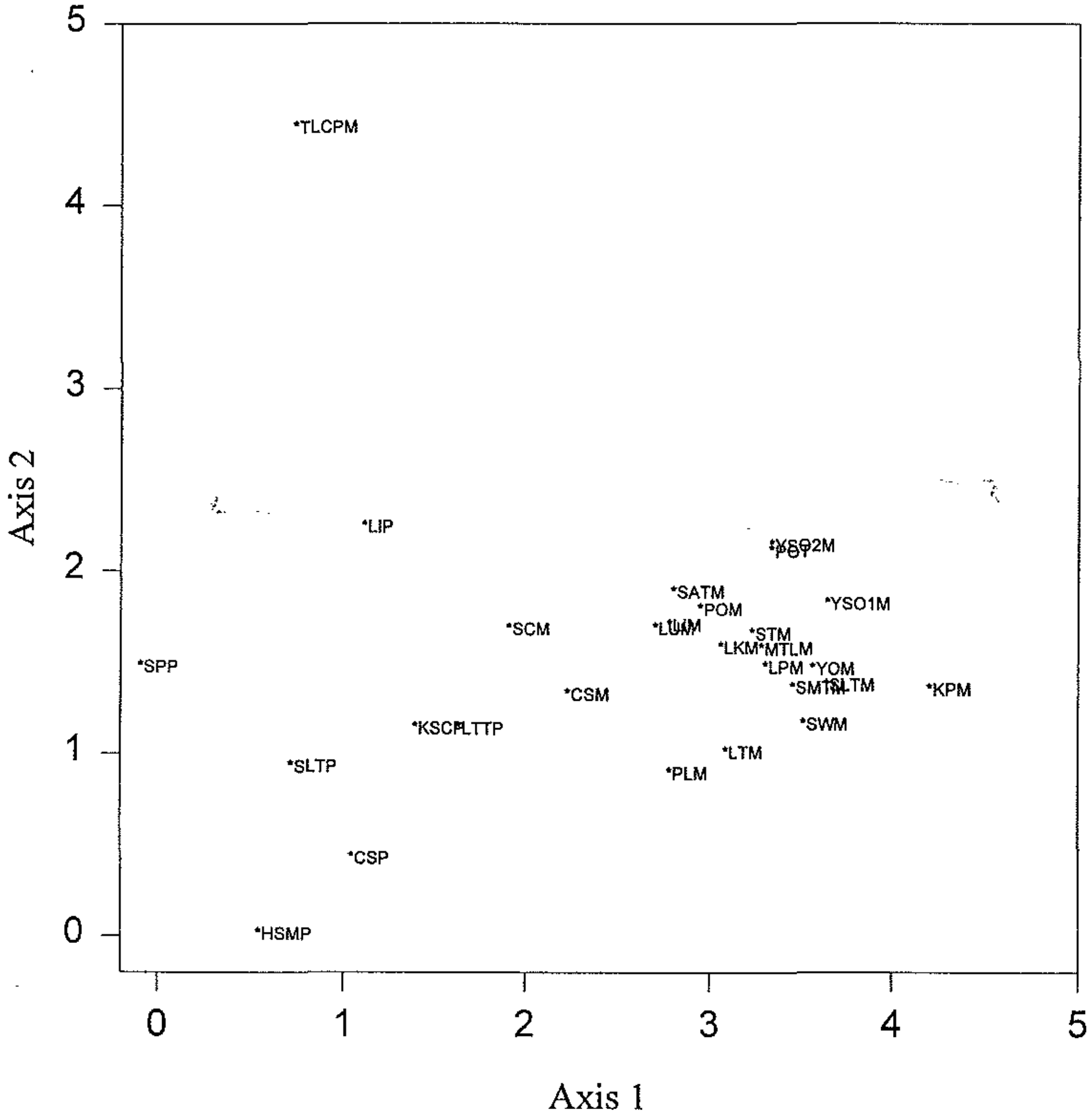


Figure 15. DCA Ordination of macroinvertebrate species data following removal of three outlying sites (TLCPM, LPM, MTLM). Abbreviations as in Table 1.

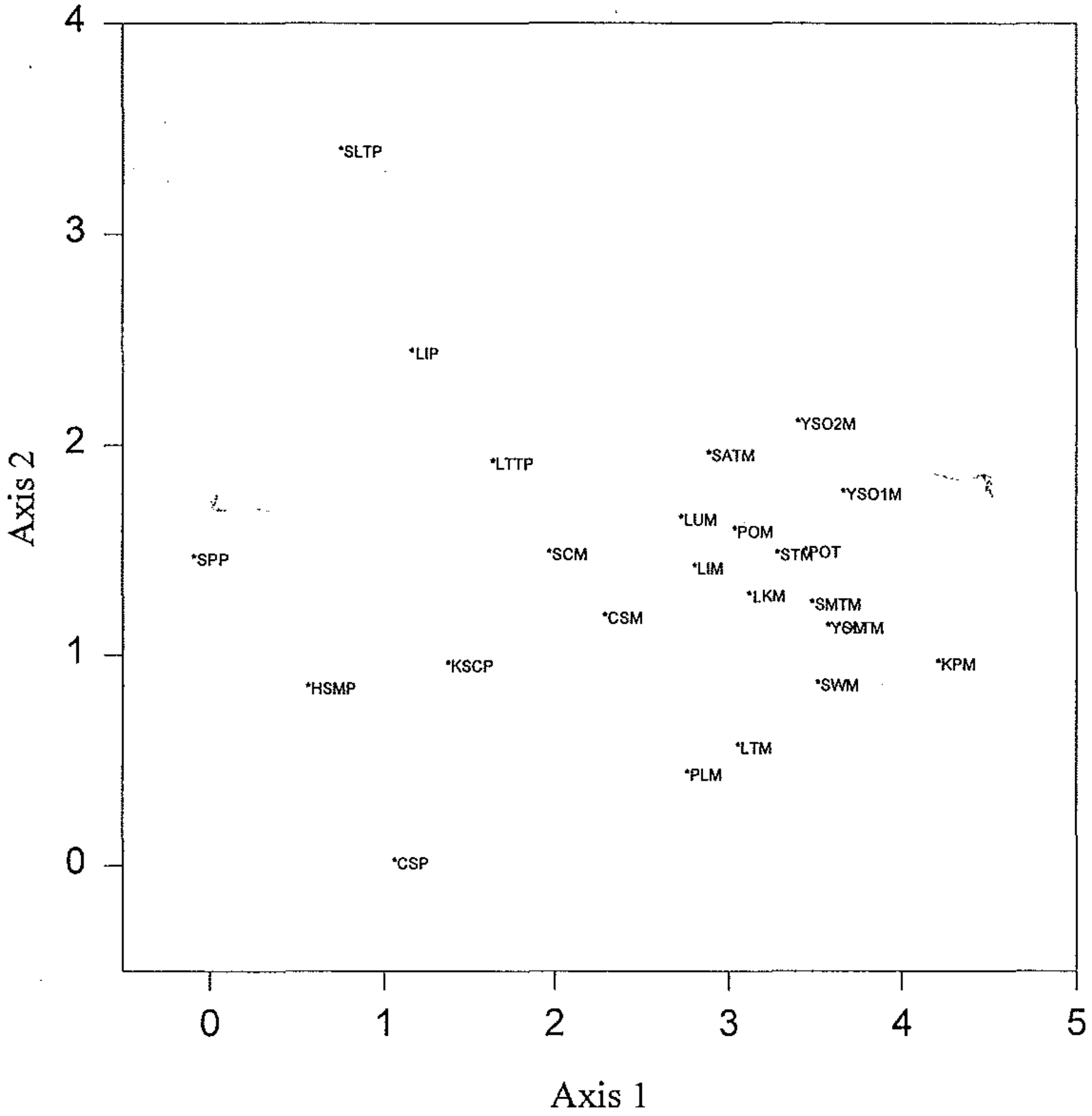


Figure 16. Four cluster solution for K-means cluster analysis of wetland sites following removal of three outlying sites and DCA of macroinvertebrate species data. Abbreviations as in Table 1.

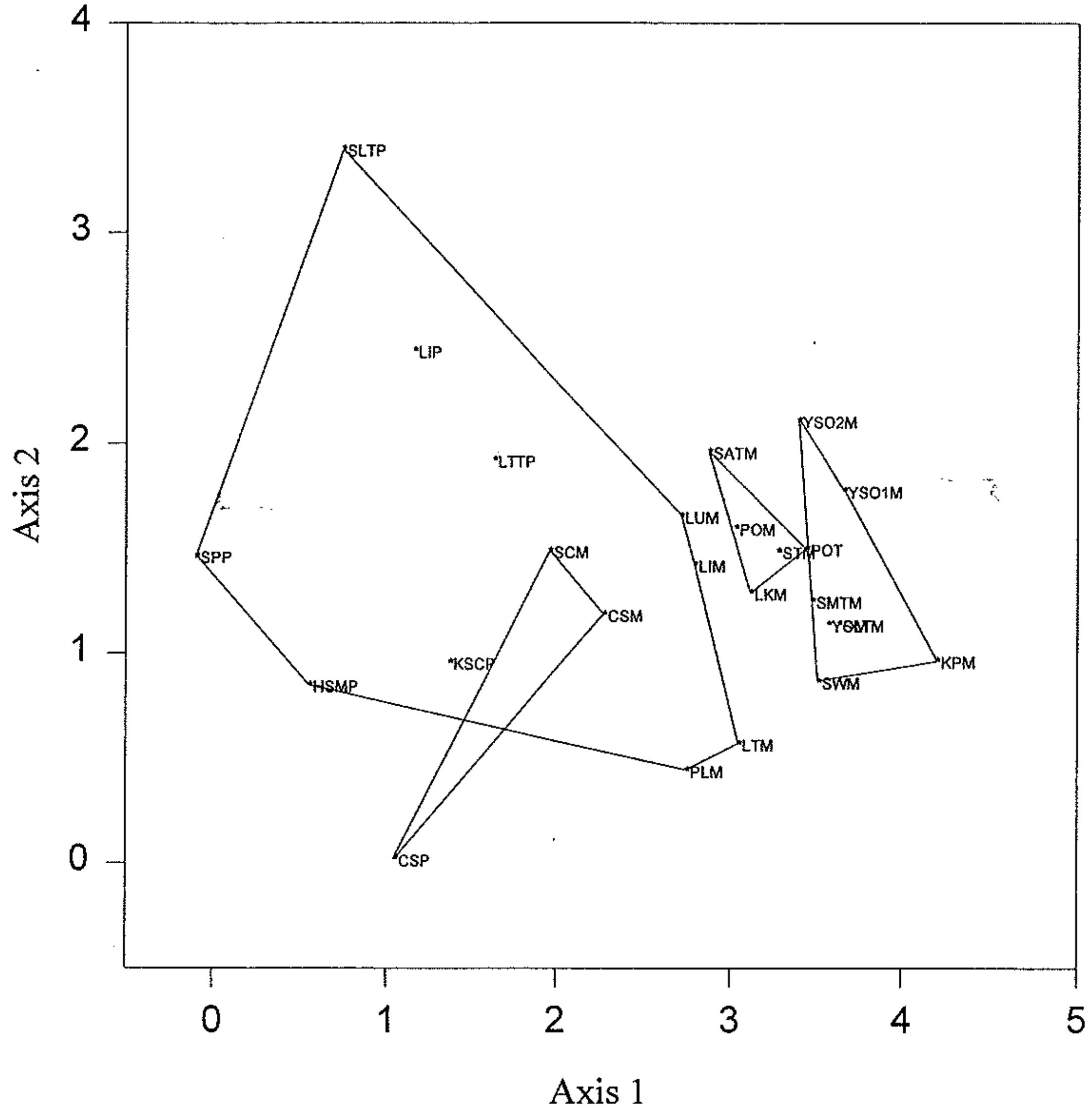


Figure 17. Three cluster solution for K-means cluster analysis of wetland sites following removal of three outlying sites (TLCPM, LPM, MTLM) and DCA of macroinvertebrate species data. Abbreviations as in Table 1.

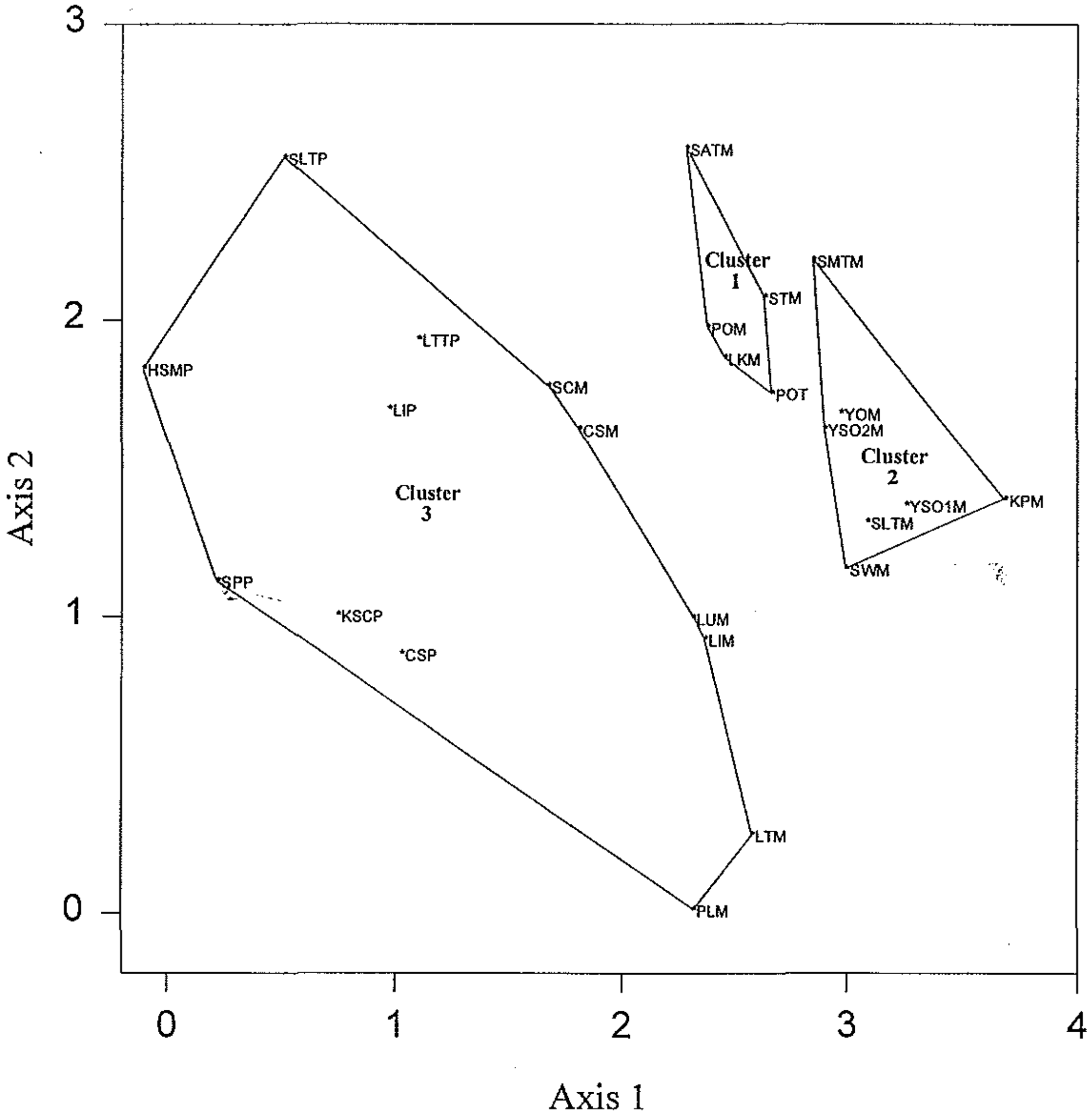


Figure 18. Four cluster solution for K-means cluster analysis of wetland sites derived from two-level clustering following removal of three outlying sites (TLCPM, LPM, MTLM) and DCA of macroinvertebrates species data. Abbreviations as in Table 1.

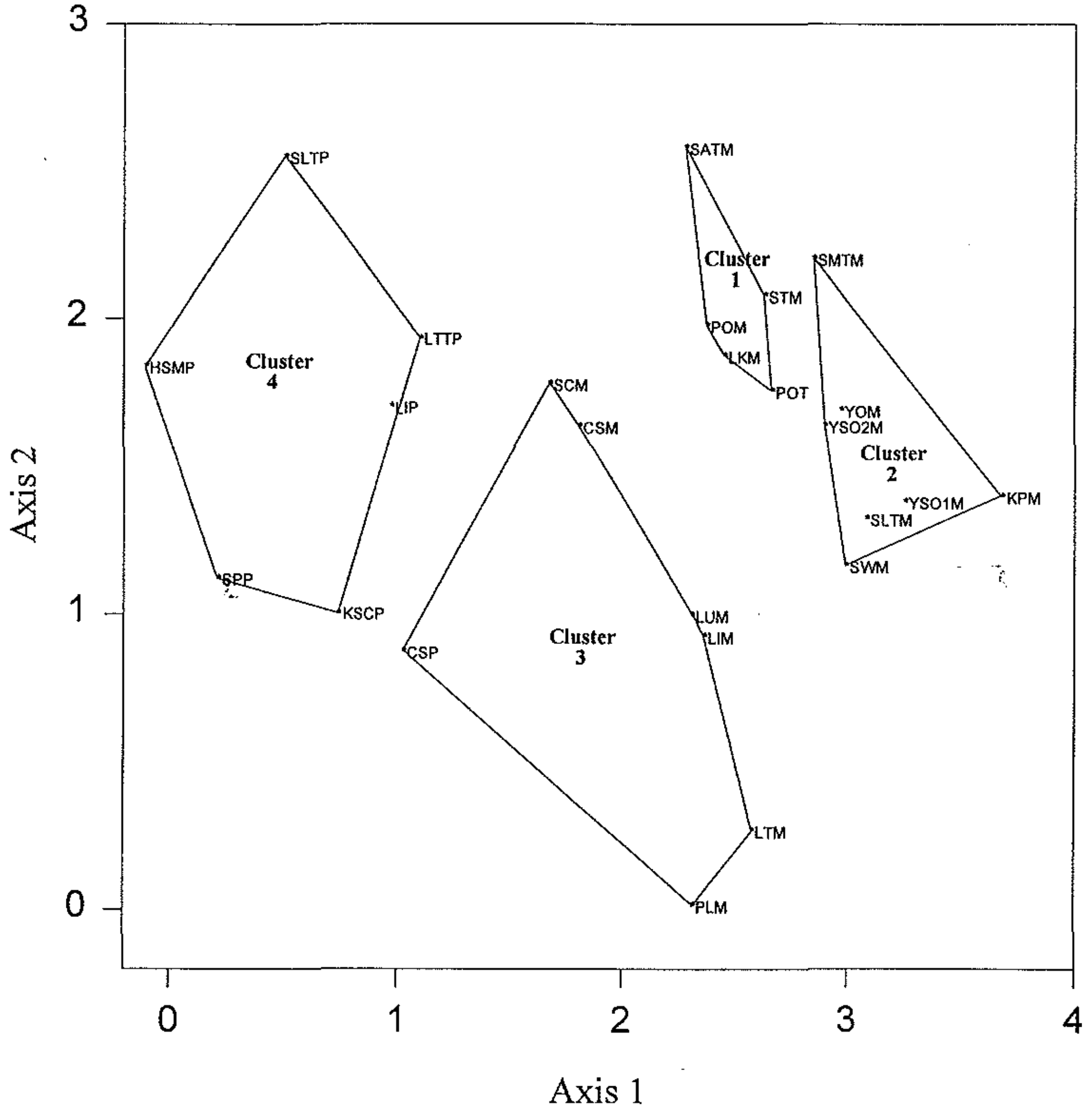


Figure 19. DCA Ordination of macroinvertebrate family data with three outlying sites (TLCPM, LPM, MTLM) removed. Abbreviations as in Table 1.

