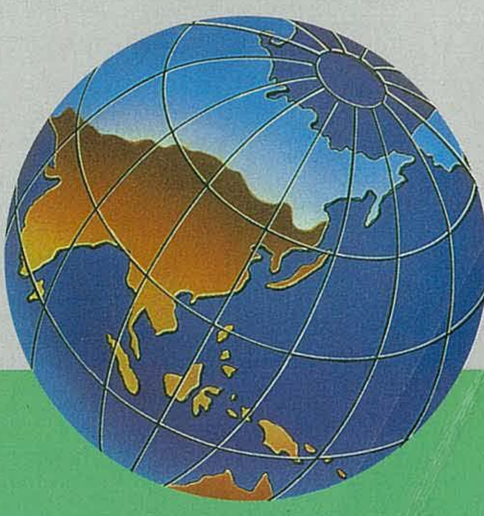
Kau Sai Chau Development

Environmental Impact Assessment

Final Report



AXIS Environmental

The Royal Hong Kong Jockey Club
英皇御准香港賽馬會

Kau Sai Chau Development

Environmental Impact Assessment

Final Report

April 1994

AXIS Environmental

AXIS Environmental Consultants Ltd

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INTRODUCTION

SECTION 1

1.0 INTRODUCTION

1.1 Overview

1.1.1 Background

The Hong Kong Government proposes to develop the northern part of Kau Sai Chau for a public golf course. Photographic plate 1.1 gives an aerial view of the Project area and surrounding features. The course would be developed and project managed by the Royal Hong Kong Jockey Club (RHKJC). The proposed development is subject to an environmental impact assessment (EIA) to determine the environmental acceptability of the Project.

The Environmental Protection Department (EPD) proposed that the Project be subject to a two stage process of EIA. Stage 1 of the EIA was submitted to EPD in October 1993, and Stage 2 was submitted in January 1994. EPD have convened Environmental Study Management Group (ESMG) meetings on 20 October 1993 and 24 February 1994. Representatives of all relevant government departments attended.

Key issues identified during the October ESMG meeting were:

1. Treatment and/or re-use of liquid waste generated by the project;
2. Assessment of impacts from the transport and traffic systems;
3. Potential loss of mangrove habitat due to construction of an irrigation reservoir;
4. Archaeological artifacts in proposed disturbance areas.

After the October 1993 ESMG meeting the issue of potential construction and operation impacts to nearby mariculture sites was raised by local fishermen's groups. Consequently, these topics were added to the above list of key issues.

Each of these issues were addressed in detail in Stage 2 of the EIA. Comments were then made by Governments and these were responded to by the Consultants. At the second ESMG the Stage 2 EIA was endorsed, and in principle approval was given for the project.

The Consultants undertook to incorporate responses into the Final EIA. This Final EIA thus represents the overall environmental impact assessment for the Kau Sai Chau project, incorporating responses to Government comments.

In addition to the EIA, AXIS Environmental Consultants Limited (AXIS) will produce a handbook on general golf course design, construction, and management procedures for Hong Kong. This is expected to be submitted to EPD in April 1994. The handbook will be independent of the proposed Kau Sai Chau golf course project, but many of the design, implementation, and assessment methods used at Kau Sai Chau may be incorporated into the handbook.

The golf course development is described in detail in Section 2. The development comprises a 36 hole golfing facility with club house, driving range and practice facilities including a golf instruction academy. The location of the development is shown in Figure 1.1, and the golf facilities and access plan are shown in Figure 1.2. The final Master Plan for the golf courses is presented in the pocket at the end of this report.

1.1.2 Environmental Design and Assessment

The environmental quality of the development has been ensured through the early consideration of environmental issues in the design of the Project. Involvement in the design process is an essential part of the environmental assessment, since it is through sensitive environmental design that the environmental impacts are most successfully mitigated.

Whereas the overall concept of the development and its feasibility have been documented in the consultant's feasibility, interim and Phase 1 reports to RHKJC, the detailed designs for many of the engineering aspects have yet to be finalised. The results of the EIA process have been fed back into the design process as part of an iterative design/assessment/redesign process.

A pro-active approach to the assessment has been adopted whereby environmental design criteria were established at the outset of the Project in order to ensure an environmentally led form of development. This ensured that environmental problems were designed out of the Project through the master plan and not simply regarded as residual impacts to be mitigated by as additional measures following completion of the plan.

This Final EIA summarises the work carried out to date on the identification and mitigation of environmental impacts, and details the key environmental issues and mitigation proposals. It also describes the environmental monitoring requirements necessary to ensure the effectiveness of the adopted environmental protection measures.

1.2 Existing Environment

1.2.1 Site Context and Description

Kau Sai Chau is the fifth largest island in Hong Kong and the largest island off the eastern coast of the New Territories. Located in the centre of Port

Shelter, the island forms a central feature with its mountain peaks rising to over 200m.

The indented coastline of the island reflects a series of deep gullies which dissect the landmass and some of which culminate in small waterfalls at the water's edge. These moist gullies are well vegetated with areas of diverse scrub/woodland. Elsewhere, however, Kau Sai Chau's vegetative cover is principally grass and low scrub. Natural regeneration has been limited by two agents. First, numerous grave sites on the northeast headland of the island have probably been the source of frequent wild fires which have precluded establishment of shrubs and trees.

Second, massive erosion caused by use of the island by various armed forces as an artillery range has created a "moonscape" over a large area of the island where vegetation has not established and soil erosion is severe. There are, however, extensive areas of mangrove and diverse high scrub/low canopy woodland along the water edge slopes. Photographic Plate 1.2 gives an aerial view of the western/ central area of Kau Sai Chau, showing eroded slopes and mixed vegetation typical of the island.

Topographically the landform divides the island into two distinct areas. The northern half is comparatively low with a maximum elevation of 72m. It has an undulating series of ridges, and valleys forming two principal dendritic drainage systems flowing outward from the north and east coasts. The southern half rises steeply from the coast line to culminate in three peaks at an elevation of up to 216m. Large areas of outwash erosion remain on the mid level flanks of these hillslopes as a result of shell fire. These areas show little evidence of natural revegetation and stabilisation since shelling ceased in 1975.

As a consequence of the island's undeveloped character its appearance contributes significantly to the natural visual amenity value of Port Shelter. Together with the Sai Kung Country Park and a plethora of smaller islands, Kau Sai Chau forms a key component of the Port Shelter archipelago and contributes to its function as the primary coastal recreational resource for Hong Kong.

Immediately west of Kau Sai Chau lies Kiu Tsui Chau (Sharp Island) which is the site of Kiu Tsui Chau Country Park. Kau Sai Chau is zoned as a Conservation Area (CA). The CA zoning is meant to include prominent ridgelines, peaks and woodlands currently excluded from Country Parks. The purpose of the zoning is to preserve the natural landscape, environment and character of the designated area.

1.2.2 Current Land Use

Kau Sai Chau is the largest island in the Port Shelter area of eastern Hong Kong. It is undeveloped, and almost completely uninhabited. Apart from the settlement at Kau Sai on the southern tip of the island, the nearest permanent development is a Hong Kong Girl Guides camp (Louisa Lansdale Camp) on Yim Tin Tsai Island to the northeast of Kau Sai Chau. There are several privately owned plots which are abandoned farms. These are located in a major drainage catchment area on the east-central portion of the island. Overhead electric power lines cross the island from Yim Tin Tsai to Kau Sai.

In recent years the island has been used as an artillery range (1936 through 1975), a small-scale agricultural site (dates unknown, currently abandoned), a permanent settlement (Kau Sai), and a recreation site. The artillery practice range appears from visible erosion scars to have been located primarily on the west-central portion of the island, but extending across the island to the southeast shore as well. Because of the risk of unexploded ordnance on the island, there are currently signposts advising visitors of the danger and warning them to remain off the island.

The agricultural plots which can be located lie in a drainage on the eastern side of the island running from south to north. There are few plots (less than 10 total) which appear to have been used for paddy farming. These are all currently abandoned, but some plots remain in private ownership. Except for these few small abandoned farm plots, there is no evidence of agriculture on the island.

A low breakwater has been constructed across the large Kwat Tau Tam inlet at the north end of the island which was apparently used to aid in trapping fish in the channel at high tides. However, the permanent settlement at Kau Sai is a fishing village near a mariculture site off the south shore of the island. The population of Kau Sai is unknown. It appears that the village economy is based on commercial fishing and mariculture.

Recreation on and near the island is based on hiking, orienteering, and water sports. Kau Sai Chau is a popular mooring site for pleasure boats on weekends during most of the year.

1.2.3 Historic and Cultural Resources

There is evidence of Bronze Age settlement of the island which indicates that Kau Sai Chau has been subjected to a number of land uses beginning with what may have been the earliest human occupants some 3000 years ago. Archaeological evidence indicates that there were settlements on Kau Sai Chau near the mouths of the larger drainages and at the upper end of Kwat Tau Tam inlet. Archaeological surveys underway at the time of this writing may reveal information about the nature of the settlements.

Historic rock carvings can be seen on a prominent peninsula on the northwest side of the island. The rock carving site is identified on Hong

Kong geographic maps. The rock carving is a declared monument (Antiquities and Monuments Office). There are also 3 sites on the island which have been reported by the Antiquities and Monuments Office to have yielded late Neolithic stone artifacts on past archaeological surveys. Due to their archaeological and historical significance a survey is now underway to identify and rescue all important artifacts. Archaeology is discussed in Section 7.

1.3 Key Environmental Issues

1.3.1 Potential Impacts

The issues of major concern are:

a) water supply, irrigation , drainage, and infrastructure development;

b) the impact of the development on water quality of the freshwater habitats and marine environment, with particular reference to sewage disposal and the use of chemicals on the golf course;

c) the potential impact of the development on the ecology of Kau Sai Chau and the adjacent marine area;

d) general concerns to mitigate the loss of mangrove areas by re-establishing mangroves elsewhere on the island;

e) development design in order to integrate within the landscape context;

f) avoiding interference with archaeological sites;

g) the impact of construction works on the local environment;

h) the impact of the development on transport.

1.3.2 Potential Benefits

In addition to these potential environmental constraints the development provides a positive opportunity for:

a) repairing the gross damage done to the areas used for target practice by the military;

b) erosion control of wash out of surface damaged areas;

c) provision of the first public golf facility in Hong Kong;

d) provision of good access to a hitherto relatively inaccessible island;

e) using the Project as a model to demonstrate and set the standard for other similar developments in Hong Kong.

The integration of environmental issues with inputs from engineers and golf course designers has allowed a number of planning and design constraints to be overcome through innovative design and implementation measures.

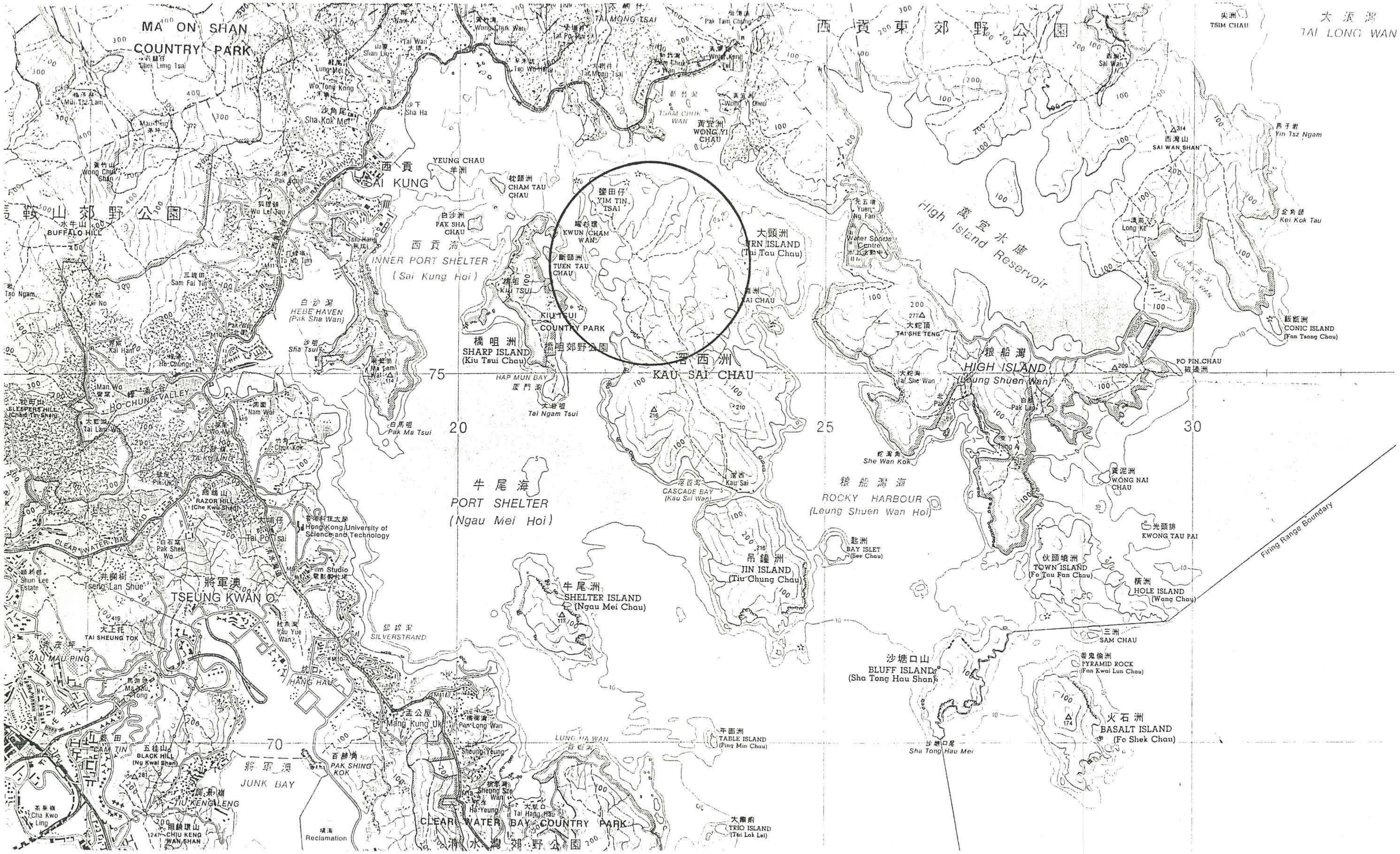
As noted in Section 1.2.1, the area around Kau Sai Chau is of rural character, much of which is designated Conservation Area (CA). The scale and intensity of the Project is considered to be compatible with the rural character of the surrounding areas which CA zoning seeks to preserve.

1.4 Final EIA Report Structure

The key issues identified above provided the focus for developing the framework of the Final Environmental Impact Assessment which is structured into the following specialist subject areas:-

- Project Description
- Water Management and Quality
- Landscape and Visual Impact Assessment
- Ecology
- Golf Course Turfgrass Management Plan
- Recreation and Culture
- Transport and Infrastructure
- Environmental Monitoring and Audit

These topics form the main sections of the assessment and are dealt with in separate chapters. Mitigation measures are proposed to overcome specific environmental impacts with respect to each subject area.



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Kau Sai Chau Project

Figure 1.1: Site Location Plan

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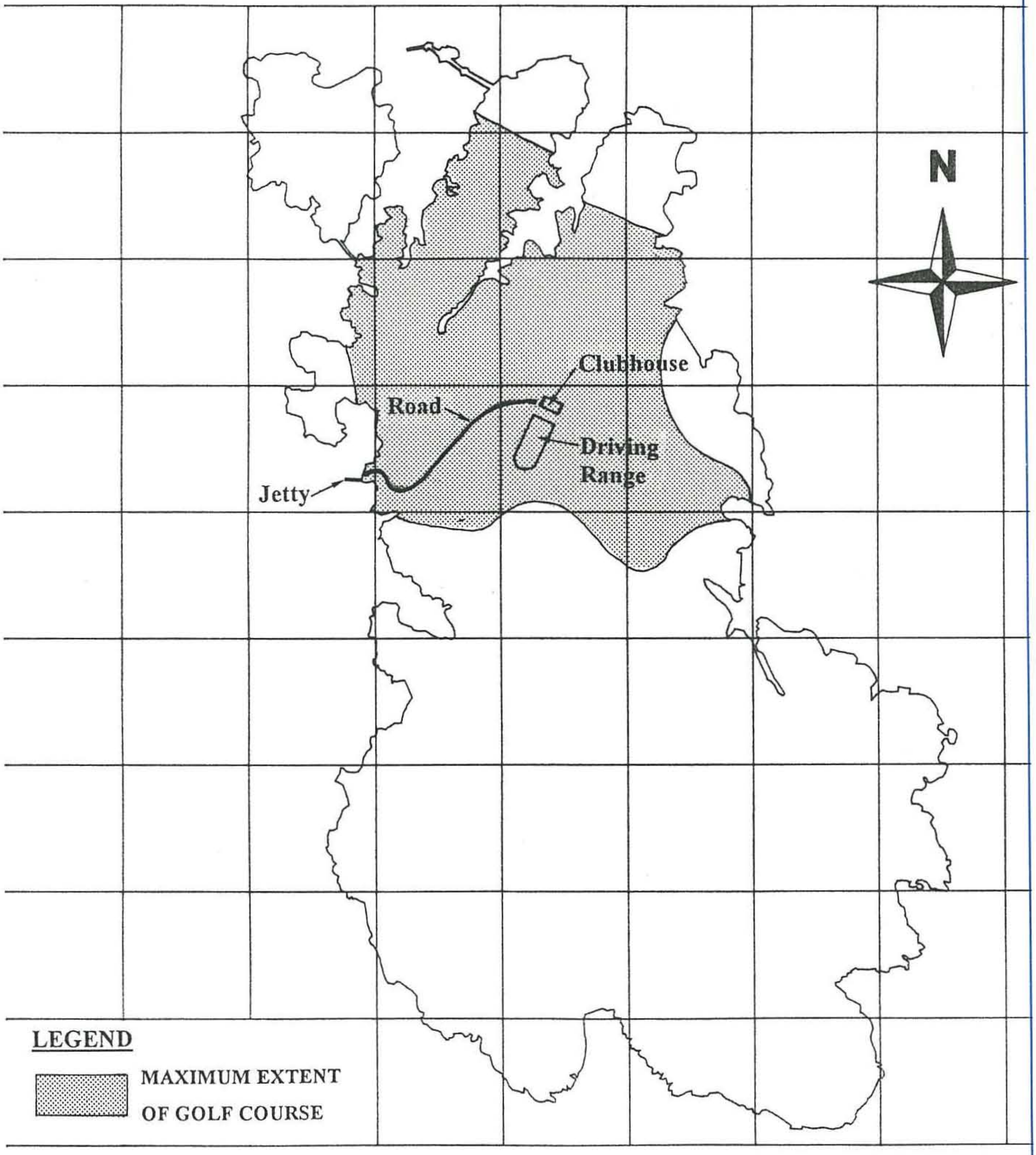

AXIS Environmental

Kau Sai Chau Project

Figure 1.2 Golf Facilities and Access Plan

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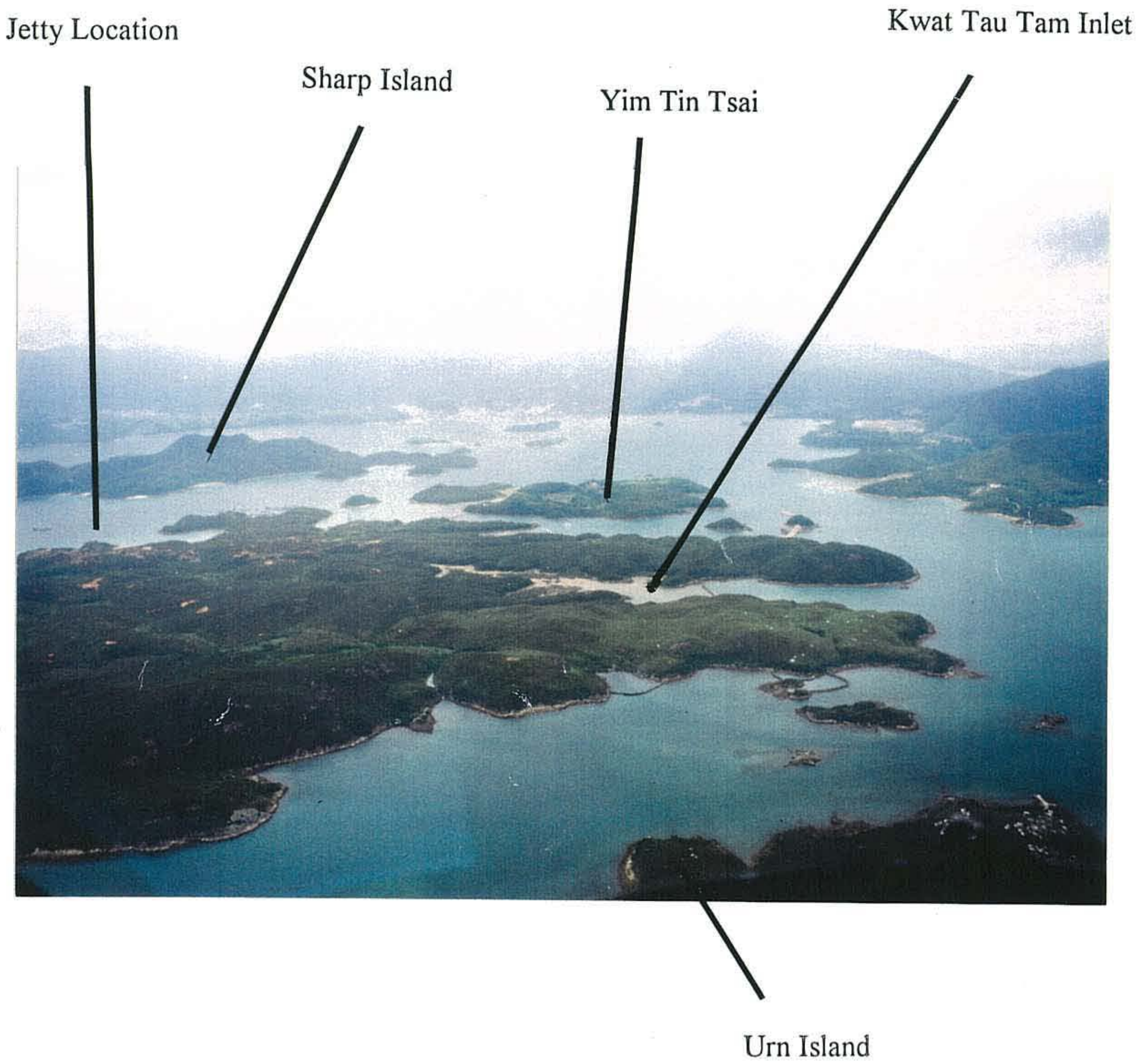


Plate 1.1 General project area on northern Kau Sai Chau (photo taken from above Urn Island).

Plate 1.2 Aerial photo of west-central Kau Sai Chau.

PROJECT DESCRIPTION

SECTION 2

2. PROJECT DESCRIPTION

2.1 Project Overview

This Section provides a general overview of the proposed golf course development, followed by a detailed description of the major components of the Project. A summary of the Scheme is presented in the Preliminary Master Plan (PMP), which is shown in Figure 2.1. The final Master Plan is presented in a pocket at the end of the report.

An area approximating 158 ha in size located towards the northern end of Kau Sai Chau Island will provide the basis for the development. The central feature is a 36 hole public golf course (two 18 hole facilities), served by small but fully equipped club facilities. In addition there will be a practice range for driving, chipping, and putting.

The area designated for the golf course is the northern, low lying half of the island. Excluded from the development area are four steeply sloping and well vegetated headlands, the steep slopes near the shoreline, and the adjoining island of Yim Tin Tsai.

The course has been carefully designed to minimise disturbance of the landform and to retain the natural topography of the site to the extent possible. A key design criterion was to balance cut and fill volumes, in order to minimise earthworks and the need to import soil.

The majority of the two proposed 18 hole golf courses will be obscured from immediate sea level views by the steeply rising slopes at the shoreline. The central location of the proposed club house and practice area, at an elevation of 40m, will similarly be obscured from close external sea level views by its inland location.

A third major component of the proposed development comprises the damming of the Kwat Tau Tam inlet to provide the freshwater storage for both the golf course irrigation and potable supply. The dam design requires raising of the internal, stored freshwater level to 12mPD, in order to provide a freshwater storage of adequate capacity.

Four potential pier sites were identified in the Feasibility Study: three within the Sam Nga Hau typhoon shelter and one on the western coastline. As an alternative the feasibility of constructing a vehicular bridge from the headland to the west of Kwat Tau Tam to the mainland was also considered, but subsequently rejected on a number of environmental grounds.

The main components and aspects of interest of the development are detailed under the following headings:

- Golf Course and Clubhouse Facilities
- Water supply system/irrigation
- Ferry pier and access
- Infrastructure and power supply
- Construction requirements
- Key issues during construction
- Key issues during operation
- Clearance of ordnance
- Course safety.

At full capacity it is estimated that some 640 golfers/day could be accommodated at the facility. Additional golfers could also be accommodated in golfing schools or on the driving range. The detailed estimates of golf players and visitors, caddies and staff indicate that the maximum daily population would be about 1440. The detailed basis of this estimate is given in Appendix 2. It should be noted that the operational use of the facility is currently under study and these preliminary estimates may be adjusted.

2.2 Golf Course and Clubhouse Facilities

2.2.1 Golf Course

The layout of the golf course is shown in the PMP prepared by the Gary Player Design Company (Figure 2.1). The total area occupied by the golf course, practice range, and associated buildings will be of the order of 158 ha, with clubhouse facilities and driving range located centrally. Dimensions of the course are:

- North golf course - 6000m in length, par 72
- South golf course - 5400m in length, par 70
- practice range - 320m x 150m.

Powered golf carts will not be used on the courses, therefore there will be no requirement for hard-surfaced cart paths.

The golf courses will be constructed to a standard that will allow championship play, and it is anticipated that international tournaments will be held occasionally on the site. The longer course is intended to be more challenging, and suited for experienced golfers. The shorter course may be adaptable to tournament play by tee placement, but will be more suited to inexperienced golfers than the longer course.

2.2.2 *Club House*

The clubhouse comprises a single building which will house changing and locker rooms, a pro shop, a restaurant and administrative offices. It will be situated on a low rise near the centre of the golf course which overlooks the northern half of the island and much of Port Shelter. The design, layout, and construction materials of the clubhouse have been selected to be minimally intrusive within the landscape and visual context of Kau Sai Chau.

The building would have two storeys and would be of traditional Oriental character, but be modern in design. It is proposed that rock walls and natural tone walls and roof would be used extensively to be sympathetic with the Kau Sai Chau land form. The clubhouse would be built into rising ground, with the upper floor leading directly to near the 10th tee and would be minimally intrusive in the landscape.

Landscape plantings would be used around the club house to moderate the scale of the development and reduce the visual impact of the building. In keeping with the natural vegetation, which is primarily low scrub land of 0.5-1.5m and grassland (Section 5.4), shrubs of 0.5-1.5m which occur on Kau Sai Chau would be used for landscaping.

Figure 2.2(a) is a plan of the clubhouse at level 40.0 mPD. Figures 2.2(b) and 2.2(c) show elevations of the current club house design. The ground floor would include changing rooms and progolf shop, and kitchen and staff canteen. The upper floor would include a restaurant, bar, golf academy rooms, and administration offices.

2.2.3 *Maintenance Facility*

A maintenance workshop and grounds administration office will be constructed comprising garage facilities for vehicles material and equipment stores, and a water treatment plant. This building would be a simple structure designed to complement the general style of the club house described in Section 2.2.2.

The maintenance facility would include a bunded chemicals store, and a bunded chemicals preparation area.

2.2.4 *Residential Accommodation (Staff)*

Residential accommodation will be provided for a small number of resident staff, such as the golf course manager and superintendent as well as the maintenance superintendent and several maintenance staff. It is expected that about five family apartments of 2 and 3 bedrooms would be provided for permanent resident staff and their families. This accommodation would be included within the clubhouse building.

In addition single share dormitory accommodation would be provided for about 30 roster staff, including club house and grounds staff. A staff canteen would also be provided for these roster staff, and other day staff.

The residential buildings would be designed to complement the general style of the club house described in Section 2.2.2.

2.2.5 Access Road

A roadway of approximately 0.8km in length will be constructed from the jetty location to the clubhouse. Because there will be no internal traffic on the island except golf course maintenance equipment and shuttle buses, there will be no hard surfaced roads other than the access road. The route from the jetty to the clubhouse will be served by several vans which will be equipped to carry passengers and their golf equipment.

To minimise maintenance it is proposed that the roadway would be constructed of concrete.

2.2.6 Interconnecting Footpaths

The interconnecting footpaths between the fairways and around the development would be kept as natural as possible. Gravel paths of 1.0 metre width would be used in high traffic areas, or areas that begin to show deterioration. Because of the steel spikes used on golf shoes, it is impractical to use timber, hard surfacing or paving bricks/for footpaths.

Where footbridges are required, these would be built of stone, timber or steel framework with suitable timber finish. Rubber matting would be used over timber or steel decking, to accommodate golfers with golf shoes.

2.3 Access to Kau Sai Chau

2.3.1 Ferry Access

Access needs for the Project have been studied separately by MVA Asia Limited. There are a number of existing piers in Port Shelter that could be used for a ferry service, however all except those in close vicinity to Sai Kung have the problem of access to buses and taxis for the return trip.

The two principal options identified are Sai Kung pier, and a possible new pier at Tui Min Hoi near an alternative new car park site to service the golf course (refer Section 2.3.3).

A scheduled ferry service is proposed for public access to Kau Sai Chau from Sai Kung. The ferry would operate at about 15 minute intervals from

Sai Kung to the north west coast of Kau Sai Chau. The ferry route is shown in Figure 2.3.

If the Tui Min Hoi site were chosen for the car park, the ferry would either stop at the Sai Kung pier en route to Tui Hin Hoi, or separate ferries may be scheduled, depending upon demand.

2.3.2 Jetty

A jetty is proposed on the northwestern shoreline of Kau Sai Chau. The jetty will be some 60m in length, 3m wide and with a 20m long by 6m wide pier head facilitating berthing on both sides. The site is readily accessible without dredging and is close to the clubhouse and facilities. The structure will be supported by driven tubular steel or pre-stressed concrete piles.

The jetty has been designed to accommodate foot passengers as well as small vehicles for the landing of plant and stores and will be linked to the club house by a paved, two-lane road. The jetty would be equipped with lights. A shuttle bus service will operate between the pier and clubhouse.