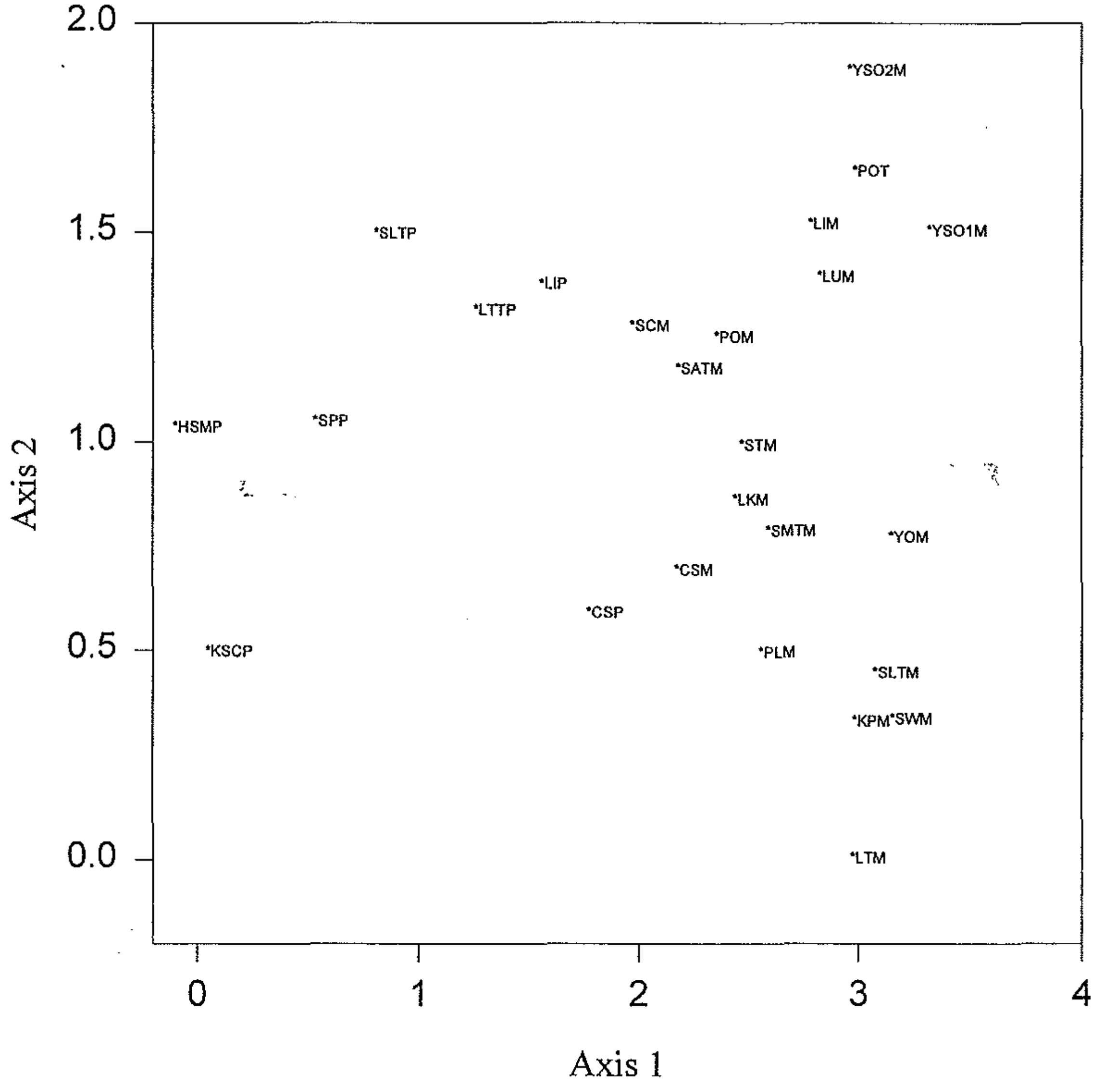


Figure 20. Three cluster solution for K-means cluster analysis of wetland sites following DCA of macroinvertebrate family data. Abbreviations as in Table 1.

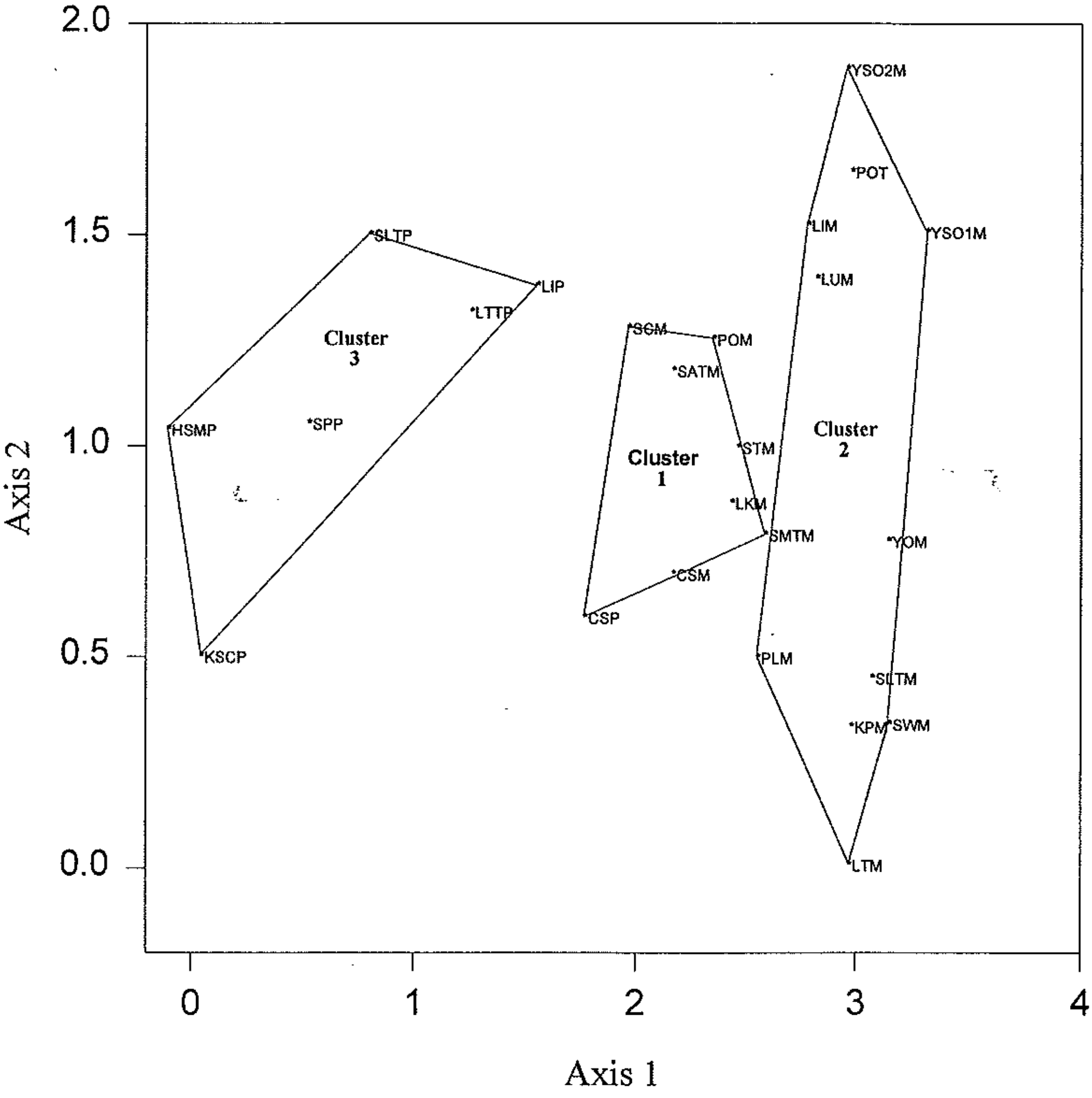


Figure 21. Indirect analysis of site characteristics using all environmental variables following DCA of macroinvertebrate species data. Abbreviations as in Table 1.

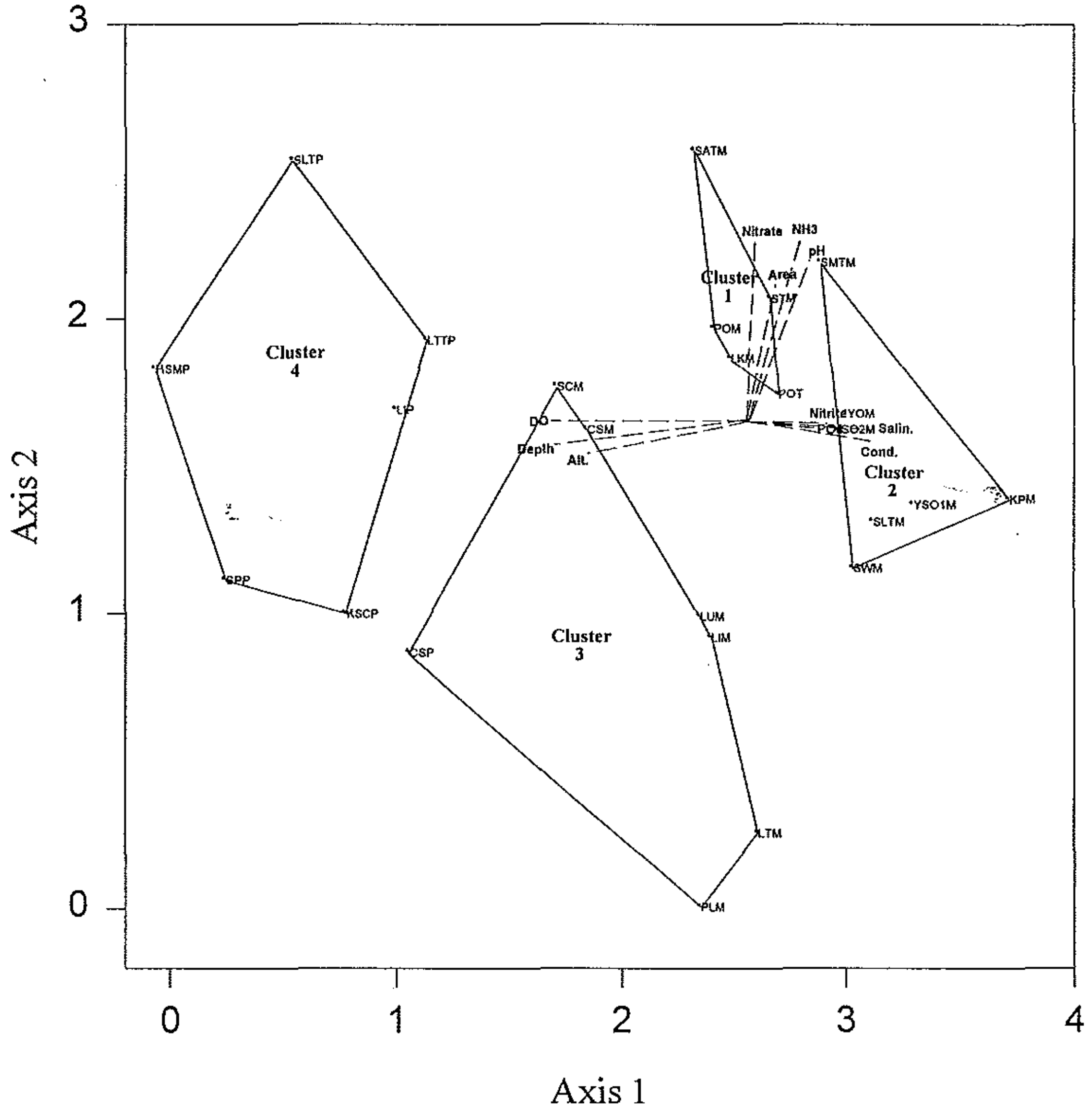


Figure 22. Indirect analysis of site characteristics using all environmental variable following DCA of macroinvertebrate family data. Abbreviations as in Table 1.

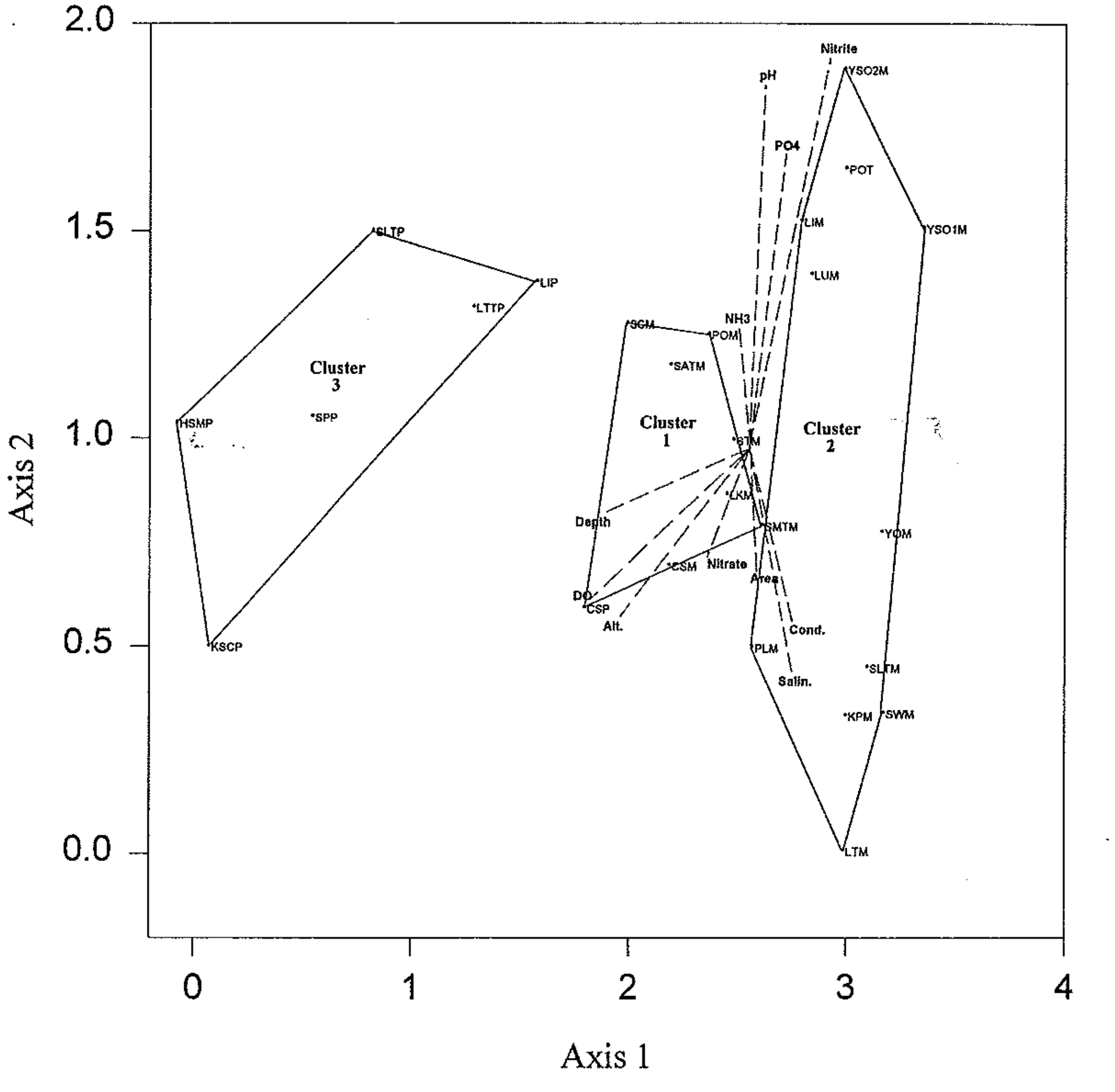


Table 1. A list of wetland sites visited, including the abbreviated site name, altitude, approxiate area, and UTM grid reference

Sites	Abbrev.	Altitude (m)	Area (ha)	Grid Reference (UTM)
Ponds				
Cheung Sheung pond	CSP	280	0.250	50 Q KV 2262 8280
Hung Shek Mun pond	HSMP	80	0.360	50 Q KV 2134 9060
Kau Sai Chau pond	KSCP	20	0.009	50 Q KV 2340 7660
Lamma Island pond	LIP	70	0.250	50 Q KV 0350 5960
Luk Tei Tong pond	LTTP	0	0.300	49 Q HQ 0872 6500
Lung Kwu Sheung Tan pond	LKSTP	0	0.006	49 Q GQ 9950 8060
Sha Lo Tung pool	SLTP	220	0.003	50 Q KV 1034 8836
So Lo Pun pond	SLPP	0	5.000	50 Q KV 1730 9460
Sunset Peak pond	SPP	680	0.080	49 Q GQ 0484 6442
Marshes				
Cheung Sheung marsh	CSM	280	1.000	50 Q KV 2290 8286
Kuk Po marsh	KPM	0	9.000	50 Q KV 1560 9420
Lamma Island marsh	LIM	50	1.000	50 Q KV 0340 5960
Leung Uk marsh	LUM	0	3.500	49 Q GQ 9510 6340
Liu Pok marsh	LPM	0	10.00	50 Q KV 0180 9450
Luk Keng marsh	LKM	0	32.00	50 Q KV 1390 9310
Lung Tsai marsh	LTM	0	0.020	49 Q HQ 0060 7870
Ma Tso Lung marsh	MTLM	0	18.00	50 Q KV 0130 9360
Pak Long marsh	PLM	0	0.010	49 Q HQ 0060 7920
Pui O marsh	POM	0	2.000	49 Q HQ 0690 6290
Pui O taro bed	POT	0	0.100	49 Q HQ 0690 6310
Sam A Tsuen marsh	SATM	0	14.00	50 Q KV 1920 9260
Sha Lo Tung marsh	SLTM	220	8.000	50 Q KV 1030 8860
Sham Chung marsh	SCM	0	9.300	50 Q KV 2080 8424
Sheung Miu Tin marsh	SMTM	100	1.000	50 Q KV 1770 9112
Shuen Wan marsh	SWM	0	12.00	50 Q KV 1230 8750
Siu Tan marsh	STM	0	3.000	50 Q KV 1860 9310
Tai Lam Country Park marsh	TLCPM	100	0.060	n/a*
Tung Chung marsh	TCM	0	30.00	49 Q HQ 0240 6700
Yi O marsh	YOM	0	2.600	49 Q GQ 9360 6080
Yung Shue O 1 marsh	YSO1M	0	0.100	50 Q KV 2130 8256
Yung Shue O 2 marsh	YSO2M	0	0.010	50 Q KV 2130 8262
Tai O reedbed	TOR	0	7.00	49 Q GQ 9510 6430
Yung Shue Au reedbed	YSAR	0	4.000	50 Q KV 1690 9570

* Tai Lam Country Park was visited with A.F.D. officials and exact coordinates were not locatable.