The jetty has also been designed to be able to be used for the occasional landing of larger items of plant (such as commercial chillers and refrigerators) and tractors and minibuses. This will avoid the need for a permanent, dredged beach-head and access road elsewhere on the island for landing such occasional items.

2.3.3 Parking at Sai Kung

The adequacy of parking facilities at Sai Kung has been investigated. Golf course traffic and parking demand is typically relatively low due to the even spacing of traffic throughout the day. However, it is anticipated that additional parking facilities will be needed at Sai Kung.

Discussions are taking place between the RHKJC and Government on car parking requirements and potential sites in Sai Kung. Two principal options have been identified, one to the north-east of the Sai Kung pier, and another at Tin Min Hoi. Parking is discussed further in Section 8.3.

2.4 Water Supply System and Irrigation

2.4.1 Potable Water and Irrigation Demand

Potable water is required to serve the clubhouse, residential accommodation and other facilities. It is estimated that about 4,600m^3/month (55,200 m^3/a) is required to meet predicted demand.

Potable water will also be supplied by a pipe from the Project potable supply to the Tai Tau Chau mariculture site on the east side of Kau Sai Chau. This will replace the existing untreated, surface flow supply to Tai Tau Chau, which will be interrupted due to abstraction of irrigation water from the indirect catchment. The only other water supply system in the project area is an existing water pipeline on the west side of Kau Sai Chau, which serves the mariculture site at Kai Lung Wan. The catchment area for this supply would not be affected by the Project. The existing above ground pipeline will be buried, but no permanent interruption of water supply will be required.

The irrigation demand for the golf course is estimated to be of the order of 3.5mm per day (105mm/month) for fairways and general practice areas, and 7mm per day (210mm/month) for greens and tees. The total area to be irrigated is estimated to be 54 ha, which includes fairways, greens, and tees. The total irrigation water demand is estimated to be 305,000 m^3/a (Section 3.4.4).

The total potable water and irrigation demand is thus estimated to be approximately 360,000 m^3/a of the total demand, of which some 15% is for potable water supply.

2.4.2 *Water Supply System*

In order to provide sufficient fresh water for irrigation and potable use, it is proposed that a freshwater reservoir (capacity 420,000 m^3 active storage and 150,000m^3 dead storage capacity) be constructed at the northern end of the island by creating a dam across the Kwat Tau Tam inlet.

The various options for water supply to Kau Sai Chau were considered in detail in the preliminary engineering investigations. These options included mains water supply, desalination and various reservoir possibilities. The discussion and evaluation of these options is presented in Section 3.4.1.

The selected Kwat Tau Tam site for the reservoir is a steep sided narrow estuary. The direct catchment draining into the estuary basin at this location is currently of the order of 600m wide by some 1300m long totaling an approximate area of 0.74 km^2 (74 ha). The maximum elevation is approximately 120m at the southern extremity of the area, and there is a single main stream draining to the estuary along a relatively deep, narrow valley.

The refilling capability of this direct catchment has been shown to be insufficient to replenish storage deficiency for the design period of the reservoir. Consequently the stream draining to the east of the direct reservoir catchment area will be developed as an indirect catchment (comprising 52 ha) to be diverted to the reservoir by use of an aqueduct.

The reservoir dam will be located upstream of the existing ruined dam structure. Conceptual designs for the dam and reservoir have been developed, and include earthfill and rockfill embankments. The crest elevation of the dam would be 14mPD, and the maximum water level would be 12mPD. The dam will be about 140m long.

Draw off and overflow works will be directed through the left abutment to facilitate construction of the dam. The draw off tower will comprise a "wet tower" with two inlets from the reservoir. Potable water will be extracted from the reservoir and pumped to storage tanks near the clubhouse at the southern end of the golf course and gravity fed to the treatment plant. A package treatment plant would be used for potable water treatment.

The treatment plant would be designed to meet Water Supply Department standards for potable water in Hong Kong. Where necessary appropriate water treatment facilities such as activated carbon filtration or ion exchange would be used for final purification and removal of chemicals.

2.5 Other Infrastructure

2.5.1 Sewage Treatment Works

The sewage treatment works will be installed underground as far as practicable. Several options are available for sewage treatment, and these are discussed in Section 3.5.3. It is proposed that a package treatment plant would be used.

2.5.2 Drainage System

Existing Site Drainage

The catchment areas (direct and indirect) are currently drained by natural stream courses, discharging ultimately into the waters of Port Shelter. Some of the area is fairly steep and many of the existing stream courses are liable to erosion. Due to use of the site as a practice range for bombing and shelling from 1936 through 1975 by Hong Kong military and police, and by occupation forces during WWII, some areas of the island are badly eroded. The resulting silt load into Port Shelter is visible following storms on the island, and during the summer rainy season in general.

The primary catchment covers approximately 74 ha in the central and western parts of the island and currently drains to the proposed reservoir area and then to the sea. There are several tributary streams which drain the main catchment area and feed the Kwat Tau Tam inlet.

The secondary catchment of 52 ha drains the eastern portion of the Project area, and drains directly to the sea along the eastern shore of the island. This catchment is drained by a single stream which flows from the upland, east-central portion of the island to the sea off the east coast. Figure 2.4 shows a plan of the proposed catchments in relation to the preliminary golf hole locations.

Project Stormwater Drainage

Existing stream courses will be maintained where possible by incorporation into the topography of the golf courses. These streams will serve to direct surface flow to the reservoir. The site will require some regrading to replace the existing steep-sided gullies with a gently undulating surface in the area of golf fairways. In some areas (the western portions of the site where bombing damage and resultant erosion is most severe) regrading of the steep gullies will reduce erosion, and facilitate revegetation of damaged sites. The storage capacity of the main reservoir shown on the PMP will be supplemented by other ponds and lakes which are described in Section 3.

Runoff from the clubhouse area and other built-up surfaces will be directed to the upper reservoir (adjacent hole 34) and integrated into the main golf irrigation system. The maintenance area runoff will be collected in a catch pit.

2.6 Power Supply

Kau Sai Chau is supplied with electric power by a China Light & Power submarine cable. This supply system will be evaluated with reference to projected power requirements of the development, and additional submarine cable(s) will be installed if needed.

2.7 Construction Requirements

2.7.1 Construction Activities and Programme

The key engineering works can be divided into civil and building works. The main construction activities will span approximately two years. The longest duration construction project will be the golf courses, which will require 15 months. Clubhouse and other building construction will require 13 months. The overall programme is shown in Figure 2.5.

The construction programme is projected to begin in May 1994 with temporary site formation works, and all facilities are planned to be completed prior to December 1995. Construction projects involving substantial earth moving (earthworks and drainage, access road, driving range, and golf courses) are scheduled to take place during the remaining autumn-winter dry seasons in 1993-1994 and in 1994-1995. This will reduce erosion and potential sedimentation during the construction period, but may increase potential for generation of dust.

Civil works will include the following construction projects:

- dam
- jetty
- earthworks and drainage
- access road
- clubhouse site formation
- practice driving range
- golf courses
- turf nursery (if required depending on turfgrass selection).

Building works will include construction of the clubhouse and associated maintenance buildings.

Construction of the dam and pier, drainage system, access road, golf courses, and clubhouse will begin on a staggered schedule beginning in month 8 of the construction period. All construction activities requiring substantial surface disturbance will be completed prior to the onset of the rainy season in year 2 of the Project. This will reduce risk of soil erosion from the site, and allow fairway grass seeding or planting before the heavy rains of the typhoon season.

The construction activities will require the formation of a temporary beach head to be used for delivery of construction materials. A site has yet to be determined, however it is proposed to be close to the jetty site. The beach-head will require some minor dredging, by use of a grab, and some site formation. The beach head would be rehabilitated after completion of construction works.

More detailed information on key aspects of the construction activities is provided below.

2.7.2 *Dam Construction*

The dam will be built over a nine month construction period. The dam structure may be formed from either earth fill or rock fill, won locally. In the case of rock fill embankment, an impermeable membrane would be required to be placed on either the upstream face or as a central core wall. The latter option is favoured as it could be founded on a concrete cut-off plug cast into the rock foundation. The dam wall foundation requires dredging of marine sediments to a base rock depth.

The depth of marine sediments at the dam site is about 11m. It is proposed that those sediments would be utilized to form a new area for mangrove replanting downstream of the dam site. This is discussed further in Sections 2.8.1 and 5.6.

The concrete case wall in the rockfill dam would be reinforced and be constructed in vertical panels with vertical joints incorporating water bars, with upstream and downstream transition zones to prevent damage during the placement of rockfill.

The dam would have an overflow culvert to handle water overflow during periods of heavy rain. Large rocks or gabions would be placed at the base of this culvert to break up the water flow and prevent erosion of the mangrove area at the base of the dam.

2.7.3 *Jetty Construction*

The jetty site selected on the west-central area of the island is near to the proposed clubhouse location. The jetty site offers relatively deep water and a sheltered location. Due to the water depth, dredging will not be required for the access and berth channel. The sheltered location will ensure safe operation of the ferry service and ease of berthing. The jetty will be built simultaneously with the dam.

Driven tubular sheet steel or pre-stressed concrete piles will be used for the structural support. Longitudinal beams would be pre-cast, pre-tensioned concrete or steel bridge girders. Three beams are proposed for the leading head and two for the jetty. Spacing would be approximately 2.5m. The deck will be formed by transverse pre-cast concrete planks with a slip resistant surfacing.

The concrete lower level landing and steps would be supported from the jetty piles on the inside and special outside support piles. The steps, landing and supporting beams will be cast in situ.

2.7.4 *Earthworks and Drainage*

Earthworks and drainage will be constructed between months 9 and 16 of the construction period. Drainage pipes will be installed between the indirect catchment and the reservoir (approximately 600mm concrete pipe), and beneath the areas of fill in the southwestern portions of the reservoir (one or two 1800mm concrete pipes).

Steel pipes will be installed for pumping water between the reservoir and the two 1000 m^3 water storage tanks near the clubhouse. All pipes will be installed using cut and cover methods except in the fill area in the southwest extent of the reservoir where pipes will be installed on fill.

2.7.5 *Access Road*

The access road from the pier to the clubhouse will measure approximately 800m in length, and will rise from the jetty elevation to about 50m elevation at the clubhouse. It will accommodate passenger shuttle buses and golf course maintenance equipment. There will be no other traffic on the access road, as there is no vehicular access to the island.

At the seaward end of the access road, a turning and temporary parking area for the shuttle bus is proposed to be formed partly by reclamation and partly by excavation into the steep shoreline. A turning area will be constructed at the clubhouse.

2.7.6 *Golf course*

The golf course will be constructed during months 10 to 24 of the Project. The total cut and fill requirements for the golf course construction are designed to balance and will be approximately 800,000m^3, due to reliance on existing topography for the finished landform of the golf course.

There is a requirement to bring in sand as cover for the formed fairways, to act as a good base for growing turf. The required depth of sand cover is about 15 cm. In total some 75,000 m^3 of sand is required, which would be brought in by barge.

Earthworks will be conducted during the dry season of 1994-1995. Planting, landscaping, construction of greens, tees, and bunkers will follow. It is anticipated that golf play will begin in late 1995.

It is expected that the fairways would be planted using hydroseeding. Greens and tees will be seeded. The requirement for soil amelioration is yet to be ascertained.

2.7.7 *Buildings*

Building construction will be the final phase of the construction project. All buildings will be constructed between months 11 and 23 of the programme. Building designs have yet to be finalised but the siting, design and materials used in construction will be sympathetic with the landform, and will not conflict with the visual or landscape resources of the island.

2.7.8 *Landscaping*

The natural landscape of Kau Sai Chau is described in detail in Section 4.4. The Project area's vegetative cover is principally grass and low scrub, other than the moist gullies which are well vegetated with areas of diverse scrub/woodland.

The Kau Sai Chau vegetation cover is largely the result of periodic wild fire which has removed most trees and tall shrubs from most of the northern part of the island. With fire being effectively controlled, it is likley that the fire affected areas will recover naturally, and that taller stands of scrub and trees will develop.

The landscaping would be confined mainly to the area around the clubhouse, and would be sympathetic with the natural low cover on the island. Species would be chosen that occur naturally on the island.

It is proposed extensively to use "no-go" areas during construction, so that areas other than the fairways and interconnecting paths are left natural and as undisturbed as possible. With this approach any areas subject to minor disturbance should recover naturally.

2.8 Key Issues During Construction

2.8.1 Mangroves

The biological significance of mangroves has been widely documented in the scientific literature (Irving and Morton 1988, Melville and Morton 1983). Hong Kong's pre-eminent nature conservation site, Mai Po Marshes, was established to protect one of the largest areas of mangrove on the South China coast and its associated wildlife. Because Hong Kong is located on the northern limit of the range of mangrove species, local mangrove trees are typically dwarf. Maximum height of individual trees is attained at Mai Po where some trees reach heights of 3-4m. Mangroves on Kau Sai Chau are very short in stature, ranging from less than 1m to 2m in height.

Due to regional loss of mangrove habitats resulting from development, the Hong Kong government is committed to protection of remaining mangroves in Hong Kong. Therefore, further threats to mangroves, mud flats, and associated wildlife due to construction of any project in Hong Kong is a significant environmental concern.

There are many areas on and near Kau Sai Chau where mangroves occur (Section 5.2). The single area where mangroves would be affected is in the proposed irrigation reservoir area at the north end of the island (Figure 5.3). This site harbours the largest area of mangroves on the island. Due to filling of the reservoir with fresh water, part of this site would be lost.

The issue of mangrove loss was considered carefully in evaluation of the reservoir dam options (Section 3.4.1). As a result of concern about the loss of mangrove, the proposed dam site was relocated upstream of the original proposed location. This will require an increased water level from 9m PD to 12m PD to maintain an acceptable storage capacity, and consequently some additional scrub land habitat will be lost.

The decision to relocate the dam was taken to address concern that mangroves should be preserved to reduce overall impacts of the project. The relative scarcity of mangroves in Hong Kong, the decline in recent years of the total Hong Kong mangrove acreage, and the relative abundance of upland shrub/woodland habitats in Hong Kong all support the decision to re-site the dam.

The relocation of the dam will save an area of about 0.5ha of mangrove that would have otherwise been lost. The issue of loss of mangroves is addressed through the mitigation plan by transplanting trees to be lost, extension of suitable mangrove substrates on other off-site locations, and extension of mangrove habitat in the area downstream of the dam site. This will be achieved by placement of sediment removed during construction of the dam into the proposed mangrove replanting site. The proposed extension of mangrove habitat area will make up for the loss of existing mangrove. This is discussed in more detail in Section 5.6.

2.8.2 *Minimization of Site Disturbance*

Several spatial constraints applied to the layout and routing of the golf course. These were:

- avoidance of the shoreline shrub/woodland habitats to reduce ecological as well as visual impacts. This ensures preservation of a naturally vegetated buffer to control sedimentation of marine waters during construction and to absorb any nutrients which could potentially be carried from the golf course during storm events.

- to avoid development of the northern headlands of the islands to minimize visual impacts and avoid disturbance of grave sites.

- to minimize excessive earthworks by confining the golf course to the northern half of the island where massive cuts of steep topography would not be required to "bench" fairways into hillsides.

- to avoid the two southern areas where cultural artifacts have been recorded, and to avoid the western headland where the stone carving is located.

Within the remaining area the overall objective of course layout was to preserve as much as possible of the gently rolling, grassy or low shrub landscape because it was seen to be a significant resource in terms of natural beauty. To accommodate the above constraints, and to provide a golf course of international standard, it is necessary to propose filling some of the natural gullies in the northern half of the island. The potential for sedimentation arising from these activities is described in the next sub-section.

2.8.3 Sedimentation

Mariculture sites are located off the northeast and northwest shorelines of the island. During construction of the dam wall, pier, golf courses, and associated buildings potential sedimentation of marine waters near mariculture sites will be a key issue. Sedimentation could adversely affect fish production. Control of sedimentation would be addressed through detailed protective measures in the construction management plan.

Marine coral occurs off the north shoreline of Kau Sai Chau (D. Melville, pers. comm.). This habitat could also be adversely affected by excessive sedimentation of marine waters during dredging of marine sediments for dam wall construction and earth moving operations. Due to the scarcity of coral in Hong Kong waters, this is potentially a key issue in construction of the Project. Protection of existing coral would be addressed through the construction management plan via sediment control measures.

The sediment control measures would be subject to the environmental monitoring and audit procedures described in Section 9.

2.8.4 Noise and Air Pollution

There are no identified Sensitive Receivers that would be affected by construction activities associated with the Project.

Owing to the remoteness of the site, noise is not considered to be an issue. Similarly air pollution nuisance from construction activities is unlikely, however in dry and windy weather fugitive dust emissions could be significant. Dust can be reduced to acceptable levels by the frequent application of water to access roads and exposed areas during the dry season.

It should be noted that it is not proposed that a temporary concrete batching plant would be erected on site. Any concrete requirements for construction would be provided by an onsite mixer.

2.9 Key Issues During Operation

2.9.1 Visual Impacts

The newly created reservoir, the pier, the golf courses and associated buildings and facilities will alter the uninhabited and undeveloped character of Kau Sai Chau. Views to and from Kau Sai Chau will be affected.

However, the course layouts do not encroach significantly upon the steeply sloping and well vegetated coastal zone, although the pier and access road will result in limited landscape impacts to the western coastline.

The primary visual envelope for the Kau Sai Chau development extends westward to the crest of the Kiu Tsui Chau island ridge, north to the Sai Kung Country Park coast road and eastwards to Tai Tau Chau and High Islands. A secondary distant visual boundary relates to the Tseung Kwan O peninsula and the skyline mountain ridges of the Ma On Shan and Sai Kung Country Parks (Section 4; Figure 4.3).

Key close viewpoints of the proposed development relate principally to the intensively used shipping lane to the north and east of Kau Sai Chau Island. This channel provides the main thoroughfare for the large numbers of pleasure and working craft en route between Tai Long Wan or Mirs Bay and Hebe Haven or Sai Kung.

The principal landscape impacts likely to arise from the proposed development relate to the filling of natural gullies with material removed from within the course area (i.e. balancing cut and fill). This major disturbance of natural landform will involve the loss of some areas of woodland and tall shrubland within the gullies and in particular the filling of the scenic upper reaches of the Kwat Tau Tam Valley. The loss of this self-contained valley ecosystem would represent a locally significant landscape and ecological impact.

The parallel orientation of holes 7, 10, 18, 19, and 20 across the natural grain of the landscape at the upper end of the Kwat Tau Tam valley may involve the total loss of this feature. In addition, the damming of the Kwat Tau Tam inlet to a depth of 12m will result in a significant landscape impact on the boulder, shrub and mangrove covered coastline.

These potential impacts were recognised in the design of the golf course (Sections 2.1 and 2.8.2), and in this respect the golf course has been designed with the express aim of minimising site disturbance as much as possible. To mitigate the landscape impacts, areas of the golf course that have been previously degraded by erosion and fire would be progressively rehabilitated (Section 4.9).

A detailed landscape and visual impact assessment is provided in Section 4.

2.9.2 *Reservoir Shoreline*

Shorelines in the proposed reservoir areas are densely vegetated with tall shrubs (over 2 m in height). The slopes are steep and inaccessible. The vegetation provides thick cover which forms an edge habitat between the tidal mud flats and the upland shrublands or grasslands. This habitat is adapted to fluctuation of the tidal water levels.

Following reservoir construction water level fluctuations will be less regular, and probably more extreme due to filling and drawdown for irrigation. This effect would be accentuated by the steepness of the existing topography between the 5 and 10 m elevations. Because of the potentially erratic changes from submergence to emergence, habitats in the shoreline area could be difficult to establish and maintain. This habitat restoration issue may be addressed through design and construction of the other water storage lakes on the golf course. Specialist treatment of this area will be provided as required.

2.9.3 *Contamination of Surface Waters*

Due to the nearby location of mariculture sites and marine coral, risk of chemical contamination of surface waters is potentially a key issue. The risk of chemical contamination arises from golf course operation, which will require application of fertilisers and pesticides to maintain quality of the turf-grass on fairways, tees, and greens. The assessment of potential contamination to surface waters, and the principles of environmentally sound turf-grass management, are dealt with in Sections 3 and 6. The assessment of impacts on mariculture areas is discussed in Section 3.8.5.

There is increasing awareness among golf course managers of the environmental and economic benefits of minimising chemical applications. Technology is also rapidly developing to enable course managers to eliminate or render insignificant the potential risks of turf-grass chemicals to the environment. Regardless of these developments, turf-grass chemicals are perceived to pose a threat to the environment, and their use may be a key issue at Kau Sai Chau. This issue can be addressed through the turfgrass management plan which is discussed in Section 6.

2.9.4 *Sewage Disposal*

Sewage will arise during the construction and operational phases of the Project. It will be necessary to provide a suitable collection, treatment and disposal method so that the surrounding marine waters and the island's freshwater do not become contaminated with faecal and other pollutants.

The options for different methods of disposal and treatment of the effluent are discussed in Section 3.5. An assessment of each of the disposal options is also given.

2.9.5 *Sedimentation of Marine Waters*

Frequent docking of ferries at the proposed piers on the northwest shoreline may result in deterioration of water quality at the nearby mariculture site or coral areas. This could result from disturbance of the sea bed by propeller wash caused by docking ferries. This issue is discussed in Section 3.8.5.

2.9.6 *Waste Disposal*

The wastes generated by the operation of the golf course, restaurant and staff quarters would be of a household/commercial nature. These wastes would be disposed of to a Government landfill. Sewage sludge arising from the sewage treatment plant would be disposed of to Sai Kung Sewage Treatment Works. This is described in greater detail in Section 3.5.4.

Small quantities of waste arising from vehicle and equipment maintenance areas and from oil traps, would be classified as chemical wastes. It would be necessary for the Golf Course Manager to register the course as a chemical waste producer, and for these wastes to be removed off-site by a licensed contractor under the Chemical Waste Control Scheme.

2.9.7 *Reduction, re-use and recycling*

A philosophy of reduction, re-use and recycling would be adopted in the operation of the golf course.

This would be achieved by implementing measures such as:

- collection of paper for recycling, or for shredding as compost;
- composting of grass clippings and prunings;
- collection of items such as aluminum cans for recycling;
- use of water saving showers and toilets;
- re-use of treated effluent for both water saving and to reduce fertilizer requirements.

2.10 Ordnance Clearance Activities

Kau Sai Chau has been used in the past as an artillery firing range. The Royal Hong Kong Police Force (RHKP) have advised that there is a potential danger of unexploded ordnance (UXO) on the site.

The RHKP Explosive Ordnance Disposal (EOD) Team have been approached to make a clearance sweep of the island to remove as much UXO as possible prior to the commencement of construction work. Should the EOD Team be unable to undertake this work, a private contractor would be engaged.

However, because UXO is likely to be buried and may be missed during the clearance sweep, safety precautions and procedures have been issued by the Project Manager for use during the construction phase. The precautions to be taken when visiting the site are:

1) Where possible use footpaths and avoid entering areas with tall shrubs.

2) Always take a mobile telephone to site to enable communications with the mainland.

The procedures in event of discovery of UXO are:

1) Unexploded ordance is likely to be buried and will therefore mainly be discovered during excavation work.

2) If a metallic sound is heard during machine or hand excavation <u>cease work</u>. Clear the soil around the object using a hand trowel.

3) If a suspicious object is uncovered during excavation or is seen on the ground, mark the location and evacuate beyond 100m of the siting.

4) Call the Policy Duty Officer at 860 2400 and wait for the dispatch of the EOD Duty Team. This telephone service is manned 24 hours a day.

The response time to calls to the EOD Duty Team in regard to findings of UXO is understood to be of order 30 minutes.

2.11 Course Safety

The two principal aspects of concern in relation to course safety is risk of injury from stray-hit balls, and the future possible findings of any UXO.

It is proposed that notices would be placed in Chinese and English at the pier advising of the hazards from stray-hit golf balls.

The principal concern in relation to stray-hit golf balls is likely to be during the Ching Ming and Chong Yeung festivals, when there may be an influx of visitors to grave sites. On these days special arrangements may be necessary, such as the use of temporary signs and additional security staff to direct visitors to safe paths to gain access grave sites.

In regard to UXO, the clearance sweep and construction activities would ensure effective removal of UXO. However, should there be any residual concerns, notices could be placed in Chinese and English at the pier advising the public to not disturb any unusual objects, and to report such objects to the Golf Course Management. Any such objects would be reported to the EOD Team for retrieval and disposal. The need for and form of any such warning signs would be resolved at the Government Project Steering Group Meetings.