Table 2. **A list of wetland sites, their abbreviations, 'wetness' type, geologic deposits, and seasons visited. p=permanent; sp=semi-permanent; s=seasonal; v=volcanic rock se=metamorphosed sedimentary rock; g=granitoid rock; rl=reclaimed land**

Site Name	Abbrev.	'wetness' type	geologic deposit	Sites visited wet season	Sites visited dry season
Ponds					
Cheung Sheung pond	CSP	p	v	+	+
Hung Shek Mun pond	HSMP	p	se	+	+
Kau Sai Chau pond	KSCP	p	v		+
Lamma Island pond	LIP	p	g	+	+
Luk Tei Tong pond	LTTP	p	g	+	+
Sha Lo Tung pool	SLTP	p	v	+	+
Sunset Peak pond	SPP	p	v	+	+
Marshes					
Cheung Sheung marsh	CSM	sp	v	+	+
Kuk Po marsh	KPM	sp	v	+	+
Lamma Island marsh	LIM	p	g	+	+
Leung Uk marsh	LUM	p	rl	+	+
Liu Pok marsh	LPM	s	s		+
Luk Keng marsh	LKM	p	v	+	+
Lung Tsai marsh	LTM	s	g	+	+
Ma Tso Lung marsh	MTLM	s	se	+	+
Pak Long marsh	PLM	s	g	+	+
Pui O marsh	POM	s	v	+	+
Pui O taro	POT	p	v	+	+
Sam A Tsuen marsh	SATM	p	se	+	+
Sham Chung marsh	SCM	sp	v	+	+
Shuen Wan marsh	SWM	p	v	+	+
Siu Tan marsh	STM	sp	v	+	+
Sha Lo Tung marsh	SLTM	sp	v	+	+
Sheung Miu Tin marsh	SMTM	p	v	+	+
Tai Lam Country Park marsh	TLCPM	n/a	g	+	
Yi O marsh	YOM	sp	v	+	+
Yung Shue O marsh 1	YSO1M	sp	v	+	+
Yung Shue O marsh 2	YSO2M	p	v	+	+
Rejected					
So Lo Pun pond	SLPP	p	v		*
Yung Shue Au marsh	YSAR	sp	v		*
Leung Kwu Sheung Tan pond	LKSTP	p	g		-
Tai O reedbed	TOR	p			*
Tung Chung marsh	TCM	sp	g		-

(*) too saline for freshwater invertebrates

(-) construction led to wetland infilling and draining

Table 3. Environmental parameters measured at each wetland site. Abbreviations as in Table 1.

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM
Date sampled	17/11/95	17/11/95	19/12/94	17/10/95	16/3/95	20/12/95	20/3/96	3/1/96	15/2/96	3/1/96	17/10/95	29/12/95
Depth (m)	0.4	1.5	1.5	0.45	1.5	2.5	0.3	0.37	0.01	2.0	0.61	0.55
Temperature (°C)	20.0	18.0	16.2	24.0	19.5	18.0	21.0	16.0	20.0	17.0	28.0	13.0
pH	5.52	5.54	6.4	6.02	5.67	6.92	6.74	6.48	6.7	7.51	6.67	5.15
Dissolved Oxygen (mg/l)	5.38	6.49	5.85	3.56	6.09	6.25	3.56	6.96	3.56	6.33	5.3	5.77
Conductivity (µS)	47.3	24.4	54.0	8137	98.1	100.4	105.7	52.1	301.3	104.8	58.8	49.6
Salinity (ppt)	0.0	0.0	0.0	6.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ammonia (mg/l N)	0.00	0.01	0.00	0.28	0.00	0.04	0.00	0.00	0.37	0.00	0.08	0.02
Nitrate (mg/l N)	2.6	4.2	4.0	5.2	5.3	3.8	0.02	4.4	3.4	4.2	1.4	3.8
Nitrite (mg/l N)	0.0	0.0	0.0	0.0	0.01	0.0	0.0	0.003	0.014	0.002	0.0	0.001
Phosphate (mg/PO_4)	10.0	7.0	9.0	13.0	15.0	16.0	13.0	7.0	4.0	12.0	10.0	7.0

	MTLM	PLM	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP
Date sampled	15/2/96	29/12/95	10/10/95	10/10/95	6/12/95	17/11/95	19/10/95	6/12/95	23/11/95	23/11/95	6/12/95	14/11/95
Depth (m)	0.01	0.35	0.4	0.65	0.25	0.4	0.76	0.15	0.25	1.0	0.4	0.1
Temperature (°C)	23.0	14.0	29.0	27.0	16.0	20.0	24.0	18.0	18.0	17.0	16.0	19.0
pH	6.42	5.36	6.24	6.15	6.69	5.47	7.1	5.19	6.24	6.38	6.56	5.84
Dissolved Oxygen (mg/l)	2.14	6.41	5.22	3.32	6.25	7.59	5.69	5.54	5.62	7.67	5.38	7.12
Conductivity (µS)	270.3	63.8	127.0	93.9	133.9	42.7	230.0	119.4	55.5	40.1	59.4	35.4
Salinity (ppt)	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0
Ammonia (mg/l N)	10.0	0.06	0.0	0.0	0.6	0.06	0.04	0.19	0.01	0.0	0.06	0.41
Nitrate (mg/l N)	3.8	3.8	1.6	2.2	10.0	4.2	5.8	9.8	2.8	3.2	10.0	6.2
Nitrite (mg/l N)	0.043	0.001	0.002	0.011	0.001	0.0	0.003	0.0	0.007	0.0	0.003	0.001
Phosphate (mg/PO_4)	10.0	10.0	15.0	14.0	10.0	17.0	21.0	4.0	13.0	17.0	10.0	12.0

	TLCPM	YOM	YSO1M	YSO2M
Date sampled	6/11/1994.	3/1/96	13/2/96	13/2/96
Depth (m)	0.3	0.1	0.08	0.38
Temperature (°C)	16.0	17.0	20.0	20.0
pH	6.32	6.26	6.83	6.97
Dissolved Oxygen (mg/l)	5.46	5.06	4.35	4.59
Conductivity (µS)	120.4	42.6	541.0	120.5
Salinity (ppt)	0.0	0.0	0.0	0.0
Ammonia (mg/l N)	0.0	0.0	0.43	0.12
Nitrate (mg/l N)	3.1	4.4	3.0	3.0
Nitrite (mg/l N)	0.0	0.003	0.05	0.019
Phosphate (mg/PO_4)	14.0	7.0	27.0	16.0

Table 4. Comparison of mean environmental variables for marshes, ponds, and all wetlands Range of environmental variables for all sites also listed. List of wetlands in Table 1.

	Wetlands		Marshes		Ponds		Range	
	mean	s.d.	mean	s.d.	mean	s.d.	low	high
Number (n)	28		21		7			
Depth (m)	0.62	0.63	0.34	0.20	1.44	0.76	0.01 (LPM, MTLM)	2.5 (LIP)
*p*H	6.26	0.61	6.24	0.59	6.32	0.71	5.15 (LTM)	7.51 (LTTP)
Dissolved Oxygen (mg/l)	5.45	1.33	5.08	1.31	6.54	0.64	2.14 (MTLM)	7.67 (SLTP)
Conductivity (mS)	401.1	1519.9	511.9	1751.3	65.3	34.6	24.4 (CSP)	8137 (KPM)
Salinity (ppt)	0.36	1.19	0.43	1.36	0.14	0.38	0 (24 sites)	6.0 (KPM)
Nitrate (mg/l N)	4.26	2.39	4.21	2.72	4.41	1.01	1.4 (LKM)	10 (SATM, SMTM)
Nitrite (mg/l N)	0.006	0.012	0.008	0.014	0.002	0.004	0 (11 sites)	0.043 (MTLM)
Ammonia (mg/l N)	0.47	1.88	0.587	2.16	0.07	0.15	0 (10 sites)	10.0 (MTLM)
Phosphate (mg/l PO4)	12.1	5.01	12.0	5.45	12.6	3.69	4 (LPM, STM)	27.0 (YSO1M)
Area (ha)	4.82	7.36	6.24	8.02	0.54	0.89	0.003 (SLTP)	32.0 (LKM)
Altitude (m)	75.0	148.2	35.7	78.3	192.9	238.2	0 (17 sites)	680 (SPP)

Table 5. A list of macrophytic plants recorded during the wetland survey. Only those species from inundated localities are included; plants from dry land outside wetland boundaries are not listed.

Amaranthaceae
- *Alternanthera sessilis* (L.) R.Br.

Araceae
- *Colocasia esculenta* (L.) Schott

Callitrichaceae
- *Callitriche stagnalis* Scop.

Characeae
- *Chara* sp.

Commelinaceae
- *Commelina communis* L.
- *Commelina nudiflora* L.
- *Floscopa scandens* Lour.

Compositae
- *Eclipta prostrata* (L.) L.
- *Wedelia chinensis* (Obs.) Merr.

Convolvulaceae
- *Ipomoea* sp.

Eriocaulaceae
- *Eriocaulon setaceum* (L.)

Cyperaceae
- *Bulbostylis barbata* (Rottb.) Kunth
- *Cyperus compressus* L.
- *C. cyperoides* (L.) O. Ktze.
- *C. difformis* L.
- *C. distans* L.f.
- *C. haspan* L.
- *C. malaccensis* Lam.
- *C. pilosus* Vahl
- *C. radicans* Nees
- *C. rotundus* L.
- *C. serotinus* Rottb.
- *C. stoloniferous* Ratz.
- *C. tenulculms* Boeck
- *Eleocharis dulcis* (Burm. f.) Trin.
- *E. variegata* Kunth
- *Fimbristylis dichotoma* (L.) Vahl
- *F. littoralis* Gaudich
- *F. ovata* (Burm. f.) Kern.
- *F. schoenoides* (Retz.) Vahl.
- *F. tetragona* (Retz.) R. Br.
- *Fuirena umbellata* Rottb.
- *Kyllinga brevifolia* Rottb.
- *K. nemoralis* (Forst.) Dandy ex. Hutch
- *Pycreus flavidus* (Ratz. Koyama
- *P. polystachyos* Rottb.
- *P. sanguinolentus* (Vahl.) Ness
- *Rhynchospora rubra* (Lour.) Makino

Euphorbiaceae
- *Glochidion* sp.
- *Sapium sebiferum* Roxb.

Gramineae
- *Isachne globosa* (Thb.) O. Ktze.
- *Isachne* spp.
- *Leersia hexandra* Sw.
- *Leersia* spp.
- *Panicum repens* L.
- *Panicum* spp.
- *Paspalum distichum* L.
- *Paspalum* spp.
- *Phragmites australis* Cav. (Steud.)

Juncaceae
- *Juncus* sp.

Labiatae
- *Leucas* sp.

Lemnaceae
- *Lemna minor* L.

Lentibulariaceae
- *Utricularia* sp.

Lythraceae
- *Ammannia baccifera* L.

Marsileaceae
- *Marsilea quadrifolia* L.

Melastomaceae
- *Melastoma candidum* D. Don.

Onagraceae
- *Ludwigia adscendens* (L.) Hara
- *L. octovalis* (Jacq.) Raven
- *Ludwigia* sp.

Parkeriaceae
- *Ceratopteris thalictroides* (L.) Copel.

Philydraceae
- *Philydrum lanuginosum* Banks ex. Gaertn.

Polygonaceae
- *Polygonum* sp.

Pontederiaceae
- *Eichhornia crassipes* Solms
- *Monochoria hastata* (L.) Solms

Ranunculaceae
- *Ranunculus sceleratus* L.

Schizaeaceae
- *Lygodium microphyllum* R. Br.

Scrophulariaceae
- *Bacopa monnieri* (L.) Pennel
- *B. floribunda* (R.Br.) Wettst.
- *Lindernia* sp.

Umbelliferae
- *Centella asiatica* (L.) Urb.
- *Hydrocotyle sibthorpioides* Lam.
- *Oenanthe javanica* (Bl.) DC.

Zingiberaceae
- *Hedychium coronarium* Koen.

Table 6. **Species richness* and rarity index[+] of macroinvertebrates recorded from each wetland; the number of families (=richness) and rarity index for families is shown also. Abbreviations as in Table 1.**

Species				Families			
Richness		**Rarity Index**		**Richness**		**Rarity Index**	
LKM	62	CSP	9	LKM	34	CSM	2
YSO2M	50	SCM	8	YSO2M	33	POT	2
SATM	43	LKM	7	SATM	30	SCM	2
SWM	40	POT	6	CSP	25	CSP	1
KPM	40	CSM	4	KPM	25	HSMP	1
CSM	39	SMTM	4	POT	25	LIM	1
POT	39	YSO2M	4	CSM	24	LIP	1
CSP	38	SWM	3	SWM	24	LKM	1
STM	37	LIP	3	YOM	23	SMTM	1
SCM	37	SPP	3	YSO1M	23	SPP	1
YOM	35	KPM	2	SCM	23	YOM	1
YSO1M	35	SLTM	2	LTM	22	YSO1	1
SLTM	32	SLTP	2	STM	21	KPM	0
SMTM	31	STM	2	SLTM	21	KSCP	0
LTM	28	TLCPM	2	SMTM	19	LUM	0
PLM	24	YOM	2	PLM	19	LPM	0
LUM	24	PLM	2	LUM	18	LTTP	0
POM	22	LTM	2	POM	16	LTM	0
LIM	18	HSMP	1	LIM	13	MTLM	0
LIP	15	LIM	1	SPP	11	PLM	0
LTTP	12	SATM	1	LIP	11	POM	0
SPP	11	LTTP	1	LTTP	10	SATM	0
LPM	9	LUM	1	HSMP	7	SWM	0
SLTP	9	LPM	0	LPM	7	STM	0
MTLM	8	MTLM	0	MTLM	7	SLTM	0
HSMP	7	POM	0	SLTP	7	SLTP	0
TLCPM	6	KSCP	0	TLCPM	6	TLCP	0
KSCP	4	YSO1M	0	KSCP	2	YSO2	0

(*) calculated as the total number of taxa at that site
(+) calculated as the total number of rare species; i.e. those species occurring exclusively at one site and no other site

Table 8. **A list of amphibians recorded from each wetland site. Abbreviations as in Table 1. (*)= presence; (-)=absence**

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM
Paramesotriton hongkongensis	-	-	-	-	-	-	-	-	-	-	-	-
Rana guentheri	-	*	-	-	*	-	-	-	-	-	*	-
Rana limnocharis	-	-	-	-	-	-	-	*	-	-	*	-
Rana macrodactyla	*	*	-	-	-	-	-	*	-	-	-	-
Bufo melanostictus	-	-	-	-	-	-	-	-	-	-	-	-
Polypedates megacephalus	-	-	-	-	-	-	-	*	-	-	-	-
Microhyla pulchra	-	-	-	-	-	-	-	-	-	-	-	-
Occidozyga lima	-	-	-	-	-	-	-	*	-	-	-	-
Kalophrynus pleurostigma	-	-	-	-	-	-	-	-	-	-	-	-
Philautus romeri	-	-	-	-	-	-	-	-	-	*	-	-

	MTLM	PLM	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP
Paramesotriton hongkongensis	-	-	-	-	-	-	-	-	-	-	-	*
Rana guentheri	-	-	*	*	-	*	-	-	*	-	-	*
Rana limnocharis	-	-	-	*	-	-	-	-	*	-	-	-
Rana macrodactyla	-	-	*	-	-	-	-	-	*	-	-	-
Bufo melanostictus	-	-	-	-	-	-	-	-	-	-	-	-
Polypedates megacephalus	-	-	*	-	-	*	-	-	*	-	-	-
Microhyla pulchra	-	-	*	-	-	-	-	-	-	-	-	-
Occidozyga lima	-	-	-	-	-	-	-	-	-	-	-	-
Kalophrynus pleurostigma	-	-	-	-	-	-	-	-	*	-	-	-
Philautus romeri	-	-	-	-	-	-	-	-	-	-	-	-

	TLCPM	YOM	YSO1M	YSO2M
Paramesotriton hongkongensis	-	-	-	-
Rana guentheri	-	-	*	-
Rana limnocharis	-	-	-	-
Rana macrodactyla	-	-	-	-
Bufo melanostictus	-	-	-	-
Polypedates megacephalus	-	-	-	*
Microhyla pulchra	-	-	-	-
Occidozyga lima	-	-	-	-
Kalophrynus pleurostigma	-	-	-	-
Philautus romeri	-	*	-	-

Table 7. A list of fishes recorded from each wetland site. Abbreviations as in Table 1. (*)= presence; (-)= absence

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM
Macropodus opercularis	-	-	-	-	*	-	-	*	-	-	*	-
Macropodus concolor	*	-	-	-	-	-	-	-	-	-	-	-
Gambusia affinis	-	-	-	-	-	*	-	-	-	*	*	-
Capoeta semifasciolatus	-	*	-	-	-	-	-	-	-	-	*	-
Paracacco spilurus	-	-	-	-	-	-	-	-	-	-	-	-
Yaoshanicus arcus	-	*	-	-	-	-	-	-	-	-	-	-
Clarius fuscus	*	-	-	-	-	-	-	-	-	-	-	-
Silurus cochinchinensis	-	-	-	-	-	-	-	-	-	-	-	-
Misgurnus sp.	-	-	-	-	-	-	-	-	-	-	*	-
Oryzias curvinotus	-	-	-	-	-	-	-	-	-	-	-	-

	MTLM	PLM	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP
Macropodus opercularis	-	-	*	*	*	-	-	-	*	-	-	-
Macropodus concolor	-	-	-	-	-	*	-	-	*	-	*	-
Gambusia affinis	-	-	*	*	-	*	-	-	*	-	-	-
Capoeta semifasciolatus	-	-	-	-	-	*	-	-	-	-	-	-
Paracacco spilurus	-	-	-	-	-	*	-	-	-	-	-	-
Yaoshanicus arcus	-	-	-	-	-	-	-	-	-	-	-	-
Clarius fuscus	-	-	-	-	*	-	-	-	-	-	-	-
Silurus cochinchinensis	-	-	-	-	-	*	-	-	-	-	-	-
Misgurnus sp.	-	-	-	-	-	-	-	-	-	-	*	-
Oryzias curvinotus	-	-	-	-	*	-	-	-	-	-	-	-

	TLCPM	YOM	YSO1M	YSO2M
Macropodus opercularis	-	*	-	-
Macropodus concolor	-	-	*	-
Gambusia affinis	-	-	-	-
Capoeta semifasciolatus	-	-	-	-
Paracacco spilurus	-	-	-	-
Yaoshanicus arcus	-	-	-	-
Clarius fuscus	-	-	-	-
Silurus cochinchinensis	-	-	-	-
Misgurnus sp.	-	-	-	-
Oryzias curvinotus	-	-	-	-

Table 8. A list of amphibians recorded from each wetland site. Abbreviations as in Table 1.
(*)= presence; (-)=absence

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM
Paramesotriton hongkongensis	-	-	-	-	-	-	-	-	-	-	-	-
Rana guentheri	-	*	-	-	*	-	-	-	-	-	*	-
Rana limnocharis	-	-	-	-	-	-	-	*	-	-	*	-
Rana macrodactyla	*	*	-	-	-	-	-	*	-	-	-	-
Bufo melanostictus	-	-	-	-	-	-	-	-	-	-	-	-
Polypedates megacephalus	-	-	-	-	-	-	-	*	-	-	-	-
Microhyla pulchra	-	-	-	-	-	-	-	-	-	-	-	-
Occidozyga lima	-	-	-	-	-	-	-	*	-	-	-	-
Kalophrynus pleurostigma	-	-	-	-	-	-	-	-	-	-	-	-
Philautus romeri	-	-	-	-	-	-	-	-	-	*	-	-

	MTLM	PLM	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP
Paramesotriton hongkongensis	-	-	-	-	-	-	-	-	-	-	-	*
Rana guentheri	-	-	*	*	-	*	-	-	*	-	-	*
Rana limnocharis	-	-	-	*	-	-	-	-	*	-	-	-
Rana macrodactyla	-	-	*	-	-	-	-	-	*	-	-	-
Bufo melanostictus	-	-	-	-	-	-	-	-	-	-	-	-
Polypedates megacephalus	-	-	*	-	-	*	-	-	*	-	-	-
Microhyla pulchra	-	-	*	-	-	-	-	-	-	-	-	-
Occidozyga lima	-	-	-	-	-	-	-	-	-	-	-	-
Kalophrynus pleurostigma	-	-	-	-	-	-	-	-	*	-	-	-
Philautus romeri	-	-	-	-	-	-	-	-	-	-	-	-

	TLCPM	YOM	YSO1M	YSO2M
Paramesotriton hongkongensis	-	-	-	-
Rana guentheri	-	-	*	-
Rana limnocharis	-	-	-	-
Rana macrodactyla	-	-	-	-
Bufo melanostictus	-	-	-	-
Polypedates megacephalus	-	-	-	*
Microhyla pulchra	-	-	-	-
Occidozyga lima	-	-	-	-
Kalophrynus pleurostigma	-	-	-	-
Philautus romeri	-	*	-	-

Table 9. A summary of all macroinvertebrate taxa taken during sampling of the study wetlands. Observations of adult Odonata (see text) are not included.