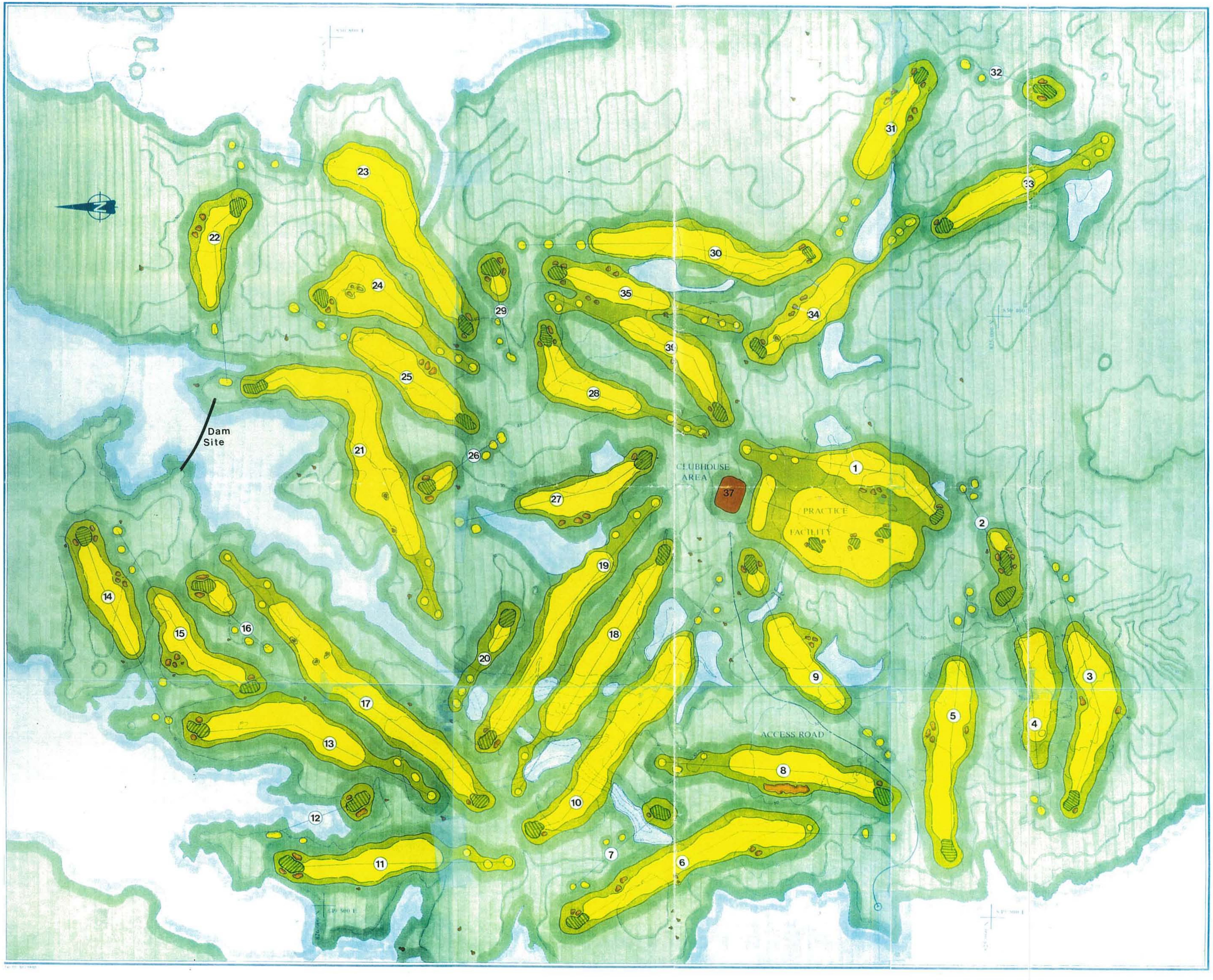


Figure 2.1

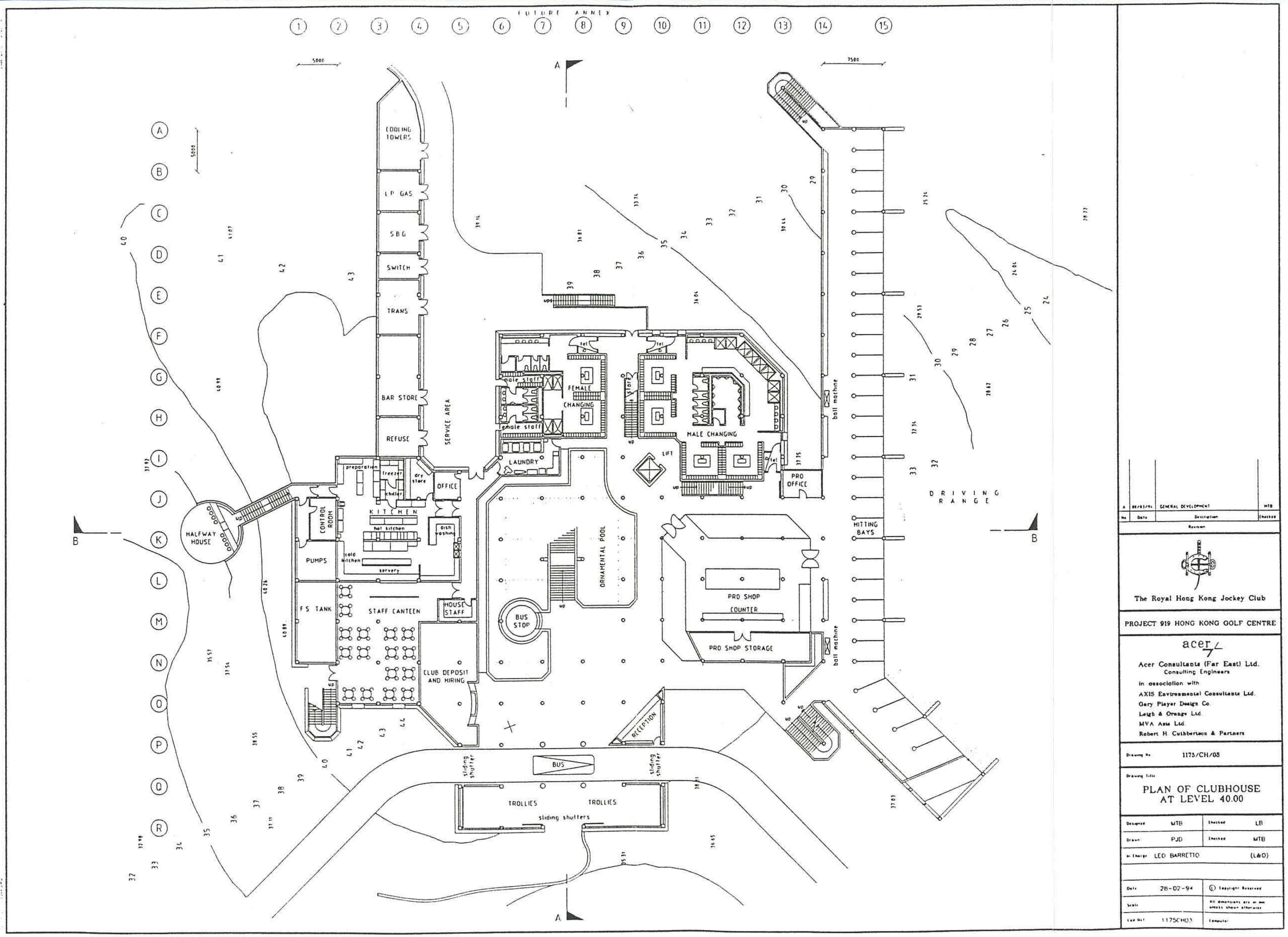
THE ROYAL HONG KONG JOCKEY CLUB

KAU SAI CHAU

PRELIMINARY MASTER PLAN

1:2500	23/8/93
HK004	P.JACOBS

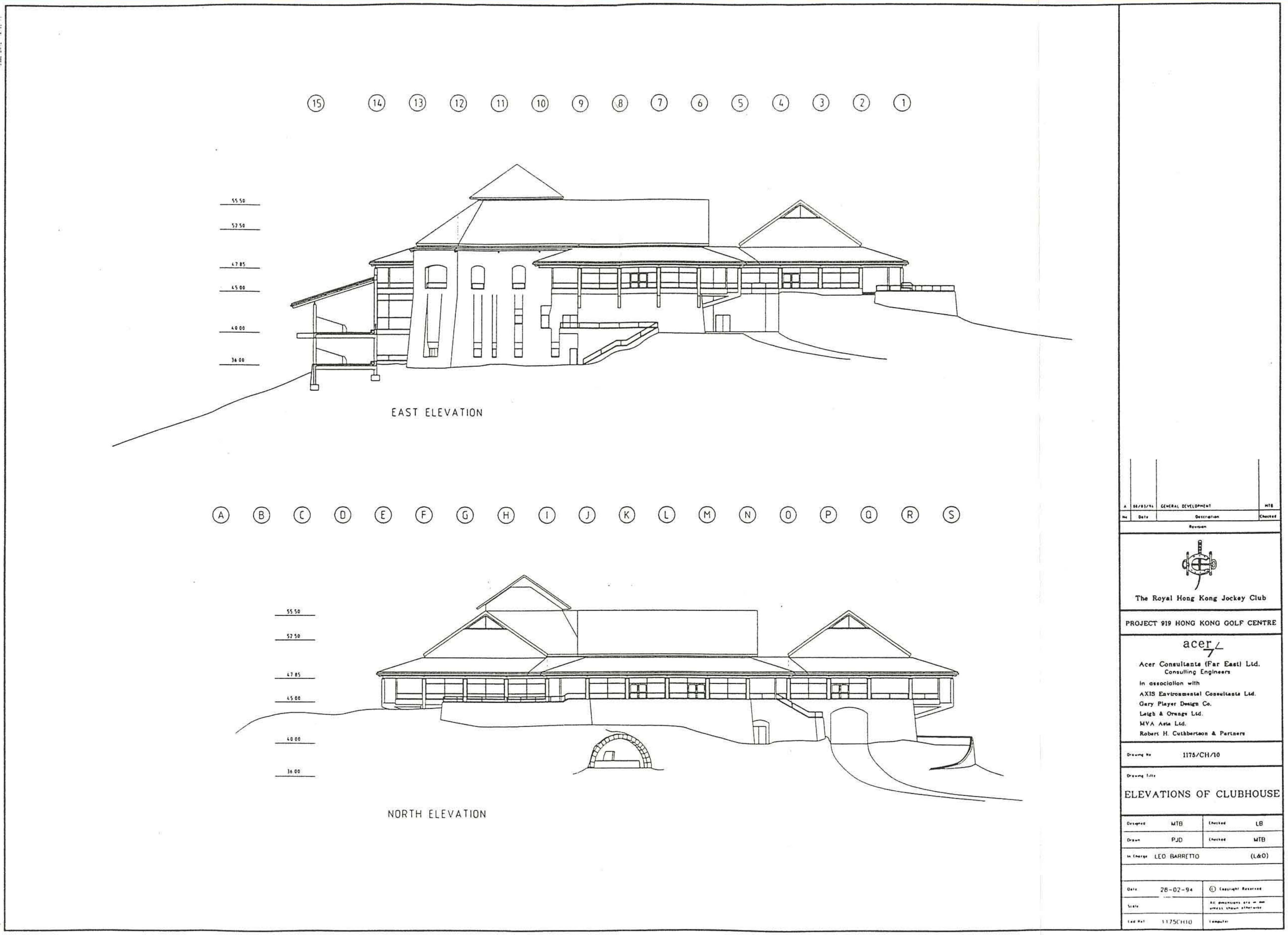
Gary Player
DESIGN COMPANY



AXIS Environmental

Figure 2.2(a)

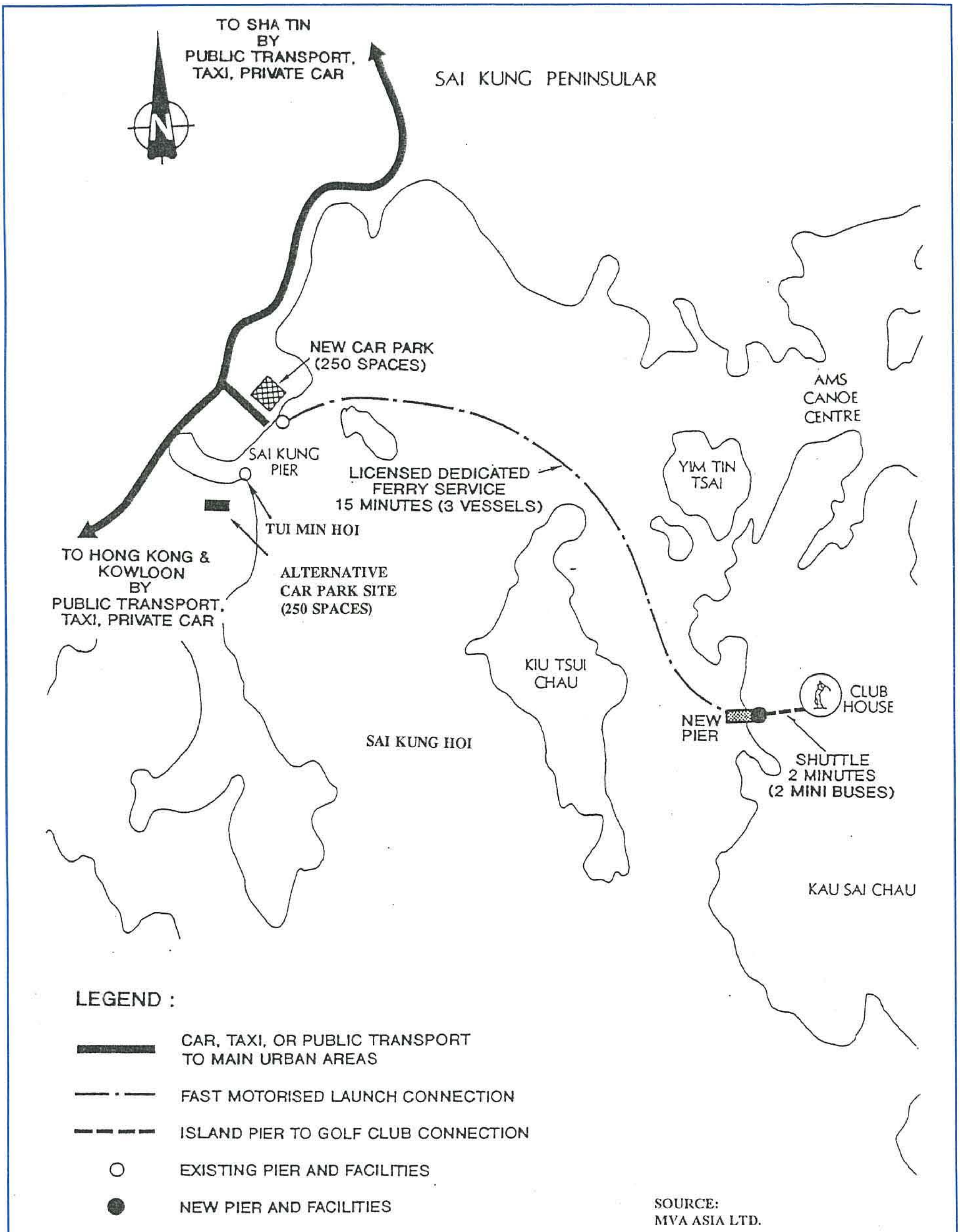
Plan of Clubhouse At Level 40.00



AXIS Environmental

Figure 2.2(b)

Elevations of Clubhouse (East, North)

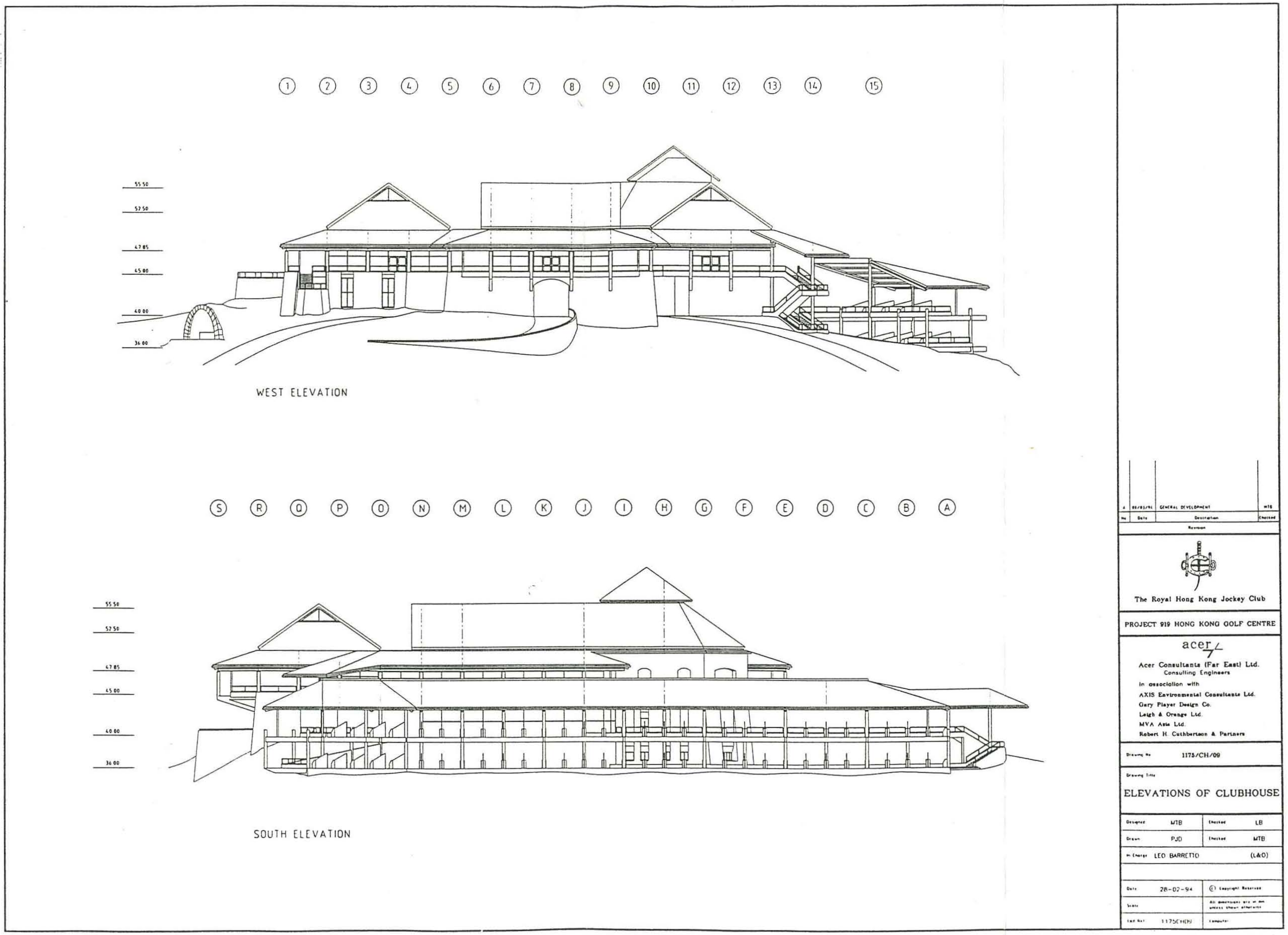


AXIS Environmental

Kau Sai Chau Project

Figure 2.3 Access to Kau Sai Chau

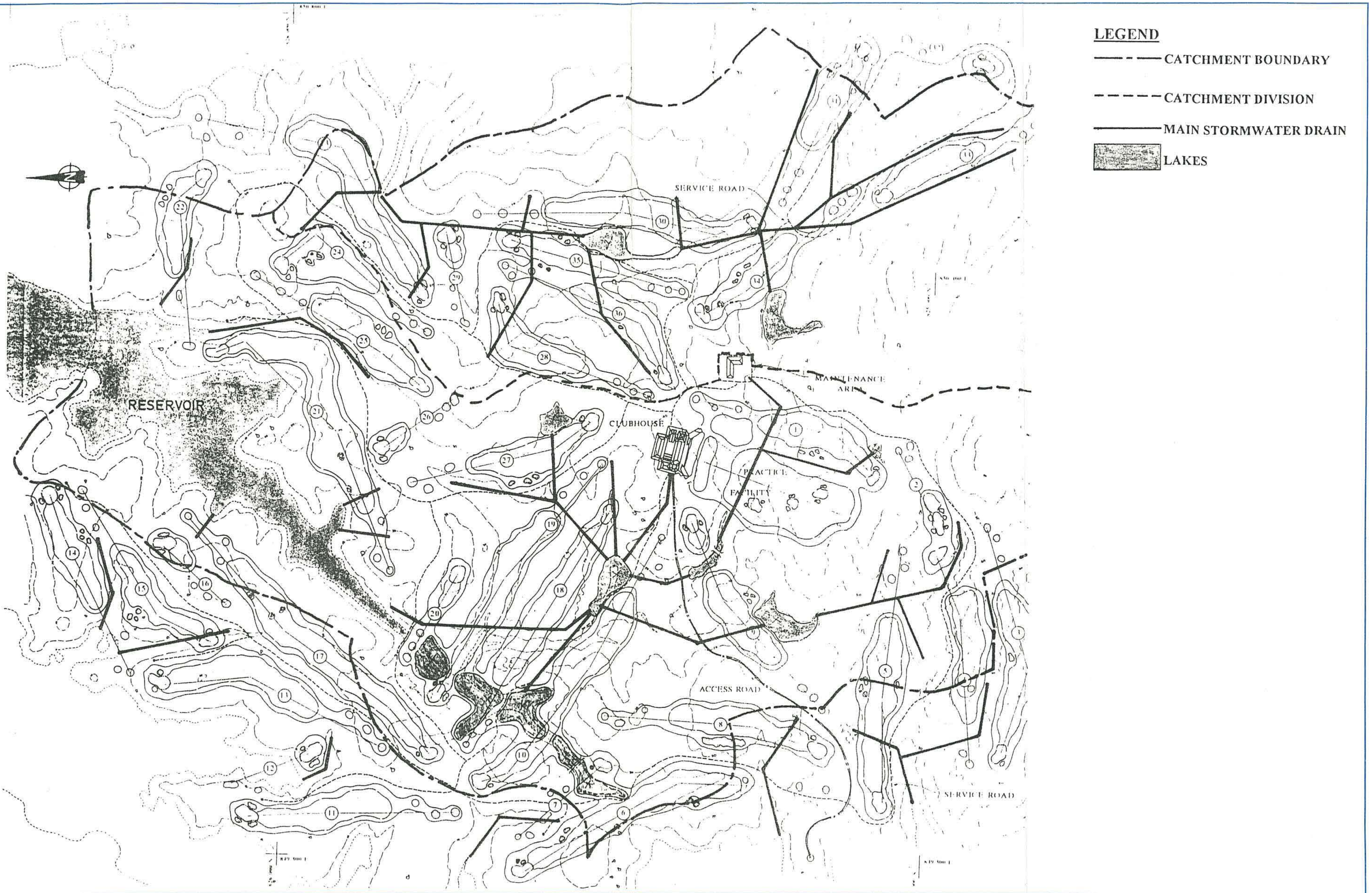
076000/January 1994



AXIS Environmental

Figure 2.2(c)

Elevations of Clubhouse (West, South)



AXIS Environmental

Kau Sai Chau Project

Figure 2.4 Catchment Map and Stormwater Drainage

076000/ December 1993

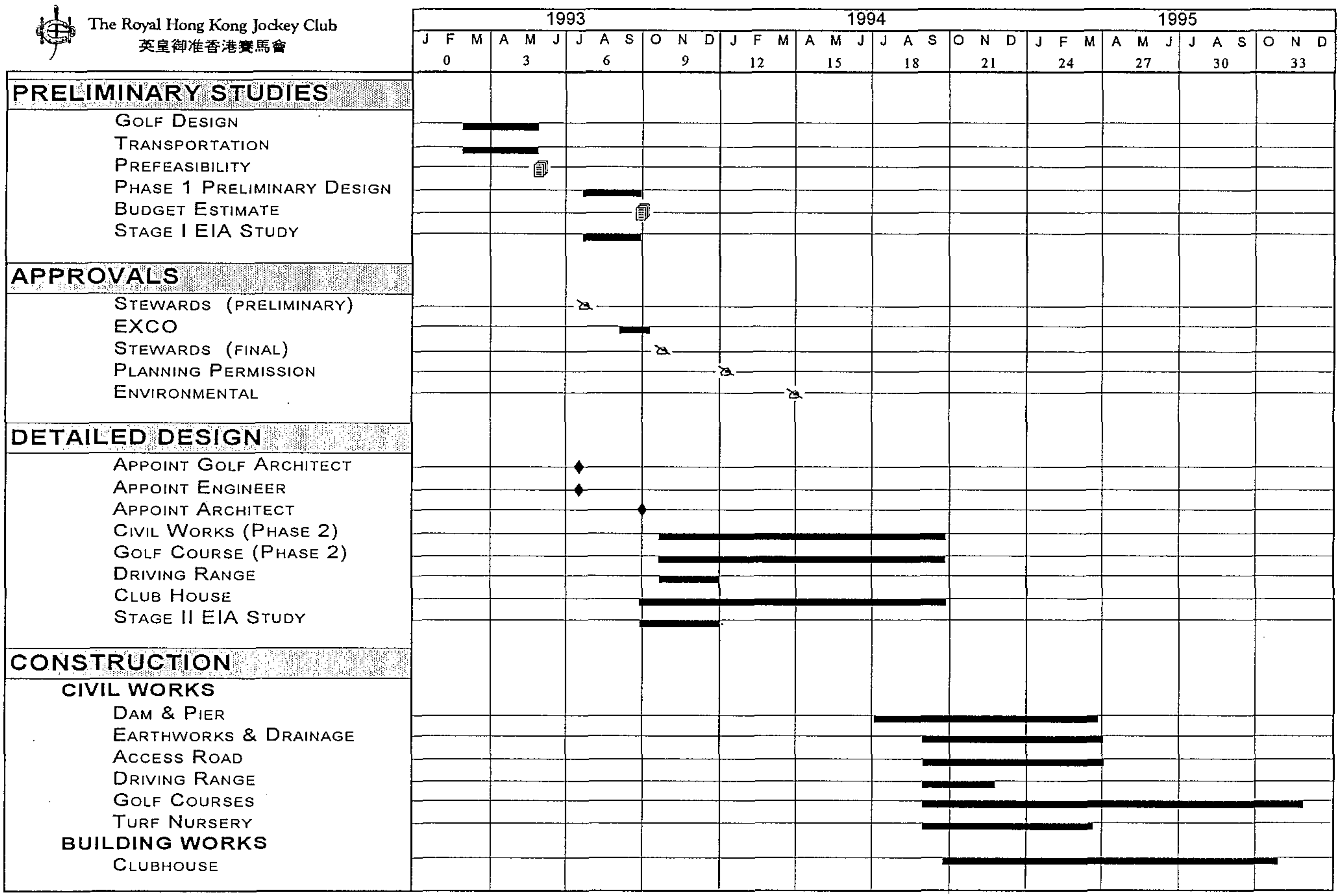


Figure 2.5 Kau Sai Chau Development, Project Programme

WATER MANAGEMENT AND QUALITY

SECTION 3

3 WATER MANAGEMENT AND QUALITY

3.1 Existing Marine Water Quality

The Island of Kau Sai Chau is located within the Port Shelter Water Control Zone (WCZ), which was gazetted in 1989. Environmental Protection Department (EPD) monitors water and sediment quality on a regular basis. Figure 3.1 shows a summary of existing water quality within Hong Kong with special reference to the Study Area based on the data given in the annual report published by EPD entitled Marine Water Quality in Hong Kong for 1991. This report covers monitoring results for year 1991, and represents the most current available data.

A tabular summary of the 1991 water quality data for Port Shelter is given in Table 3.1. Since the gazettal of the Port Shelter WCZ the water quality within the area has been governed by the Water Pollution Control Ordinance (WPCO), which provides a series of objectives for various water quality parameters. A summary of the more important objectives is given in Table 3.2.

Table 3.1 : Water Quality Data for Port Shelter WCZ for 1991

	Area	Inner Port Shelter				Hebe Haven		Outer Port Shelter		
Parameter	Station	PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9
Temperature	Surface	23.7	23.7	23.6	23.5	23.1	22.8	22.6	22.3	22.6
	Bottom	21.8	21.9	21.4	21.9	22.2	21.3	20.9	20.5	20.6
Salinity	Surface	31.8	31.5	32.2	32.0	31.7	31.7	32.1	32.2	32.1
	Bottom	32.7	32.8	32.9	32.8	32.3	32.7	32.9	33.0	32.9
D.O.	Surface	104	112	113	102	109	106	110	109	105
	Bottom	76	83	87	81	88	72	89	92	91
pH		8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Secchi Disc		2.6	2.3	3.4	2.8	2.1	2.5	4.0	4.2	3.8
Turbidity		2.8	3.5	2.3	3.0	3.7	2.9	2.5	2.6	2.8
S.S.		2.4	3.2	2.7	4.9	4.4	4.8	5.5	3.7	4.1
BOD_5		1	1	1	1	2	1	1	1	1
Inorganic N		0.11	0.11	0.1	0.1	0.14	0.12	0.11	0.09	0.09
Total N		0.41	0.41	0.38	0.32	0.53	0.47	0.41	0.36	0.37
PO_4-P		0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.01	0.01
TP		0.1	0.1	0.1	0.08	0.1	0.1	0.08	0.09	0.08
Chlorophyll		1.36	1.79	1.29	1.33	3.51	2.49	0.53	0.66	0.7
E. coli		1	16	1	1	14	8	<1	<1	<1

Note:
1. *Except as specified all data presented are depth averaged data.*
2. *Data presented are annual arithmetic means except for E. coli which are geometric means.*

Source : EPD Annual Report, Marine Water Quality in Hong Kong for 1991.

Table 3.2 : Water Quality Objectives for Port Shelter

Water Quality Parameters	Objective	Part(s) of Zone
E. coli	Annual geometric mean not to exceed 610/100ml	secondary contact recreation subzone, fish culture subzones
D.O. within 2m of bottom	not less than 2mg/l for 90% of the samples	marine waters
Depth average D.O.	not less than 4mg/l for 90% of the samples not less than 5mg/l for 90% of the samples	marine waters except fish culture subzones fish culture subzones
pH Value	within the range of 6.5 to 8.5 units, change due to waste discharge not to exceed 0.2	marine waters except bathing beach subzones
Salinity	change due to waste shall not exceed 10% of the natural ambient level	whole zone
Temperature change	change due to waste not to exceed 2°C	whole zone
Suspended Solids	waste discharge not to raise the ambient level by 30%, nor cause the accumulation of suspended solids which may adversely affect aquatic communities	marine waters
Dangerous substances	not to be present at levels producing significant toxic effects	whole zone
Unionised ammonia	annual mean not to exceed 0.021mg/l	whole zone
Nutrients	not to be present in quantities that cause excessive algal growth annual mean depth average inorganic nitrogen not to exceed 0.1mg/l	marine waters

Note : *Refer to Water Pollution Control Ordinance (WPCO) for the full list of water quality objectives.*
Source : *EPD Annual Report, Marine Water Quality in Hong Kong for 1991.*

3.1.1 General Oceanography

The coastal waters of Hong Kong are influenced by the fresh water flow of the Pearl River and the ocean current from the South China Sea. As a result, there is a general shift from estuarine to oceanic conditions in a west to east direction. The effect of the Pearl River flow is more pronounced during the wet seasons. During the wet seasons, the salinity and pH of the surface waters are lower in the western waters than in the east.

The oceanography of the marine waters, especially the inshore waters, is also affected by other factors such as stream run-off and coastline shape.

such as Port Shelter or Tolo Harbour is weak and the turbulent mixing of the water body within the bay is poor. During summer, the surface water is heated up rapidly, while the bottom water remains cool. This results in the stratification of water layers, which further reduces mixing in the water column. The warm surface water run-off also contributes to the stratification of inshore waters. In the open marine waters currents are strong and the water body is better mixed with only slight stratification.

3.1.2 *Temperature*

The surface sea temperature in Hong Kong reflects the seasonal variation in air temperature. During the summer the relatively enclosed bays of Port Shelter, Tolo Harbour, and Deep Bay are characterised by high surface water temperatures and cooler bottom water temperatures. The bottom waters detected in Port Shelter are due to the intrusion of cool ocean current from the South China Sea. Because currents are not strong enough a temperature stratification occurs in the water column.

In winter, the strong northeast monsoon causes good turbulent mixing within the water column and a fairly homogeneous water body can be found over the coastal waters of Hong Kong.

3.1.3 *Salinity*

Due to the influence of the large amounts of freshwater from the Pearl River, the coastal waters of Hong Kong show prominent geographical and seasonal variations in salinity. Wider ranges were recorded in the western waters with a decreasing range towards the east. In summer, low salinity levels are usually recorded.

In winter, all the marine waters were fairly homogeneous with salinity approaching that of the oceanic water (27 to 33 ppt).

In Port Shelter and other relatively enclosed bays it would be expected that the freshwater runoff would form a layer of lower salinity above the sea water. During 1991 there is little evidence that this occurred; the absence of the layering was probably due to the lower annual rainfall (74% of the ten year average).

3.1.4 *pH*

The pH in the coastal waters of Hong Kong ranged from 7.4 to 8.8 during 1991. The pH levels were lower in the North Western Waters, Deep Bay and Victoria Harbour, and increased towards the eastern waters. The pH pattern also reflects the shift from estuarine to oceanic conditions from west to east.

Apart from the Pearl River influence, pH values are also affected by the activities of organic decomposition and algal photosynthesis in the water. The higher pH levels and chlorophyll-a in the water of inner Port Shelter reflect the impacts associated with elevated levels of algal productivity.

3.1.5 *Transparency And Light Penetration*

The transparency and light penetration of sea water are affected by suspended particles such as clay and silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. The parameters which are used to indicate these properties include Secchi disc depth, turbidity and suspended solids content. The greater the Secchi disc depth, the more transparent the surface layer of the water is. The transparency and light penetration of the coastal waters of Hong Kong, in particular the western waters, are to a large extent influenced by the Pearl River, which discharges a substantial quantity of suspended solids.

In general, the eastern waters exhibited greater Secchi disc depths (annual mean of 2.0m to 7.0m), and hence higher transparency than the western (annual mean of 1.0m to 3.0m).

3.1.6 *Turbidity and Suspended Solids*

Turbidity in water is caused by the presence of suspended matter. In general, the eastern waters had lower turbidity and suspended solids levels than the western southern waters.

3.1.7 *Dissolved Oxygen*

When organic matter is discharged into marine water, a substantial portion of it decomposes. During this process, oxygen is consumed, lowering the dissolved oxygen (DO) content of the water. Thus the DO content reflects the level of organic pollution in a water body.

Most of the coastal waters of Hong Kong were fairly well oxygenated in 1989. All marine areas had annual mean DO levels of above 50% saturation.

In contrast to oxygen depletion, supersaturation of DO (annual mean above 100% saturation) was detected in the surface waters of Port Shelter and Tolo Harbour. Supersaturation of dissolved oxygen caused by the active growth of algae indicates eutrophication. While algal blooms result in high dissolved oxygen content in water, oxygen depletion occurs at night and when the algae die and decay. This depletion in DO can have serious implications for marine communities, especially fish culture zones (FCZ) where the captive fish cannot move to a less DO depleted area.

3.1.8 Biochemical Oxygen Demand

Relatively high Biochemical Oxygen Demand (BOD) levels were recorded in Hebe Haven due to local organic discharges, although these higher levels were still within the acceptable range. The BOD levels in the more open area of Port Shelter were low with annual means generally about 1.0mg/l. These levels indicate the lower influence of local pollution sources and are more comparable with those in the open ocean.

3.1.9 Bacterial Conditions, Escherichia coli

The bacterial condition of most coastal waters of Hong Kong, indicated by *E. coli*, continued to be unsatisfactory in 1991. Apart from the faecal pollution of certain beaches, most marine waters were also affected by faecal pollution.

The more eastern waters of Hong Kong are in general of good water quality with low *E. coli* levels (annual geometric mean below 100/100ml). As can be seen from Table 3.1, the waters of Port Shelter had a maximum annual geometric mean of 44/100ml at point PM5, which is located in Hebe Haven; however, most of the stations, especially those at the outer edge of the WCZ, indicated an *E. coli* count of 1/100ml or less.