- **Tricladida**
  - Dugesiidae
    - *Dugesia* sp.
- **Oligochaeta**
- **Hirudinea**
  - Glossosophonidae
    - *Helobdella stagnalis*
  - Erpobdellidae
    - *Erpobdella* sp.
  - Hirudinidae
    - *Limnatis* sp.
- **Pelecypoda**
  - Sphaeriidae
    - *Pisidium annandelei*
    - *Pisidium clarkeanum*
- **Gastropoda**
  - Ancyclidae
    - *Ferrissia baconi*
  - Hydrobiidae
    - *cf.* Hydrobiidae
  - Lymnaeidae
    - *Austropeplea ollula*
    - *Radix* sp.
  - Planorbidae
    - *Hippeutis cantonenesis*
    - *Segmentina* sp.
  - Stenothyridae
    - *cf. Stenothyra* sp.
  - Thiaridae
    - *Brotia hainanensis*
    - *Melanoides tuberculata*
- **Ostracoda**
- **Isopoda**
- **Decapoda**
  - Atyidae
    - *Caridina lanceifrons*
    - *Neocaridina serrata*
  - Palaemonidae
    - *Macrobrachium hainenense*
  - Grapsidae
    - *Eriocheir japonicus*
  - Parathelphusidae
    - *Somanniathelphusa zanklon*
  - Sesarmidae
    - *Holometopus serenei*
- **Ephemeroptera**
  - Baetidae
    - *Baetis* L7
    - *Cloeon* sp.
  - Heptageniidae
    - *Cinygmina* T2
  - Caenidae
  - Caenidae Unid.
    - *Caenodes* T1
    - *Caenodes* T2
  - Leptophlebiidae
    - *Choroterpes* sp.
    - *Habrophlebiodes gilliesi*
- **Odonata**
  - Coenagrionidae
    - *Agriocnemis lacteola*
    - *Agriocnemis* sp. 1
    - *Agriocnemis* sp. 2
    - *Ceriagrion melanurum*
    - *Ceriagrion* sp. 2
    - *cf. Ceriagrion*
    - *Ischnura senegalensis*
    - Unid. Coenagrionidae 2
    - Unid. Coenagrionidae 3
    - Unid. Zygoptera
  - Platycnemididae
    - *Copera ciliata*
    - *Copera* sp. 2
  - Aeshnidae
    - *Aeschnophlebia* sp. 1
    - *Anax immaculifrons*
    - *Anax* sp. 2
  - Gomphidae
    - *Megalogomphus sommeri*
    - *Sinogomphus* sp.
  - Libellulidae
    - *Crocothemis* sp.
    - *Hydrobasileus croceus*
    - *Orthetrum* sp. 1
    - *Orthetrum* sp. 2
    - *Orthetrum* sp. 3
    - *Pantala flavescans*
    - *Rhyothemis* sp.
    - *Trithemis* sp.
    - *Macrodiplax* sp.
  - Macromiidae
    - Macromiidae sp. 1
  - Corduliidae
    - *Somatochlora* sp.
- **Hemiptera**
  - Hydrometridae
    - *Hydrometra* sp.
  - Veliidae
    - *Angilia* sp.
    - *Microvelia* sp.
    - *Rhagovelia* sp.
    - Veliidae U1

Table 9. cont.

Diptera

- Anthomyiidae
- Ephydridae
  - *Ephydra* sp.
  - Ephydridae U1
  - Ephydridae U2
- Phoridae
  - *cf*. Phoridae
- Sciomyizdae
  - Sciomyzidae U1
- Syrphidae
  - *Eristalis* sp.
- Dolichopodidae
  - Dolichopodidae U1
- Empididae
  - *Hemerodromia* sp.
  - Empididae sp. 2
- Statiomyidae
  - *Odontomyia* sp.
  - Stratiomyidae sp. 2
- Tabanidae
  - *Chrysops* sp.
  - *cf. Merycomyia* sp.
- Ceratopogonidae
  - *Atrichopogon* sp.
  - *Bezzia* sp. 1
  - *Bezzia* sp. 2
  - *Ceratopogon* sp.
  - *Culicoides* sp.
  - *cf. Dasyhelea* sp.
  - *Forcipomyia* sp. 1
  - *Forcipomyia* sp. 2
  - *Mollochohelea* sp.
  - *Monohelea* sp.
  - *Probezzia* sp.
  - *Serromyia* sp.
  - *Sphaeromias* sp.
- Chironomidae
  - Chironominae
  - Orthocladiinae
    - *Tanytarsini*
  - Tanypodinae
- Corethrellidae
  - Corethrellidae U1
- Culicidae
  - *Anopholes sinensis*
  - *Culex* sp. 1
  - *Culex* sp. 2
  - *Culex* sp. 3
  - *Culiseta* sp.
  - *Mansonia* sp.
  - Culicidae U1
- Psychodidae
  - *Pericoma* sp.
  - Psychodidae sp.3
  - Psychodidae sp.4
  - *cf. Psychoda* sp.
  - *cf. Telmatoscopus* sp.
- Simuliidae
  - *Simulium* S6
- Tipulidae
  - *Hexatoma* sp.
  - *Limonia* sp.
  - *Pseudolimnophila* sp.
  - *Tipula (Angarotipula)*
  - *Tipula (Tipula)*
  - *Tipula (Tipulodina)*
  - *Tipula* U1
  - *Tipula* U2
  - Tipulidae U1
  - Tipulidae U2
  - Tipulidae U3
  - Tipulidae U4
  - Tipulidae U5
- Unid. diptera

Table 9. cont.

Diptera

- Anthomyiidae
- Ephydridae
  - *Ephydra* sp.
  - Ephydridae U1
  - Ephydridae U2
- Phoridae
  - *cf.* Phoridae
- Sciomyizdae
  - Sciomyzidae U1
- Syrphidae
  - *Eristalis* sp.
- Dolichopodidae
  - Dolichopodidae U1
- Empididae
  - *Hemerodromia* sp.
  - Empididae sp. 2
- Statiomyidae
  - *Odontomyia* sp.
  - Stratiomyidae sp. 2
- Tabanidae
  - *Chrysops* sp.
  - *cf. Merycomyia* sp.
- Ceratopogonidae
  - *Atrichopogon* sp.
  - *Bezzia* sp. 1
  - *Bezzia* sp. 2
  - *Ceratopogon* sp.
  - *Culicoides* sp.
  - *cf. Dasyhelea* sp.
  - *Forcipomyia* sp. 1
  - *Forcipomyia* sp. 2
  - *Mollochohelea* sp.
  - *Monohelea* sp.
  - *Probezzia* sp.
  - *Serromyia* sp.
  - *Sphaeromias* sp.
- Chironomidae
  - Chironominae
  - Orthocladiinae
    - *Tanytarsini*
  - Tanypodinae
- Corethrellidae
  - Corethrellidae U1
- Culicidae
  - *Anopholes sinensis*
  - *Culex* sp. 1
  - *Culex* sp. 2
  - *Culex* sp. 3
  - *Culiseta* sp.
  - *Mansonia* sp.
  - Culicidae U1
- Psychodidae
  - *Pericoma* sp.
  - Psychodidae sp.3
  - Psychodidae sp.4
  - *cf. Psychoda* sp.
  - *cf. Telmatoscopus* sp.
- Simuliidae
  - *Simulium* S6
- Tipulidae
  - *Hexatoma* sp.
  - *Limonia* sp.
  - *Pseudolimnophila* sp.
  - *Tipula (Angarotipula)*
  - *Tipula (Tipula)*
  - *Tipula (Tipulodina)*
  - *Tipula* U1
  - *Tipula* U2
  - Tipulidae U1
  - Tipulidae U2
  - Tipulidae U3
  - Tipulidae U4
  - Tipulidae U5
- Unid. diptera

Table 10. **Sites comprising each cluster in a two-stage four-cluster solution for K-means cluster analysis of wetland sites following DCA of macroinvertebrate species data.**

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Luk Keng Marsh	Kuk Po Marsh	Cheung Sheung Marsh	Hung Shek Mun Pond
Pui O Marsh	Sha Lo Tung Marsh	Cheung Sheung Pond	Kau Sai Chau Pond
Pui O Taro	Sheung Miu Tin Marsh	Lamma Island Marsh	Lamma Island Pond
Sam A Tsuen Marsh	Shuen Wan Marsh	Leung Uk Marsh	Luk Tei Tong Pond
Siu Tan Marsh	Yi O Marsh	Lung Tsai Marsh	Sha Lo Tung Pond
	Yung Shue O Marsh 1	Pak Long Marsh	Sunset Peak Pond
	Yung Shue O Marsh 2	Sham Chung Marsh	

Table 11. **Sites comprising each cluster in a three-cluster solution for K-means cluster analysis of wetland sites following DCA of macroinvertebrate family data.**

Cluster 1	Cluster 2	Cluster 3
Cheung Sheung marsh	Kuk Po marsh	Hung Shek Mun pond
Cheung Sheung pond	Lamma Island marsh	Kau Sai Chau pond
Luk Keng marsh	Lung Tsai marsh	Lamma Island pond
Pui O marsh	Leung Uk marsh	Luk Tei Tong pond
Sam A Tsuen marsh	Pak Long marsh	Sha Lo Tung pond
Sham Chung marsh	Pui O taro	Sunset Peak pond
Sheung Miu Tin marsh	Sha Lo Tung marsh	
Siu Tan marsh	Shuen Wan marsh	
	Yi O marsh	
	Yung Shue O marsh 1	
	Yung Shue O marsh 2	

Table 12. **Comparison of macroinvertebrate community composition among clusters including number of sites, mean richness, mean rarity index, and range of species richness within each cluster. Clusters as in Figures 18 & 19 and Tables 10 & 11.**

	Number of sites	Richness mean	Richness s.d.	Rarity Index mean	Rarity Index s.d.	Range low	Range high
Species*							
Cluster 1	5	40.6	14.4	3.2	3.1	22	62
Cluster 2	7	37.6	6.5	2.4	1.4	31	50
Cluster 3	7	29.7	8.3	3.9	3.3	18	39
Cluster 4	6	9.7	3.9	1.7	1.2	4	15
Family*							
Cluster 1	8	24.0	5.8	0.88	0.83	16	34
Cluster 2	11	22.4	5.0	0.45	0.69	13	33
Cluster 3	6	8.0	3.5	0.50	0.55	2	11

Table 13. **Mean values of environmental variables for sites in each cluster, where each cluster cluster is based on species composition. Units for each variable as in Tables 1 and 4.**

Species

	Cluster 1		Cluster 2		Cluster 3		Cluster 4	
	mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
Depth	0.41	0.22	0.35	0.23	0.55	0.42	1.40	0.83
*p*H	6.19	0.61	6.57	0.41	5.75	0.61	6.45	0.68
D.O.	5.13	1.09	4.89	0.77	6.02	1.31	6.55	0.70
Conductivity	106.6	30.7	1309.5	3015.9	55.1	25.3	72.1	32.4
Salinity	0.40	0.89	1.00	2.24	0.00	0.00	0.17	0.41
NH_3	5.00	4.48	4.89	2.54	3.29	1.56	4.45	1.10
Nitrate	0.003	0.005	0.012	0.018	0.001	0.001	0.002	0.004
Nitrite	10.600	4.340	15.300	6.800	10.100	3.760	13.500	3.020
PO_4	0.174	0.251	0.134	0.162	0.021	0.027	0.075	0.165
Area	10.220	1.330	4.670	4.900	2.750	4.050	0.542	0.971
Altitude	0.0	0.0	46.0	85.0	87.0	133.0	178.0	258.0

Table 14. **Mean values of environmental variables for sites in each cluster, where clusters were based on family composition. Units for each variable as in Tables 1 and 4.**

Family

	Cluster 1		Cluster 2		Cluster 3	
	mean	s.d.	mean	s.d.	mean	s.d.
Depth	0.51	0.42	0.39	0.21	1.40	0.83
*p*H	5.99	0.62	6.3	0.63	6.45	0.68
D.O.	5.89	0.83	5.02	1.17	6.55	0.70
Conductivity	76.6	43.1	862.9	2416.9	72.1	32.40
Salinity	0.25	0.71	0.55	1.80	0.167	0.408
NH_3	5.48	3.83	3.49	1.57	4.45	1.10
Nitrate	0.001	0.001	0.005	0.006	0.002	0.004
Nitrite	10.4	4.10	13.4	6.20	13.5	3.02
PO_4	0.125	0.202	0.09	0.14	0.075	0.165
Area	7.79	10.9	3.71	4.57	0.542	0.971
Altitude	83.0	127.0	25.0	67.0	178.0	258.0

Table 15. **Indicator species selection. Figures in bold represent species with significant differences among sites in cluster groups (*P*-value <=0.05). Values in italics represent species occuring exclusively in one cluster. Underlined values are those species where the mean score in one cluster was more than twice the sum of the mean scores in other clusters. Rare species not included in calculation.**

	P-value	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean	Indicator species
Dugesia sp.	0.4945	0.2	0.2857	0.1429	0.0000	
Oligochaete	0.4643	0.2	0.5714	0.7143	0.1667	
Helobdella stagnalis	0.3162	0.2	0.1429	0.0000	0.0000	
Pisidium clarkeanum	0.1117	0.8	0.1429	0.2857	0.0000	
Ferrissia baconi	0.3162	0.2	0.1429	0.0000	0.0000	
Austropeplea ollula	0.0910	0.4	0.0000	0.1429	0.0000	
Hippeutis cantonensis	0.5767	0.6	0.7143	0.4286	0.5000	
Segmentina sp.	**0.0034**	1.0	0.7143	0.2857	0.1667	
cf. Stenothyra sp.	**0.0002**	0.8	0.5714	0.0000	0.0000	
Melanoides tuberculata	**0.0057**	0.8	0.2857	0.0000	0.1667	
Ostracoda	0.4439	0.0	0.2857	0.2857	0.0000	
Isopoda	**0.0105**	0.2	0.8571	0.4286	0.0000	
Caridina lanceifrons	0.0722	0.6	0.0000	0.1429	0.5000	
Neocaridina serrata	0.7210	0.2	0.1429	0.1429	0.5000	
Macrobrachium hainenense	0.4237	0.2	0.0000	0.0000	0.5000	y
Eriocheir japonicus	**0.0000**	*0.8*	0.0000	0.0000	0.0000	y
Somanniathelphusa zanklon	**0.0061**	0.2	0.5714	0.0000	0.0000	y
Holometopus serenei	0.2802	0.0	0.2857	0.1429	0.0000	
Baetis L7	0.7773	0.2	0.1429	0.0000	0.1667	
Cloeon sp.	0.1348	0.4	0.1429	0.8571	0.3333	
Canidae Unid.	0.7955	0.4	0.2857	0.4286	0.0000	
Caenodes T2	0.5178	0.0	0.1429	0.4286	0.0000	
Caenodes T1	0.6954	0.0	0.1429	0.1429	0.0000	
Habrophlebiodes gilliesi	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Agriocnemis sp. 1	**0.0092**	1.0	0.4286	0.4286	0.0000	
Agriocnemis sp. 2	**0.0002**	*0.6*	0.0000	0.0000	0.0000	y
Agriocnemis lacteola	0.3984	0.0	0.0000	*0.2857*	0.0000	y
Ceriagrion melanurum	0.1794	1.0	0.4286	1.0000	0.5000	
cf. Ceriagrion	**0.0006**	0.0	*0.5714*	0.0000	0.0000	y
Copera ciliata	0.2277	0.0	0.0000	0.1429	0.3333	y
Anax immaculifrons	0.2277	0.0	0.0000	0.1429	0.3333	y
Anax sp. 2	0.3984	0.0	0.0000	0.1429	0.1667	
Orthetrum sp. 1	**0.0075**	1.0	1.0000	0.8571	0.0000	
Orthetrum sp. 3	0.1923	0.4	0.0000	0.2857	0.0000	
Trithemis sp.	0.6812	0.0	0.1429	0.1429	0.1667	
Hydrobasileus croceus	0.3984	0.0	0.0000	0.1429	0.1667	
Hydrometra sp.	0.1369	0.2	0.5714	0.2857	0.0000	
Microvelia sp.	0.4439	0.0	0.2857	0.2857	0.0000	
Neogerris sp.	0.4857	0.2	0.0000	0.1429	0.0000	

Table 15. cont.

	P-value	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean	Indicator species
Gerridae sp. 2	0.2855	0.2	0.0000	0.5714	0.0000	
Diplonychus rusticum	0.2358	0.4	0.0000	0.4286	0.0000	
Laccotrephes sp.	0.3162	0.2	0.1429	0.0000	0.0000	
Helotrephes sp.	0.2277	0.0	0.0000	0.2857	0.1667	
Pelocoris sp.	**0.0109**	0.0	0.7143	0.1429	0.0000	y
Mesovelia sp.	0.7367	0.4	0.5714	0.7143	0.0000	
Corisella sp.	**0.0099**	0.8	0.0000	0.4286	0.1667	
Anisops sp.	0.3984	0.0	0.0000	0.1429	0.1667	
Paraponyx sp.	0.9660	0.2	0.1429	0.2857	0.0000	
Unid. Pyralidae 1	0.2802	0.0	0.2857	0.1429	0.0000	
Oxyethira sp.	0.9660	0.2	0.1429	0.2857	0.0000	
Tricholeichiton sp.	0.0558	0.0	0.0000	0.2857	0.5000	
Cybister sp. L	0.5309	0.2	0.0000	0.1429	0.1667	
cf. Hyphydrus 1L	**0.0012**	1.0	0.2857	0.2857	0.0000	
cf. Hyphydrus 2L	0.3162	0.2	0.1429	0.0000	0.0000	
Hydrophilidae L1	**0.0064**	0.8	0.4286	0.1429	0.0000	
Hydrophilidae L2	**0.0099**	0.6	0.2857	0.0000	0.0000	y
Hydrophilidae L3	**0.0307**	0.4	0.4286	0.0000	0.0000	
Hydraenidae sp. 1 L	0.2513	0.0	0.4286	0.4286	0.0000	
Hydraenidae sp. 2 L	0.2802	0.0	0.2857	0.1429	0.0000	
Eubrianax sp. L	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Cyphon sp. L	**0.0004**	1.0	1.0000	0.5714	0.0000	
Scirtes sp. L	0.1887	0.2	0.4286	0.1429	0.0000	
Luciola sp. L	0.3162	0.2	0.1429	0.0000	0.0000	
Noteridae L1	**0.0045**	0.6	0.1429	0.0000	0.0000	y
Hydrovatus bonvouloiri	**0.0002**	1.0	0.4286	0.1429	0.0000	
Hydrovatus pumilis	0.9442	0.2	0.2857	0.4286	0.0000	
Cybister tripunctatus orientalis	0.5545	0.2	0.2857	0.7143	0.1667	
Hydaticus rhantoides	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Helochares complex 1	0.4895	0.6	0.2857	0.5714	0.0000	
Helochares complex 2	0.7773	0.2	0.1429	0.1429	0.0000	
Hydrobiomorpha sp.	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Hydrophilus sp.	**0.0091**	*0.4*	0.0000	0.0000	0.0000	y
Hydrophilidae sp. 1	**0.0004**	0.2	0.7143	0.0000	0.0000	y
cf. Hydrophilidae sp. 1	0.3162	0.2	0.1429	0.0000	0.0000	
cf. Stenelmis sp.	0.3162	0.2	0.1429	0.0000	0.0000	
Hydrocanthus indicus	0.4857	0.2	0.0000	0.1429	0.0000	
Canthydrus weisei	0.3984	0.0	0.0000	*0.2857*	0.0000	y
Noteridae sp. 3	**0.0087**	0.0	*0.4286*	0.0000	0.0000	y
Limnichidae	0.4439	0.0	0.2857	0.2857	0.0000	
Anthomyiidae	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Ephydra sp.	0.7773	0.2	0.1429	0.1429	0.0000	

Table 15. cont.

	P-value	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean	Indicator species
Ephydridae U1	**0.0002**	0.8	0.5714	0.0000	0.0000	
Ephydridae U2	0.4024	0.0	0.2857	0.5714	0.0000	
cf. Phoridae	**0.0404**	0.0	0.5714	0.2857	0.0000	y
Eristalis sp.	0.1551	0.2	0.2857	0.0000	0.0000	
Dolichopodidae	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Empididae sp. 2	0.2802	0.0	0.2857	0.1429	0.0000	
Chrysops sp.	**0.0099**	0.6	0.2857	0.0000	0.0000	y
cf. Merycomyia sp.	0.3162	0.2	0.1429	0.0000	0.0000	
Atrichopogon sp.	0.2704	0.4	0.2857	0.1429	0.0000	
Ceratopogon sp.	0.3162	0.2	0.1429	0.0000	0.0000	
Forcipomyia sp. 1	**0.0045**	0.6	0.1429	0.0000	0.0000	y
Forcipomyia sp. 2	**0.0404**	0.0	0.5714	0.2857	0.0000	y
Monohelea sp.	**0.0057**	0.8	0.2857	0.1429	0.0000	
Culicoides sp.	**0.0000**	0.8	0.7143	0.0000	0.0000	
Mollochohelea sp.	0.5309	0.2	0.0000	0.2857	0.0000	
Serromyia sp.	0.1923	0.4	0.0000	0.2857	0.0000	
Bezzia sp. 1	0.3400	0.4	0.5714	0.2857	0.1667	
Bezzia sp. 2	0.7210	0.2	0.1429	0.5714	0.0000	
Chironominae	0.6954	1.0	0.8571	1.0000	0.8333	
Tanypodinae	0.3400	1.0	0.8571	0.8571	0.5000	
Orthocladiinae	0.9117	0.8	0.7143	0.8571	0.5000	
Corethrellidae	0.6496	0.0	0.0000	0.1429	0.0000	
Culex sp. 1	0.0676	0.8	0.5714	0.4286	0.0000	
Culex sp. 2	0.4909	0.4	0.1429	0.2857	0.0000	
Mansonia sp.	**0.0049**	0.8	0.0000	0.4286	0.0000	
Culicidae U1	0.2802	0.0	0.2857	0.1429	0.0000	
cf. Psychoda	0.3162	0.2	0.1429	0.0000	0.0000	
cf. Telmatoscopus	0.1551	0.2	0.2857	0.0000	0.0000	
Pericoma sp	**0.0008**	0.8	0.7143	0.1429	0.0000	
Psychodidae sp. 3	0.2802	0.0	0.2857	0.1429	0.0000	
Pseudolimnophila sp.	**0.0005**	0.6	0.8571	0.1429	0.0000	
Limonia sp.	**0.0064**	0.6	0.0000	0.1429	0.0000	y
Tipula (Tipula)	0.2875	0.0	*0.1429*	0.0000	0.0000	y
Tipulidae U1	**0.0000**	0.4	1.0000	0.0000	0.0000	y
Tipulidae U2	**0.0006**	0.0	*0.5714*	0.0000	0.0000	y
Tipulidae U3	**0.0006**	0.0	*0.5714*	0.0000	0.0000	y
Tipulidae U4	0.0618	0.0	*0.2857*	0.0000	0.0000	y
Unid. diptera	0.1709	0.0	0.4286	0.2857	0.0000	

Table 16. Indicator species for sites in four cluster solution of K-means clustering following DCA of macroinvertebrate species presence-absence data.

Cluster 1*	Cluster 2*	Cluster 3*	Cluster 4+
Eriocheir japonicus	*Somanniathelphusa zanklon*	*Agriocnemis lacteola*	*Macrobrachium hainenense*
Agriocnemis sp. 2	*Habrophlebiodes gilliesi*	*Canthydrus weisei*	*Anax immaculifrons*
Hydrophilidae L2	*cf. Ceriagrion*		*Copera ciliata*
Hydrophilus sp.	*Pelocoris* sp.		
Noteridae L1	*Eubrianax* L1		
Limonia sp.	*Hydaticus rhantoides*		
Chrysops sp.	*Hydrobiomorpha* sp.		
Forcipomyia sp. 1	Hydrophilidae sp. 1		
	Noteridae sp. 3		
	Anthomyiidae		
	Dolichopodidae		
	Forcipomyia sp. 2		
	Tipula (Tipula)		
	Tipulidae U1		
	Tipulidae U2		
	Tipulidae U3		
	Tipulidae U4		
	cf. Phoridae		

(*) indicator species determined by having met at least of the three two pre-defined criteria set out in Table 15
(+) indicator species determined by having met one pre-defined criteria set out in Table 15.

Table 17. **Indicator families selection. Figures in bold represent families with significant differences among sites in cluster groups (*P*-value <=0.05). Values in italics represent families occuring exclusively in one cluster. Underlined values are those families where the mean score in one cluster was more than twice the sum of the mean scores in other clusters.**

	P-value	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Indicator family
Dugesiidae	**0.0472**	0.000	*0.3636*	0.0000	y
Oligochaete	**0.0328**	0.250	0.7273	0.1667	
Sphaeriidae	0.0843	0.625	0.1818	0.1667	
Ancyclidae	0.7122	0.125	0.0909	0.0000	
Hydrobiidae	0.5492	0.000	*0.0909*	0.0000	y
Lymnaeidae	0.0933	0.375	0.0000	0.1667	
Planorbidae	0.3300	0.875	0.7273	0.5000	
Stenothyridae	0.1386	0.500	0.3636	0.0000	
Thiaridae	0.3699	0.500	0.1818	0.3333	
Ostracoda	**0.0472**	0.000	*0.3636*	0.0000	y
Isopoda	**0.0000**	0.000	*0.0909*	0.0000	y
Atyidae	**0.0056**	0.500	0.0909	0.8333	
Palaemonidae	**0.0220**	0.125	0.0000	0.5000	y
Grapsidae	0.1264	0.375	0.0909	0.0000	
Parathelphusidae	0.4019	0.250	0.2727	0.0000	
Sesarmidae	0.1229	0.000	*0.2727*	0.0000	y
Glossosophonidae	0.5492	0.000	*0.0909*	0.0000	y
Erpobdellidae	0.2752	0.000	*0.1818*	0.0000	y
Hirudinidae	0.5492	0.000	*0.0909*	0.0000	y
Baetidae	0.9016	0.625	0.5455	0.5000	
Heptageniidae	0.2109	0.000	0.0000	*0.1667*	y
Caenidae	**0.0003**	0.750	0.0909	0.0000	y
Leptophlebiidae	0.5772	0.125	0.1818	0.0000	
Coenagrionidae	0.0689	1.000	0.8182	0.5000	
Platycnemididae	0.1403	0.125	0.0000	0.3333	
Aeshnidae	0.1533	0.250	0.0000	0.3333	
Gomphidae	0.3607	0.125	0.0000	0.0000	
Libellulidae	**0.0017**	1.000	0.9091	0.3333	
Macromiidae	0.3607	0.125	0.0000	0.0000	
Corduliidae	0.3607	0.125	0.0000	0.0000	
Hydrometridae	0.1283	0.500	0.2727	0.0000	
Veliidae	0.4018	0.250	0.2727	0.0000	
Gerridae	0.8293	0.500	0.1818	0.0000	
Belostomatidae	0.0002	0.625	0.0000	0.0000	
Nepidae	0.3654	0.250	0.0909	0.0000	
Helotrephidae	0.4802	0.000	0.1818	0.1667	
Naucoridae	0.1788	0.125	0.3636	0.0000	
Mesoveliidae	**0.0138**	0.750	0.5455	0.0000	
Hebridae	0.3607	0.125	0.0000	0.1667	
Corixidae	0.4088	0.500	0.2727	0.0000	
Notonectidae	0.1403	0.125	0.0000	0.3333	
Pyralidae	0.2363	0.375	0.3636	0.0000	
Hydroptilidae	**0.0181**	0.500	0.0000	0.5000	

Table 17. **Cont.**

	***P*-value**	**Cluster 1 mean**	**Cluster 2 mean**	**Cluster 3 mean**	**Indicator family**
Polycentropodidae	0.2109	0.000	0.0000	*0.1667*	y
Lepidostomatidae	0.2752	0.000	*0.1818*	0.0000	y
Calamoceratidae	0.4419	0.125	0.0000	0.1667	
Beraeidae	0.5492	0.000	*0.0909*	0.0000	y
DytiscidaeL	0.0998	0.750	0.5455	0.0000	
HydrophilidaeL	0.0847	0.375	0.5455	0.0000	
HydraenidaeL	0.0748	0.125	0.4545	0.0000	
PsephenidaeL	0.2752	0.000	*0.1818*	0.0000	y
HelodidaeL	**0.0000**	0.750	1.0000	0.0000	
ElmidaeL	0.3607	0.125	0.0000	0.0000	
LampyridaeL	0.7122	0.125	0.0909	0.0000	
PtilodactylidaeL	0.3607	0.125	0.0000	0.0000	
NoteridaeL	0.1264	0.375	0.0909	0.0000	
Gyrinidae	0.3607	0.125	0.0000	0.0000	
Dytiscidae	**0.0015**	0.000	0.7273	0.1667	
Hydrophilidae	**0.0008**	0.750	0.8182	0.0000	
Elmidae	0.7122	0.125	0.0909	0.0000	
Noteridae	0.2679	0.250	0.3636	0.0000	
Limnichidae	**0.0472**	0.000	*0.3636*	0.0000	y
Anthomyiidae	0.2752	0.000	*0.1818*	0.0000	y
Ephydridae	**0.0225**	0.625	0.6364	0.0000	
Phoridae	0.0748	0.125	0.4545	0.0000	
Sciomyzidae	0.3607	0.125	0.0000	0.0000	
Syrphidae	0.1228	0.000	*0.2727*	0.0000	y
Dolichopodidae	0.7122	0.125	0.0909	0.0000	
Empididae	**0.0472**	0.000	*0.3636*	0.0000	y
Stratiomyidae	0.2752	0.000	*0.1818*	0.0000	y
Tabanidae	**0.0301**	5.000	0.0909	0.0000	
Ceratopogonidae	**0.0015**	1.000	0.7273	0.1667	
Chironomidae	n/a	1.000	1.0000	1.0000	
Corethrellidae	0.5492	0.000	*0.0909*	0.0000	y
Culicidae	**0.0002**	1.000	0.7273	0.0000	
Psychodidae	**0.0347**	0.375	0.6364	0.0000	
Simuliidae	0.5492	0.000	*0.0909*	0.0000	y
Tipulidae	**0.0225**	0.625	0.6364	0.0000	

Table 19. **Probability of occurrence of macroinvertebrate species in any given cluster based on cluster means derived from K-means cluster analysis. Rare species not included in calculations. Values recorded as a percentage (%) with clusters as in Figure **.**

	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean
Dugesia sp.	20.0	28.6	14.3	0.0
Oligochaete	20.0	57.1	71.4	16.7
Helobdella stagnalis	20.0	14.3	0.0	0.0
Pisidium clarkeanum	80.0	14.3	28.6	0.0
Ferrissia baconi	20.0	14.3	0.0	0.0
Austropeplea ollula	40.0	0.0	14.3	0.0
Hippeutis cantonensis	60.0	71.4	42.9	50.0
Segmentina sp.	100.0	71.4	28.6	16.7
cf. Stenothyra sp.	80.0	57.1	0.0	0.0
Melanoides tuberculata	80.0	28.6	0.0	16.7
Ostracoda	0.0	28.6	28.6	0.0
Isopoda	20.0	85.7	42.9	0.0
Caridina lanceifrons	60.0	0.0	14.3	50.0
Neocaridina serrata	20.0	14.3	14.3	50.0
Macrobrachium hainenense	20.0	0.0	0.0	50.0
Eriocheir japonicus	80.0	0.0	0.0	0.0
Somanniathelphusa zanklon	20.0	57.1	0.0	0.0
Holometopus serenei	0.0	28.6	14.3	0.0
Baetis L7	20.0	14.3	0.0	16.7
Cloeon sp.	40.0	14.3	85.7	33.3
Canidae Unid.	40.0	28.6	42.9	0.0
Caenodes T2	0.0	14.3	42.9	0.0
Caenodes T1	0.0	14.3	14.3	0.0
Habrophlebiodes gilliesi	0.0	28.6	0.0	0.0
Agriocnemis sp. 1	100.0	42.9	42.9	0.0
Agriocnemis sp. 2	60.0	0.0	0.0	0.0
Agriocnemis lacteola	0.0	0.0	28.6	0.0
Ceriagrion melanurum	100.0	42.9	100.0	50.0
cf. Ceriagrion	0.0	57.1	0.0	0.0
Copera ciliata	0.0	0.0	14.3	33.3
Anax immaculifrons	0.0	0.0	14.3	33.3
Anax sp. 2	0.0	0.0	14.3	16.7
Orthetrum sp. 1	100.0	100.0	85.7	0.0
Orthetrum sp. 3	40.0	0.0	28.6	0.0
Trithemis sp.	0.0	14.3	14.3	16.7
Hydrobasileus croceus	0.0	0.0	14.3	16.7
Hydrometra sp.	20.0	57.1	28.6	0.0
Microvelia sp.	0.0	28.6	28.6	0.0
Neogerris sp.	20.0	0.0	14.3	0.0
Gerridae sp. 2	20.0	0.0	57.1	0.0
Diplonychus rusticum	40.0	0.0	42.9	0.0
Laccotrephes sp.	20.0	14.3	0.0	0.0
Helotrephes sp.	0.0	0.0	28.6	16.7
Pelocoris sp.	0.0	71.4	14.3	0.0
Mesovelia sp.	40.0	57.1	71.4	0.0
Corisella sp.	80.0	0.0	42.9	16.7
Anisops sp.	0.0	0.0	14.3	16.7

Table 18. Indicator families for sites in three cluster solution of K-means clustering following DCA of macroinvertebrate family presence-absence data.

Cluster 1	Cluster 2	Cluster 3
Caenidae	Ostracoda	Palaemonidae
	Dugesiidae	Heptageniidae*
	Isopoda	Polycentropodidae*
	Hydrobiidae*	
	Sesarmidae	
	Glossosophonidae	
	Erbopdellidae*	
	Hirudinidae*	
	Lepidostomatidae	
	Beraeidae*	
	Psephenidae L	
	Limnichidae	
	Syrphidae	
	Anthomyiidae	
	Stratiomyidae	
	Simuliidae*	
	Empididae	
	Corethrellidae	

* rare families that occurred at only one site.

Table 19. Probability of occurrence of macroinvertebrate species in any given cluster based on cluster means derived from K-means cluster analysis. Rare species not included in calculations. Values recorded as a percentage (%) with clusters as in Figure **.

	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean
Dugesia sp.	20.0	28.6	14.3	0.0
Oligochaete	20.0	57.1	71.4	16.7
Helobdella stagnalis	20.0	14.3	0.0	0.0
Pisidium clarkeanum	80.0	14.3	28.6	0.0
Ferrissia baconi	20.0	14.3	0.0	0.0
Austropeplea ollula	40.0	0.0	14.3	0.0
Hippeutis cantonensis	60.0	71.4	42.9	50.0
Segmentina sp.	100.0	71.4	28.6	16.7
cf. Stenothyra sp.	80.0	57.1	0.0	0.0
Melanoides tuberculata	80.0	28.6	0.0	16.7
Ostracoda	0.0	28.6	28.6	0.0
Isopoda	20.0	85.7	42.9	0.0
Caridina lanceifrons	60.0	0.0	14.3	50.0
Neocaridina serrata	20.0	14.3	14.3	50.0
Macrobrachium hainenense	20.0	0.0	0.0	50.0
Eriocheir japonicus	80.0	0.0	0.0	0.0
Somanniathelphusa zanklon	20.0	57.1	0.0	0.0
Holometopus serenei	0.0	28.6	14.3	0.0
Baetis L7	20.0	14.3	0.0	16.7
Cloeon sp.	40.0	14.3	85.7	33.3
Canidae Unid.	40.0	28.6	42.9	0.0
Caenodes T2	0.0	14.3	42.9	0.0
Caenodes T1	0.0	14.3	14.3	0.0
Habrophlebiodes gilliesi	0.0	28.6	0.0	0.0
Agriocnemis sp. 1	100.0	42.9	42.9	0.0
Agriocnemis sp. 2	60.0	0.0	0.0	0.0
Agriocnemis lacteola	0.0	0.0	28.6	0.0
Ceriagrion melanurum	100.0	42.9	100.0	50.0
cf. Ceriagrion	0.0	57.1	0.0	0.0
Copera ciliata	0.0	0.0	14.3	33.3
Anax immaculifrons	0.0	0.0	14.3	33.3
Anax sp. 2	0.0	0.0	14.3	16.7
Orthetrum sp. 1	100.0	100.0	85.7	0.0
Orthetrum sp. 3	40.0	0.0	28.6	0.0
Trithemis sp.	0.0	14.3	14.3	16.7
Hydrobasileus croceus	0.0	0.0	14.3	16.7
Hydrometra sp.	20.0	57.1	28.6	0.0
Microvelia sp.	0.0	28.6	28.6	0.0
Neogerris sp.	20.0	0.0	14.3	0.0
Gerridae sp. 2	20.0	0.0	57.1	0.0
Diplonychus rusticum	40.0	0.0	42.9	0.0
Laccotrephes sp.	20.0	14.3	0.0	0.0
Helotrephes sp.	0.0	0.0	28.6	16.7
Pelocoris sp.	0.0	71.4	14.3	0.0
Mesovelia sp.	40.0	57.1	71.4	0.0
Corisella sp.	80.0	0.0	42.9	16.7
Anisops sp.	0.0	0.0	14.3	16.7

Table 19. cont.