3.1.10 Eutrophication

Eutrophication can be defined as nutrient enrichment that results in high biological productivity in a water body. The increase in biological productivity can lead to algal blooms. When an algal bloom declines, the decay of the dead microscopic algae (phytoplankton) consumes oxygen, and thus depletes the water of oxygen. Under serious conditions, the waterbody can become anoxic, leading to the die-off of other aquatic organisms. Therefore, when a waterbody becomes eutrophic, the water quality can deteriorate to a very poor state.

Nitrogen and phosphorus are the major nutrients required for plant growth. The Port Shelter WCZ showed very low levels of inorganic nitrogen, ranging from 0.01 to 0.23mg/l. An inorganic nitrogen range of 0.3 to 0.5mg/l is generally taken as the nutrient criterion for eutrophication.

3.1.11 Chlorophyll-a

The measurement of chlorophyll-a, which is the biomass indicator of microscopic algae (phytoplankton), can indicate the intensity of algal blooms and can reflect the extent of eutrophication. A mean chlorophyll-a level higher than 10μg/l is generally accepted as being indicative of eutrophic conditions.

The surface chlorophyll-a levels in Port Shelter ranged between about 1 and 15μg/l but with an average of less than 5μg/l.

3.1.12 Red Tides

Red tides are created by the discolouration of sea water brought about by the rapid growth in numbers of certain microscopic algae (dinoflagellates). Red tides are harmful to marine life and can be hazardous to man. Some red tides are toxic and the toxins produced can kill fish. While shellfish are unaffected, they can accumulate the toxins. These contaminated shellfish when consumed by man may cause paralytic shellfish poisoning (PSP) which can be fatal.

There has been a general decline in the number of red tides which occur in the coastal waters of Hong Kong for a number of years. During 1991 three red tide incidents occurred in the Port Shelter WCZ.

In summary it should be noted that the overall water quality within Port Shelter is generally very good and during 1991 the majority of the water quality objectives were met. Figure 3.1 shows the rates of compliance with certain key water quality objectives in Port Shelter for the period 1985 to 1991.

3.2 Sensitive Receivers

3.2.1 Fish Culture Zones (FCZs)

There are four FCZs in the general area of Kau Sai Chau, and these are shown in Figure 3.2. The sites and number of licences issued are:

- Kai Lung Wan (site A, 27 licences)
- Tai Tau Chau (site B, 75 licences)
- Tiu Cham Wan (site C, 1 licence)
- Kau Sai (site D, 69 licences).

Sites D is remote from the Project area, and is unlikely to have any impact from the development.

3.2.2 Gazetted Beaches

There are eight gazetted beaches in Port Shelter (WCZ), and of these three are located near Kau Sai Chau (Figure 3.3). These beaches and their approximate water travel distance from the project jetty are:

- Pak Sha Chau, to the west of Kiu Tsui Chau (Sharp Island) - 2.5 km
- Kiu Tsui, on the western side of Kiu Tsui Chau - 3 km
- Hap Mun Bay, on the western side of Kiu Tsui Chau- 2.5 km.

Of the other five gazetted beaches, three are in Port Shelter (Trio, Campers and Silverstrand), the closest of which is some 5km water travel distance from the Project area. Two are in Clear Water Bay (Clear Water Bay 1st and Clear Water Bay 2nd), some 11km distant.

3.2.3 Port Shelter WCZ

As noted from the discussion in Section 3.1, the overall water quality in Port Shelter is good, with most water quality objectives over the period 1985-1991 being met. The water quality around Kau Sai Chau is generally good, although the coves and inlets are subject to high levels of suspended solids from eroded slopes, particularly during the wet season.

3.3 Potential Construction Phase Impacts

3.3.1 Surface Water Run-Off

Careful timing of the Construction Programme, choice of construction techniques and water supply catchment planning consideration, incorporated during the design process will significantly reduce the potential for water run-off from the Project area to the marine environment, for example:

a) activities involving substantial earth moving (earthworks and drainage, access road, during range and the main golf course areas) will be undertaken during the dry seasons in 1993/94 and 1994/95;

b) Earth berms will be constructed marking out the golf holes and therefore distinguishing works areas from natural vegetation to be preserved. The berms will reduce and control the volume of surface water run-off;

c) The Golf Courses have been planned with emphasis on utilising the existing water catchment area for water supply and irrigation. As a result the drainage pattern of Kau Sai Chau has not been altered significantly.

With good site practices/mitigation (see below), it is concluded that surface water run-off during the construction period will not have a significant impact on marine water quality, FCZs or on gazetted beaches.

3.3.2 Dam Construction

Dredging of up to 11 metres of marine sediment will be required for the dam construction. During the nine moths construction period there will be potential for a significant increase in sedimentation. It is proposed that a silt curtain be placed north of the dam construction area to confine the sediments. Additional mitigation measures recommended during the dam construction are detailed below. The sediments will then be utilised to encourage the expansion of the mangrove areas and create mud flats of significant ecological value. This is discussed in detail in Section 5. Given the distances involved there will be no impact on FCZs or on gazetted beaches from the dam construction.

Monitoring of the dam construction would be undertaken as part of the ecological monitoring designed to preserve areas identified to be of ecological interest. This will be supplemented by water quality monitoring to detect any deterioration in water leaving the inlet. The monitoring requirements are discussed further in Section 9.

3.3.3 Jetty Construction

A small area of the seabed will be dredged during the construction of the jetty. This activity will have a very localised impact in increasing suspended solids. However, this will not impact on the FCZ at site A which is some 500 metres away.

3.3.4 Mitigation

General Construction

All site construction runoff and drainage would be controlled and treated because of the potential for adverse water quality impacts on adjacent coastal waters and to protect any fishing grounds in the area. The following mitigation measures would be included in the construction contract documents:

- The boundaries of critical areas of earthworks would be marked and surrounded by dykes or embankments for flood protection;
- Temporary ditches would be provided to facilitate runoff discharge into the appropriate water courses, via a silt retention pond;
- All traps (temporary or permanent) would incorporate oil and grease removal facilities;
- Sediment traps would be regularly cleaned and maintained by the contractor. Daily inspections of such facilities would be required of the contractor;
- All drainage facilities would be designed to be adequate for the controlled release of storm water flows;
- Exposed soil areas would be minimised (see 6.6.1) to reduce the potential for increased siltation and contamination of runoff.

Dredging

The dredging process can lead to large amounts of suspended solids being released into the water column. To mitigate against this potential impact, proper precautions would be taken to ensure that all loss of material to the surrounding water is minimised. The following would be included in the construction contract documents.

- The Contractor shall ensure that no visible foam, oil, grease, scum, litter or other objectionable matter is present on the water;

- For the dam construction a silt curtain shall be placed across the inlet prior to the commencement of any dredging activities and shall remain in place until completion of the dam;

- The dredger would be fitted with a closed seabed grab, with tight seals, and the dredged material loaded onto a split barge with a water tight seal. No barge overflowing would be permitted.

3.4 Water Supply System

3.4.1 Water Supply Options

The question of water supply was examined in depth in the preliminary engineering investigations. Three alternatives were considered for water supply to the development:

- mains water supply;
- desalination;
- reservoir supply.

For the option of a reservoir supply, other considerations in the water supply investigation were:

- the catchment should be wholly within the Project area, and be designed as much as possible to recirculate any run-off irrigation water;

- the catchment should be separated from the treated sewage disposal area and careful design of the STW and irrigation system must ensure the water supply could not become contaminated;

- the dam structure should be of minimum height and be appropriately sited to minimise environmental and visual impact;

- the dam site should be located to minimise the loss of mangrove and scrubland habitat;

- the reservoir should be incorporated as a feature of the final landform, and become part of the golf course design.

Mains water supply

Mains water supply, although feasible, is not considered to be an option for the project. It is the policy of the Water Supply Department (pers. comm.) that mains water supply should not be used for large-scale irrigation. For this project, some 85% of the water demand is for irrigation.

An environmental disadvantage of mains water supply would be the need for construction and installation of a pipeline in a marine trench from the mainland.

Desalination

Desalination techniques are considerably more expensive than conventional supply systems both in terms of capital and operating costs, and are also less reliable. A desalination plant for the potable water demand was costed to be in the order of five times that of the ultimate proposed system.

The potable water demand is only approximately 15% of the expected peak water demand. The use of desalination for potable water supply would thus not lead to any major reduction in the size of the reservoir. The use of desalination for all water demand would be prohibitively expensive both in terms of capital and operating costs.

Reservoir supply

For reservoir supply, three potential sites were identified during the prefeasibility stage of the Project:

- the Yim Tin Tsai typhoon shelter;
- the inlet some 500m south of the proposed jetty site;
- the Kwat Tau Tam inlet.

Yim Tin Tsai: The conversion of Yim Tin Tsai typhoon shelter to a reservoir was considered as likely to be unacceptable, both because of conflicts with other uses and inadequacy of catchment area. There were also concerns of potentially contaminated sediments as a result of its use as a typhoon shelter, which would make it unsuitable for use as a reservoir.

In terms of use conflicts, if Yim Tin Tsai were to be converted to a reservoir, it is likely that another site would need to be identified in the area for a typhoon shelter. The area adjacent to the typhoon shelter is also presently used as a girl guide camp, and this and similar uses for the site could expand in the future. These and other activities would be beyond the control of the golf management, which is considered undesirable from a water supply management perspective.

In terms of water catchment, the typhoon shelter does not have sufficient catchment, and thus additional supplementary catchment areas would be necessary. This would require construction of additional dams in other areas and hydraulic and pumping systems.

Inlet some 500m to the south of the proposed jetty site: This inlet takes in a large part of the southern part of Kau Sai Chau as its catchment area. The use of this area as the reservoir would be feasible, however a very high and expensive dam structure would be required, and an indirect catchment with one or more further dams would be required to supplement yield. In addition some areas of high quality woodland would be flooded.

The main concerns with the site were:

- the high visual impact of the main dam;
- the cost of the main dam stucture;
- the flooding of one of the best woodland areas on the island, with consequent loss of habitat for wildlife;
- the indirect catchment would also be expensive to provide, and require an additional dam or dams and hydraulic systems;
- the catchment is outside the Project area, which is against the principle of self-containment for the development;
- the reservoir would effectively sterilise a significant portion of the southern area of Kau Sai Chau for future uses, and affect its likely future use for walkers and other recreational use.

For these reasons this site became the second choice in the evaluation of potential reservoir sites.

The Kwat Tau Tam inlet: The Kwat Tau Tam inlet has as its catchment an area of about 74 ha, which takes in a significant portion of the Project area. The dam would be some 14m high and be of an embankment structure. The water level would be about 12m PD high. The catchment area would not be adequate for demand, and an additional catchment would be required. This would be accommodated by a small supplementary weir to the eastern part of the Project area, and an aqueduct. It is proposed that a treatment reservoir be provided in the upper reaches of the inlet for control of nutrient levels (Section 3.4).

The site conforms to the principle of self-containment within the Project area, and the reservoir would become integrated into the landscape of the golf course.

The principal concern with the site is the loss of mangrove. As a result of this concern the original selected dam site was moved some 170m upsteam, and this has resulted in the saving of about 0.5 ha of mangrove that would have otherwise been lost. As a result of moving the dam site the dam water level has been raised from the original 9m PD to 12m PD, which will result in some additional loss of shrubland habitat. A detailed discussion of the conservation value of the mangroves, and on mitigation, is provided in Section 5.

Nevertheless the revised dam site will still result in the loss of about 1 ha of mangrove. In mitigation it is proposed to create over 1 ha of new mangrove habitat downstream of the new dam site. It is also proposed to transplant as many of the plants as possible to other areas on the island where mangroves occur.

Taking account of the advantages and disadvantages of the options and potential reservoir sites, the use of the Kwat Tau Tam inlet as a reservoir is the preferred water supply option for the Project.

3.4.2 *Reservoir and Water Supply System*

As described in Sections 2.4.2 and 3.2.1, it is proposed that a freshwater reservoir (capacity 420,000m^3 active storage and 150,000m^3 dead storage capacity) at the northern end of the island be constructed by creating a dam across the Kwat Tau Tam inlet.

The selected site for the reservoir is a steep sided narrow estuary. The direct catchment draining into the estuarial basin at this location is currently of the order of 600m wide by some 1300m long (Figure 2.4) totalling an approximate area of 0.74 km^2 (74ha). The maximum elevation is approximately 120m at the southern extremity of the area, and there is a single main stream draining to the estuary along a relatively deep, narrow valley.

The refilling capability of this direct catchment has been shown to be barely sufficient to replenish storage deficiency for the design period of the reservoir. Consequently the stream draining to the east of the direct reservoir catchment area will be developed as an indirect catchment (comprising 52ha) capable of being diverted to the reservoir at times of increased drawdown. This can be achieved by construction of a weir structure and an underground pipe (of not less than 600m) to the direct catchment. The method of pipe laying has not yet been determined.

The dam will be located upstream of the existing ruined dam structure. Conceptual designs for the dam and reservoir were developed in the prefeasibility study and include earth fill and rockfill embankments. As described in Section 3.4.1, because of concerns about loss of mangrove area, the dam site has since been relocated some 170m upstream. The dam will be approximately 140m long and have a crest height of 14mPD. The maximum water level inside the dam will be approximately 12mPD.

Draw off and overflow works will be directed through the right abutment to facilitate construction of the dam. The draw off tower will comprise a 'dry tower' containing raw water and irrigation pumps with inlet pipework from the reservoir. Water from the reservoir will be pumped to two storage tanks from where it will be distributed by gravity to the treatment plant and then to the clubhouse for potable use. Water for irrigation will be pumped to an upper reservoir (adjacent hole 34) to the south of the main reservoir, from where it will extracted for the main irrigation system, described in Section 3.4.4.

3.4.3 Potable Water Supply

The total potable water supply demand for the development is estimated to be 4,600 m^3 per month (55,200m^3/yr) . This will supply the clubhouse, the maintenance facility and permanent on-site accommodation.

Water for potable supply will be extracted from the reservoir and pumped to storage tanks adjacent to the maintenance yard where the water treatment facility will be located. The water will be gravity fed to the treatment plant and on to the water supply distribution network. A package treatment plant would be used for potable water treatment.

As noted in Section 2.4.2, the treatment plant would be designed to meet Water Supply Department standards for potable water in Hong Kong. Where necessary appropriate water treatment facilities such as activated carbon filtration or ion exchange would be used for final purification and removal of any residual chemicals. Appropriate standards are current international standards, which are discussed in Attachment 1.

3.4.4 Irrigation Water Supply

The reservoir will fill during the wet season and hold enough water to supply the expected demand during the dry season. As there is no other water supply proposed for the Project it is essential that the reservoir holds sufficient water and that the water quality is maintained at a high level. It is proposed, however, that treated sewage effluent will be used to supplement the irrigation supply (Section 3.5.3) for holes 3, 4 and 5 (Figure 2.1) which are outside the main catchment at the south east of the course. The sewage effluent will be stored in a tank with capacity for 5 days effluent (average flow) and pumped or fed to the area in question. Sewage effluent will not be utilised eleswhere. This isolates the effluent from the main reservoir. Any potential public health risk is thus eliminated.

The water from the main reservoir would be pumped to the potable water treatment works and to the upper reservoir (adjacent hole 34) where it would feed to the irrigation system and be used to maintain the water level in the four treatment reservoirs (adjacent holes 7,10,20) and other ponds (adjacent holes 18,9).

The overall principal is to rationalise the engineering works based on the requirement to utilise the sewage effluent for irrigation purposes. The discharge of the treated and disinfected effluent is to a storage tank and will pose no material health risk.

The effluent will be discharged to the tank to a standard equal to or better than that agreed with EPD (Table 3.5) (e.g. <100 *E.coli*/100ml), but the actual quality of the waters used for irrigation on holes 3, 4 and 5 will be much higher since the irrigation water will be formed by amending the treated effluent with water from the main reservoir or from the upper reservoir (adjacent hole 34).

The irrigation demand for the golf course is different for the various areas of the course. For the fairways and general practice areas the requirement is 3.5mm/day/m^2, and for the greens and tees the requirement is 7mm/day/m^2. It is estimated that there is a total irrigation water demand of some 305,000m^3 per year.

The detailed design of the irrigation water distribution system is not yet finalised, however, it is anticipated to follow normal designs adopted on golf courses elsewhere, comprising an underground network of pipes attached to fixed sprinkler heads. There are a number of issues which will require to be resolved and incorporated into the adopted design; of these the major concern is the potential eutrophication of the reservoir from the additional nutrient loading derived from the collected surface water run off and the need for some form of nitrogen sink to act as a buffer. However this is not seen as a major issue since any nitrogenous material in the drainage can be captured and recirculated, which will enable fertilizer requirements to be reduced on some holes. This is discussed further in Sections 3.6 and 6.

3.4.5 Natural Site Drainage

The catchment areas (direct and indirect) are currently drained by natural stream courses, discharging ultimately into the waters of Port Shelter. The area is fairly steep and many of the existing stream courses are liable to erosion. Due to use of the site as a practice range for bombing and shelling from 1936 to 1975 by the Hong Kong military and police forces, and by the occupation forces during World War II, some areas of the island are very badly eroded. The resulting silt load into Port Shelter is visible following badly eroded. The resulting silt load into Port Shelter is visible following storm events on the island, and also during the summer rainy season in general.

The primary catchment covers approximately 74ha in the central and western parts of the island and currently drains to the proposed reservoir area and then to the sea. There are several tributary streams which drain the main catchment area and feed the Kwat Tau Tam inlet.

The secondary catchment drains the eastern portion of the Project area, and drains directly to the sea along the eastern shore of the island. This catchment is drained by a single stream which flows from the upland, east-central portion of the island to the sea off the east coast.

3.4.6 Stormwater Drainage

The existing stream courses will be preserved where possible by incorporation into the topography of the golf courses. These streams will serve to direct surface flow to the reservoir. The site will require some regrading to replace the existing steep-sided gullies with a gently undulating surface in the areas of golf fairways. In the western portions of the site where bomb damage and resultant erosion is most severe, regrading of the steep gullies will reduce erosion and facilitate revegetation of damaged sites.

Runoff from the clubhouse and other built-up surfaces will be directed to the upper reservoir and integrated into the main golf irrigation system. Mitigation measures are discussed further in Section 3.7.

The maintanence area runoff will be collected in a catch pit and disposed of in the appropriate manner. Such wastes may be classified as chemical waste and will be disposed of under the Chemical Waste Control Scheme as directed by EPD.

3.5 Sewage Treatment and Disposal

3.5.1 Sewage Flows and Loads

The Technical Memorandum *Guidelines for the Design of Small Sewage Treatment Plants* provides recommended design flow rates of 55 1/head/day for offices (excluding canteen), 0.5 m^3/m^2/kitchen area/day, 70 1/head/day for shops, and 300-460 1/head/day for village housing and residential R1 to R4.

The project includes accommodation for 30 roster staff and for 5 families (Section 2.2.4), and it is estimated (Appendix 2) that the maximum daily population would be about 1440 people. This figure excludes family members (for about 5 families) accommodated on site.

Based on a permanent staff (and resident family members) of 50 and an average usage of 370 l/head/day for residents (residential R2), 70 l/head/day for 1400 visitors and an allowance of 25m^3/d for restaurants, a daily sewage flow of about 140 m^3 is estimated.

Estimated sewage loads and sewage characteristics, based on per capita loads derived for the Sewage Strategy Study (EPD 1990), are shown in Table 3.3.

Table 3.3 : Estimated Sewage Loads

Parameter	Per Capita Loads		Total Daily Load	Sewage Concentration
	Residents	Visitors		
BOD	42g	34g	50kg	350mg/L
Suspended solids	40g	34g	50kg	350mg/L
Total N	8.5g	6.7g	9.8kg	70mg/L
Ammoniacal N	5.0g	4.0g	5.8kg	40mg/L
E.coli	4.3x10^{10}no	3.5x10^{10}no	5.1x10^{13}no	3.6x10^{7}no/100mL

3.5.2 *Effluent Quality Requirements*

The site lies within the Port Shelter WCZ but discharge will be to an effluent tank for use in supplementing irrigation to holes 3, 4 and 5 (3.4.4). The guidelines for effluent standards set out in Table 4 of the Technical Memorandum *Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland Waters and Coastal Waters* (EPD, January 1991) are therefore relevant and the standards applicable to the flow range 10-200 m^3/d are reproduced in Tables 3.4(a) and (b).

Table 3.4(a) : Key Standards for Effluents Discharged into Group B Inland Waters

Determinand	Level	Determinand	Level
BOD	20mg/l	Chloride	1,000mg/l
Suspended solids	30mg/l	Oil & Grease	10mg/l
E. coli	100 counts/100ml	Surfactants (total)	5mg/l
Nitrate + Nitrite Nitrogen	30mg/l	Total Phosphorus	10mg/l

Source: Technical Memorandum; Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TMES), EPD, January 1991.

Table 3.4(b) : Key Standards for Effluents Discharged into Coastal Waters of Port Shelter WCZ

Determinand	Level	Determinand	Level
BOD	20mg/l	Total Residual Chlorine	1mg/l
Suspended solids	30mg/l	Oil & Grease	20mg/l
E. coli	1,000 counts/ 100ml	Surfactants (total)	15mg/l
Total Nitrogen	20mg/l	Total Phosphorus	8mg/l

Source: Technical Memorandum; Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters (TMES), EPD, January 1991.

Reuse of effluent for irrigation is to be adopted and it is intended that the available nitrogen would be utilised as a fertilizer. However, due to possible operational problems with the irrigation system, the level of suspended solids removal required would be greater than that required for compliance with the Technical Memorandum, and this level of treatment would have a resultant reduction in BOD.

A further treatment consideration in the use of sewage effluent for irrigation is the microbiological quality of the effluent. A conference held in Engelberg, Switzerland, in 1985, co-sponsored by the World Health Organization, recommended quality criteria for effluent to be used for irrigation of various land uses based on levels of faecal coliforms and intestinal nematode eggs. After consideration of the above issues, the particular quality criteria considered appropriate for the reuse of effluent for irrigation at Kau Sai Chau is given in Table 3.5.

Table 3.5 Specific Effluent Quality Criteria for Reuse of Effluent for Irrigation

Determinand	Level
BOD	15 mg/l
SS	15 mg/l
Total N	45 mg/l
Faecal Coliforms	100 No/100ml
Nematode Eggs	≤ 1 No/L

Other effluent quality criteria would generally comply with the indicative guidelines for effluent reuse suggested by EPD.

3.5.3 *Evaluation of Sewage Effluent Disposal Options*

Four disposal options were considered for the disposal of treated effluent:

- connection to Port Shelter sewer mains;
- use of a soak away;
- discharge to coastal waters;
- utilisation of effluent as irrigation water for the course.

An assessment of each of the disposal options is given below.

Connection to Mains

The possibility of connection to the Port Shelter sewer system was raised with Drainage Services Department (DSD). DSD advised that sewerage services will not be available in the area until about 1998.

Thus for this option, an interim disposal method would be required. In any event, DSD also consider that the high maintenance costs for such a low effluent volume (about 2 1/sec) would not warrant connection to the mains system, and as a result DSD is not in favour of this option.

Mains connection was therefore rejected as an option.

Soakaway

If the effluent were to be disposed of via a soakaway then it is unlikely that further treatment of the wastewater would be required (e.g. disinfection with chlorine or ultra violet) after reaction in the primary sedimentation tanks and RBC. Thus a benefit of the use of a soakaway as compared to an outfall is that no impact on the local marine water quality would normally be expected.

Although the use of a soakaway for effluent disposal was the initial preferred choice for effluent disposal, permeability tests in December 1993 have demonstrated that the Kau Sai Chau soils are of low permeability and are unsuitable for the use of a soakaway.

Discharge to Coastal Waters

In this option the effluent would be treated to meet the requirements of the Technical Memorandum standards.

The limiting criterion for a discharge to coastal waters is the Technical Memorandum requirement to limit Total N discharges to the Port Shelter WCZ of 20mg/l (Table 3.4(b)). Based on the estimated sewage concentration in Table 3.3 a denitrification stage would need to be incorporated into the sewage treatment works to remove some 70% of the Total N in the sewage.

A number of treatment methods are available for denitrification based on biological, chemical or physical processes. Biological methods considered suitable are:

- Two stage rotating biological contactor (RBC) incorporating a submerged second stage RBC;
- Activated sludge plant or oxidation ditch incorporating an anoxic zone.

Chemical and physical treatment processes for denitrification include the use of ion exchange resins, membrane technology, breakpoint chlorination and air stripping. However, none of these methods are considered to be suitable for a small works.

The principal disadvantage of the RBC option is that carbon has to be added at the second denitification stage, usually in the form of methanol. The control of the carbon addition is critical as overdosing could cause consent failure on BOD, while underdosing could cause failure on nitrogen. These systems are generally more appropriate for large, highly automated and well maintained works.

It is concluded that an activated sludge plant or oxidation ditch incorporating an anoxic zone is the only viable option for a discharge to coastal waters complying with the Technical Memorandum. The principal disadvantages of this option are that careful operation is required to ensure optimum performance, and there is potential for visual and noise intrusion.

To achieve the *E.coli* standard in Table 3.4(b), disinfection will be required and chlorination and ultra-violet light (UV) are considered suitable methods for this type of plant.

If chlorination disinfection is to be used, given the concerns regarding the pollution of aquatic species by chlorine-based compounds and the proximity of FCZs, the chlorine levels in the effluent would need to be carefully monitored and the EPD effluent criterion of 1mg/l (total residual chlorine) strictly observed. For this reason, and in view of the small flow, UV disinfection is preferred.

The marine discharge location needs to ensure no adverse affect on FCZs, and must be in an area where currents are sufficient to allow adequate dispersion of the effluent.

A marine outfall is impractical because of the low and very variable flow. The remaining options are for discharge to a stream that flows to the sea, discharge to an open drain running to the sea, or discharge from a seawall or the jetty. Of these options, discharge from the jetty is preferred.

For this option, it would be proposed that a sea discharge should be used, by means of a discharge pipe from the end of the jetty. This site, combined with the low design flowrate of 2 1/s, is sufficiently remote from the nearest FCZ so as not to give rise to any concerns about adversely affecting the FCZ. A quantitative assessment of the impacts of marine discharges is given under the comparison of options below. For aesthetic reasons it is proposed that the discharge pipe would be below low tide level.

Utilisation of Effluent as Irrigation Water

Although sewage effluent will account for only about 5% of the total irrigation demand, the principal advantage of utilising effluent for this purpose is the potential for Total N reduction and reduction in fertilizer demand by turfgrass on parts of the course which do not drain to the main reservoir. This option also permits the elimination of the requirement for a denitrification stage at the sewage treatment works.

In this case the sewage treatment works could be based on a nitrifying RBC process. To minimize the risk of blockages in the irrigation system tertiary treatment would need to be incorporated, probably in the form of sand filtration. Disinfection would also be required, the preferred method being UV disinfection as discussed above combined with ozonation to limit the size and cost of the UV unit.

To prevent the recycling of sewage effluent into the reservoir the effluent should only be used for the irrigation of those areas outside the reservoir catchment. Holes 3, 4 and 5 on the south-west side of the island are considered suitable for this purpose (see Figure 2.1), which would have an irrigation demand in excess of the estimated sewage flow. If there are any alterations to these holes, which affect the drainage towards the reservoir, areas of holes 6 and 8, which drain away from the reservoir, would be included for effluent disposal.

The broader area for potential disposal of the effluent around holes 3, 4 and 5 is $>112{,}000m^2$. The peak supply of treated effluent has been previously calculated at $150m^3$/day. It has also been calculated that the total cultivated playing surface (tees, fairways and greens) within this area would be approximately $16{,}650m^2$ (at $58.3m^3$/day). However, a broader zone on the course, including rough areas immediately adjacent, of around $56{,}000m^2$ would actually require regular irrigation ($196m^3$/day) and be readily available for effluent distribution as necessary. In the unlikely event that effluent reuse is not possible on the course, effluent could be distributed further into the remaining $>56{,}000m^2$ of natural vegetation adjacent. The peak supply of treated effluent ($150m^3$/day) can therefore be accommodated in this area. In the event that holes 3, 4 or 5 are alterred to affect drainage and potential effluent disposal, suitable areas of holes 6 and 8 will also be used.

The grasses in the playing area would be able to utilise the nitrogenous compounds in the treated effluent which would also supply phosphorous, potassium, and micronutrients as well as being a potential source of organic compounds. At peak effluent supply of $150m^3$/day, at say 10mgN/l (max.30mg nitrate/l & 5mgNH_4/l, approximately 1.5kg/day of nitrogen would be supplied.

The fertilizer nitrogen requirement will be at least 1 kg/ha/day for greens and fairways. The nitrogen supplied could be sufficient for about 1.5 ha of greens and fairways. This is less than the playing surface areas of holes 3, 4 and 5 and about 25% of the area readily available for effluent distribution (see above).

In assessing the potential for effluent reuse, the following assumptions were made:

- The peak volume of effluent will be $<150m^3$/day with an average flow of approximately $90m^3$/day.

- The above average effluent volumes are based on a resident visitor population ranging from 750 to 1500 which could be much less at certain times of year, in which case effluent arising could be even less.

- A high specification has been pursued for the STW and there is allowance for extra performance over and above that required to achieve the discharge standard. Therefore, engineering estimates suggest that the effluent could be considerably better than 100 *E.coli*/100ml.

Irrigated effluent would additionally be subject to further nutrient removal, physico-chemical and microbiological breakdown in the soil. Therefore, the likelihood of the system being excessively loaded is remote since the chemicals in the effluent will enter the nutrient cycles of the soil. The additional organic material available will also be of particular value in the sandy growing medium proposed for the Kau Sai Chau courses.

The irrigated effluent will be spread over a large area of ground, will be exposed to the elements, and therefore any remaining pathogens would be degraded. The chances of pathogens being entrained into the water gathering system is eliminated. The chances of direct human exposure will be removed by the timing of irrigation to dawn and dusk, before and after play.

It would be necessary to provide an effluent storage tank with a facility for topping up with raw water from the main irrigation system, to ensure that adequate irrigation water is always available during times of low sewage flow. It would also be necessary to incorporate overflow to the coastal non golf course areas which would only come into operation during the wet season (May to September) at times when irrigation of the course is not required on a regular basis.

The possibility of providing additional storage of effluent further reduces the need for any marine discharge. Any excess effluent would be discharged diffusely to non golf course areas draining away from the main reservoir. A quantitative assessment of the impacts of marine discharges is given under the comparison of options below, based on a direct discharge from an outfall as a worst case scenario.

Comparison of Options

Connection to the mains sewer is not considered to be an available option. In addition, the soil permeability tests have indicated that a soakaway system is unacceptable as a disposal method.

For the other two options, an assessment of the pollution loads which would be discharged to the coastal waters and the impact of those discharges has been carried out and is given below.