	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean
Paraponyx sp.	20.0	14.3	28.6	0.0
Unid. Pyralidae 1	0.0	28.6	14.3	0.0
Oxyethira sp.	20.0	14.3	28.6	0.0
Tricholeichiton sp.	0.0	0.0	28.6	50.0
Cybister sp. L	20.0	0.0	14.3	16.7
cf. Hyphydrus 1L	100.0	28.6	28.6	0.0
cf. Hyphydrus 2L	20.0	14.3	0.0	0.0
Hydrophilidae L1	80.0	42.9	14.3	0.0
Hydrophilidae L2	60.0	28.6	0.0	0.0
Hydrophilidae L3	40.0	42.9	0.0	0.0
Hydraenidae sp. 1 L	0.0	42.9	42.9	0.0
Hydraenidae sp. 2 L	0.0	28.6	14.3	0.0
Eubrianax sp. L	0.0	28.6	0.0	0.0
Cyphon sp. L	100.0	100.0	57.1	0.0
Scirtes sp. L	20.0	42.9	14.3	0.0
Luciola sp. L	20.0	14.3	0.0	0.0
Noteridae L1	60.0	14.3	0.0	0.0
Hydrovatus bonvouloiri	100.0	42.9	14.3	0.0
Hydrovatus pumilis	20.0	28.6	42.9	0.0
Cybister tripunctatus orientalis	20.0	28.6	71.4	16.7
Hydaticus rhantoides	0.0	28.6	0.0	0.0
Helochares complex 1	60.0	28.6	57.1	0.0
Helochares complex 2	20.0	14.3	14.3	0.0
Hydrobiomorpha sp.	0.0	28.6	0.0	0.0
Hydrophilus sp.	40.0	0.0	0.0	0.0
Hydrophilidae sp. 1	20.0	71.4	0.0	0.0
cf. Hydrophilidae sp. 1	20.0	14.3	0.0	0.0
cf. Stenelmis sp.	20.0	14.3	0.0	0.0
Hydrocanthus indicus	20.0	0.0	14.3	0.0
Canthydrus weisei	0.0	0.0	28.6	0.0
Noteridae sp. 3	0.0	42.9	0.0	0.0
Limnichidae	0.0	28.6	28.6	0.0
Anthomyiidae	0.0	28.6	0.0	0.0
Ephydra sp.	20.0	14.3	14.3	0.0
Ephydridae U1	80.0	57.1	0.0	0.0
Ephydridae U2	0.0	28.6	57.1	0.0
cf. Phoridae	0.0	57.1	28.6	0.0
Eristalis sp.	20.0	28.6	0.0	0.0
Dolichopodidae	0.0	28.6	0.0	0.0
Empididae sp. 2	0.0	28.6	14.3	0.0
Chrysops sp.	60.0	28.6	0.0	0.0
cf. Merycomyia sp.	20.0	14.3	0.0	0.0
Atrichopogon sp.	40.0	28.6	14.3	0.0
Ceratopogon sp.	20.0	14.3	0.0	0.0
Forcipomyia sp. 1	60.0	14.3	0.0	0.0
Forcipomyia sp. 2	0.0	57.1	28.6	0.0
Monohelea sp.	80.0	28.6	14.3	0.0
Culicoides sp.	80.0	71.4	0.0	0.0
Mollochohelea sp.	20.0	0.0	28.6	0.0
Serromyia sp.	40.0	0.0	28.6	0.0
Bezzia sp. 1	40.0	57.1	28.6	16.7
Bezzia sp. 2	20.0	14.3	57.1	0.0

Table 19. cont.

	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean	Cluster 4 mean
Chironominae	100.0	85.7	100.0	83.3
Tanypodinae	100.0	85.7	85.7	50.0
Orthocladiinae	80.0	71.4	85.7	50.0
Corethrellidae	0.0	0.0	14.3	0.0
Culex sp. 1	80.0	57.1	42.9	0.0
Culex sp. 2	40.0	14.3	28.6	0.0
Mansonia sp.	80.0	0.0	42.9	0.0
Culicidae U1	0.0	28.6	14.3	0.0
cf. Psychoda	20.0	14.3	0.0	0.0
cf. Telmatoscopus	20.0	28.6	0.0	0.0
Pericoma sp	80.0	71.4	14.3	0.0
Psychodidae sp. 3	0.0	28.6	14.3	0.0
Pseudolimnophila sp.	60.0	85.7	14.3	0.0
Limonia sp.	60.0	0.0	14.3	0.0
Tipula (Tipula)	0.0	14.3	0.0	0.0
Tipulidae U1	40.0	100.0	0.0	0.0
Tipulidae U2	0.0	57.1	0.0	0.0
Tipulidae U3	0.0	57.1	0.0	0.0
Tipulidae U4	0.0	28.6	0.0	0.0
Unid. diptera	0.0	42.9	28.6	0.0

Table 20. Probability of occurrence of macroinvertebrate families in any given cluster based on cluster means derived from K-means cluster analysis. Values recorded as a percentage (%) with clusters as in Table 11.

	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean
Dugesiidae	0.0	36.4	0.0
Oligochaete	25.0	72.7	16.7
Sphaeriidae	62.5	18.2	16.7
Ancyclidae	12.5	9.1	0.0
Hydrobiidae	0.0	9.1	0.0
Lymnaeidae	37.5	0.0	16.7
Planorbidae	87.5	72.7	50.0
Stenothyridae	50.0	36.4	0.0
Thiaridae	50.0	18.2	33.3
Ostracoda	0.0	36.4	0.0
Isopoda	0.0	9.1	0.0
Atyidae	50.0	9.1	83.3
Palaemonidae	12.5	0.0	50.0
Grapsidae	37.5	9.1	0.0
Parathelphusidae	25.0	27.3	0.0
Sesarmidae	0.0	27.3	0.0
Glossosophonidae	0.0	9.1	0.0
Erpobdellidae	0.0	18.2	0.0
Hirudinidae	0.0	9.1	0.0
Baetidae	62.5	54.6	50.0
Heptageniidae	0.0	0.0	16.7
Caenidae	75.0	9.1	0.0
Leptophlebiidae	12.5	18.2	0.0
Coenagrionidae	100.0	81.8	50.0
Platycnemididae	12.5	0.0	33.3
Aeshnidae	25.0	0.0	33.3
Gomphidae	12.5	0.0	0.0
Libellulidae	100.0	90.9	33.3
Macromiidae	12.5	0.0	0.0
Corduliidae	12.5	0.0	0.0
Hydrometridae	50.0	27.3	0.0
Veliidae	25.0	27.3	0.0
Gerridae	50.0	18.2	0.0
Belostomatidae	62.5	0.0	0.0
Nepidae	25.0	9.1	0.0
Helotrephidae	0.0	18.2	16.7
Naucoridae	12.5	36.4	0.0
Mesoveliidae	75.0	54.6	0.0
Hebridae	12.5	0.0	16.7
Corixidae	50.0	27.3	0.0
Notonectidae	12.5	0.0	33.3

Table 20. Cont.

	Cluster 1 mean	Cluster 2 mean	Cluster 3 mean
Pyralidae	37.5	36.4	0.0
Hydroptilidae	50.0	0.0	50.0
Polycentropodidae	0.0	0.0	20.0
Lepidostomatidae	0.0	20.0	0.0
Calamoceratidae	12.5	0.0	20.0
Beraeidae	0.0	10.0	0.0
DytiscidaeL	75.0	50.0	0.0
HydrophilidaeL	37.5	50.0	0.0
HydraenidaeL	12.5	50.0	0.0
PsephenidaeL	0.0	20.0	0.0
HelodidaeL	75.0	100.0	0.0
ElmidaeL	12.5	0.0	0.0
LampyridaeL	12.5	10.0	0.0
PtilodactylidaeL	12.5	0.0	0.0
NoteridaeL	37.5	10.0	0.0
Gyrinidae	12.5	0.0	0.0
Dytiscidae	0.0	70.0	20.0
Hydrophilidae	75.0	80.0	0.0
Elmidae	12.5	10.0	0.0
Noteridae	25.0	40.0	0.0
Limnichidae	0.0	40.0	0.0
Anthomyiidae	0.0	20.0	0.0
Ephydridae	62.5	60.0	0.0
Phoridae	12.5	50.0	0.0
Sciomyzidae	12.5	0.0	0.0
Syrphidae	0.0	30.0	0.0
Dolichopodidae	12.5	10.0	0.0
Empididae	0.0	40.0	0.0
Stratiomyidae	0.0	20.0	0.0
Tabanidae	50.0	10.0	0.0
Ceratopogonidae	100.0	70.0	20.0
Chironomidae	100.0	100.0	100.0
Corethrellidae	0.0	10.0	0.0
Culicidae	100.0	70.0	0.0
Psychodidae	37.5	60.0	0.0
Simuliidae	0.0	10.0	0.0
Tipulidae	62.5	60.0	0.0

Table 21. A comparison of mean (and range) values of the environmental and biological characteristics of wetland sites inhabited by Paradise Fishes (*Macropodus concolor* and *M. opercularis*) in Hong Kong.

	Macropodus concolor	*Macropodus opercularis*
Number of sites	5	8
Wetland type	marshes	marshes & ponds
Altitude (m asl)	120 (0 - 280)	30 (0 - 220)
Rock type	volcanic	mostly (6/8) volcanic
Area (ha)	3.9 (0.1 - 9.3)	8.3 (0.009 - 32)
Depth (m)	0.3 (0.08 - 0.4)	0.5 (0.1 - 1.5)
*p*H	6.12 (5.47 - 6.83)	6.30 (5.67 - 6.69)
Dissolved oxygen (mg/l)	5.66 (4.35 - 7.59)	5.48 (3.32 - 6.96)
Conductivity (μS)	149 (43 - 541)	83 (43 - 134)
Salinity (ppt)	0	0.1 (0 - 1)
Ammonia-N (mg/l)	0.11 (0 - 0.43)	0.18 (0 - 0.8)
Nitrate-N (mg/l)	4.52 (2.6 - 10.0)	4.01 (1.4 - 10.0)
Nitrite-N (mg/l)	0.012 (0 - 0.050)	0.005 (0 - 0.011)
Phosphates (mg/l)	15.4 (10.0 - 27.0)	11.4 (7.0 - 15.0)
Species richness	34.8 (31 - 39)	32.6 (4 - 62)
Family richness	22.0 (19 - 24)	21.1 (4 - 34)
No. rare species	3.6 (0 - 8)	2.4 (0 - 7)

Appendix I Vegetation lists for selected wetland sites

	Tung Chung marsh			Luk Keng marsh					
	5/9/94	19/9/94	22/9/94	19/8/94					
	Trans. 1	**Trans. 2**	**Trans. 3**	**Area 1**	**Area 2**	**Trans. 1**	**Trans. 2**	**Trans. 3**	**Trans. 4**
Amaranthaceae									
Alternanthera sessilis (L.) R.Br.	0	0	0	0	0	0	0	0	0
Araceae									
Colocasia esculenta (L.) Schott	0	0	0	0	0	0	0	0	0
Callitrichaceae									
Callithriche staganalis Scop.	0	0	0	0	1	0	0	0	0
Commenlinaceae									
Commelina communis L.	0	0	0	1	0	0	0	0	0
Commelina nudiflora L.	0	3	0	0	1	0	0	0	0
Floscopa scandens Lour.	0	0	0	1	1	0	0	0	0
Compositae									
Eclipta prostrata (L.) L.	0	0	0	0	0	0	0	0	0
Wedelia chinensis (Obs.) Merr.	0	9	0	1	0	0	0	0	0
Convolvulaceae									
Ipomoea sp.	0	0	0	0	0	0	0	0	0
Eriocaulaceae									
Eriocaulon setaceum L.	0	0	0	0	1	0	0	0	0
Cyperaceae									
Bulbostylis barbata (Rottb.) Kunth.	0	1	0	0	0	0	0	0	0
Cyperus compressus L.	0	1	0	0	0	0	0	0	0
Cyperus cyperoides (L.) O. Ktze.	0	0	0	0	0	0	0	0	0
Cyperus difformis L.	0	1	0	0	0	0	0	0	0
Cyperus distans L.f.	0	0	0	0	0	0	0	0	0
Cyperus hapan L.	1	0	0	0	0	0	0	0	0
Cyperus malaccensis Lam.	0	0	0	1	0	0	0	0	0
Cyperus pilosus Vahl	1	1	0	0	0	0	0	0	0
Cyperus radicans Nees.	1	1	0	0	0	1	0	0	0
Cyperus rotundus L.	0	1	0	0	0	0	0	0	0
Cyperus serotinus Rottb.	1	1	0	0	0	0	1	0	0
Cyperus stoloniferus Ratz.	0	0	0	0	0	0	0	0	0
Cyperus tenulculms Boeck	0	0	0	0	0	0	0	0	0
Eleocharis dulcis (Burm. f.) Trin.	0	0	0	0	0	0	1050	113	0
Fimbristylis dichotoma (L.) Vahl	0	0	0	0	0	0	0	0	0
Fimbristylis littoralis Gaudich	0	0	0	0	0	0	0	0	0
Fimbristylis ovata (Burm. f.) Kern.	0	0	0	0	0	0	0	0	0
Fimbristylis schoenoides (Retz.) Vahl.	1	0	0	0	0	0	0	0	0
Fimbristylis tetragona (Retz.) R. Br.	1	0	0	0	0	0	0	0	0
Fuirena umbellata Rottb.	0	0	0	1	1	0	0	0	0
Kyllinga brevifolia Rottb.	0	3	0	0	0	0	0	0	0
Kyllinga nemoralis (Forst.) Dandy ex. Hutch	0	1	0	0	0	0	0	0	0
Pycreus flavidus (Ratz.) Koyama	0	0	1	0	0	0	0	0	0
Pycreus polystachos Rottb.	1	1	0	1	0	1	2	0	1
Pycreus sanguinolencus (Vahl) Ness	1	1	0	0	0	0	0	0	0
Rynchospora rubra (Lour.) Makino	0	1	0	0	0	0	0	0	0
Euphorbiaceae									
Glochidion sp.	0	0	0	0	1	0	0	0	0
Sapium sebiferum Roxb.	0	0	0	1	0	0	0	0	0

Appendix I cont.

	Tung Chung marsh			Luk Keng marsh					
	5/9/94	19/9/94	22/9/94	19/8/94					
	Trans. 1	Trans. 2	Trans. 3	Area 1	Area 2	Trans. 1	Trans. 2	Trans. 3	Trans. 4
Graminae									
Isachne globosa (Thb.) O. Ktze.	0	360	0	0	0	0	0	0	34
Isachne spp.	0	0	0	0	1	1	0	0	84
Leersia hexandra Sw.	0	0	0	1	0	1	0	0	1
Leersia spp.	0	0	0	0	1	0	0	0	0
Panicum repens L.	0	7	0	0	0	1	133	272	0
Panicum spp.	0	292	0	0	0	1	0	0	0
Paspalum distichum L.	0	0	0	0	0	0	157	86	0
Paspalum spp.	0	0	0	0	1	1	0	0	0
Phragmites australis Cav. (Steud.)	0	0	0	0	1	0	0	0	0
Labiatae									
Leucas sp.	0	0	0	1	0	0	0	0	1
Marsileaceae									
Marsilea quadrifolia L.	0	0	0	0	1	0	0	0	0
Melostomaceae									
Melostoma candidum D. Don.	0	0	0	0	0	1	0	0	0
Onagraceae									
Ludwigia adcendens (L.) Hara	0	0	0	0	0	1	0	0	0
Ludwigia octavalis (Jacq.) Raven	0	0	0	0	0	1	0	0	1
Ludwigia sp.	0	0	0	1	1	0	0	0	0
Philydraceae									
Philydrum lanuginosum Banks ex Gaertn.	0	0	0	0	1	0	0	0	0
Polygonaceae									
Polygonum spp.	0	0	0	1	1	1	0	0	78
Pontederiaceae									
Eichhornia crassipes Solms	0	0	0	1	0	0	0	0	0
Monochoria hastata (L.) Solms	0	0	0	0	0	0	0	0	0
Ranunculaceae									
Ranunculus sceleratus L.	0	0	0	0	0	0	0	0	0
Schizaeaceae									
Lygodium microphyllum R.Br.	0	0	0	0	1	0	0	0	0
Scrophulariaceae									
Bacopa monnieri (L.) Pennel	0	0	0	1	1	0	0	0	1
Lindernia sp.	0	2	0	1	0	0	0	0	1
Umbelliferae									
Centella asiatica (L.) Urb.	0	0	0	0	0	0	0	0	0
Hydrocotyle sibthorpioides Lam.	0	7	0	0	1	0	0	0	0
Oenathe javanica DC.	0	0	0	0	0	0	0	0	0
Zingiberaceae									
Hedychium coronarium Koen.	0	1	0	0	0	0	0	0	0

Appendix I cont.

	Pui O marsh 30/08/94 Trans. 1	Yi O marsh 29/08/94 Trans. 1	Shuen Wan 26/08/94 Trans. 1	Kuk Po marsh 18/08/94 Trans. 1	Trans. 2	Trans. 3
Amaranthaceae						
Alternanthera sessilis (L.) R.Br.	0	0	0	0	1	0
Araceae						
Colocasia esculenta (L.) Schott	0	0	1	0	0	0
Callitrichaceae						
Callithriche staganalis Scop.	0	0	0	0	0	0
Commenlinaceae						
Commelina communis L.	0	0	0	0	0	0
Commelina nudiflora L.	6	0	16	6	7	0
Floscopa scandens Lour.	0	0	0	0	0	0
Compositae						
Eclipta prostrata (L.) L.	0	0	0	0	67	0
Wedelia chinensis (Obs.) Merr.	0	5	0	0	0	165
Convolvulaceae						
Ipomoea sp.	0	0	9	0	0	0
Eriocaulaceae						
Eriocaulon setaceum L.	0	0	0	0	0	0
Cyperaceae						
Bulbostylis barbata (Rottb.) Kunth.	0	0	0	0	0	0
Cyperus compressus L.	0	1	0	0	0	0
Cyperus cyperoides (L.) O. Ktze.	1	1	1	0	0	0
Cyperus difformis L.	0	0	0	0	0	0
Cyperus distans L.f.	1	0	0	1	0	0
Cyperus hapan L.	0	0	0	0	0	0
Cyperus malaccensis Lam.	0	0	0	0	0	0
Cyperus pilosus Vahl	0	0	0	0	0	0
Cyperus radicans Nees.	6	0	0	0	0	0
Cyperus rotundus L.	0	0	0	0	0	0
Cyperus serotinus Rottb.	0	0	0	0	0	0
Cyperus stoloniferus Ratz.	0	0	0	0	0	0
Cyperus tenulculms Boeck	0	0	0	1	0	0
Eleocharis dulcis (Burm. f.) Trin.	0	0	9	0	0	24
Fimbristylis dichotoma (L.) Vahl	0	0	0	1	0	108
Fimbristylis littoralis Gaudich	1	0	0	0	0	0
Fimbristylis ovata (Burm. f.) Kern.	4	0	0	0	0	0
Fimbristylis schoenoides (Retz.) Vahl.	0	0	0	0	0	0
Fimbristylis tetragona (Retz.) R. Br.	0	0	0	0	0	0
Fuirena umbellata Rottb.	0	0	0	0	0	0
Kyllinga brevifolia Rottb.	10	0	0	2	0	1
Kyllinga nemoralis (Forst.) Dandy ex. Hutch	0	0	0	0	0	0
Pycreus flavidus (Ratz.) Koyama	0	0	1	0	0	1
Pycreus polystachos Rottb.	2	0	1	2	0	6
Pycreus sanguinolencus (Vahl) Ness	0	0	0	0	0	0
Rynchospora rubra (Lour.) Makino	0	0	0	0	0	0
uphorbiaceae						
Glochidion sp.	0	3	0	0	0	0
Sapium sebiferum Roxb.	0	0	0	0	0	0

Appendix I cont.