It should be noted that, if treated for irrigation use, effluent would only be otherwise disposed of if it was not possible to reuse it, i.e. when rainfall was greater than the irrigation requirement for golf course and all storage capacity was used up. The option to discharge to the roughs and surrounding vegetation would then be chosen. Under such inclement conditions it is likely that the number of visitors to the golf course would be considerably less than average with a resultant reduction in effluent quantity and possible improvement in quality. The intention to provide storage of, say, 5 days peak flow would reduce the chances of discharge of any significant quantities to the coastal waters to virtually nil.

Based on the effluent quality standards given in section 3.5.2 and the expected number of visitors and ground staff during an average week (rather than the peak daily visitors used for sizing the sewage treatment plant), the annual effluent loads for the two treatment options would be as given in Table 3.6. The figures assume that for the re-use option, effluent would be overflowed off-course on 10 days per month during the 5 months between May and September, and that all such effluent diffusely discharges to sea.

Table 3.6 Annual Effluent Discharges Comparison

Options	Annual Discharges (kg/yr)		
	Total N	SS	BOD
1. Coastal discharge - treatment to Technical Memorandum	657	986	657
2. Treatment for irrigation use - overflow * (50 days/a)	135	135	90
- indirect** (315 days/a)	255	-	-
- total	390	135	90

* Assumes 100% of overflow diffusely discharges to sea, which is most conservative.

** Assumes run-off of N of 30%, which is probably excessive given the extent of buffer areas around the irrigated golf course areas.

In order to assess the impacts from marine discharges (Option 1), a quantitative assessment in a 100m mixing zone has been undertaken, and the results are summarised in Tables 3.7 and 3.8. More detail on the quantitative assessment is given in Appendix 3. The results indicate that at the edge of the mixing zone, the levels of any indicator parameters would be below detectable limits.

Table 3.7 Discharge dilutions at edge of 100m mixing zone

Current (m/s)	Dry Season	Wet Season
0.1	28,500	25,000

Table 3.8 Concentrations at edge of 100m mixing zone

Determinand	Effluent Quality		Concentration at edge of mixing zone			
			Dry Season		Wet Season	
	Outfall	Irrigation	Outfall	Irrigation	Outfall	Irrigation
BOD (mg/l)	20	15	0.0007	0.0005	0.0008	0.0006
SS (mg/l)	30	15	0.0011	0.0005	0.0012	0.0006
Total N (mg/l)	20	45	0.0007	0.0016	0.0008	0.0018
E. Coli (No/100ml)	1000	100	0.035	0.0035	0.040	0.0040

A coastal discharge complying the Technical Memorandum guideline standards has the disadvantage of requiring a relatively complex denitrification process in order to achieve the required Total N removal, which may result in operational difficulties. For this reason, utilisation of final effluent for irrigation is the preferred option assuming that overflow to off course areas, which may then diffusively discharge to coastal waters during occasional periods of the wet season (May-October) when irrigation demand is low, is acceptable.

It should also be noted that discharge of the amended effluent to the roughs virtually rules out this possibility. Since wet periods will not coincide with high utilization of the golf course, storage capacity is unlikely to be exceeded, and discharges are likely to be rare. The utilisation of treated effluent is also in keeping with the broader environmental objectives of the Project.

The advantages and disadvantages of each option are summarised in Table 3.9.

Table 3.9 : Comparison of Sewage Effluent Disposal Options

Option	Advantages	Disadvantages
Marine Discharge	. No impact on the island; . Full compliance with Technical Memorandum standard all year round.	. Disinfection required; . Relatively complex activated sludge plant with denitrification stage required; . Potential noise and visual impacts; . Low and variable flow rate means an outfall is impractical; an open or seawall discharge would be required; . Overall higher annual discharges than effluent re-use.
Soakaway	. Disinfection not required; . Minimal maintenance requirements.	. Possible contamination of groundwater; . Design flow considered large for this disposal option; . Permeability affected by rainfall; . Land area required; . Permeability tests have indicated that a soakaway is impractical.
Utilisation for Irrigation	. Effluent normally contained within the site; . Minor reduction in raw water irrigation demand; . Denitrification treatment stage not required; . Robust, simple to operate RBC treatment process can be employed. - Overall lower annual discharges than TM treatment.	. Tertiary treatment and disinfection required; . Separate irrigation system required for effluent; . Possible occasional diffuse discharge to coastal waters during periods in wet season when irrigation not required and storage is exceeded (mitigated by difuse discharge).

Of the options in Table 3.9, it is proposed that the utilization for irrigation option be adopted. A schematic of the proposed sewage treatment works is shown in Figure 3.3. The primary sedimentation stage would provide sufficient capacity for 7 days of sludge production, to minimize sludge handling requirements, and an equalisation tank upstream of the RBC to reduce fluctuations in loading. Peak flows to the works are likely to be in the range 4-6 times average daily flow.

3.5.4 Sludge treatment and disposal

It is proposed that primary sludge together with co-settled humus sludge would be removed from the site by tanker on a weekly basis and transported by barge to Sai Kung sewage tretment works for further treatment and disposal. It is estimated that approximately 8.6m^3 of sludge would be generated in a typical week.

It is noted that the Sai Kung sewage treatment plant has a quota for receival of sludge. Discussions have however indicated that this quota is 60,000m^3/month compared with the estimate of some 40m^3/month from the golf course. Thus sludge dispoal in this manner should not be any problem since the sludge arising is insignificant ($<0.01\%$) compared to the quota.

3.6 Reservoir Water Quality Management

The water which drains from the fertizied playing areas could potentially become enriched with nutrients from the fertilizers and other chemical compounds which would be applied to the golf course to maintain turf grass quality.

The gradual enrichment of the reservoir water would occur over a period of time with nutrient levels ultimately approaching an equilibrium level. With suitable light and temperature conditions, and sufficient nutrients in plentiful supply, the level of primary productivity could increase and lead to the generation of nuisance biomass (algae & weeds etc.). This natural process of gradual entrophication could cause long term problems in the reservoir, causing algal blooms and a general degradation in water quality, if nutrient inputs are not limited and productivity of the waters is allowed to accelerate uncontrolled.

High levels of biomass can have adverse impacts on a number issues including:

- a secondary BOD loading is created that can deplete DO as the algal filaments decompose;
- water intakes may become blocked with floating clumps of filaments;
- undesirable taste and odours can be created, making the water unsuitable as a potable source. Additional water treatment may be then needed if the quality of reservoir water were to deteriorate significantly;

- dense mats can cover the bottom, restricting intersticial water flow in the gravel, which can inhibit fish reproduction;

- a general reduction in the aesthetic appeal of the water body.

Although the eutrophication of the reservoir would not directly affect the requirements of the irrigation water, it would however create a detrimental effect on the potable water usage and the appearance and amenity value of the reservoir. The high algal levels would also give rise to severe maintenance problems.

Because of the potential for eutrophication of the reservoir it is proposed that a nutrient sink be established so that any extra nitrogen loading carried in the water draining from the playing areas is removed before the water reaches the reservoir.

The proposed nitrogen sink would take the form of a series of ponds forming subsidiary treatment reservoir (TR) created above the main water storage reservoir (adj. holes 20,19,18,10,7). The surface water flows during the dry weather season and the initial pulse of runoff water from a storm event will be directed to the TR. In the TR, the nitrogen and other nutrients would be assimilated by the algae and fish, and thereby be removed from the water supply system. The surface water run-off will be diverted to the TR by a series of weirs and overflows.

Water for irrigation purposes will, be taken initially from the TR. This will be supplemented, and blended with water from the main reservoir to produce irrigation water with a consistent quality. Water from the TR will be regularly analysed for nutrient levels, and discharge of water from the TR to the main reservoir will only be allowed when the nutrient levels in the water are at a level unlikely to accelerate entrophication (e.g. nitrate less than 0.3 mgN/l). On a periodic basis, fish from the TR could be monitored for levels of pesticide residues as a reassurance test. During the wet season it is expected that the TR will provide the majority of the water required for irrigation purposes. This TR provides an effective buffer for the main reservoir.

3.7 Stormwater Drainage Impacts

During the construction of the golf course storm events could create significant erosion from the exposed areas with consequent effects on water quality in the area. Because of this potential problem the main construction activities are planned for the dry season. It also should be possible to restrict the amount of exposed area during the wet season so that the SS loading is reduced, and the storm water could be intercepted and directed through silt traps/sedimentation ponds which would allow much of the loading to be retained on-site.

During operation of the course no significant impacts are expected from the run-off during storm events apart from any additional nutrient loading which would be present. This is discussed in Sections 3.8 and 6.

Where motorised vehicles are maintained, and in other hard surfaced areas where fuel is stored, there is the potential for oil and fuel spills, especially at the fueling points, etc. Although such an event is unlikely, given the small number of vehicles on the site, oil traps would be installed in the drainage network of maintenance areas, and the traps would be regularly checked and maintained (see also 3.4.6).

3.8 Water Quality Impacts of Chemicals Usage

3.8.1 Principles

The scientific literature reveals that the chemical used most commonly on the golf course which is most likely to pose a threat to water quality is nitrogen and more specifically nitrate. This is the chemical most likely to impact on the water supply or water quality at Kau Sai Chau. Unlike nitrogen, phosphorous, the other major nutrient, is not readily leached.

The requirement for and the use of nitrogen fertilisers at Kau Sai Chau will be determined by the type of turfgrass chosen and the management practices adopted at the course. The impact of chemicals on water quality is based on assumptions about turfgrass management practices. Chemicals usage and their potential impacts are discussed in detail in Sections 6.7 to 6.10.

The Kau Sai Chau course is designed to utilize the natural catchments for the provision of the irrigation and potable water supply. About half of the holes will drain towards the sea. Drainage from the remainder of the course will either naturally fall to the reservoir or will be directed to the reservoir via pipes and gullies. The precise details of this drainage are currently in development but are summarised in Figure 2.4.

One potential concern is that of nutrients accumulating in the reservoir, or the potential effects on the marine habitats should nutrients leach from the course off site. Nutrient management is discussed in Sections 3.4 and 6, and the potential for impact on FCZs is discussed in Section 3.8.5.

3.8.2 Criteria

Threshold criteria for eutrophication in Hong Kong waters are generally regarded as nitrogen in excess of 0.3 to 0.5mg/l. (EPD, 1988. *Marine Water Quality in Hong Kong*). The WHO guideline value for nitrate nitrogen in drinking water is 10mg/l.

3.8.3 *Management of Nitrate Losses from Soil*

It is important to recognise certain aspects of the behavior of nitrogen fertilisers in soil. If soluble nitrate is present in the soil in a concentration greater than can be utilised by the grass, and there is surplus water to percolate through the soil, then leaching may occur. The use of insoluble or slow release forms of nitrogen will reduce leaching.

Leaching is more likely to be a problem on sandy greens whereas increased applications of nitrogen to sand-loam greens, commensurate with the ability of the grass to take up the nitrogen, does not necessarily lead to a deterioration in drainage water quality.

Turfgrass systems generally have high infiltration capacity and consequently the possibilities for surface runoff to lead to deterioration in water quality are significantly reduced. This will certainly be the case at Kau Sai Chau where sand will be used as the initial base growing medium for grass. Several studies indicate that losses of nutrients in surface runoff from grassland can be managed to very low levels (see Section 6).

The potential for the loss of subsurface nitrogen is greatly increased by irrigation and fertilization in excess of that which can be successfully utilised by the grasses. In addition the use of slow release fertilisers and timing of applications all contribute to the limitation of nitrogen losses.

There are three primary methods to be used at Kau Sai Chau which will act together to reduce non-point losses of nitrogen. Excessive irrigation will not be practiced at Kau Sai Chau since water supply will be at a premium. Slow release and realistic non-calendar applications of fertilisers, based on soil testing to suit specific turf requirements will be the methods of choice. Organic matter will be mixed with the native soils to ensure nutrients are retained in the sod.

3.8.4 *Quantification of Impacts*

A detailed quantification of impacts is provided in Section 6. In particular the discussion in Section 6.7.4 is relevant there, and is therefore partly repeated below for ease of reference.

A preference has been indicated to use bermudagrass for the greens and fairways at Kau Sai Chau. The following estimations of chemical usage will be subject to review but are based on typical application rates for bermudagrass fairways and greens in order to assess the likely impact of nitrogen fertilisers on water quality.

Application rates are usually given in pounds per acre or pounds per 1,000 square feet. Where conversion is necessary we have assumed 1,000 square feet to be approximately equal to 0.01 ha.

The two golf courses will consist of about 49 ha of fairways and 3.6 ha of greens (including practice areas). Application rates for the fairways range between 11 to 45 kg/ha/growing month with irrigation (lower rates without irrigation). Application rates for the bermudagrass greens range between 20 to 50 kg/ha for every 20 to 30 growing days with water soluble carriers (a slightly higher rate is used for slow release carriers).

Nitrogen applications per month to fairways would thus total a maximum of about 2,205 kg (49x45). On greens the figure would be 180 kg (50 x 3.6). Total monthly applications of nitrogen during each growing month would be <2400 kg. Assuming six growing months the total annual application would be <14,500 kg.

The literature indicates that good management practices can reduce leaching losses to <1%; it is therefore assumed that about 145 kg is leached. About half of the fertilised areas will drain to the reservoir, and therefore about 73 kgN/a could enter the reservoir.

The reservoir has a designed gross storage capacity of approximately 570,000 m^3. Thus if all the 73 kg nitrogen accumulated in the reservoir the resulting concentration would be :

$$73/570 = 0.13 \text{ mg/l}$$

3.8.5 *Evaluation of Impacts*

Given the above fertilization rates it seems likely that the reservoir would be subject to gradual eutrophication. If the predicted quantities of nitrate migrate into the water supply, the potable water criterion (10mg/l) would not be exceeded and nitrate levels would be at least an order of magnitude below the criterion.

For the current drainage regime half of the holes would eventually drain towards the sea creating at least potentially a diffuse low level source of nitrogen. However, this would most likely be mopped up by the roughs and adjacent natural vegetation. The ambient levels of inorganic nitrogen in the surrounding waters are below the criteria for eutrophication and given the massive diluting effects it is unlikely that any impact would be detectable in the marine habitats.

Overall the Project would have a minor impact on the Port Shelter WCZ. The chemical applications under the Turf Management Plan, (Sections 6), would be designed to minimise both usage and impacts off-site. In addition much of the Project area is a closed system forming much of the catchment of the reservoir area.

There is potential for run-off of some nutrients to the sea from those holes that are not part of the closed system catchment. However, given the distance of the holes from the sea and the intervening buffer areas of natural vegetation, the expected moderate fertiliser application rates, and the diffuse nature of any such run-off, it is most unlikely that there would be any impact by this on the WCZ.

The FCZ Sites A and B have no drainage from any of the golf holes and thus would be unaffected by any run-off from the course. Site C which has one remaining licence will receive some run off from holes 31 and 32. However, the maintained grass area for these holes is small, in the order of $1000m^2$. The impact of surface water run-off from this area is therefore considered to be insignificant. As noted in Section 3.2.1, Site D is remote from the Project area, and is unlikely to be affected.

The only effluent discharge from the Project area would be a diffuse overflow discharge of treated effluent during the wet season. The options for sewage treatment and disposal of treated effluent were considered in detail in Section 3.5 and are summarised in Tables 3.6 and 3.9.

It may be expected that there would be some deterioration in water quality in the immediate vicinity of the jetty, as a result of the effluent discharge, and from propeller wash from ferries and other boats. However any such deterioration would be expected to be very localised, with very little impact overall on the quality of the WCZ.

As noted in Section 3.2.2, the closest gazetted beaches are 2.5 to 3 km from the jetty. At this distance it is most unlikely that the project would have any effect on these beaches.

3.8.6 Mitigation

In order to mitigate the possible effects of eutrophication it is proposed to remove as much of the nitrogen from the drainage as possible. The method currently in development has been discussed earlier in this chapter. By introducing a weir or series of weirs at the head of the reservoir it is proposed that the dry weather flow from holes 1, 2, 7, 8, 9, 10, 17, 18, 19 and 20 could be intercepted. Water in this pond would be recirculated for irrigation purposes and monitored to determine nitrogen levels and the need for supplementary fertilisation. Thus the dry weather flow from these holes would be retained on this part of the course.

The ponding system would cross holes 10, 18, 19 and 20 linking the four smaller ponds currently proposed. Emergent macrophyte vegetation would be planted in the margins of the pond, and algae would become established in the ponds, which would utilise or mop up surplus nitrogen so reducing the load on the reservoir.

Herbivorous fish species (Refer Section 6) would be introduced to the ponds to crop off the algae. Excessive vegetative growth at the margins could be cropped off and composted at intervals to keep the system free flowing. The ponds adjacent to holes 9, 30, 33, 34 and tees 1, 10, 19, 27, could be similarly designed and could also provide habitat for waterfowl.

Good management practices, integrated pest control methods and the careful choice of chemicals will maintain chemicals at manageable levels. The methods of choice are discussed in Section 6.

3.9 Attachments

Attachment 1: Final Treated Water Quality

WSD (pers. com. 1994) Recommendations

(A) The water treatment plant shall be capable of producing a reliable and continuous supply of potable water which is pure and wholesome. The final water after treatment shall comply with the following standards:

pH	:	8.2 - 8.8
Colour	:	not exceeding 5 HU
Turbidity	:	not exceeding 1.0 FTU (prior to final pH conditioning)
Iron as Pe	:	not exceeding 0.10 mg/l
Manganese as Mn	:	not exceeding 0.05 mg/l
aluminium as Al	:	not exceeding 0.10 mg/l
Free residual chlorine	:	0.5 - 1.5 mg/l
Fluoride (F)	:	± 10% of nominal level (currently 0.5 mg/l)
Taste and odour	:	unobjectionable
Coliform organsims & *E. Coli.* (MPN/100ml)	:	absent

(B) For individual water quality parameters not referred to above, the parameters shall meet the guideline values in the "Guidelines for Drinking Water Quality, Volume 1 Recommendation" published by the World Health Organization, 1993. For those pesticides not specified in the WHO Guidelines for Drinking-Water Quality 1993, it shall comply with the EC drinking water Directive of a maximum admissible concentration of 0.1 μg/l for individual pesticides and 0.5 μg/l for total pesticides.

Consultants Comments

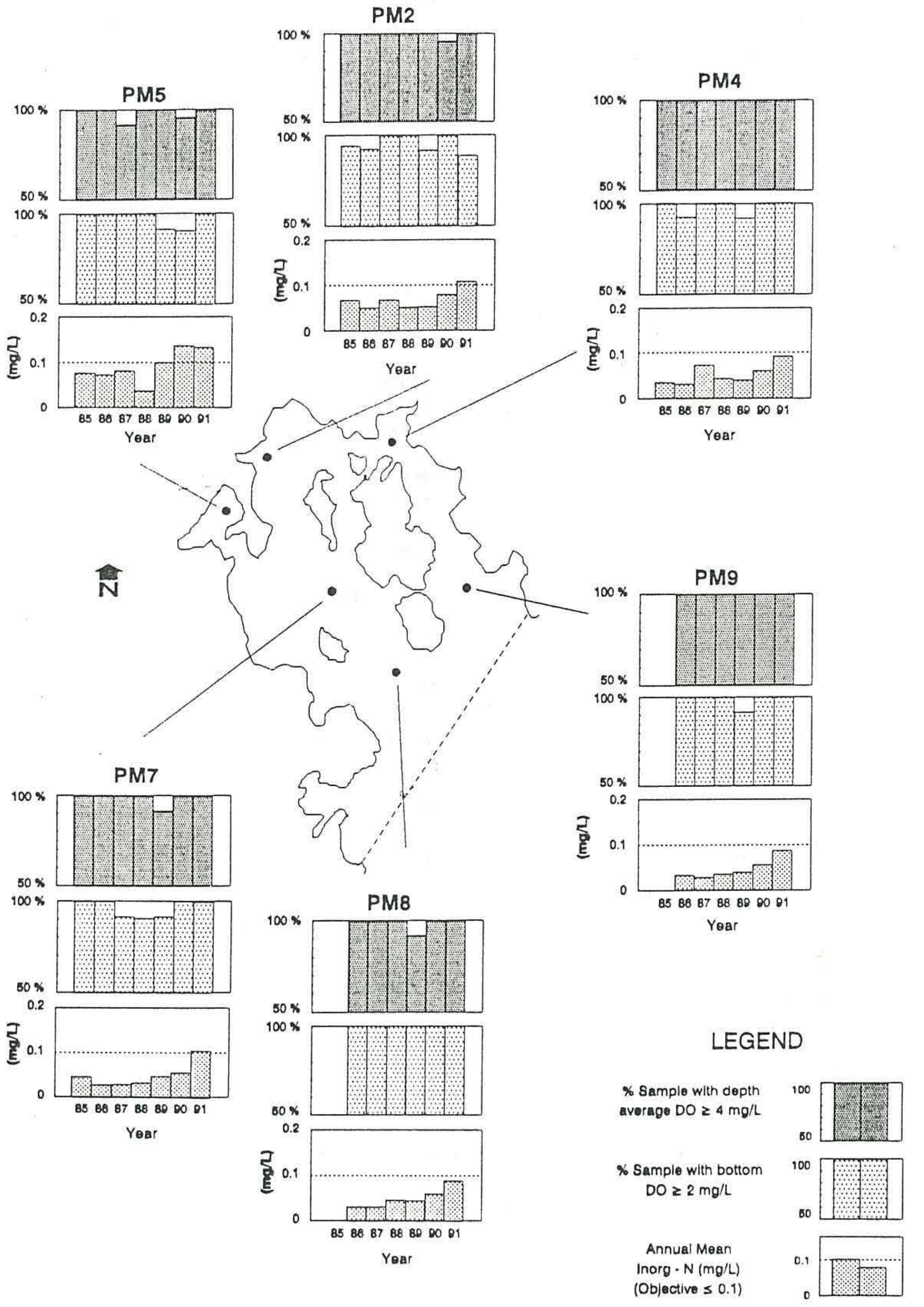
Neither WHO or EC cover the candidate chemicals for use on the golfcourse.

However, USEPA Drinking Water Health Advisory values expressed as Lifetime No Effect Health Advisory Limits for candidate chemicals are:

Carbaryl	0.70 mg/l
Glyphosate	0.70 mg/l

for a 70 kg adult drinking 2 litres per day with a safety margin of at least one order of magnitude.

We would recommend adoption of the USEPA standards for the candidate chemicals to be used at the golf course, since they are based on a toxicological evaluation of health risks and a methodology which derives similar figures to the WHO Guideline Values.

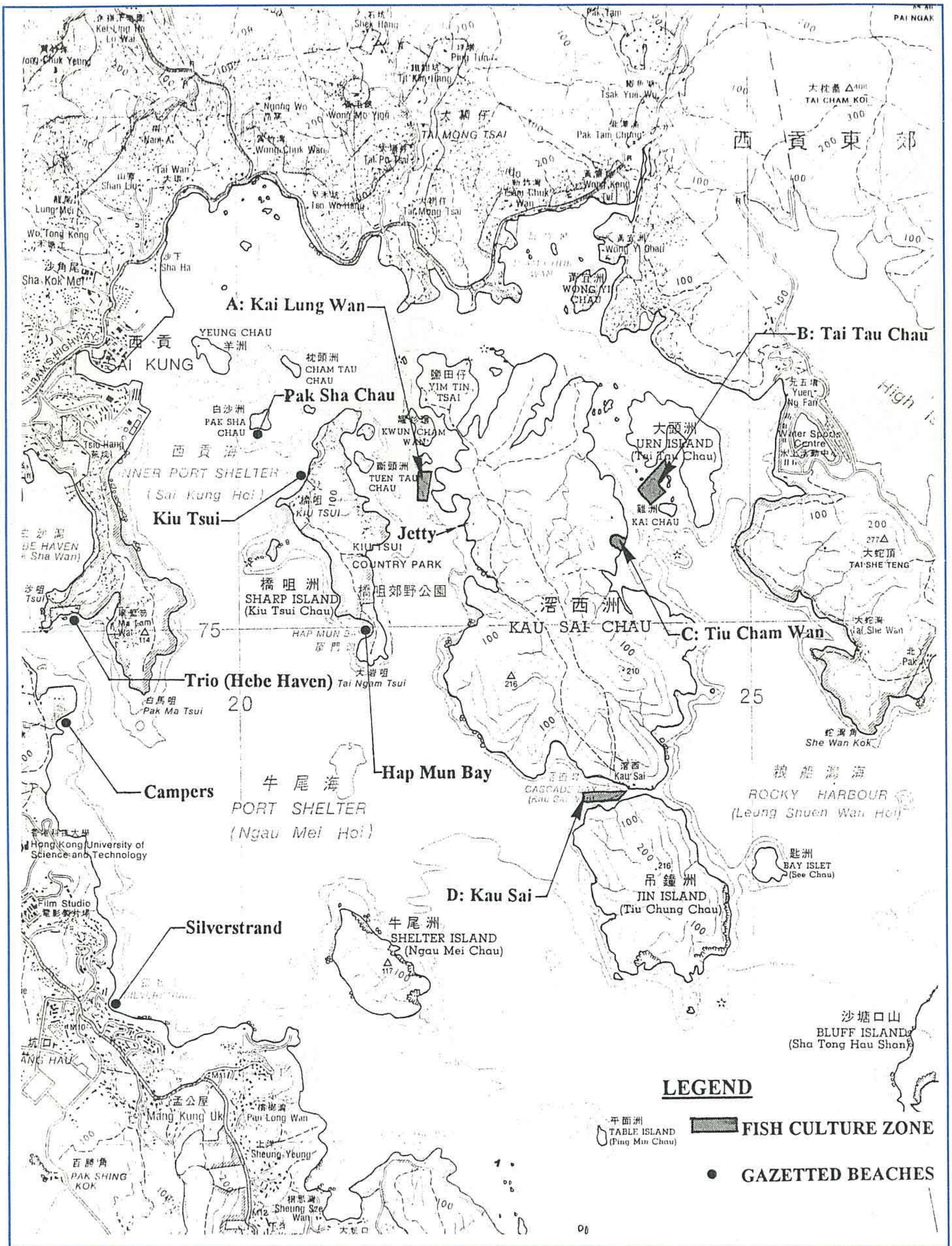


AXIS Environmental

Kau Sai Chau Project

Figure 3.1: Water Quality Compliance Rates in Port Shelter

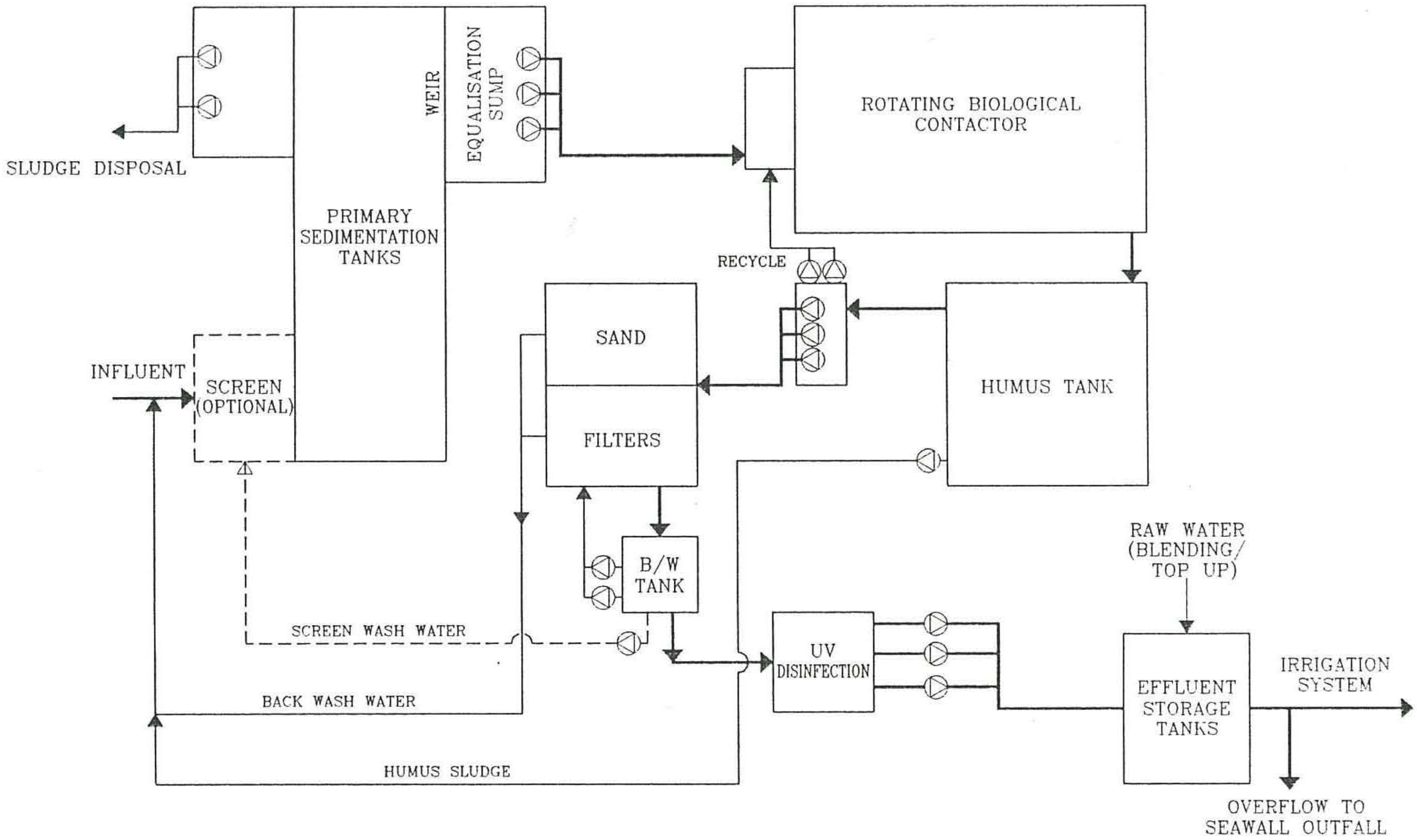
076000/ September 1993



Kau Sai Chau Project

Figure 3.2 Port Shelter Fish Culture Zones and Gazetted Beaches

076000/December 1993



KAU SAI CHAU GOLF COURSE
SEWAGE TREATMENT PLANT (SCHEMATIC)

AXIS Environmental

Kau Sai Chau Project

Figure 3.3 Sewage Treatment Facilities

07600/December 1993

LANDSCAPE AND VISUAL IMPACT ASSESSMENT

SECTION 4

4. LANDSCAPE AND VISUAL IMPACT ASSESSMENT

4.1 Introduction

Contemporary environmental assessment equates the value of good quality landscape and views to say clean air and water. Good landscape, is, therefore, considered a valuable environmental resource which development should seek to preserve and enhance.

There is no legislation in Hong Kong which specifically relates to the landscape and visual impact of development. However, a degree of control is achieved through the requirement to address visual issues as part of the environmental review and assessment process. The Environmental Protection Department's Advice Note (2/90), relating to the *Application of the Environmental Impact Assessment Process to Major Private Sector Projects*, identifies visual impacts as being an issue of concern to be addressed. Landscape impact, however, is not specifically identified.

The White Paper *Pollution in Hong Kong - A Time to Act* states that the Governments' overall policy objectives for environmental planning are:

'to avoid creating new environmental problems by ensuring the consequence for the environment is properly taken into account in site selection, planning and design of all new development'.

Whilst these policy objectives were originally related to the specific environmental issues of noise, air, water and waste disposal, they may now be regarded as applying to the landscape and visual impacts of development.

In addition, the Hong Kong Planning Standards and Guidelines Chapter 10 -Landscape and Conservation - outlines those design criteria which should be considered when planning within the rural environment.

This section of the report addresses these design criteria and presents the landscape and visual assessment of impacts for the proposed Kau Sai Chau golf development.

4.2 Approach

The approach to the evaluation of landscape and visual impact is based upon a proactive assessment technique, whereby design criteria are established at the outset of the Project in order to ensure an environmentally led form of development. The results of the preliminary assessment of impacts are fed back into the design process and the scheme progressively fine tuned as part of a single iterative design/assessment/redesign process.

Once the scheme design has been finalised at the detail design stage, a detailed assessment of the residual impacts is undertaken with a view to identifying mitigation measures. Final assessment will identify significant residual impacts remaining in Year 10 following completion of the construction process.

Figure 4.1 shows in flow diagram form the assessment method adopted in order to assess the potential landscape and visual impacts of the proposed Kau Sai Chau golf development.

4.3 Methodology

4.3.1 General

For the purpose of the environmental assessment process a clear distinction is drawn between landscape and visual impacts:

•landscape impacts relate to the effects of development upon the physical characteristics or components, which together form that landscape, e.g. landform, vegetation, streams, boulders and sand beaches etc.

•visual impacts relate to the changes arising from development to individual "receptor groups" views of that landscape, e.g. residents of Sai Kung or passing recreational boat users.

The form of landscape and visual impact assessment adopted for the proposed Kau Sai Chau development has been formulated in order to address the specific issues typically raised by a development of this scale and nature. The following section outlines the main components of this methodology.

In order for the subsequent assessment to be seen against the context of the existing landscape and individuals views of that landscape, the first stage of the assessment process is to establish the baseline conditions.

The baseline landscape and visual conditions are assessed through an appraisal of the:

- landscape context
- topography and natural drainage
- landuse, settlement and circulation
- vegetation
- landscape features
- views

- landscape character and perception.

For the purpose of comparison, and in order to establish a 'control' scenario against which effects may be assessed, the baseline conditions are projected forward to predict a 'no development' alternative to the development of the island for golf purposes. The appraisal of baseline conditions also assists in the formulation of those key environmental design criteria which should determine an appropriate form of development.
The key potential impacts of the proposed development upon the baseline landscape and identified receptor groups views of that landscape are then identified and assessed.

Potential Landscape and visual impacts (both positive and negative) are considered at three points in time:

- during construction
- on day of opening
- in year 10 of operation.

Through the assessment of impacts at these three points in time, distinctions may be drawn between temporary, permanent, cumulative, long term and short term effects.

Landscape and visual impacts identified may be further categorised as being either direct impacts i.e. within the study area or visual envelope or indirect impacts, e.g. off site visual impact of construction traffic movements.

4.3.2 Landscape Impacts

Landscape impacts are assessed at three levels:

- firstly in terms of the systematic consideration of impact upon individual landscape features;

- secondly in terms of the aggregate impact upon discrete Landscape Character Areas (LCA's);

- thirdly in terms of the overall impact of development upon the site.

The effects of development upon individual landscape features are assessed in order to "build up" an overview of landscape impact across the site.

Landscape impacts are predicted primarily on the basis of the order of change to baseline conditions prevalent at the time of assessment (September 1993). No attempt is made to "quantify" what is essentially a subjective but systematic and structured assessment process. However, a simple "scoring" system has been applied in order to cross relate and aggregate impacts across the site.

The criteria utilised in order to define potential impacts into the three generic categories of Severe, Moderate and Low are given below.

Impacts on Landscape Resources:

- character and quality of existing landscape
- key features of the existing landscape
- the nature of predicted impacts
- degree of change to key features
- the ability of the landscape to accommodate change (i.e. sensitivity)
- the significance of change within a local, regional and national context.

4.3.3 *Visual Impacts*

The assessment of visual impacts is structured by individual receptor groups. Receptors are identified through the definition of a visual envelope, or zone of visual influence, within which views of the development are possible and the categorisation of individuals into 'user groups' within that envelope area. The sensitivity of receptors is categorised as being high, moderate or low. Highly sensitive receivers include existing residents of Kau Sai village and passing recreational boat users. Moderately sensitive receivers include visitors to the Louisa Landscape Guides Camp on Yim Tim Tsai island. Low sensitiveity receivers would, for example, include workers on the adjoining fish farms.

The sensitivity of receptors relates principally to four factors:

(i) social, cultural, and educational background
(ii) receptors function whilst exposed to view
(iii) degree of exposure to view
(iv) period of exposure to view.

The criteria used to assess the degree of visual impact (severe, moderate and low) are as follows:

- value of existing views
- degree of change to existing views
- proximity of receptor
- sensitivity of receptor
- number of receptors in group
- availability of amenity value of alternative views.

It should be noted that the effects of development which are considered negligible in their impact (i.e. low) are termed insignificant whereas moderate and severe impacts are termed significant.

4.3.4 *Mitigation Measures*

As a result of the highly inter-dependant nature of the effects of development, proposals to mitigate unacceptable landscape and visual impacts are considered together. Significant landscape and visual impacts identified during the assessment process (i.e. those impacts categorised as either Moderate or Severe) have, where possible been the subject of specific mitigation proposals and are thus, 'designed out' of the project through the masterplan. These proposals, in the case of landscape and visual impacts, may vary in scope from the major redesign of areas to the introduction of protection measures for valuable landscape features during construction. Additional mitigation proposals are outlined for the construction and operational phases of the development where necessary.

4.3.5 *Monitoring procedures*

Where required, appropriate monitoring procedures are specified to ensure the protection of valuable landscape features during construction and the successful establishment of on and off site planting during the operation of the project.

4.4 The Existing Landscape

4.4.1 *Landscape Context*

Kau Sai Chau is the fifth largest island in Hong Kong and is the largest "free standing" island off the eastern coast of the New Territories. Located in the centre of Port Shelter, the island forms a central feature with its mountain peaks rising to over 200m ASL (Figure 1.1).

Kau Sai Chau is encircled by a ring of smaller islands which characterise Port Shelter including:

- Yin Tin Tsai
- Sharp Island
- Shelter Island
- Jin Island
- High Island and
- Urn Island.

Port Shelter Bay is, in turn, enclosed by the Sai Kung and Ma On Shan mountain ranges to the west, north and east which form a dramatic 'backdrop' to the indented Sai Kung coastline.

4.4.2 *Topography and Natural Drainage*

Topographically, the landform divides the island into two distinct areas (Figure 1.2). The northern half is comparatively low, with a maximum elevation of 72m . An undulating series of ridges and valleys form two principal dendritic drainage systems which outflow from the north and east coasts. The northern extremity of the island comprises two elongated headlands divided by the Kwat Tau Tam inlet. The coastline of the islands northern half is characterised by a well vegetated steeply sloping shoreline rising from sea level to an elevation of between 10 & 20m ASL. This coastal strip largely precludes views inland from sea level. In contrast the southern half of the island displays a mountainous landform rising directly from sea to culminate in three peaks at over 200m ASL. The 'grain' of this mountainous landscape is aligned NS/SE and is defined by a series of steeply sloping 'V' shaped valleys which extend from the coast to the high level valleys which separate the mountain peaks.

4.4.3 *Landscape Use, Settlement and Circulation*

Kau Sai Chau is the largest island in the Port Shelter area of eastern Hong Kong. The island has been used until 1975 as recently used as a practice range by Hong Kong government (and possibly by WWII occupation forces) for military training in aerial bombing and artillery shelling. There are signboards at numerous locations around the shoreline advising that the island is dangerous and public access is denied. There are currently no opportunities for public recreation except for pleasure boating off-shore, bathing-picnicking at several small beaches and occasional use for orienteering purposes.

Kau Sai Chau is underdeveloped, and largely uninhabited. Apart from the small fishing village of Kau Sai on the southern tip of the island, the nearest permanent developments is the Hong Kong Girl Guides camp (Louisa Lansdale Camp) on Yim Tin Island to the north-west. There are a number of abandoned fields located on the floor of the eastern central valley, and a single farm worker's hut on the valley side. Overhead power lines cross the island from Yim Tin Tsai to Kau Sai whilst on the west side of the island, there is a galvanised steel water pipe which appears to serve as a fresh-water supply to the mariculture off the west coast.

Except for the few small abandoned farm plots, there is no evidence of agriculture on the island. However, a low dam has been built across the Kwat Tau Tam inlet to aid in the trapping of fish in the channel at high tides.

Although public access to the island is discouraged, a number of groups use the island intermittently including relatives of those persons whose remains are buried in graves, orienteering parties and guides from the Yim Tin Tsai Camp. Two tracks link Yim Tin Tsai island in the north with Kau Sai village on the southern coast, whilst two ridgeline paths extend northwards along the headlands which enclose the Kwat Tau Tam inlet.

4.4.4 Vegetation

As a result of shelling and recent hill fires, Kau Sai Chau's vegetative cover is principally grass and low scrub. The exceptions are the moist gullies which are well vegetated with areas of diverse scrub/woodland, and the steeply sloping zone with its scrub woodland upper slopes and inter-tidal mangrove. Figure 5.3 shows the distribution of vegetation across the northern part of the island.

The vegetation of Kau Sai Chau cover is, therefore, largely a reflection of the effects of fire upon the process of natural regeneration. The recent effects of fire restricting the development of scrub are most evident in the northern parts of the island, particularly in areas where graves are concentrated.

Table 5.1 contains a summary of those plant species present on Ka Sai Chau.

4.4.5 Landscape features

The principal features of the islands landscape relate to its dramatic and contrasting topography and vegetation, which varies from the intimate sub-tropical enclosure of the Kwat Tau Tam valley to the barren mountainous peaks and valleys to the south. The diverse scrub/woodland of the coastal margins and valleys contrast with the exposed grassland ridges.

Other landscape features of note include a number of small sandy beaches, including Whiskey Beach and Cascade Bay, several small coastal waterfalls and areas of intertidal mangrove, prehistoric rock carvings and the numerous craters which are the legacy of shellfire.

4.4.6 Views

The mountainous topography and high scenic value of Port Shelter combine to create numerous views both of and from Kau Sai Chau of considerable visual amenity value. Views of the islands lower areas are, however, largely obscured from sea level views by the steeply sloping intervening coastal edge. The proposed development site's immediate "visual envelope" is limited by the adjoining islands and the mountainous southern half of the island.

4.4.7 Landscape Character and Perception

As a consequence of Kau Sai Chau's undeveloped character, its appearance contributes significantly to the natural visual amenity value of Port Shelter.

Together with the Sai Kung Country Park and a plethora of smaller islands, Kau Sai Chau forms a key component of the Port Shelter archipelago and contributes to its function as the primary coastal recreational resource for Hong Kong. This function is recognised in the areas current zoning as a Countryside Conservation Area (CCA) by Sai Kung District Planning Office.

4.5 The "No Development" Scenario

Should the development of Kau Sai Chau for golf purposes not proceed the islands landscape may evolve in a number of ways. The most likely scenario, however, given the islands designation as a Countryside Conservation Area, is that the northern areas will continue to be regularly subject to burning as a result of the intensification of burial sites. Further to this, the central and western areas subject to shell damage will continue to erode further exposing increasingly large areas of bare rock to view. The areas of scrub/woodland protected from the effects of fire in moist gullies and along the coastal margins are, however, likely to regenerate further towards the establishment of a sub-tropical climax woodland.

It is considered unlikely that active agricultural use on the island would resume, whilst occasional informal recreational uses would continue.

4.6 Key Environmental Design Criteria

Following a preliminary assessment of the baseline landscape and visual conditions characteristic of the proposed development site, a number of environmental design criteria were established in order to guide the form of development in an environmentally responsive manner. The following criteria were aimed at the mitigation of potentially significant landscape and visual impacts as an integral part of the design process:

~ cut and fill is to be balanced and earthworks limited to the area of course construction i.e. the use of "off site" borrow areas on the island is not required in view of the disturbance to the natural topography and the difficulties of revegetating and stabilising cut slopes in the exposed coastal environment.

~ planting would make good vegetation removed through construction, screen exposed parts of the course from sea level views as much as is practicable, and seek to maintain the undeveloped character of the island.

~ the external face of the reservoir dam is to be concave in alignment, graded into the adjoining landform and revegetated to replicate natural coastal vegetation.

- a "Coastal Protection Strip" is to be left intact and undisturbed during construction and natural regeneration/colonisation protected during operation as part of the course management plan.

- the four headlands are to be retained as features and natural regeneration/succession protected and encouraged through course management.

- where possible the upper Kwat Tau Tam Valley ecosystem would be retained as a landscape feature within the course(s).

- the ferry pier is to be timber clad and any shelter or structures designed in traditional style and constructed of timber. Where necessary treated timber will be used for long durability.

- adequate landscape protection measures will be implemented during construction.

- new course planting is to be of indigenous species, tolerant of coastal exposure, and of documented ecologically utility. Ornamental planting of exotics is not considered acceptable. Planting would be designed and managed to facilitate the progressive establishment of sub-tropical climax woodland, where appropriate.

- course planting would seek to integrate the adjoining coastal areas, headlands and gulleys into the course landscape structure.

- driving range gallery is to be sited and designed to minimise visual impact.

- opportunities for habitat creation and protection through course design are to be maximised and ecological corridor links provided to existing habitats.

- the club house is to be two storey, and the residential accommodation and maintenance depot are to be single storey, and constructed of appropriate materials and finished in order to blend into the rural landscape.

- access road turning area and parking areas are to be integrated into the landform, avoiding retaining walls or hard surfaced cut slopes where possible.

- construction disturbance of the shoreline is to be minimised and reinstated where necessary.

- areas of shell damaged hillside beyond the golf course area would be stabilised and revegetated over time as an off site mitigation measure.

4.7 Potential Landscape Impacts

Landscape Character Areas

In order to assess the potential landscape impacts, the site has been sub-divided into 7 discrete Landscape Character Areas (LCA's). Each of which has a subtle but clearly identifiable, landscape character (Figure 4.2). The assessment of landscape impact is therefore undertaken in relation to the potential impacts of development upon the physical components which make up each LCA's individual character at three points in time:

- during construction (1993-1995)
- on day of opening (December 1995)
- in year 10 of operation (2005)

The results of this assessment are then brought together to form an overview of landscape impacts within each LCA and subsequently across the whole site, over a 12 year period. Reference should be made to the Development Master Plan in considering this assessment.

Landscape Character Area 1 (LCA1)

LCA1 comprises the outer tidal reaches of the Kwat Tau Tam inlet. This coastal inlet forms a cohesive landscape feature with its steeply sloping, well vegetated sides, its mangrove lined shore, intertidal mud flats and boulder strewn beaches. The construction of a new dam across the inlet and the flooding to a depth of 10m of the valley's upper reaches, will result in a severe construction landscape impact as a consequence of the total loss of those landscape features inundated.

Mitigation through the transplanting of mangrove and the revegetation of the dam face will not mitigate the long term severe operational landscape impacts to a significant degree.

Landscape Character Area 2 (LCA 2)

LCA2 forms the upper reaches of the Kwat Tau Tam inlet. This valley feature forms a self contained ecosystem of significant landscape value. The combination of steeply sloping valley sides, a diverse scrub/woodland vegetation cover and the flowing stream combine to create an intimate sub-tropical landscape.

The current golf course design proposals will involve the infilling of this valley system and the total loss of its various landscape features. This would result in both severe constructional and operational landscape impacts, incapable of effective mitigation.

Landscape Character Area 3 (LCA3)

This area is clearly distinguished from the remainder of the proposed development site by its peninsular landform and grassland vegetation. Recent hillfires, within the last 2-3 years, have limited the extent of natural regeneration to a grassland layer. The exception to this being the presence of occasional self sown pine saplings (Pinus elliotii) within the grass sward, the diverse scrub/woodland coastal margins and small areas of mangrove which characterise Yim Tin Tsai channel.

The northern headland of LCA3 beyond the proposed dam site and the western headland which contains the rock carvings are to be left intact and undisturbed by the proposed development. However, the intervening central part of the peninsular will accommodate holes 11-17 of one course. The green for hole 12 will involve minor regrading and clearance of a limited area of diverse scrub/woodland, whilst the construction of holes 13, 15, 16 and 17 will require some limited localised regrading. The construction of holes 11 and 14 will require virtually no regrading of the natural landform.

The impact of course construction upon the landform and vegetation of this area will, therefore, be moderate whilst the long term operational impacts will be reduced to a low level as the fairways and rough swards become established and new planting progressively matures.

Landscape Character Area 4 (LCA 4)

LCA4 comprises the peninsular to the east of the Kwat Tau Tam estuary. This grass covered area accommodates numerous graves and has, as a result, suffered from repeated hill fires which have limited vegetative cover to grass. The tip of the headland to the north of the proposed dam is to be retained intact and undisturbed by the construction of the golf course. The remaining undulating landscape which comprises LCA 4 will accommodate the entirety of hole 22 and parts of holes 21, 23, 24 and 25.

Holes 24 and 25, located in the centre of the peninsular, will require minimal regrading. Holes 21, 22 will necessitate some limited changes in landform to accommodate fairways and greens, whilst the construction of hole 23, located on the east coast will require considerable regrading of the natural landform. The impact of these construction works upon the landscape of LCA 4 is considered to be moderate whilst the operational impact, by Year 10, will be mitigated to a low level, as a result of the maturation of course planting. The long term impact of the proposed development may, however, be considered positive in landscape terms, as hill fires are irradicated and natural regeneration encouraged as part of the course management plan.

Landscape Character Area 5 (LCA5)

LCA 5 comprises the eastern coastal extent of the proposed development site. This area includes the highest range of grass covered hills in the northern half of the island and as such is largely excluded from the area of golf development. Holes 31, 32 and 33 and half of hole 34, are, however, located along the lower valleys and ridges of the southern part of this area. (Figure 2.1)

The landscape impact of the construction of these holes relates principally to significant changes in natural landform required in order to accommodate new lakes and fairways, particularly for Hole 33. Holes 31 and 32 require minimal regrading.

The landscape impact of these works during construction will be moderate, whilst by Year 10 of operation, the disturbance will be reduced to a low level as the course becomes integrated into the islands maturing landscape structure.

Landscape Character Area 6 (LCA 6)

LCA 6 comprises the largest central portion of the development site. This inland area comprises a complex ridge/valley landscape which partly distinguished from the adjoining areas by virtue of its more highly developed and diverse low scrub ground cover and the absence of shellfire damage. Several deep valleys and gulleys also contain areas of diverse well established scrub/woodland. This area is the most intensely developed part of the site and includes the club house, practice facility and holes 1, 26, 27, 28, 29, 30, 35 and 36, and parts of holes 18, 19, 20, 21, 23, 24, 25, and 34 and several proposed water bodies. (Figure 2.1).

The construction impact upon both the natural landform and vegetation of the area will be severe in the higher more extreme areas to the south, whereas the impact upon the lower more gently undulating areas to the north (holes 21, 24, 25, 26 and 29) which require minimal regrading will be moderate.

The long term landscape impacts upon LCA 6, however, will be mitigated to a moderate level by Year 10 by virtue of the maturation of the courses landscape structure planting.

Landscape Character Area 7 (LCA 7)

LCA7 differs from LCA6 principally in the concentration of shell fire damage and subsequent severe gullying erosion in this area. Since shelling ceased in 1975 shell craters have, as a result of rainfall action, progressively increased in both area and depth. The area also includes well vegetated tributary valleys of the Kwat Tau Tam inlet.

The construction of Holes 2, 3, 4, 5, 6, 8, 9 and 10 across this complex undulating landform will result in extensive regrading as valleys are filled and ridges levelled to accommodate tees, fairways and greens. However, construction of the course will facilitate the stabilisation and revegetation of areas of shellfire damage, both within LCA7 and in off site areas to the south.

Thus, although the overall landscape impact of construction will be severe in this area, the long term impact will be positively beneficial.

Summary of Landscape Impacts

Table 4.1 summarises the aggregate potential landscape impacts of development upon each Landscape Character Area during construction, on day of opening and in Year 10 of operation. From this table, it may be seen that the construction and day of opening impacts of the development as a whole are considered to the Severe, whereas by Year 10 of operation the impact will be mitigated to a moderate level, principally as a result of the maturation of planting, and stabilisation and revegetation of shell damaged areas.

Table 4.1 Summary of Landscape Impacts

	Construction		Day of opening		Year 10	
LCA 1	SEVERE	3	SEVERE	3	SEVERE	3
LCA 2	SEVERE	3	SEVERE	3	SEVERE	3
LCA 3	MODERATE	2	MODERATE	2	LOW	1
LCA 4	MODERATE	2	MODERATE	2	LOW	1
LCA 5	MODERATE	2	MODERATE	2	LOW	1
LCA 6	SEVERE	3	SEVERE	3	MODERATE	2
LCA 7	SEVERE	3	MODERATE	2	POSITIVE	-

KEY: SEVERE = 15 - 21 MODERATE = 8 - 14 LOW = 1 -7

4.8 Potential Visual Impacts

4.8.1 Visual envelopes and receptors

Visual Envelopes

The primary and secondary visual envelopes for the site are shown on Figure 5.3. From this assessment, it may be seen that notwithstanding the Kau Sai Chau's coastal location the area within which close views of the development site will be visible is limited by:

- the surrounding islands
- Kau Sai Chau's mountain range to the south.

A secondary visual envelope extends across the mainland mountain skylines of Ma On Shan and Sai Kung Country Parks. Views of Kau Sai Chau from between the primary and secondary visual envelopes will, however, be intermittent and distant, with the development site forming a relatively insignificant part of the wider landscape.

Key viewpoints

Figure 5.3 identifies 5 key external viewpoints from which views of the site will be obtained:

- Sharp Island and Channel (Viewpoint 1)
- Floral Villas, Tai Mong Tsai (Viewpoint 2)
- The Japanese Occupation Memorial off Sai Kung Road (Viewpoint 3)
- The navigational channel to the north (Viewpoint 4)
- Rocky Harbour (Viewpoint 5).

It should be noted, however, that as a function of the elevated "plateau" nature of the proposed golf course site, sea level views of the course(s) and the associated structures will be limited. Where elevated views over the island are obtained from the mainland (e.g. Viewpoints 2 and 3), these are relatively distant and the site forms part of a wider panorama.

Receptor Groups

In order to assess the potential visual impacts of the proposed development it is necessary to identify the key visual receptor groups and evaluate their sensitivity to changes in their views of the site.

The receptor groups identified within the sites primary visual envelope and their sensitivity to change are classified as follows:

~ High Sensitivity Receptors

- residents of Kau Sai
- passing recreational boat users
- visitors to Kiu Tsui Country Park

~ Medium Sensitivity Receivers

- visitors to Yim Tin Tsai Camp
- residents of Tai Mong Tsai
- visitors to Japanese occupation Memorial

~ Low Sensitivity Receivers

- motorists on Sai Kung Road
- workers on adjoining fish farms

4.8.2 *Visual Impact Assessment*

High Sensitivity Receivers

(i) Existing residents of Kau Sai village

The small fishing village of Kau Sai is located on the southern tip of the island in the narrow channel which separates Kau Sai Chau from Tiu Chung Chau. Although the village has no direct views of the proposed golf development, the presence of two footpaths which link Kau Sai village to the ferry pier off Yim Tin Tsai, will require their diversion and residents to cross part of the proposed course.

The visual impact of the developments construction will be severe upon those residents who use these footpaths. This impact will reduce to a moderate level, however, as the site landscape planting matures and areas of shell damage, both within and outwith of the site, are restored.

(ii) Passing recreational boat users

Port Shelter is one of Hong Kong's most scenic and popular cruising waters. Those recreational boat users who pass the island, particularly in the navigational channel to the north and east, are highly sensitive to changes in the quality and nature of the coastal landscape.

As a function of the elevated plateau landform of north Kau Sai Chau and its steeply sloping coastal margins, sea level views of the islands interior are limited.

Thus, whilst some limited coastal areas will be disturbed during the construction process, the maintenance of a coastal protection area and the progressive maturation of existing and new indigenous planting will effectively mitigate those severe constructional impacts to a moderate level by Year 1 of operation and to a low level by Year 10.

(iii) Visitors to Kiu Tsui Country Park

Occasional visitors to the island of Kiu Tsui have unobstructed views across the intervening channel towards the proposed site of Kau Sai Chau golf course (Figure 5.3). The intervening distance and the form of development will largely mitigate the visual impacts of the sites operation. Sea level receptors will, however, be aware of increased ferry movements and the construction of a substantial pier, whilst country park visitors walking the elevated ridgeline trails will have an overview of the golf course itself.

The visual impacts of construction are, therefore, considered to be severe whilst the operational impacts will be mitigated to a moderate level by virtue of the maturation of existing and proposed planting.

Medium Sensitivity Receivers

(i) Visitors to Yim Tin Tsai Camp

The girl guide camp on Yim Tin Tsai island is a popular and well established facility used by groups of guides from throughout Hong Kong. Despite the camps proximity and elevation, views from Yim Tin Tsai are severely limited by the islands well established vegetation and the camps westward orientation. The visual impact of the developments construction phase will be moderate and relate partly to the passage of seaborne construction traffic, whilst the operational impact will be low and also partly relate to regular ferry movements.

(ii) Residents of Tai Mong Tsai

A number of scattered, waters-edge, residential properties overlook the north of the island from Sai Kung road whilst a number of villa developments located in the foothills also have a distant overview of Kau Sai Chau.

The visual impact of the construction phase of works will be severe as a result of the extensive earthworks required. However, this will be mitigated by seeding and sprigging works in Year 1 to a moderate level and by planting in Year 10 to low level.

(iii) Visitors to the Japanese Occupation Memorial

Several publicly accessible viewpoints exist along the Sai Kung coast road which provide views of Kau Sai Chau between its surrounding islands. The most prominent of these is the Japanese Occupation Memorial.

These lower level views of the north coast of the island will be affected by the proposed golf course earthworks, although the preservation of the islands headlands will assist in the screening of these works. The moderate visual impact of the schemes construction will be mitigated by the maturation of existing and proposed coastal planting to a low level.

Low Sensitivity Receivers

(i) Motorists on Sai Kung Coast Road

Motorists travelling in either direction on the Sai Kung coast road obtain intermittent glimpses of Kau Sai Chau through the woodland which characterises this part of the Sai Kung coast. The visual impact of the developments construction and operation upon this receptor group will be low.

(ii) Workers on adjoining fish farms

Two mariculture areas are located off the east and west coasts of Kau Sai island. Workers on these fish pens will have limited sea level views of the construction process where holes encroach upon the coastal slopes. These views will, however, be of low impact during both the construction and operation phases.

4.8.3 *Summary of Visual Impacts*

Impact on identified receptors

Table 4.2 summarises the potential visual impacts of development upon each of the identified receptor groups, during construction, on day of opening and in Year 10 of operation.

From this table, it may be seen that the overall visual impact of the construction phase of the development will have a generally severe impact upon receptors. However, by Year 10 of operation, this impact will have been mitigated to a moderate level.

Table 4.2 Summary of Visual Impacts

Receptor Group	Construction		Day of opening		Year 10	
HIGH SENSITIVITY						
(i)	SEVERE	3	SEVERE	3	MODERATE	2
(ii)	SEVERE	3	MODERATE	2	LOW	1
(iii)	SEVERE	3	MODERATE	2	MODERATE	2
MEDIUM SENSITIVITY						
(i)	MODERATE	2	MODERATE	2	LOW	1
(ii)	SEVERE	3	MODERATE	2	LOW	1
(iii)	MODERATE	2	MODERATE	2	LOW	1
LOW SENSITIVITY						
(i)	LOW	1	LOW	1	LOW	1
(ii)	LOW	1	LOW	1	LOW	1
TOTAL		18		15		10

KEY: SEVERE = 17 - 24 MODERATE = 9 - 16 LOW = 1 - 8

Indirect and off site visual impacts

During the construction phase of development an intensification of sea born construction traffic will result in insignificant visual impacts upon those receptor groups previously identified. Similarly any additional construction traffic using Hirams Highway will cause a nominal increase in visual impact to those residents of Sai Kung who overlook the road corridor.

During the operational phase the increase in road and sea bourn traffic movements will result in an insignificant intensification of visual impact upon receptor groups. The off site regrading, stabilisation and revegetation of shellfire damaged hillsides in the southern half of Kau Sai Chai is a positive landscape and visual impact to arise from the proposed development.

4.9 Mitigation

Where possible those landscape and visual impacts identified at an early stage of the design/assessment process have been addressed through the project masterplan. Thus, the environmental design criteria specified in Section 4.6 have been incorporated as practicable in an environmentally led plan.

Landscape Mitigation

The site masterplan for the development of Kau Sai Chau, whilst requiring substantial regrading of the islands naturally undulating landform in order to create a playable course, does retain the well vegetated coastal edges and headlands largely intact and undisturbed. The loss of diverse scrub/woodland from infilled gulleys and the flooded Kwat Tau Tam estuary is, however, only partly mitigated by the provision of replacement indigenous planting. The scarred appearance of the present landscape will also be mitigated by the revegetation of bombed and fire damaged areas. The wider landscape impact of the inundation of the Kwat Tau Tam inlet is largely incapable of mitigation.

Landscape mitigation in the form of the control of hillfires will progressively enable the regeneration of an indigenous and diverse scrub/woodland on the headlands and around the coastal edges. New planting can extend these areas of indigenous woodland habitat between the course fairways to form new landscape features.

A comparison of the extent of scrubland, to be removed/transplanted, with the areas subject to bomb damage and hill fires is presented in Figure 4.4. Wherever possible the scrub vegetation will be transplanted to a location to the edge of the nearest holes fairway/rough. These plants will also be used as natural hazards where appropriate.