	Pui O marsh 30/08/94 Trans. 1	Yi O marsh 29/08/94 Trans. 1	Shuen Wan 26/08/94 Trans. 1	Kuk Po marsh 18/08/94 Trans. 1	Trans. 2	Trans. 3
Graminae						
Isachne globosa (Thb.) O. Ktze.	0	0	0	55	0	0
Isachne spp.	122	151	363	0	226	414
Leersia hexandra Sw.	0	0	0	0	30	0
Leersia spp.	70	0	82	22	0	0
Panicum repens L.	0	0	0	0	0	0
Panicum spp.	11	0	88	0	12	0
Paspalum distichum L.	7	0	0	41	0	0
Paspalum spp.	0	0	0	1	2	12
Phragmites australis Cav. (Steud.)	0	4	1	0	0	0
Labiatae						
Leucas sp.	0	0	0	0	0	0
Marsileaceae						
Marsilea quadrifolia L.	0	18	1	8	18	30
Melostomaceae						
Melostoma candidum D. Don.	0	0	1	0	1	0
Onagraceae						
Ludwigia adcendens (L.) Hara	0	0	0	0	0	0
Ludwigia octavalis (Jacq.) Raven	0	0	0	0	0	0
Ludwigia sp.	0	0	0	0	0	2
Philydraceae						
Philydrum lanuginosum Banks ex Gaertn.	0	0	0	0	0	0
Polygonaceae						
Polygonum spp.	0	0	0	0	0	0
Pontederiaceae						
Eichhornia crassipes Solms	0	0	0	0	0	0
Monochoria hastata (L.) Solms	62	0	0	0	0	0
Ranunculaceae						
Ranunculus sceleratus L.	0	0	0	0	5	0
Schizaeaceae						
Lygodium microphyllum R.Br.	0	0	0	0	0	0
Scrophulariaceae						
Bacopa monnieri (L.) Pennel	0	0	0	0	0	0
Lindernia sp.	15	0	3	0	1	0
Umbelliferae						
Centella asiatica (L.) Urb.	3	0	0	0	20	0
Hydrocotyle sibthorpioides Lam.	0	0	0	0	45	72
Oenathe javanica DC.	9	0	1	0	0	0
Zingiberaceae						
Hedychium coronarium Koen.	0	0	1	0	0	0

Appendix II Species/morphospecies list for each wetland site. Abbreviations in Table 1.
(*)= presence; (-)= absence

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM
Tricladida														
Dugesiidae														
Dugesia sp.	-	-	-	-	-	-	-	*	-	-	-	-	-	-
Oligochaeta	*	-	-	-	-	-	*	*	*	*	*	*	*	*
Hirudinea														
lossosophonidae														
Helobdella stagnalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erpobdellidae														
Erpobdella sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Iirudinidae														
Limnatis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelecypoda														
phaeriidae														
Pisidium clarkeanum	*	-	-	-	-	-	-	-	-	-	*	-	-	-
Pisidium annandelei	-	-	-	-	-	-	-	-	-	-	-	-	-	-
astropoda														
ncyclidae														
Ferrissia baconi	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrohiidae														
cf. Hydrobiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaeidae														
Austropeplea ollula	*	-	-	-	-	-	-	-	-	-	*	-	-	-
Radix sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lanorbidae														
Hippeutis cantonenesis	*	-	-	-	-	*	-	*	-	*	*	-	-	-
Segmentina sp.	-	-	-	*	-	-	-	*	-	*	*	-	*	*
tenothyridae														
cf. Stenothyra sp.	-	-	-	*	-	-	-	-	-	-	*	-	-	-
Thiaridae														
Melanoides tuberculata	-	-	-	*	-	-	-	-	-	*	*	-	-	-
Brotia hainanensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ostracoda	-	-	-	-	-	-	*	*	-	-	-	-	-	-
opoda	-	-	-	*	-	-	-	*	-	-	-	*	*	*
ecapoda														
Atyidae														
Caridina lanceifrons	-	-	*	-	-	-	-	-	-	*	*	-	-	-
Neocaridina serrata	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Palaemonidae														
Macrobrachium hainenense	-	-	*	-	-	-	-	-	-	*	-	-	-	-
rapsidae														
Eriocheir japonicus	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Parathelphusidae														
Somanniathelphusa zanklon	-	-	-	*	-	-	-	-	-	-	*	-	-	-
sarmidae														
Holometopus serenei	-	-	-	*	-	-	-	-	-	-	-	*	-	-
Ephemeroptera														
aetidae														
Baetis L7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cloeon sp.	*	*	-	-	-	*	-	*	-	*	*	*	-	*
eptageniidae														
Cinygmina T2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenidae														

Appendix II cont.

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM
Caenidae Unid.	*	*	-	-	-	-	-	-	-	-	*	-	-	-
Caenodes T2	*	*	-	-	-	-	-	-	-	-	-	-	-	-
Caenodes T1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Leptophlebiidae														
Habrophlebiodes gilliesi	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Choroterpes sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata														
Coenagrionidae														
Agriocnemis sp. 1	*	-	-	-	-	-	*	-	-	-	*	-	-	-
Agriocnemis sp. 2	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Agriocnemis lacteola	*	*	-	-	-	-	-	-	-	-	-	-	-	-
Ceriagrion melanurum	*	*	*	-	-	*	-	*	-	*	*	*	-	*
Ceriagrion sp. 2	-	-	-	*	-	-	-	-	-	-	-	-	-	-
cf. Ceriagrion	-	*	*	-	*	-	-	-	-	-	-	-	-	-
Ischnura senegalensis	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Unid. Coenagrionidae 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unid. Coenagrionidae 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unid. Zygoptera	-	-	*	-	-	-	-	-	-	-	-	-	-	-
Platycnemididae														
Copera ciliata	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Copera sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Aeshnidae														
Anax immaculifrons	-	*	-	-	-	-	-	-	-	*	-	-	-	-
Anax sp. 2	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Aeschnophlebia sp. 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gomphidae														
Megalogomphus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sinogomphus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Libellulidae														
Orthetrum sp. 1	*	*	-	*	-	-	*	*	-	-	*	*	-	-
Orthetrum sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Orthetrum sp. 3	-	*	-	-	-	-	*	-	-	-	*	-	-	-
Trithemis sp.	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Rhyothemis sp.	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Crocothemis sp.	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Hydrobasileus croceus	-	*	-	-	-	*	-	-	-	-	-	-	-	-
Pantala flavescans	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Macrodiplax sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macromiidae														
Macromiidae sp. 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corduliidae														
Somatochlora sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemiptera														
Hydrometridae														
Hydrometra sp.	*	-	-	*	-	-	-	-	-	-	*	-	-	-
Veliidae														
Rhagovelia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microvelia sp.	-	*	-	-	-	-	-	*	-	-	-	-	-	-
Angilia sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Veliidae U1	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Gerridae														
Limnogonus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neogerris sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix II cont.

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM
Gerridae sp. 2	*	*	-	-	-	-	-	-	-	-	-	*	-	*
Belostomatidae														
Diplonychus rusticum	*	*	-	-	-	-	-	-	-	-	*	-	-	-
lepidae														
Laccotrephes sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Ranatra sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Ielotrephidae														
Helotrephes sp.	-	-	-	-	-	-	-	*	-	-	-	-	-	*
Naucoridae														
Pelocoris sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
lesoveliidae														
Mesovelia sp.	*	*	-	*	-	-	*	*	-	-	-	*	-	-
Hebridae														
Hebrus sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-
orixidae														
Corisella sp.	-	*	-	-	-	*	*	*	-	-	*	-	-	-
otonectidae														
Anisops sp.	-	*	*	-	-	-	-	-	-	-	-	-	-	-
Enithares sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
epidoptera														
yralidae														
Paraponyx sp.	*	*	-	-	-	-	-	-	-	-	*	-	-	-
Unid. Pyralidae 1	-	-	-	*	-	-	-	-	-	-	-	-	-	*
Unid. Pyralidae 2	-	-	-	-	-	-	-	-	-	-	-	*	-	-
richoptera														
Hydroptilidae														
Oxyethira sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Tricholeichiton sp.	*	-	-	-	-	*	-	-	-	-	-	-	-	-
Polycentropodidae														
Polycentropus U1	-	-	-	-	-	*	-	-	-	-	-	-	-	-
epidostomatidae														
Goerodes sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Calamoceratidae														
Anisocentropus maculatus	-	*	-	-	-	-	-	-	-	-	-	-	-	-
eraeidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera larvae														
Dytiscidae														
Cybister tripunctatus orientalis	-	*	-	-	-	*	-	-	-	-	*	-	-	-
Hydaticus sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Bidessus sp.	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Ilybius sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroporus sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
cf. Hyphydrus 0	-	*	-	-	-	-	-	-	-	-	-	-	-	-
cf. Hyphydrus 1	-	-	-	*	-	-	-	-	-	-	*	*	-	*
cf. Hyphydrus 2	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Hydrophilidae														
Hydrophilidae L1	-	-	-	*	-	-	-	-	-	-	*	*	-	-
Hydrophilidae L2	-	-	-	*	-	-	-	-	-	-	*	-	-	-
Hydrophilidae L3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae L4	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Hydrophilidae L5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilus L	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Hydraenidae														

Appendix II cont.

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM
Hydraenidae sp. 1	-	*	-	*	-	-	-	-	-	-	-	*	-	*
Hydraenidae sp. 2	-	-	-	*	-	-	-	-	-	-	-	-	-	*
Psephenidae														
Eubrianax sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helodidae														
Cyphon sp.	-	-	-	*	-	-	*	*	*	-	*	*	-	-
Scirtes sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Elmidae														
Elmidae U1	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampyridae														
Luciola sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Ptilodactylidae														
Epilichas sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noteridae														
Noteridae sp. 1	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Coleoptera adults														
Gyrinidae														
Gyrinus sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Dineutus sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae														
Hydrovatus bonvouloiri	-	-	-	-	-	-	-	-	*	-	*	-	-	-
Hydrovatus ferrugatus	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrovatus pumilus	-	-	-	*	-	-	*	-	*	-	*	*	-	*
Cybister tripunctatus orientalis	*	*	-	-	-	-	*	-	-	-	*	*	-	-
Hydaticus rhantoides	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Neptosternus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Laccophilus pulicarius	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Hydrocoptus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae														
Enochrus complex spp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helochares complex sp. 1	*	*	-	*	-	-	-	-	-	-	*	*	-	*
Helochares complex sp. 2	-	-	-	-	-	-	-	*	-	-	*	-	-	-
Helochares complex sp. 3	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Hydrobiomorpha sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Hydrophilus sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Sternolophus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae sp. 1	-	-	-	*	-	-	-	-	-	-	*	-	-	-
Hydrophilidae sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. Hydrophilidae sp. 1	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Elmidae														
cf. Stenelmis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noteridae														
Hydrocanthus indicus	-	-	-	-	-	-	-	-	-	-	*	-	-	*
Canthydrus weisei	-	*	-	-	-	-	-	-	-	-	-	-	-	*
Noteridae sp. 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Limnichidae U1	-	-	-	*	-	-	-	-	-	-	-	*	-	*
Diptera														
Anthomyiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephydridae														
Ephydra sp.	-	-	-	-	-	-	*	-	-	-	*	-	-	-
Ephydridae U1	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Ephydridae U2	*	*	-	-	-	-	*	*	-	-	-	-	-	-
Phoridae														

Appendix II cont.

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM
cf. Phoridae	-	-	-	*	-	-	-	-	-	-	-	*	-	-
Sciomyizdae														
Sciomyzidae U1	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Syrphidae														
Eristalis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichopodidae														
Dolichopodidae U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Empididae														
Hemerodromia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Empididae sp. 2	-	-	-	-	-	-	-	-	-	-	-	*	*	-
Statiomyidae														
Odontomyia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stratiomyidae sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Tabanidae														
Chrysops sp.	-	-	-	*	-	-	-	-	-	-	*	-	-	-
cf. Merycomyia sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Ceratopogonidae														
Atrichopogon sp.	*	-	-	*	-	-	-	-	-	-	-	-	-	-
Ceratopogon sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Forcipomyia sp. 1	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Forcipomyia sp. 2	*	-	-	*	-	-	-	-	-	-	-	*	-	-
Monohelea sp.	*	-	-	-	-	-	-	-	-	-	*	-	-	-
Culicoides sp.	-	-	-	*	-	-	-	-	-	-	*	-	-	-
Sphaeromias sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mollochohelea sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Serromyia sp.	-	-	-	-	-	-	-	-	-	-	*	*	-	*
cf. Dasyhelea sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Probezzia sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Bezzia sp. 1	*	-	-	*	-	*	-	-	-	-	*	-	-	-
Bezzia sp. 2	*	*	-	-	-	-	-	-	-	-	-	*	-	-
hironomidae														
Chironominae	*	*	*	-	*	*	*	*	*	*	*	*	*	*
Tanypodinae	*	*	-	-	*	*	*	*	*	-	*	*	-	-
Orthocladiinae	*	-	-	-	*	*	*	*	-	-	*	*	*	*
Tanytarsini	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corethrellidae														
Corethrellidae U1	-	-	-	-	-	-	-	-	*	-	-	*	-	-
ulicidae														
Culex sp.1	*	*	-	*	-	-	-	*	-	-	*	-	-	-
Culex sp. 2	-	-	-	-	-	-	-	-	-	-	*	*	-	*
Culex sp. 3	-	-	-	-	-	-	-	*	-	-	-	-	-	-
Culiseta sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mansonia sp.	*	-	-	-	-	-	-	-	-	-	*	-	-	*
Anopholes sinensis	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae U1	-	-	-	-	-	-	*	-	-	-	-	-	-	-
Psychodidae														
cf. Psychoda sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. Telmatoscopus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pericoma sp.	-	-	-	-	-	-	-	*	*	-	-	-	*	-
Psychodidae sp.3	-	-	-	-	-	-	-	*	-	-	-	-	-	-
Psychodidae sp.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
muliidae														
Simulium S6	-	-	-	-	-	-	*	-	-	-	-	-	-	-

Appendix II cont.

	CSM	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM
Tipulidae														
Hexatoma sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pseudolimnophila sp.	*	-	-	*	-	-	-	-	*	-	*	-	*	-
Limonia sp.	*	-	-	-	-	-	-	-	-	-	*	-	-	-
Tipula (Tipula)	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Tipula (Tipulodina)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipula (Angarotipula)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipula U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipula U2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipulidae U1	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Tipulidae U2	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Tipulidae U3	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Tipulidae U4	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Tipulidae U5	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Unid. diptera	-	-	-	*	-	-	*	*	-	-	-	-	-	-

Appendix II cont.

	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	LCP	YOM	YSO1	YSO2M
Tricladida														
Dugesiidae														
Dugesia sp.	-	*	-	-	-	-	-	-	-	-	-	-	*	*
Oligochaeta	-	-	-	-	-	-	*	-	-	-	-	*	*	*
Hirudinea														
Glossosophonidae														
Helobdella stagnalis	-	*	-	-	-	-	-	-	-	-	-	*	-	-
Erpobdellidae														
Erpobdella sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Hirudinidae														
Limnatis sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Pelecypoda														
Sphaeriidae														
Pisidium clarkeanum	*	*	*	*	-	-	-	-	-	-	*	-	-	*
Pisidium annandelei	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Gastropoda														
Ancyclidae														
Ferrissia baconi	-	-	*	-	-	-	-	-	-	-	-	*	-	-
Hydrobiidae														
cf. Hydrobiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Lymnaeidae														
Austropeplea ollula	-	-	*	-	-	-	-	-	-	-	-	-	-	-
Radix sp.	-	-	-	-	-	-	-	*	-	-	-	-	-	-
Planorbidae														
Hippeutis cantonenesis	*	-	*	*	*	-	-	*	*	-	-	*	*	*
Segmentina sp.	*	*	*	-	*	*	-	-	-	-	-	*	*	*
Stenothyridae														
cf. Stenothyra sp.	-	*	*	-	*	*	-	-	*	-	-	*	-	-
Thiaridae														
Melanoides tuberculata	*	-	*	-	-	*	-	-	-	-	-	-	-	*
Brotia hainanensis	-	-	-	-	-	-	-	*	-	-	-	-	-	-
Ostracoda	-	-	-	-	-	-	*	-	-	-	-	-	-	*
Isopoda	-	*	-	-	*	-	*	-	-	-	-	*	*	*
Decapoda														
Atyidae														
Caridina lanceifrons	-	-	*	*	-	*	-	*	-	-	-	-	-	-
Neocaridina serrata	-	-	*	*	-	-	-	*	-	*	*	-	-	*
Palaemonidae														
Macrobrachium hainenense	-	-	*	-	-	-	-	*	-	-	-	-	-	-
Grapsidae														
Eriocheir japonicus	*	*	*	-	-	-	-	-	-	-	-	-	-	-
Parathelphusidae														
Somanniathelphusa zanklon	-	-	-	-	*	-	*	-	*	-	-	-	-	-
Sesarmidae														
Holometopus serenei	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Ephemeroptera														
Baetidae														
Baetis L7	-	-	*	-	-	-	-	-	-	*	-	-	-	*
Cloeon sp.	-	*	-	*	-	-	-	-	-	-	-	*	-	-
Heptageniidae														
Cinygmina T2	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Caenidae														

Appendix II cont.

	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCP	YOM	YSO1	YSO2M
Caenidae Unid.	-	-	*	*	-	-	-	-	*	-	-	-	-	*
Caenodes T2	-	-	-	*	-	-	-	-	*	-	-	-	-	-
Caenodes T1	-	-	-	*	-	-	-	-	-	-	-	-	-	*
Leptophlebiidae														
Habrophlebiodes gilliesi	-	-	-	-	-	-	*	-	-	-	-	-	-	*
Choroterpes sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Odonata														
Coenagrionidae														
Agriocnemis sp. 1	*	*	*	*	*	*	*	-	-	-	-	-	-	*
Agriocnemis sp. 2	*	-	*	-	-	-	-	-	-	-	-	-	-	-
Agriocnemis lacteola	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ceriagrion melanurum	*	*	*	*	*	*	*	-	-	-	-	-	-	*
Ceriagrion sp. 2	-	-	-	-	*	-	*	-	-	-	-	*	-	-
cf. Ceriagrion	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ischnura senegalensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unid. Coenagrionidae 2	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Unid. Coenagrionidae 3	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Unid. Zygoptera	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Platycnemididae														
Copera ciliata	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copera sp. 2	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Aeshnidae														
Anax immaculifrons	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Anax sp. 2	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Aeschnophlebia sp. 1	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Gomphidae														
Megalogomphus sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Sinogomphus sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Libellulidae														
Orthetrum sp. 1	*	*	*	*	*	*	*	-	*	-	-	*	*	*
Orthetrum sp. 2	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Orthetrum sp. 3	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Trithemis sp.	-	-	-	*	-	-	-	-	-	-	-	*	-	-
Rhyothemis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Crocothemis sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobasileus croceus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pantala flavescans	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrodiplax sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Macromiidae														
Macromiidae sp. 1	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Corduliidae														
Somatochlora sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Hemiptera														
Hydrometridae														
Hydrometra sp.	-	-	-	*	*	-	-	-	*	-	-	*	-	-
Veliidae														
Rhagovelia sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Microvelia sp.	-	-	-	-	*	-	*	-	-	-	-	-	-	-
Angilia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Veliidae U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gerridae														
Limnogonus sp.	-	-	*	-	-	-	-	-	-	-	-	-	-	-
Neogerris sp.	-	-	*	-	-	-	-	-	-	-	-	-	-	-

Appendix II cont.

	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCP	YOM	YSO1	YSO2M
Gerridae sp. 2	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Belostomatidae														
Diplonychus rusticum	*	-	-	*	-	-	-	-	-	-	-	-	-	-
Nepidae														
Laccotrephes sp.	-	-	-	-	-	-	-	-	-	-	-	-	*	-
Ranatra sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helotrephidae														
Helotrephes sp.	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Naucoridae														
Pelocoris sp.	-	-	-	*	*	-	-	-	-	-	-	*	*	*
Mesoveliidae														
Mesovelia sp.	-	-	*	-	*	*	*	-	*	-	-	-	-	-
Hebridae														
Hebrus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corixidae														
Corisella sp.	-	*	*	-	-	*	-	-	-	-	*	-	-	-
Notonectidae														
Anisops sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Enithares sp.	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Lepidoptera														
Pyralidae														
Paraponyx sp.	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Unid. Pyralidae 1	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Unid. Pyralidae 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera														
Hydroptilidae														
Oxyethira sp.	-	-	*	*	-	-	-	-	*	-	-	-	-	-
Tricholeichiton sp.	-	-	-	*	-	-	-	*	-	*	-	-	-	-
Polycentropodidae														
Polycentropus U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidostomatidae														
Goerodes sp.	-	-	-	-	-	-	-	-	-	-	-	-	*	*
Calamoceratidae														
Anisocentropus maculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
leraeidae	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Coleoptera larvae														
Dytiscidae														
Cybister tripunctatus orientalis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydaticus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bidessus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ilybius sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydroporus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. Hyphydrus 0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. Hyphydrus 1	*	*	*	-	-	*	*	-	-	-	-	-	-	-
cf. Hyphydrus 2	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Hydrophilidae														
Hydrophilidae L1	-	*	*	-	-	*	-	-	-	-	-	*	*	-
Hydrophilidae L2	-	*	-	-	-	*	-	-	-	-	-	*	-	-
Hydrophilidae L3	-	*	*	-	-	-	-	-	-	-	-	*	*	*
Hydrophilidae L4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae L5	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Hydrophilus L	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydraenidae														

Appendix II cont.

	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCP	YOM	YSO1	YSO2M
Hydraenidae sp. 1	-	-	-	-	*	-	-	-	-	-	-	-	-	*
Hydraenidae sp. 2	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Psephenidae														
Eubrianax sp.	-	-	-	-	*	-	-	-	-	-	-	*	-	-
Helodidae														
Cyphon sp.	*	*	*	*	*	*	*	-	*	-	-	*	*	*
Scirtes sp.	-	-	-	-	-	*	*	-	-	-	-	*	-	*
Elmidae														
Elmidae U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampyridae														
Luciola sp.	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Ptilodactylidae														
Epilichas sp.	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Noteridae														
Noteridae sp. 1	-	-	*	-	-	*	*	-	-	-	-	-	-	-
Coleoptera adults														
Gyrinidae														
Gyrinus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dineutus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae														
Hydrovatus bonvouloiri	*	*	*	*	-	*	*	-	*	-	-	*	-	-
Hydrovatus ferrugatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrovatus pumilus	-	-	-	-	-	-	-	-	-	-	-	-	*	-
Cybister tripunctatus orientalis	-	-	-	*	-	-	-	-	*	*	-	*	-	-
Hydaticus rhantoides	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Neptosternus sp.	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Laccophilus pulicarius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrocoptus sp.	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Hydrophilidae														
Enochrus complex spp.	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Helochares complex sp. 1	*	-	*	-	-	-	-	-	-	-	-	*	-	-
Helochares complex sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Helochares complex sp. 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiomorpha sp.	-	-	-	-	-	-	-	-	*	-	-	-	-	-
Hydrophilus sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Sternolophus sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae sp. 1	-	-	-	-	*	-	*	-	*	-	-	*	-	-
Hydrophilidae sp. 2	-	*	-	-	-	-	-	-	-	-	-	-	-	-
cf. Hydrophilidae sp. 1	-	-	-	-	-	-	-	-	-	-	-	*	-	-
Elmidae														
cf. Stenelmis sp.	-	-	*	-	-	-	-	-	-	-	-	-	-	*
Noteridae														
Hydrocanthus indicus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Canthydrus weisei	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noteridae sp. 3	-	-	-	-	*	-	-	-	-	-	-	-	*	*
Limnichidae U1	-	-	-	-	-	-	*	-	-	-	-	-	-	-
Diptera														
Anthomyiidae	-	-	-	-	-	-	-	-	-	-	-	-	*	*
Ephydridae														
Ephydra sp.	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Ephydridae U1	*	*	-	-	*	*	-	-	-	-	-	*	*	*
Ephydridae U2	-	-	-	-	*	-	-	-	-	-	-	-	*	-
Phoridae														

Appendix II cont.

	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCP	YOM	YSO1	YSO2M
cf. Phoridae	-	-	-	*	*	-	*	-	-	-	-	-	*	-
Sciomyizdae														
Sciomyzidae U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
yrphidae														
Eristalis sp.	-	*	-	-	-	-	-	-	-	-	-	-	*	*
Dolichopodidae														
Dolichopodidae U1	-	-	-	-	-	-	-	-	*	-	-	-	-	*
mpididae														
Hemerodromia sp.	-	-	-	-	-	-	*	-	-	-	-	-	-	-
Empididae sp. 2	-	-	-	-	*	-	-	-	-	-	-	-	*	-
tatiomyidae														
Odontomyia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	*
Stratiomyidae sp. 2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
abanidae														
Chrysops sp.	-	-	*	-	-	*	-	-	*	-	-	-	-	-
cf. Merycomyia sp.	-	-	-	-	-	*	-	-	-	-	-	-	-	-
eratopogonidae														
Atrichopogon sp.	-	-	*	-	-	*	-	-	*	-	-	-	-	-
Ceratopogon sp.	-	-	*	-	-	-	*	-	-	-	-	-	-	-
Forcipomyia sp. 1	-	-	*	-	-	*	-	-	-	-	-	-	-	*
Forcipomyia sp. 2	-	-	-	-	-	-	*	-	-	-	-	-	*	*
Monohelea sp.	-	*	*	-	-	*	-	-	*	-	-	-	*	-
Culicoides sp.	-	*	*	-	*	*	-	-	*	-	-	-	*	*
Sphaeromias sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Mollochohelea sp.	-	-	-	*	-	*	-	-	-	-	-	-	-	-
Serromyia sp.	*	-	-	-	-	-	-	-	-	-	-	-	-	-
cf. Dasyhelea sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Probezzia sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bezzia sp. 1	-	-	-	*	*	*	*	-	*	-	-	-	-	-
Bezzia sp. 2	-	*	-	*	*	-	-	-	-	-	-	-	-	-
hironomidae														
Chironominae	*	*	*	*	*	*	*	*	*	-	*	*	*	*
Tanypodinae	*	*	*	*	*	*	*	*	*	-	-	*	*	*
Orthocladiinae	-	*	*	*	*	*	*	-	-	*	-	*	*	*
Tanytarsini	-	-	-	*	-	-	-	-	-	-	-	-	-	-
Corethrellidae														
Corethrellidae U1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ulicidae														
Culex sp.1	-	*	*	-	-	*	-	-	*	-	-	-	*	*
Culex sp. 2	-	*	-	-	-	-	-	-	-	-	-	-	-	*
Culex sp. 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culiseta sp.	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Mansonia sp.	*	*	-	*	-	*	-	-	-	-	-	-	-	-
Anopholes sinensis	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae U1	-	-	-	-	-	-	-	-	-	-	-	-	*	*
Psychodidae														
cf. Psychoda sp.	-	*	-	-	-	-	-	-	-	-	-	-	-	*
cf. Telmatoscopus sp.	*	-	-	-	-	-	-	-	-	-	-	-	*	*
Pericoma sp.	*	*	*	-	*	*	*	-	-	-	-	*	*	*
Psychodidae sp.3	-	-	-	-	-	-	-	-	-	-	-	-	*	*
Psychodidae sp.4	-	-	-	-	-	-	-	-	-	-	-	-	-	*
imuliidae														
Simulium S6	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix II cont.

	POM	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCP	YOM	YSO1	YSO2M
Tipulidae														
Hexatoma sp.	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Pseudolimnophila sp.	-	-	*	-	*	*	*	-	*	-	-	-	*	*
Limonia sp.	-	*	-	-	-	*	-	-	-	-	-	-	-	-
Tipula (Tipula)	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Tipula (Tipulodina)	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Tipula (Angarotipula)	-	-	-	-	-	-	*	-	-	-	-	-	-	-
Tipula U1	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Tipula U2	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Tipulidae U1	-	-	*	-	*	*	*	-	*	-	-	*	*	*
Tipulidae U2	-	-	-	-	*	-	*	-	*	-	-	-	-	-
Tipulidae U3	-	-	-	-	-	-	*	-	*	-	-	-	-	*
Tipulidae U4	-	-	-	-	-	-	-	-	-	-	-	-	*	-
Tipulidae U5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unid. diptera	-	-	-	-	-	-	-	-	-	-	-	-	*	*

Appendix III **Family and Order lists for each wetland site. Abbreviations as in Table 1. (*)=presence; (-)=absence**

	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM	POM
Tricladida														
Dugesiidae	-	-	-	-	-	-	*	-	-	-	-	-	-	-
Oligochaeta	-	-	-	-	-	*	*	*	*	*	*	*	*	-
Hirudinea														
Glossosophonidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Erpobdellidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hirudinidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pelecypoda														
Sphaeriidae	-	-	-	-	-	-	-	-	-	*	-	-	-	*
Gastropoda														
Ancyclidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lymnaeidae	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Planorbidae	-	-	*	-	*	-	*	-	*	*	-	*	*	*
Stenothyridae	-	-	*	-	-	-	-	-	-	*	-	-	-	-
Thiaridae	-	-	*	-	-	-	-	-	*	*	-	-	-	*
Ostracoda	-	-	-	-	-	*	*	-	-	-	-	-	-	-
Isopoda	-	-	*	-	-	-	*	-	-	-	*	*	*	-
Decapoda														
Atyidae	-	*	-	-	*	-	-	-	*	*	-	-	-	-
Palaemonidae	-	*	-	-	-	-	-	-	*	-	-	-	-	-
Grapsidae	-	-	-	-	-	-	-	-	-	*	-	-	-	*
Parathelphusidae	-	-	*	-	-	-	-	-	-	*	-	-	-	-
Sesarmidae	-	-	*	-	-	-	-	-	-	-	*	-	-	-
Ephemeroptera														
Baetidae	*	-	-	-	*	-	*	-	*	*	*	-	*	-
Heptageniidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenidae	*	-	-	-	-	-	-	-	-	*	-	-	-	-
Leptophlebiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Odonata														
Coenagrionidae	*	*	*	-	*	*	-	-	*	*	*	-	*	*
Platycnemididae	*	*	-	*	-	-	-	-	-	-	-	-	-	-
Unid. zygoptera	-	*	-	-	-	-	-	-	-	-	-	-	-	-
Aeshnidae	*	-	-	-	-	-	-	-	*	-	-	-	-	-
Gomphidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Libellulidae	*	-	*	-	*	*	*	-	*	*	*	-	-	*
Macromiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corduliidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hemiptera														
Hydrometridae	-	-	*	-	-	-	-	-	-	*	-	-	-	-
Veliidae	*	-	-	-	-	-	*	-	-	*	-	-	-	-
Gerridae	*	-	-	-	-	-	-	-	-	-	*	-	*	-
Belostomatidae	*	-	-	-	-	-	-	-	-	*	-	-	-	*
Nepidae	*	-	-	-	-	-	-	-	-	*	-	-	-	-
Helotrephidae	-	-	-	-	-	-	*	-	-	-	-	-	*	-
Naucoridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mesoveliidae	*	-	*	-	-	*	*	-	-	-	*	-	-	-
Hebridae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Corixidae	*	-	-	-	*	*	*	-	-	*	-	-	-	-
Notonectidae	*	*	-	-	-	-	-	-	-	-	-	-	-	-
Lepidoptera														
Pyralidae	*	-	*	-	-	-	-	-	-	*	*	-	*	-
Trichoptera														
Hydroptilidae	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Polycentropodidae	-	-	-	-	*	-	-	-	-	-	-	-	-	-
Lepidostomatidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix III cont.

	CSP	HSMP	KPM	KSCP	LIP	LIM	LUM	LPM	LTTP	LKM	LTM	MTLM	PLM	POM
Calamoceratidae	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Beraeidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Coleoptera larvae														
Dytiscidae	*	-	*	-	*	-	-	-	-	*	*	-	*	*
Hydrophilidae	-	-	*	-	-	-	-	-	-	*	*	-	-	-
Hydraenidae	*	-	*	-	-	-	-	-	-	-	*	-	*	-
Psephenidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Helodidae	-	-	*	-	-	*	*	*	-	*	*	-	*	*
Elmidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampyridae	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Ptilodactylidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noteridae	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Coleoptera adult														
Gyrinidae	*	-	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae	*	-	*	-	-	*	-	*	-	*	*	-	*	*
Hydrophilidae	*	-	*	-	-	-	*	-	-	*	*	-	*	*
Elmidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Noteridae	*	-	-	-	-	-	-	-	-	*	-	-	*	-
Limnichidae	-	-	*	-	-	-	-	-	-	-	*	-	*	-
Diptera														
Anthomyiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephydridae	*	-	-	-	-	*	*	-	-	*	-	*	-	*
Phoridae	-	-	*	-	-	-	-	-	-	-	*	-	-	-
Sciomyzidae	-	-	-	-	-	-	-	-	-	*	-	-	-	-
Syrphidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dolichopodidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Empididae	-	-	-	-	-	-	-	-	-	-	*	-	-	-
Stratiomyidae	-	-	-	-	-	-	-	-	-	-	-	-	*	-
Tabanidae	-	-	*	-	-	-	-	-	-	*	-	-	-	-
Ceratopogonidae	*	-	*	-	*	-	-	-	-	*	*	-	*	*
Chironomidae	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Corethrellidae	-	-	-	-	-	-	-	*	-	-	*	-	-	-
Culicidae	*	-	*	-	-	*	*	-	-	*	*	-	*	*
Psychodidae	-	-	-	-	-	-	*	*	-	-	-	*	-	*
Simuliidae	-	-	-	-	-	*	-	-	-	-	-	-	-	-
Tipulidae	-	-	*	-	-	-	-	*	-	*	-	*	-	-
Unid. diptera	-	-	*	-	-	*	*	-	-	-	-	-	-	-

Appendix III cont.

	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCPM	YOM	YSO1M	YSO2M
Tricladida													
Dugesiidae	*	-	-	-	-	-	-	-	-	-	-	*	*
Oligochaeta	-	-	-	-	-	*	-	-	-	-	*	*	*
Hirudinea													
Glossosophonidae	*	-	-	-	-	-	-	-	-	-	-	-	-
Erpobdellidae	*	-	-	-	-	-	-	-	-	-	*	-	-
Hirudinidae	*	-	-	-	-	-	-	-	-	-	-	-	-
Pelecypoda													
Sphaeriidae	*	*	*	-	-	-	-	-	*	*	-	-	*
Gastropoda													
Ancyclidae	-	*	-	-	-	-	-	-	-	-	*	-	-
Hydrobiidae	-	-	-	-	-	-	-	-	-	-	-	-	*
Lymnaeidae	-	*	-	-	-	-	*	-	-	-	-	-	-
Planorbidae	*	*	*	*	*	-	*	*	-	-	*	*	*
Stenothyridae	*	*	-	*	*	-	-	*	-	-	*	-	-
Thiaridae	-	*	-	-	*	-	*	-	-	-	-	-	*
Ostracoda	-	-	-	-	-	*	-	-	-	-	-	-	*
sopoda	*	-	-	*	-	*	-	-	-	-	*	*	*
Decapoda													
Atyidae	-	*	*	-	*	-	*	-	*	*	-	-	*
alaemonidae	-	*	-	-	-	-	*	-	-	-	-	-	-
rapsidae	*	*	-	-	-	-	-	-	-	-	-	-	-
Parathelphusidae	-	-	-	*	-	*	-	*	-	-	-	-	-
esarmidae	-	-	-	-	-	-	-	-	-	-	*	-	-
phemeroptera													
Baetidae	*	*	*	-	-	-	-	-	*	-	*	-	*
Heptageniidae	-	-	-	-	-	-	-	-	*	-	-	-	-
aenidae	-	*	*	-	-	-	-	*	-	-	-	-	*
Leptophlebiidae	-	-	*	-	-	*	-	-	-	-	-	-	*
Odonata													
oenagrionidae	*	*	*	*	*	*	-	*	-	-	*	-	*
latycnemididae	-	-	-	-	-	-	-	-	-	-	-	-	-
Unid. zygoptera	-	-	-	-	-	-	-	-	-	-	-	-	-
eshnidae	-	-	*	-	-	-	-	-	*	-	-	-	-
omphidae	-	-	*	-	-	-	-	-	-	*	-	-	-
Libellulidae	*	*	*	*	*	*	-	*	-	-	*	*	*
Macromiidae	-	-	*	-	-	-	-	-	-	-	-	-	-
orduliidae	-	-	*	-	-	-	-	-	-	-	-	-	-
Hemiptera													
Hydrometridae	-	-	*	*	-	-	-	*	-	-	*	-	-
eliidae	-	-	-	*	-	*	-	-	-	-	-	-	-
erridae	-	*	-	-	*	-	-	-	-	-	-	-	-
Belostomatidae	-	-	*	-	-	-	-	-	-	-	-	-	-
Nepidae	-	-	-	-	-	-	-	-	-	-	-	*	-
elotrephidae	-	-	-	-	-	-	-	-	*	-	-	-	-
Naucoridae	-	-	*	*	-	-	-	-	-	-	*	*	*
Mesoveliidae	-	*	*	*	*	*	-	*	-	-	-	-	-
ebridae	-	-	-	-	-	-	-	-	-	-	-	-	-
orixidae	*	*	-	-	*	-	-	-	-	*	-	-	-
Notonectidae	-	-	-	-	-	-	-	-	*	-	-	-	-
epidoptera													
yralidae	-	-	-	*	-	-	-	-	-	-	-	-	-
Trichoptera													
Hydroptilidae	-	*	*	-	-	-	*	*	*	-	-	-	-
olycentropodidae	-	-	-	-	-	-	-	-	-	-	-	-	-
Lepidostomatidae	-	-	-	-	-	-	-	-	-	-	-	*	*

Appendix III cont.

	POT	SATM	SCM	SWM	STM	SLTM	SLTP	SMTM	SPP	TLCPM	YOM	YSO1M	YSO2M
Calamoceratidae	-	-	-	-	-	-	-	-	*	-	-	-	-
Beraeidae	-	-	-	-	-	-	-	-	-	-	*	-	-
Coleoptera larvae													
Dytiscidae	*	*	-	-	*	*	-	-	-	-	*	-	-
Hydrophilidae	*	*	-	-	*	-	-	-	-	-	*	*	*
Hydraenidae	-	-	-	*	-	-	-	-	-	-	-	-	*
Psephenidae	-	-	-	*	-	-	-	-	-	-	*	-	-
Helodidae	*	*	*	*	*	*	-	*	-	-	*	*	*
Elmidae	-	-	-	-	-	-	-	-	-	-	-	-	-
Lampyridae	-	-	-	*	-	-	-	-	-	-	-	-	-
Ptilodactylidae	-	-	-	-	-	-	-	*	-	-	-	-	-
Noteridae	-	*	-	-	*	*	-	-	-	-	-	-	-
Coleoptera adult													
Gyrinidae	-	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae	*	*	*	-	*	*	-	*	*	-	*	*	-
Hydrophilidae	*	*	-	*	-	*	-	*	-	-	*	-	*
Elmidae	-	*	-	-	-	-	-	-	-	-	-	-	*
Noteridae	-	-	-	*	-	-	-	-	-	-	-	*	*
Limnichidae	-	-	-	-	-	*	-	-	-	-	-	-	-
Diptera													
Anthomyiidae	-	-	-	-	-	-	-	-	-	-	-	*	*
Ephydridae	*	-	-	*	*	-	-	-	-	-	*	*	*
Phoridae	-	-	*	*	-	*	-	-	-	-	-	*	-
Sciomyzidae	-	-	-	-	-	-	-	-	-	-	-	-	-
Syrphidae	*	-	-	-	-	-	-	-	-	-	-	*	*
Dolichopodidae	-	-	-	-	-	-	-	*	-	-	-	-	*
Empididae	-	-	-	*	-	*	-	-	-	-	-	*	-
Stratiomyidae	-	-	-	-	-	-	-	-	-	-	-	-	*
Tabanidae	-	*	-	-	*	-	-	*	-	-	-	-	-
Ceratopogonidae	*	*	*	*	*	*	-	*	-	-	-	*	*
Chironomidae	*	*	*	*	*	*	*	*	*	*	*	*	*
Corethrellidae	-	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae	*	*	*	-	*	-	-	*	-	-	-	*	*
Psychodidae	*	*	-	*	*	*	-	-	-	-	*	*	*
Simuliidae	-	-	-	-	-	-	-	-	-	-	-	-	-
Tipulidae	*	*	-	*	*	*	-	*	-	*	*	*	*
Unid. diptera	-	-	-	-	-	-	-	-	-	-	-	*	*