Mitigation (compensation) planting with native species will also take place at locations on all holes and will exceed the scrub removed overall. However, at this stage the detailed Landscape Master Plan is yet to be finalised. It is clear from Figure 4.4 that revegetation will far exceed the removal of some areas of scrub.

Detailed planting plans for the development of Kau Sai Chau will form a key component of the schemes mitigation measures.

Visual Mitigation

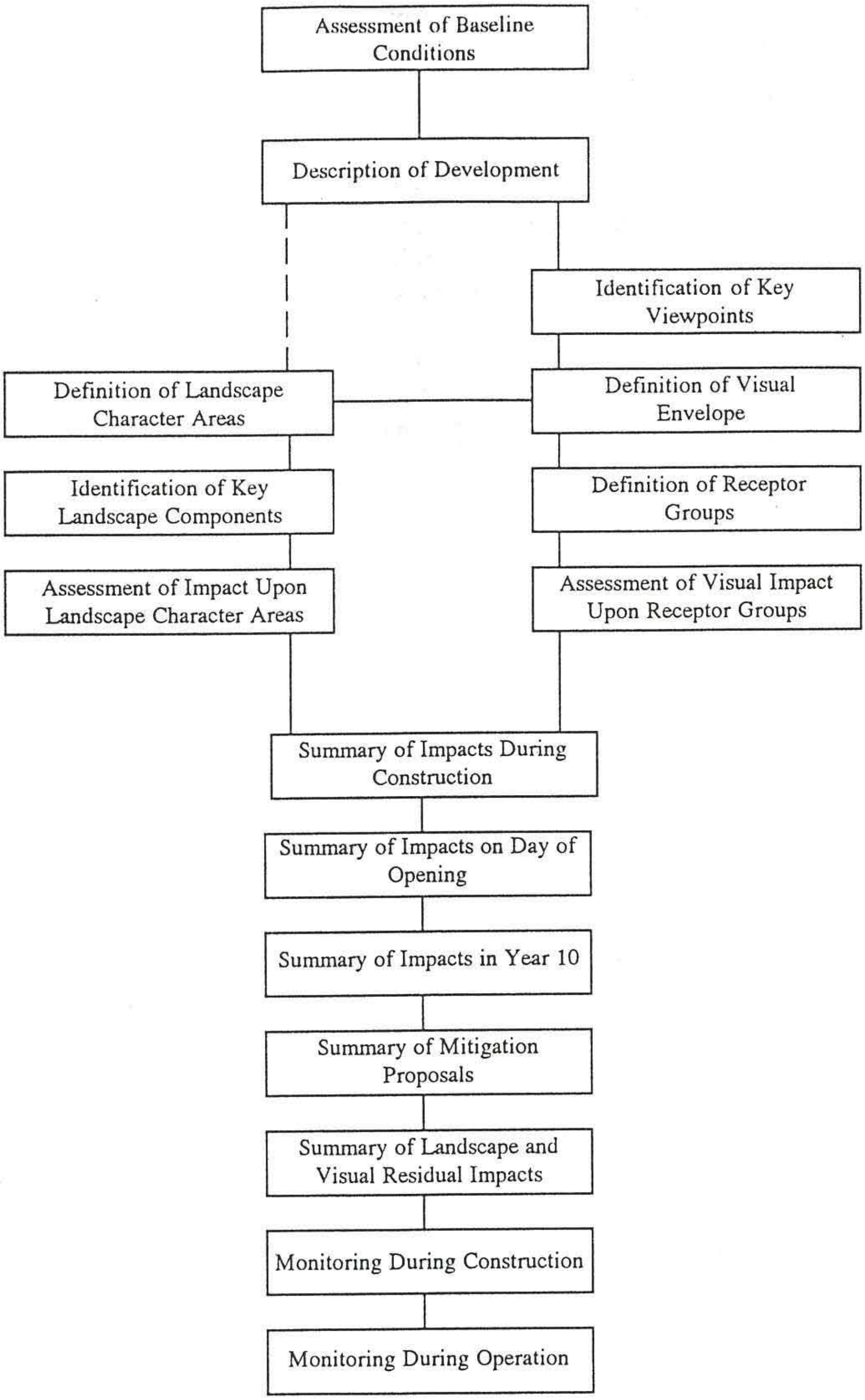
The mitigation of the visual impacts of development is closely related to those landscape mitigation measures proposed.

The key visual mitigation measure identified is the retention of a coastal protection area during construction and the subsequent management of the natural succession of this diverse scrub woodland belt in order to provide a visual screen to the course, particularly from sea level.

4.10 Landscape Management

It is proposed that a detailed Landscape Management Plan to be prepared for the short term establishment and long term maintenance of the islands landscape. The Plan should address all aspects of course management including the use of chemicals (fertiliser, herbicides, pesticides) and the management of the course landscape for habitat creation purposes.

A key long term objective of the Management Plan would be the establishment of a diverse, stable and natural landscape structure for the course which is fully integrated into the islands natural vegetation.



AXIS Environmental

Kau Sai Chau Project

Figure 4.1: Landscape and Visual Assessment Methodology

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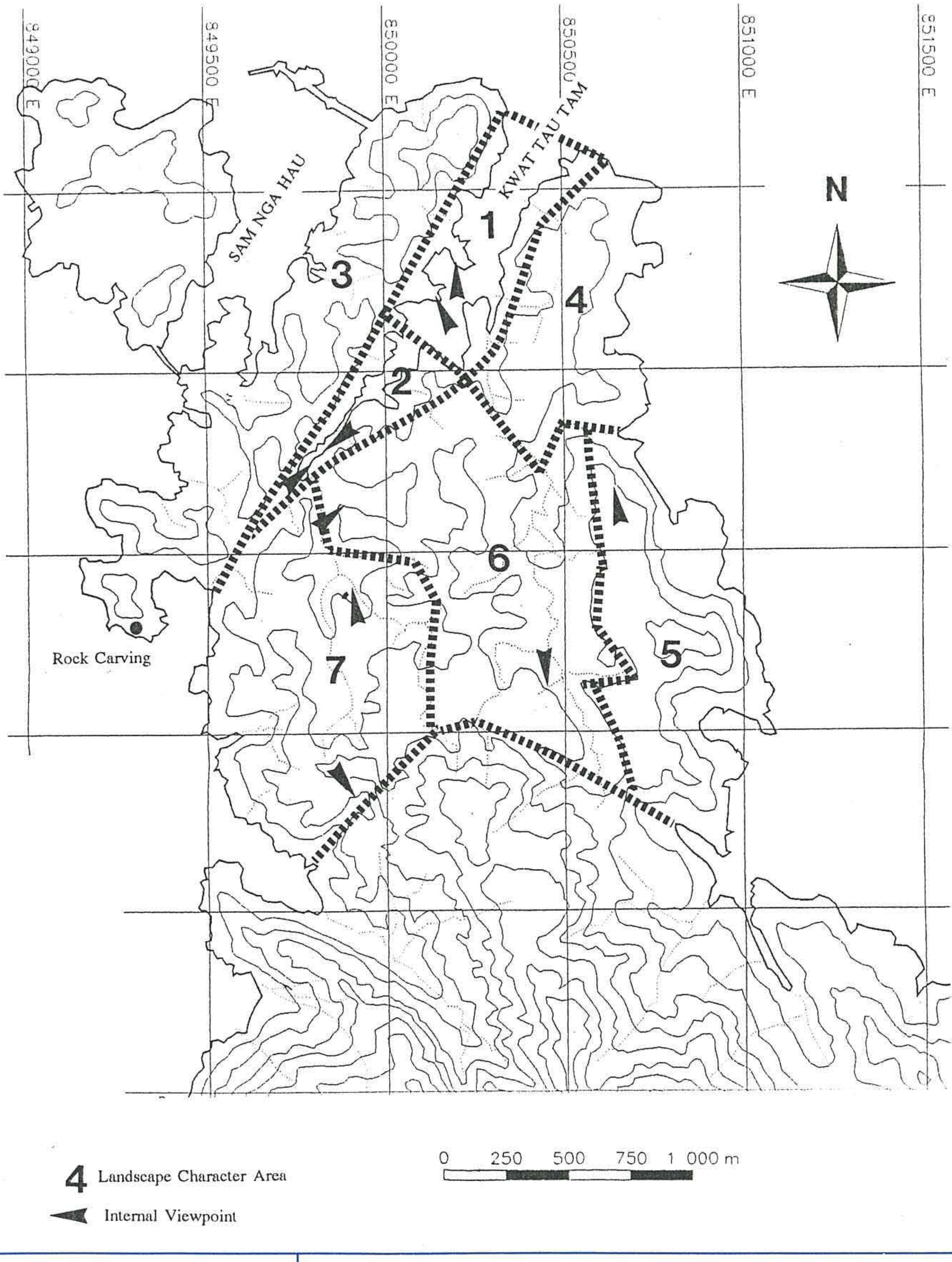

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Figure 4.2: Landscape Character Areas and Internal Viewpoints

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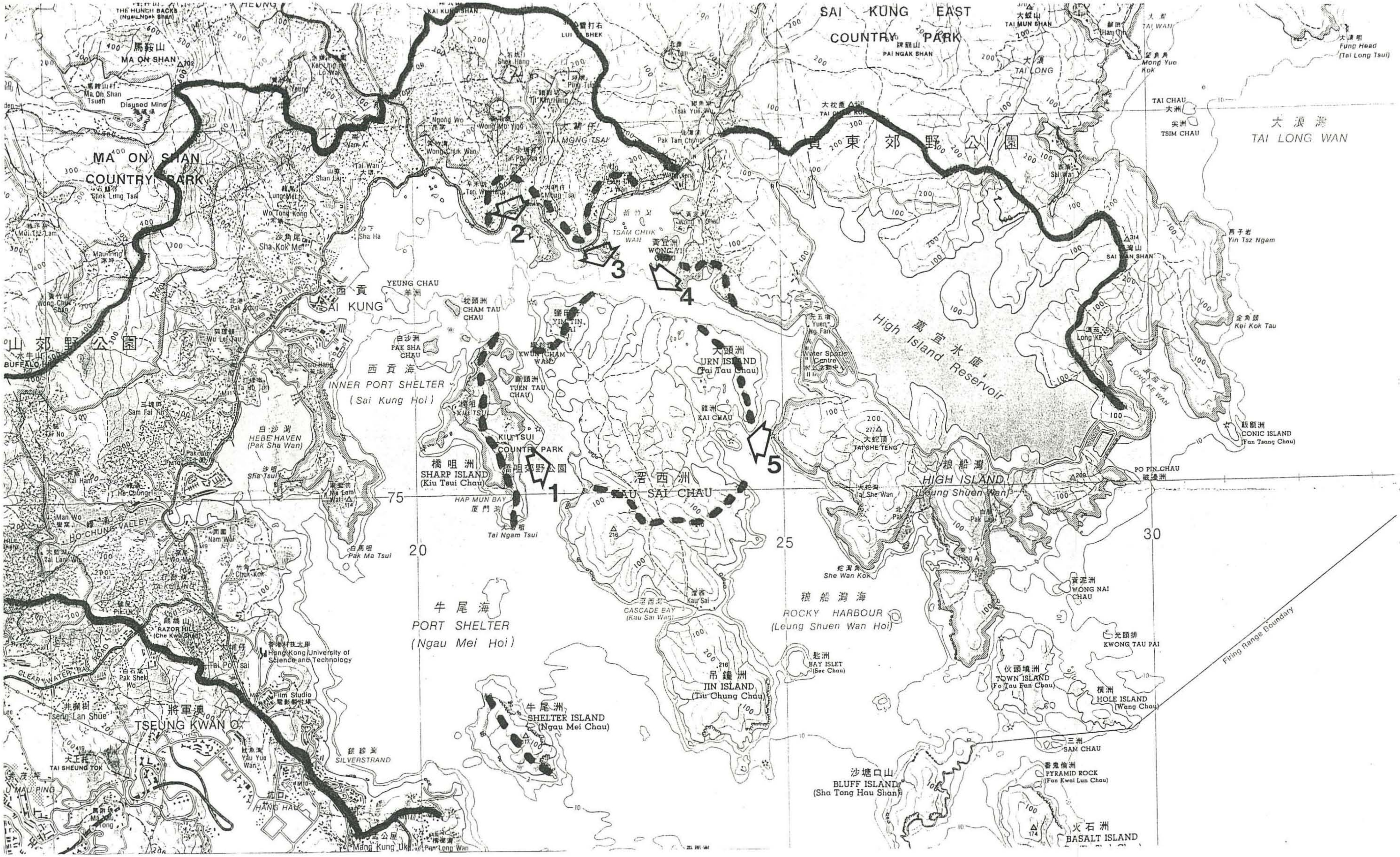

Primary Visual Envelope

Secondary Visual Envelope

Key External Viewpoint

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Figure 4.3: Landscape Context Visual Envelopes and Key External Viewpoints

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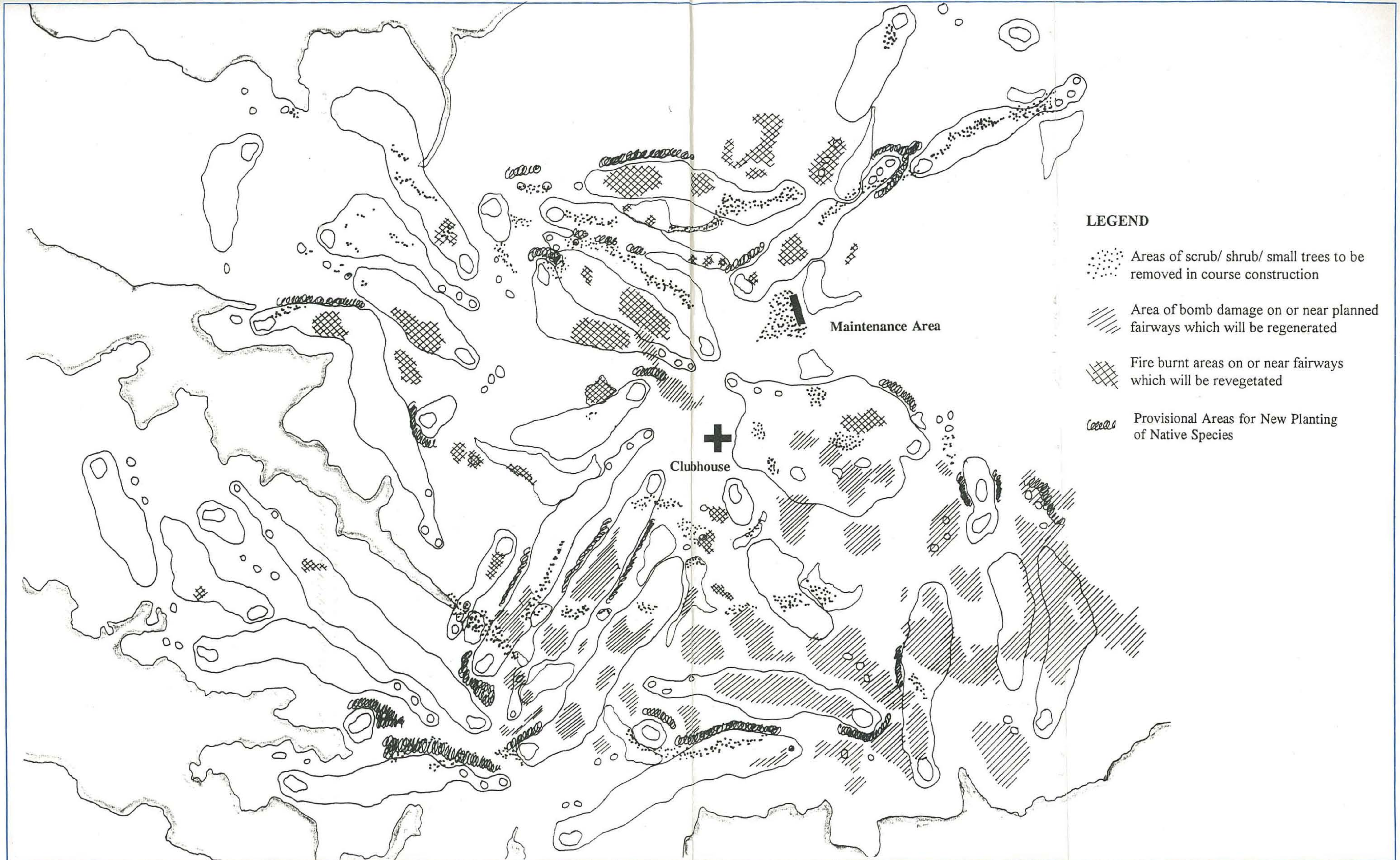

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Figure 4.4

Extent of Scrubland Loss Versus Areas Subject to Bomb Damage and Hill Fires

ECOLOGY

SECTION 5

Lumnitzera racemosa and *Acanthus ilicifolius*. The less common *Bruguiera gymnorrhiza* is also frequently seen here. Other seashore plants of interest include *Scaevola hainanensis* and *Pandanus tectorius*. The former is uncommon in Hong Kong and so far only reported in the Sai Kung region. The latter is known as the screw-pine and is, in a sense, a back-mangrove. It is common and widely distributed in Hong Kong.

Bruguiera gymnorrhiza can readily be seen in Hong Kong at a limited number of locations some of which are difficult to reach. They include Mai Po, Tsim Bei Tsui, Lai Chai Wu and Chek Keng. The Mai Po site is protected as part of the Mai Po Nature Reserve. The Tsim Bei Tsui site is near Mai Po, but was degraded during Spring 1993 by felling of trees, and awaits attention from agencies interested in mangrove rehabilitation. The Chek Keng location is accessible via a thirty minute walk from the bus terminus on Pak Tam Au Road in Sai Kung East Country Park.

5.2.2 Biogeographic Importance

The mangrove association which gives character to the Kwat Tau Tam estuary (Photographic Plate 5.1) at the northern end of Kau Sai Chau is of considerable biogeographic importance in the Indo-Pacific region. Like the Chek Keng mangroves of Sai Kung east, those at Kwat Tau Tam (KTT) contain Hong Kong's two eco-dominant mangrove species, *Avicennia marina* and *Kandelia candel*. They are seen at these locations in good numbers and in an ecological combination that probably represents the natural situation for Hong Kong as part of the mangrove ecosystems of the south China coast (Maxwell 1993). The importance at Kau Sai Chau and ecological status as co-dominants of these two species is shown in Table 5.1.

In addition, *Bruguiera gymnorrhiza* is also found at Kau Sai Chau (and on nearby islands Yim Tin Tsai and Kwun Cham Wan) as it is at Chek Keng. Unlike the rather squat, dwarf plants at Chek Keng, *B. gymnorrhiza* at Kau Sai Chau includes some tree forms which are not only large by Hong Kong standards but also impressive in size and stature for *Bruguiera* growing anywhere along the northern extent of the species range. Furthermore, *Bruguiera* at Kau Sai Chau is very productive in terms of propagule production (the mangrove reproductive unit; see Table 5.2).

B. gymnorrhiza trees can be found in some of the many small bays and inlets around Kau Sai Chau, thus making the entire island of interest biogeographically.

The *B. gymnorrhiza* trees increase in abundance and quality (in terms of tree height, girth, foliage quantity and quality, flower and fruit formation and density of seed beds associated with parental trees) as one moves from the seaward to the landward zones of the KTT estuary (Table 5.3). This species is sometimes found in the inner mangrove zones in the tropics (Aksorkoae et

5. ECOLOGY

5.1 Introduction

The potential ecological impacts of the proposed golf course development on the northern half of Kau Sai Chau were assessed based on initial surveys of the island carried out in August and September 1993. Results were reported in the Stage 1 Environmental Assessment which was submitted for governmental review on 4 October 1993.

Based on the conclusions of the Stage 1 assessment, potential loss of mangrove habitat was identified as a key ecological issue requiring additional study during Stage 2 of the overall environmental impact assessment. To address this issue additional mangrove and intertidal substratum studies were conducted in November and December 1993. Results of these studies and the subsequent impact mitigation planning exercise are described below.

Other than the issue of mangroves, two plant species which are currently protected by Hong Kong government regulation were also recorded during field surveys of Kau Sai Chau. Preparation of plans to avoid or mitigate potential impacts to these species was also identified as a key issue for Stage 2 of the EIA. Measures to address the regulatory requirements for these species are proposed in this report.

5.2 Mangrove Vegetation

5.2.1 General Description

Mangrove species composition and spatial distribution were quantified using the point-centered quarter method (PCQM, Cintron and Novelli 1984). Substratum samples were collected using a D-section corer and analysis was carried out as described under Section 5.2.4 of this report. Sampling sites are shown on Figure 5.1.

Mangroves and associated plant species are commonly found along the coast of northern Kau Sai Chau, and nearby islands and mainland inlets in northern Port Shelter. All the mangroves found in this area are dwarf in stature (1-2m tall), as is typical of Hong Kong mangroves. Dwarfness is thought to be associated with the cool winters in Hong Kong (Morton and Morton 1983), but may also be due to the higher salinity of oceanic waters on the eastern seaboard of Hong Kong combined with sub-optimal substrates. The gnarled, squat mangroves of Chek Keng, also in the Sai Kung region, are associated with a difficult, stony substratum (Maxwell 1993).

The dominant mangrove species at Kau Sai Chau are *Avicennia marina* and *Kandelia candel*. Other important species include *Aegiceras corniculatus*, al. 1992) where its growth is enhanced by more brackish conditions caused by freshwater runoff.

Table 5.1 Results of PCQM (Point centered quarter method) survey of mangrove vegetation on **Transect 1** (see Fig. 5.1), Kwat Tau Tam estuary on Kau Sai Chau, 10 Dec. 1993.

Sampling point	Quarter Number	Distance (m)	Species	Gbh (cm)	Basal Area (m^2)
1	1	1.39	K.c.	29.6	0.0070
1	2	0.43	K.c.	11.4	0.0010
1	3	1.05	K.c.	9.0	0.0006
1	4	0.44	K.c.	8.7	0.0006
2	1	3.54	A.m.	50.5	0.2030
2	2	3.39	A.m.	55.2	0.0243
2	3	2.32	A.m.	34.0.	0.0092
2	4	0.67	K.c.	14.0	0.0016
3	1	0.63	K.c.	26.2	0.0055
3	2	0.74	K.c.	11.0	0.0009
3	3	0.79	A.m.	15.2	0.0018
3	4	1.53	K.c.	18.4	0.0027
4	1	1.83	K.c.	32.4	0.0084
4	2	2.15	K.c.	26.1	0.0054
4	3	0.91	K.c.	14.0	0.0016
4	4	1.75	K.c.	19.8	0.0031
5	1	1.26	K.c.	26.6	0.0056
5	2	2.29	K.c.	20.2	0.0032
5	3	2.66	K.c.	38.8	0.0120
5	4	1.63	K.c.	18.0	0.0026
6	1	2.89	K.c.	23.0	0.0042
6	2	1.65	K.c.	16.5	0.0022
6	3	2.30	K.c.	23.3	0.0043
6	4	1.67	K.c.	14.0	0.0016
7	1	0.67	K.c.	18.6	0.0028
7	2	2.90	K.c.	20.5	0.0033
7	3	0.71	K.c.	9.1	0.0006
7	4	2.56	K.c.	22.4	0.0040
8	1	1.28	K.c.	28.0	0.0062
8	2	1.58	K.c.	24.3	0.0047
8	3	1.48	K.c.	11.0	0.0009
8	4	1.81	K.c.	20.0	0.0032
9	1	1.10	K.c.	18.0	0.0026
9	2	1.20	K.c.	23.6	0.0044
9	3	1.32	K.c.	62.8	0.0314
9	4	1.46	K.c.	36.0	0.0103
10	1	1.20	K.c.	13.8	0.0015
10	2	0.49	K.c.	17.6	0.0025
10	3	0.40	K.c.	18.1	0.0026
10	4	0.62	K.c.	19.5	0.0030
11	1	1.40	K.c.	39.8	0.0126
11	2	2.10	K.c.	19.3	0.0030
11	3	1.90	K.c.	36.4	0.0105
11	4	1.60	K.c.	37.2	0.0110

Data summary footnote:
Mean distance = 1.54 m
Total Stem Density/0.1ha = 420
Mean Density = 0.42 stems/m^2

Key:
A.e. = *Aegiceras corniculatum*
A.m. = *Avicennia marina*
B.g. = *Brugiera gymnorrhiza*
K.c. = *Kandelia candel*

Table 5.2 ***Bruguiera gymnorrhiza*** **tree sample from Kau Sai Chau: heights and propagule production.**

Tree No.	Height (m)	No. of established propagules	
		Under canopy	Beyond canopy
1	1.7	67	8
2	1.5	54	12
3	1.8	48	11
Mean	1.66	66.3	10.3

Table 5.3 Mangrove density, basal area, absolute and relative frequencies from **Transect 1** on Kwat Tau Tam Estuary on Kau Sai Chau, 10 Dec. 1993.

Species	No.stems/ 0.1ha	Rel.dens. (%)	Mean basal area(m^2)	Basal area (m^2/0.1ha)	Abs/rel freq(%)
K. candel	381.82	91	0.0049	1.87	100/84.75
A. marina	38.18	9	0.0139	0.53	18/15.25

The KTT estuary is unusually long for Hong Kong (about 1.5 km), and has a relatively distinctive mangrove zonation. Such zonation is typically found only where estuary lengths are adequate (Duke 1992). The long, thin estuarine arm of site A1 (Fig. 5.1) south east of Kwat Tau Tam in central Kau Sai Chau is similar to KTT. Although it supports fewer mangrove trees, the zonation of species distribution is similar to that at KTT.

Deep sediment deposits were recorded in the KTT inlet during site investigations for the proposed dam. Near the mouth of KTT inlet sediments were up to 10m in depth. Although no measurements of sediment depth are known to have been made prior to the onset of use of Kau Sai Chau as an artillery practice range, it is probable that the shelling and consequent erosion of the upper slopes on Kau Sai Chau accelerated sedimentation of KTT inlet. This, in turn, possibly accelerated formation of suitable mangrove substrate, and may account in part for the quality and quantity of mangrove trees present today on the site.

The northwest portion of Kau Sai Chau and the coves and tidal mud flats between Kau Sai Chau and the nearby islands Yim Tin Tsai and Kwun Cham Wan have been similarly affected since 1936 by accelerated sedimentation caused by shelling of Kau Sai Chau. Waters in these areas are typically clouded with suspended solids which have washed from the eroded bomb sites. The mud flats have increased in size, and the total area which is suitable for mangrove colonization has increased in extent due to the deposit of sediments.

The outer, seaward zone of the KTT mangrove is characterised by *Avicennia marina* trees. These trees are dwarf but reach heights and canopy expansions which are excellent by Hong Kong standards. The ecotype here is the cold tolerant variety designated as *Avicennia marina* var. *australasica* Duke (1990). The superior chill tolerance of this ecotype was recently demonstrated at Mai Po in Hong Kong (Maxwell 1993).

Mixed stands of *Avicennia marina* and *Kandelia candel* form the middle zone of the KTT mangrove which lies immediately landward of the outer front of the *A. marina* zone. *Kandelia candel* is found in good numbers in the middle zone of the mangrove.

The brackish inner mangrove zone is marked by a gradual transition to occasional *A. marina*, fewer *K. candel*, some *Acanthus ilicifolius*, few *Lumnitzera racemosa*, and relatively good numbers of *B. gymnorrhiza*. The quantitative importance of *B. gymnorrhiza* in the more landward mangrove vegetation is illustrated in Tables 5.4 and 5.5.

Several characteristics contribute to the biogeographic importance of Kau Sai Chau generally, and of KTT and sample site A1 (Fig. 5.1) in particular. These characteristics include: (1) the somewhat distinct mangrove zonation; (2) good representation of *B. gymnorrhiza*; and (3) an atypically long estuary for Hong Kong's littoral environment.

5.2.3 Ecological Importance

The long inlet at KTT is of considerable ecological importance in Hong Kong because few such habitats exist on large islands in the Territory. Furthermore, fewer yet are relatively undisturbed by prior maricultural, agricultural, residential, or industrial land uses. Although Deep Bay is a large estuarine system with a variety of associated habitats, the immediately surrounding area has been dramatically influenced by man. The mangrove stands of Mai Po, for example, are substantial but dominated by *Kandelia* especially in the extensive man-modified gei wei system (Morton and Melville 1983; Lee 1989). These stands lack the zonation and species diversity seen at KTT.

Although Kwat Tau Tam has experienced no direct industrial, residential, or agricultural impact since the departure of the neolithic settlers whose presence was documented by recovery of archaeological remains, the inlet has been modified recently by two types of human activity: (1) construction of the breakwater for fish (fingerling) trapping (date unknown); and (2) artillery shelling of the drainage with resultant erosion and sedimentation (1936-1975).

The combination of these land uses was probably important in development of the KTT mangrove due to the affect of accelerating formation of suitable mangrove growth substrate. Artillery shelling led to massive erosion on the upper slopes of the drainage which accelerated sedimentation into KTT.

Simultaneously, the breakwater reduced the energy of tidal flows and storm-driven waves reaching the inner portion of the inlet, thereby lowering the rate of sediment removal. The combined effect resulted in sedimentation of the channel to a depth of roughly 10 m near the breakwater. The effectiveness of the breakwater as an agent of sediment retention is demonstrated by the profile of the channel on either side of the breakwater. On the landward side sediments are deep and water depth at high tide is roughly one metre. On the seaward side sediments have accumulated only immediately adjacent to the breakwater, and the water depth increases sharply toward the mouth of the inlet.

Table 5.4 Results of PCQM survey of mangrove vegetation structure along **Transect 2** (see Figure 5.1) of Kwat Tau Tam estuary on Kau Sai Chau, 10 Dec. 1993.

Sampling point	Quarter No.	Distances (m)	Species	Gbh (cm)	Basal area (m^2)
1	1	0.43	B.g.	15.1	0.0018
1	2	1.22	A.e.	35.0(est)	0.0098
1	3	1.12	B.g.	23.5	0.0044
1	4	1.25	A.m.	12.6	0.0013
2	1	0.35	B.g.	15.0	0.0018
2	2	1.45	A.m.	11.7	0.0011
2	3	0.92	B.g.	14.4	0.0016
2	4	0.54	A.e.	19.0(est)	0.0029
3	1	0.93	A.e.	24.0	0.0046
3	2	1.25	A.m.	25.5	0.0052
3	3	1.02	B.g.	19.4	0.0030
3	4	2.33	B.g.	11.5	0.0010
4	1	0.61	A.m.	39.2	0.0122
4	2	1.09	B.g.	16.7	0.0022
4	3	1.81	A.m.	11.4	0.0010
4	4	1.20	A.m.	18.1	0.0026
5	1	1.33	B.g.	23.9	0.0045
5	2	1.36	A.m.	7.7	0.0005
5	3	1.77	A.m.	12.5	0.0012
5	3	1.46	B.g.	10.0	0.0008

Data summary footnote:
Mean distance = 1.172 m
Total stem density = 728 stems/0.1ha
Mean density = 0.728 stems/m^2

Key : see (Table 5.8a)

Table 5.5 Mangrove density, basal area, absolute and relative frequencies from **Transect 2** of Kwat Tau Tam estuary on Kau Sai Chau, 10 Dec., 1993.

Species	No.stems/ 0.1ha	Rel.dens (%)	Mean basal area(m^2)	Basal area (m^2/ 0.1ha)	Abs/Rel freq (%)
Bruguiera gymnorrhiza	328	45.1	0.0023	0.7544	100/38.46
Avicennia marina	291	39.97	0.0031	0.9021	100/38.46
Aegiceras corniculatum	109	14.97	0.0058	0.6322	60/23.08

As mentioned in Section 5.2.2, the mangrove zonation found in KTT is of special importance because it is unusually well developed for Hong Kong. In ecological terms the mangroves of KTT sustain a variety of intertidal yet protected shore habitats each supporting a distinct array of invertebrate fauna. Recent work at Mai Po associated with the Asia-Pacific Mangrove Symposium (September 1993) demonstrated that many intertidal mangrove-associated molluscan species can still be found in Hong Kong in spite of the contamination of coastal waters due to intensive industry, a large human population, and inadequate sewage treatment facilities.

Because Port Shelter is, in contrast to Deep Bay, largely unpolluted, it is reasonable to assume that the intertidal fauna (macro and meio) at Kau Sai Chau is of importance ecologically in the context of Hong Kong's vanishing shorescapes. This assumption is supported by the diversity of marine fauna recorded at KTT during this study (Section 5.3).

5.2.4 Substratum Studies

A substratum survey was conducted at low tide throughout the KTT estuary on 1 November 1993. D-section mud cores (uncompacted) were taken using the method of Boto (1984). Redox (reduction-oxidation potential) values were determined in the mud cores at various depths. These determinations provide useful chemical windows into the macrochemical attributes of the mangrove substratum. They focus on the degree of anoxia (anaerobic level) in the mud at various levels from the mud surface to c. 20 cm deep. An LD80A model combination pH-redox-temperature meter was used to obtain redox and temperature values. Pre- and post-use checks and calibrations were conducted with the LD80A at the University of Hong Kong. A platinum-tipped 'spike' electrode was used for the redox probes. All redox values were taken in the field from fresh mud cores. Results of the substratum survey appear in Table 5.6. Mean values are based on at least three readings per sample.

Table 5.6 Results of substratum survey in Kwat Tau Tam (KTT) estuary of Kau Sai Chau, 1 Nov. 1993.

KTT Zone	Core No.	Core Depth (cm from surface).	Mean redox value (mV)	Surface water temp (°C).	Remarks; mud texture and colour.
A. marina (outer seaward mangrove); saline water.	1	surface	-37	26.0	Yellow silty mud with isolated pockets of anoxia.
		3	-96	-	
		5	-122	-	
		20	-58	-	
A.marina (outer seaward margin)	2	surface	-60	25.4	Dark grey clay; more organic material.
		3	-160	-	
		5	-257	-	
		15	-240	-	
K.candel (mid mangrove zone)	3	surface	-76	25.7	Dark, dense, firm mud.
		5	-262	-	
		15	-250	-	
B. gymnorrhiza (inner mangrove landward margins); brackish water, freshwater seepage evident.	4	surface	-57	-	Tight, compact yellow/orange clay-mud.
		5	-154	-	
		15	-144	-	

These results indicate that :

- There is, generally, an increase in negative redox potential (Eh) as depth increases.
- Mud redox conditions under *Avicennia marina* and *Kandelia candel* trees are similar.
- Slightly less anaerobic mud occurs where *Bruguiera gymnorrhiza* stands develop.

These results are broadly similar to those reported elsewhere in the region (Maxwell 1989), and consistent with those reported by Kyuma *et al.* (1989) in similar Japanese studies. When Eh values approach -150 to -200 mud sulphate ions are reduced to sulphide. The presence of the latter chemical species can sometimes be detected by a normal sense of (human) smell. The surface muds at the KTT site did not yield such odours on the day of sampling.

As redox Eh values move closer to -250 to -300 carbon dioxide gas is changed to methane. Both methane (CH_4) and sulphide (S^{2-}) are indicator chemicals of strongly anoxic (or poorly aerated) mud or soil conditions.

Clearly, there was no indication that KTT sediments were undesirable due to anaerobic or anoxic conditions. Indeed, because the site has been historically unaffected by industrial or residential development the sediments are uncontaminated. Therefore, they are desirable and useful for mangrove habitat creation.

5.3 Marine Fauna Associated With the Kwat Tau Tam Mangrove

Because mangroves are typically productive in terms of invertebrate fauna, this was also considered as a component of the investigation for Stage 2 of the EIA. A survey was conducted of the aquatic fauna of the project site to describe the marine life associated with mangroves of the tidal inlet Kwat Tau Tam.

Four sites were visited in Kwat Tau Tam, ranging from the inlet mouth to the uppermost extent of the mangroves. The species present and their relative abundance were recorded through direct sighting and active searching. Sixteen species of crustacean were recorded, 13 of these belonging to the order Decapoda, plus five species of gastropod, four species of bivalve and the ubiquitous mudskipper, *Periophthalmus cantonensis* (Table 5.7). All species recorded are common to mangroves and or muddy shores in Hong Kong.

Of the five species of Gastropod that were observed, the dominant species were the potamidids *Terebralia sulcata* and *Cerithidea djadjariensis* , which were both present in very large numbers. They were most abundant towards the mouth of the inlet, lying on the mud surface. *Terebralia* was higher zoned than the *Cerithidea* spp, occurring on well drained, sand/mud banks up to half way up the inlet.

Crabs were abundant at all four study sites. The most abundant crab species was *Chiromanthes bidens*, although many *Macrophthalmus* spp. were also observed. Fiddler crabs (*Uca* spp.) were common at the higher levels where the substrate was firmer for burrowing. Some large specimens of the Portunid *Scylla serrata* were also recorded in this zone.

The Venerid bivalve *Gafrarium tumidium* was common in the softer substrate at low levels in the inlet, as was the large mangrove clam, *Geloina erosa.* In the stream bed winding down the inlet were quite large numbers of the bearded arc shell, *Barbatia obliqua.*

Table 5.7 Resident fauna associated with the mangroves of Kwat Tau Tam estuary, Kau Sai Chau.

Crustacea		
	Decapoda	
		Scylla serrata
		Chiromanthes bidens.
		C.maipoensis
		Chasmagnathus convexum.
		Macrophthalmus spp.
		Uca spp. - *U. vocans, U. arcuata, U. chloropthalmus*
		Crangon affinis
		Palaeomontes sp
		Laomedia astacina
		Clibanarius longitarsus
		Metagrapsus frontalis
	Cirripedia	
		Balanus a. albicostatus
		Euraphia withersi
	Isopoda	
		Ligia exotica
Gastropoda		
		Terebralia sulcata
		Cerithidea cingulata
		C. rhizophorarum.
		C.djardjariensis.
		Littorina melanostoma
		Clithon oualaniensis
Bivalvia		
		Saccostrea culcullata
		Gafrarium tumidium
		Barbatia obliqua
		Geloina erosa
Pisces		
		Periophthalmus cantonensis

5.4 Terrestrial flora

5.4.1 Habitats of Northern Kau Sai Chau

The habitats found within the study site at Kau Sai Chau include mangrove, tall shrub/woodland, scrub land, grassland and eroded areas. They are described below, and their extent is shown in Figure. 5.2.

Trees - Tall shrubs

Narrow strips of wooded areas are found along the steep slopes of the coastline. The vegetation is closed and dense and the trees are around 3-5m tall. These trees and shrubs must have escaped disturbances such as fire for a period of 20 years or more to attain this size and density. This is possibly due to their position on steep, leeward slopes. Although these areas occupy a relatively small area compared to other types of vegetation on the island, they have high species diversity.

No particular plant species dominates these habitats, but *Schefflera octophylla, Synplocos* spp., *Cratoxylum ligustrinum, Cinnamomum porrectum, Rhus succedanea* and *Sapium discolor* are frequently seen. All species found here are common in Hong Kong.

There are many ephemeral streams on northern Kau Sai Chau, and although the hills are generally low, in places the valleys harbour trees and tall shrubs on either side of the streams. The extent of this type of vegetation cover is usually small and discrete.

There are no dominant species. The more common species include *Gardenia jasminoides, Ormosa emarginata, Homalium chinensis, Zanthoxylum avicenniai* and *Glochidion* spp. Many of the plants are the same as those occurring in the coastal woodland, and are listed in Table 5.8 (at end of Section 5) under the column "Local Abundance - WL/R."

Scrubland

Scrub land is the commonest type of vegetation on northern Kau Sai Chau, occupying more than 80% of the study area. It consists of species poor plant communities dominated by the shrub *Baeckea frutescens* together with a limited number of plant species. Phytoecologically they are known as *Baeckea frutescens Formations* and can be sub-divided into different *Associations* depending on the plant species with which the *Baeckea* is coexisting. The co-dominant plant include *Dicranopteris linearis, Lepidosperma chinense* and *Rhodomyrtus tomentosa.*

The height of the scrub vegetation varies from 0.5-1.5m. The ground coverage of these communities ranges from 60 - 100% , with a mean of over 80%. There is a general trend for the communities on the southern and eastern parts of the study area to be taller and more dense than those in the north and west.

Most of the scrub land species on the island are common to Hong Kong. They are listed in Table 5.8 under the column "Local Abundance - SL".

Grassland

An area of grassland occurs on the headland at the northeast end of the island. The grassland stretches from the northern end of this headland towards the south, with an area of approximately 12 ha. The dominant plant species are *Ischaemum* spp., *Cymbopogon tortilis, Rhyncospora rubra, Arundinella nepalensis,* and the sub-shrubs such as *Helicteris angustifolia* and *Inula cappa*. The grass layer is usually very low, about 0.5-0.8m tall.

Other shrubs are sparse and also short. This plant community is maintained by frequent and regular fire caused by visitors to the numerous graves found on the island.

The species found are listed in Table 5.8 under the column "Local Abundance - GL". They are typical of fire climax grasslands which occur extensively over the countryside in Hong Kong.

Eroded areas

Badly eroded bare land and gullies have resulted from shelling and bombing practice carried out on Kau Sai Chau from 1936 to 1975. In these areas the surface soil has been completely washed away, leaving a hard, compact substrate that can hardly support plant growth. The vegetation coverage is very low (20-50%). A few plant species are established on such sites, including *Baeckea, Dicranopteris, Lepidosperma, Rhodomyrtus, Embelis laeta* and *Wistroemia indica.*

5.4.2 *Protected Species*

Two plant species found in the study site are protected under the Forests and Countryside Ordinance (Cap.96) Forestry (Amendments) Regulations 1993. They are *Enkianthus quinqueflorus* (Ericaceae) and *Arundina chinensis* (Orchidaceae). The orchid is also protected by the Animals and Plants (Protection of Endangered Species) Ordinance (Cap.187) against unlawful possession or trading.

There are a few individuals of *Enkianthus* in a valley in the southern part of the study site (KV229758). This species is not rare in Hong Kong and is presumably protected to prevent mass commercial harvesting as a Nien Fa (flower for the Lunar New Year).

The Bamboo orchid (*Arundina chinensis)* was found in two places. One is on the NE headland (KV227769) where only one specimen was seen on exposed low scrub land. The other location is on an exposed hillside of low shrubs on the southern part (KV228757), where a group of about thirty individuals were found in an area of 30 x 15m. This species is one of the most common orchids in Hong Kong, which occurs on exposed hillsides and by streams from lowland to high ground.

5.4.3 *Conservation Value*

From a botanical point of view, none of the plant species encountered in this study is rare in Hong Kong or Southern China. Ecologically the terrestrial habitats are, on the whole, not of major conservation significance for Hong Kong, since such a large part of the area is eroded or covered in highly disturbed, species poor grass and scrub land, a habitat very common in the territory.

The coastal and valley woodlands are of higher conservation value due to their rich species diversity. Many of the woodland species (Table 5.9) provide food and cover for birds, butterflies and wasps. One specimen of civet scat was found in the study area. The specimen contained primarily *Rhodomyrtus* seeds. Apart from *Rhodomyrtus*, the fruits of *Diospyros morrisiana* and *Gnetum montanum* (both of which occur in the study site) are common food for civets.

Table 5.9 Native plants recorded on Kau Sai Chau which are attractive to frugivorous birds (after Corlett 1992).

Species	Habit	Bird *	Attract **	Period ***
Diospyros morrisiana	tree	2	xx	Dec-Jan
Mallotus paniculatus	tree	3	xxx	Dec-Jan
Rhus hypoleuca	tree	5	x	Nov-Dec
Sapium discolor	tree	12	xxxx	Oct-Dec
Schefflera octophylla	tree	7	xxxx	Jan-Mar
Eurya japonica	shrub	5	xxx	Nov-Jan
Ilex pubescens	shrub	4	x	Nov-Dec
Litsea rotundifolia	shrub	8	xxx	Oct-Dec
Melastoma candidum	shrub	4	xx	Nov-Jan
Melastoma sanguineum	shrub	8	xxx	Nov-Jan
Psychotria rubra	shrub	8	x	Oct-Jan
Rhaphiolepis indica	shrub	2	xxx	Dec-Jan
Rhodomyrtus tomentosa	shrub	6	xxx	Aug-Nov
Cassytha filiformis	parasite	3	x	Oct-Mar
Morinda umbellata	climber	3	xxx	Aug-Sept
Paederia scandens	climber	4	xxx	Nov-Mar

*	Birds	= Number of species known to feed on plant
**	Attract	= Relative scale of attractiveness to birds
***	Period	= Period of fruit availability

The ecological importance of mangrove communities on tropical coasts is well documented, and the pressure on Hong Kong mangroves is currently a conservation issue due to the limited amount of mature mangrove left in the territory and its vulnerability to development. The mangrove stands of Kau Sai Chau were, therefore, identified as a key issue in assessing the environmental impact of this project, and are addressed in Section 5.2 of this report.

5.5 Terrestrial Fauna

Due to the predominantly poor upland habitat quality on Kau Sai Chau, the native fauna was found to be of limited diversity and low abundance. For this reason, terrestrial and avian fauna were not identified as key issues for Stage 2 of the EIA. However, the following sub-sections are included to document the combined results of surveys during Stages 1 and 2 of the EIA.

5.5.1 *Birds*

Table 5.10 lists bird species sighted on Kau Sai Chau from 14 September through early December 1993. All birds, nests and eggs are protected in Hong Kong under the Wild Animals Protection Ordinance. From this list, the red-winged crested cuckoo and the broad-billed roller are of limited distribution. The most common bird species were the black drongo, swallow and night heron.

Table 5.10 Bird Species Recorded during non-systematic surveys on Kau Sai Chau, Sept. through Dec. 1993

Species	Number	Habitat
Night heron	5-10	*
Black Kite	2-5	G,S
Osprey	1	*
Marsh sandpiper	2	M
Fantail snipe	1	F
Red-winged crested cuckoo	1	W
Nightjar	1	G,S
Broad-billed roller	1	S,G
Common kingfisher	2	M
White-breasted kingfisher	1	M
Swallow	5-10	G,S,F
Red-vented bulbul	2-5	W,S
Chinese bulbul	2-5	W,S
Black-faced laughing thrush	2-5	W
Rufous-backed shrike	2-5	W,G,S
Brown wren-warbler	2-5	S,G
Fantail warbler	2-5	G
Black-necked starling	2-5	W
Crested mynah	2-5	W,S
Black drongo	Over 10	W,G,S,F
W = woodland	G = grassland	S = shrubland
F = abandoned paddy	M = mangrove	* = flying high up

5.5.2 *Mammals*

Wild boar *Sus scrofula* have been recorded on the island, and tracks and diggings were found in the study area. The areas of most frequent wild boar use appeared to be on the northern headland between Kwat Tau Tam inlet and the typhoon shelter, and on the west central side of the island at the site of mangrove transplant area A3 (Fig. 1.).

Scats of one species of civet were found in low shrub/grassland in the centre of the island. No other sign of civet was seen on the island.

5.5.3 *Amphibians and Reptiles*

Reptiles and amphibians were recorded through direct sighting, active searching and, in the case of amphibians, mating calls. A dip-net was also used to sample tadpoles in the water. Quantitative assessment was not possible due to the secretive nature of the animals, the dense vegetation and the large study area. Only two species of reptile and one of amphibian were found (Table 5.11).

Table 5.11 Reptile and Amphibian species recorded on Kau Sai Chau, 14-15 Sept. 1993.

Habitat.	Species.	Number.
Grassland	*Hemidactylus bowringi* (Bowrings gecko)	1 adult + eggs
	Hemidactylus garnoti (Garnots gecko)	1 juvenile
Abandoned field	*Rana macrodactyla* (Three-striped grass frog)	1 juvenile

5.5.4 Other Fauna

Ecology of other fauna on the island was not identified as a key issue, and was, therefore, was not investigated.

5.6 Potential Impacts and Mitigation Measures

5.6.1 Potential Impacts to Kau Sai Chau Mangroves

The largest mangrove on Kau Sai Chau or the immediately surrounding islands occurs inside the tidal inlet of Kwat Tau Tam. This mangrove covers roughly 1.5 ha. Of the Kwat Tau Tam mangrove approximately 0.5 ha would be preserved, and 1.0 ha would be lost due to construction of the proposed dam and irrigation reservoir. The portion to be lost constitutes roughly 38% of the mangrove acreage on Kau Sai Chau. According to a 1993 estimate, the total acreage of mangrove in Hong Kong as of August 1993 was approximately 270 ha (M. Yipp, pers. comm.). Therefore, the potential loss of mangrove at Kwat Tau Tam would constitute roughly 0.4% of the total Hong Kong mangrove habitat.

Several alternative dam locations were considered prior to selection of the proposed site. One site was evaluated immediately landward of the existing breakwater in the Kwat Tau Tam inlet (proposed dam site no. 1, Figure 5.3). This site provided the advantage of approximately equivalent water storage capacity in the reservoir with a lower dam elevation due to the greater surface area to be impounded.

The lower dam elevation would have reduced visual impacts to a degree. The dam site would have facilitated exercise of management control over runoff over a slightly larger area of the golf course, and enabled re-use of runoff in irrigation. However, use of the site would have resulted in loss of all but one of the mangrove stands in the inlet, and would have increased the mangrove acreage to be lost from 1.0 ha to 1.5 ha. The impact of the increased loss of mangrove habitat was considered excessive, therefore alternative sites were sought to preserve as much mangrove as possible.

Another prospective site was located at the mouth of a deep valley on the southwest side of the island (proposed dam site no.3, Figure 5.3). This site did not fit the project design criteria that the golf and support facilities should be contained to the extent possible within a single drainage system. The runoff from the golf course and associated facilities would not naturally drain to this reservoir, thereby reducing the capability of the facilities managers to deal with potentially contaminated runoff.

Surface runoff from the golf course would not be available for re-use from this reservoir site, as all of the runoff would drain to the sea, or to Kwat Tau Tam inlet. Also, the extent of the drainage was not as great as that at Kwat Tau Tam, resulting in an additional requirement for a dam at another site. Finally, the landscape and visual impacts of this alternative location would have greatly exceeded the level of impact to be expected from a dam in the Kwat Tau Tam inlet. This would have resulted from the much higher profile and greater length of the dam.

Additionally, the mixed tall shrub-woodlands at lower elevations in this drainage have been protected from fire probably since the termination of use of the artillery range. Therefore, the vegetation cover is dense, and plant communities are diverse in speciation and complex in structure. The potential impact to terrestrial flora and fauna due to loss of this habitat was considered excessive, particularly because selection of this site would necessitate construction of another impoundment to provide enough water storage capacity for the project.

The selected dam site (proposed site number 2, Figure 5.3) is in KTT inlet some 170 m landward of site number 1. This site meets the design criteria regarding re-use of surface run-off, and is located deep enough in the KTT inlet to be virtually obscured from all views outside the inlet. Dam site number 2 would result in loss of 1.0 ha of mangrove in the mid and inner mangrove zones of the tidal inlet of Kwat Tau Tam through direct removal during construction or drowning when the reservoir is filled. Mangroves outside the reservoir area should survive and may even benefit from increased sediment availability under proper management (Maxwell 1984). These are predominantly *K. candel* which are growing along the western shore of KTT inlet.

The reduction in freshwater input (non-saline, surface water runoff) following damming and shortening of the Kwat Tau Tam estuary should not negatively affect the main mangrove species here (*A. marina, K. candel, B. gymnorrhiza).* Extensive work done in Australia (Bunt *et al*, 1982) has shown that both *A. marina* and *Bruguiera gymnorrhiza* have wide ecological amplitudes, i.e. are tolerant of a wide range of salinity and temperature.

The less common *Aegiceras corniculatum* is also in this category of mangrove trees. It has been observed that *B. gymnorrhiza* can do better (taller and faster growth) where salinity is lower than full sea water (Aksorkoae *et al.* 1992) but this seems to be the case with most mangroves for which there is an extensive eco-physiological literature (Conner 1969; Clough 1984, Field 1985). Likewise, *K. candel*, a less studied mangrove, can cope with a wide range of saline regimes but may, at least in the tropics, be more typically found as a riverine species (Maxwell 1989, 1993).

During construction of the reservoir dam it would be necessary to dewater a works area. To accomplish this a coffer dam would be constructed in Kwat Tau Tam inlet on either side of the reservoir dam site (Figure 5.1). The landward coffer dam would contain fresh water which would otherwise flow into the works area, and the seaward coffer dam would control the sea water.

Construction of the coffer dam on the seaward side of the reservoir dam would potentially affect the mangrove stand between the two dams. Potential impacts would arise due to dewatering, which may alter surface and subsurface hydrology and adversely affect mangrove survival. To preclude impacts to this mangrove due to loss of fresh and salt water supply pumps would be installed for periodic irrigation. The pumps may circulate surplus ground water which seeps into the works area, or they may pump supplies of fresh and salt water from outside the works area.

Because this effort to avoid impact to a mangrove is a new technology, little is known regarding potential outcomes or the most effective means of precluding damage. Therefore, this would be an experimental programme which would require refinement as it proceeds. The role of the Environmental Supervisor during the construction project would be to work with the construction crew to ensure that designated measures are implemented, and that monitoring studies are pursued to ensure that appropriate refinements and adjustments are made in a timely manner (Section 9.5).

5.6.2 Mitigation Plan for Impact to Kau Sai Chau Mangroves

An intensive and extensive on-site mangrove mitigation plan is proposed to counter the impact of the project on the Kwat Tau Tam mangroves. Details of the mangrove mitigation plan should be incorporated into specific clauses to be included in the construction contract documents. This mitigation plan seeks to accomplish the following objectives:

- preserve mangroves outside the dam and reservoir locations through protection during construction;
- establish replacement mangroves on Kau Sai Chau and

immediately surrounding islands to compensate for the losses caused by the project;

- enhance the spatial distribution of *B. gymnorrhiza* in the Kau Sai Chau area through transplanting.

The following types of management treatments would be employed in the mitigation programme.

- transplantation of mangrove trees from the sites to be disturbed to existing mangrove habitats which are secure from disturbance;
- creation of new substrate suitable for mangrove establishment immediately seaward of the proposed dam location;
- transplantation of mangroves from disturbance sites to newly created substrates;
- enhancement of existing mangrove propagule survival and distribution potential;
- plantation of mangrove propagules collected from other Hong Kong sites into new substrates at Kau Sai Chau.

The on-site mitigation plan is described in Table 5.12 and illustrated in Figures 5.1 and 5.3. Transplantation would involve propagules and established seedlings of all mangrove species including the relatively rare inner mangrove, *Lumnitzera racemosa*. The source for transplant stock would be those portions of Kwat Tau Tam inlet which are to be flooded by the reservoir. Transplant sites would be those shown on Figures 5.1 and 5.3.

In addition, some transplantations of mature trees would be attempted experimentally. It is anticipated that the mature trees would be transplanted using excavators brought on-site for dam construction. The purpose of this experiment is to determine whether it is possible to transplant mature propagule producers, thereby beginning a new stand of trees with plants which can begin dissemination of additional propagules within a short time period (less than one year). Should this technique prove successful, it could accelerate colonization of new substrates or of existing substrates which have been degraded though destruction of mangrove forests.

Planting trials with propagules and small seedlings will begin in Spring 1994 to assess local feasibility of the proped methods. Transplanting of seedlings has been successfully implemented on other projects in Hong Kong, and propagules have been successfully planted at Futien Nature Reserve (Deep Bay). Therefore, there are local precedents for the two primary mitigation methods in this proposal.

A mangrove substrate would be created immediately seaward of the reservoir dam location. The existing breakwater across the Kwat Tau Tam inlet would be extended to block the passages which were left open to facilitate passage of light water craft. This would reduce the force of tidal flows, and assist in retention of sediment behind the breakwater.

Sediments removed during the reservoir dam construction project would be filled into the area between the existing breakwater and the reservoir dam to create a mangrove planting substrate. Upon completion of the substrate seedlings and propagules from the mangroves to be flooded would be planted/transplanted into the new substrate. This would result in restoration of approximately 1.0 ha of mangrove in the Kwat Tau Tam inlet, an amount comparable to that lost due to flooding in the reservoir.

Monitoring of plant phenology in mangrove source areas would ensure that mature 'fruits' (propagules) are selected and collected from reproductively mature species in the proposed dam area before dam construction is complete and flooding occurs. Propagules would be mature beginning in April 1994, and collection would begin at that time. Trees with good flower/embryonic fruit production were identified in the proposed dam area during the field surveys of November and December 1993. Also, mangroves on the mainland immediately north of Kau Sai Chau are well established and can provide a ready supply of propagules as well.

The success of mangrove tree transplants will be monitored, and where transplanted trees have not survived, these would be replaced with new seedlings or propagules. This is discussed further in Chapter 9.5.

Mangrove propagules and seedlings distant from the parental canopy area have a much better chance of survival than those clustered under the intact canopy (Ellison and Farnsworth 1993). To relocate propagules or transplant seedlings from areas near parental trees to "canopy removal areas" is to enhance survivorship, growth rates and leaf formation. In addition, the negative effects of leaf herbivory by insects are typically lower at suitable sites distant from the parental trees.

Thus the mitigation project presents an opportunity to enhance mangrove numbers and distribution by relocating excessive numbers of crowded propagules away from parental trees. Suitable seedling sizes for transplantation have been identified and characterised (Table 5.13). The transplantation would be professionally supervised by staff experienced in such silvicultural methods and technology.

Few trees of *Lumnitzera racemosa* occur in the KTT estuary. If inadequate propagule numbers are available on site due to a poor 1993/94 season before the proposed dam area is flooded, a search for propagules elsewhere in the Sai Kung region would be conducted. There are mature trees of this mangrove species at Chek Keng. Propagules from this species, like those from *A. marina*, are small and some nursery cultivation may be needed to optimize establishment potential for both species. Such an approach may have the added advantage of negating predation on mangrove propagules by sesarmid crabs (Maxwell 1993). It may also be necessary to purchase seedlings from mangrove nurseries in China to ensure availability of species with a maximum chance of survival following transplantation to new or modified substrates.

Co-lateral mitigation measures involving mangrove macroinvertebrates would also be undertaken. For example, a population of mud processing gastropod molluscs has been identified in KTT, and some of these along with sub-surface invertebrates, would be re-located with mud removed intact as part of mangrove seedling transplantation (Table 5.12). Thus the transplanting of mangrove trees and seedlings and the extension of other stands on the island would also provide additional habitat for mangrove faunal species outside the proposed reservoir area (disturbance area).

As mentioned in section 5.2.4 the substratum (sediment) of KTT is regarded as a valuable resource. Much of the sediment would be used in the substrate creation project immediately seaward of the dam. Some sediment would be used in the mangrove habitat extension and/or improvement at suitable sites on the island. The primary fill site would be immediately seaward of the dam where the new planting area would be created (Fig. 5.3). Some of the other mangrove mitigation sites outlined in Table 5.12 would benefit from controlled and managed inputs of quality sediment as well.

The dam would be constructed with a penstock for draining the reservoir from the bottom of the dam in addition to the surface runoff. This would permit occasional flooding of the newly created mudflat with sediment bearing, fresh water from the bottom of the reservoir. It is anticipated that erosion control through restoration of the upper slopes in the middle and southwest portion of the island would reduce sediment input to the reservoir below levels which would be problematic. However, should sediments accumulate, the penstock system would provide the double benefit of eliminating sediment buildup from the reservoir while supplying additional sediments for the mangrove plantation area.

As noted in Section 2.7.2, the dam would also have an overflow culvert to handle water overflow during periods of heavy rain. Large rocks or gabions would be placed at the base of this culvert to break up the water flow and prevent erosion of the mangrove area at the base of the dam.

Table 5.12 Description of mangrove mitigation sites on Kau Sai Chau. (This Table is co-lateral with Fig. 5.1b) [*** = ideal ; ** = good ; * = fair]

Site Designation	Description	Mangrove suitability rating
A1	A hastate-shaped coastal indentation 1.5 to 2 km S.E. of Kwat Tau Tam estuary (KTT), the southern arm of which is c.200m long and narrow with good freshwater input.	B.g. *** Other spp.*
A2	A small polyp-like indentation on N.W. coast of Kau Sai Chau (KSC) <500m from KTT with a narrow boulder lined mouth and a 15x7m muddy planting site at the landward end. Freshwater seepage evident. Suggested propagule/seedling planting density: 1 unit per 0.25m.	B.g. *** K.c. ** A.m. * Other spp.*
A3	A finger shaped indentation some 300m deep on central west coast of KSC, the alternative dam site. Deep (20-30cm+) sand deposits on inner estuary. Space for 50+ transplant stems planted with mud +propagule/seedling intact.	A.m. *** Others *
A4	Edge of KTT, beyond proposed dam site. Limited transplanting (TP) between established mangrove trees.	All spp; with B.g. in landward and A.m. in seaward zones.(**)
B1	Northern tongue of hastate indentation described in A1 above; partly dammed off - some mud infilling desirable before TP	As for A4 (**)
B2	Small bay near causeway linking YimTin Tsai to KSC; limited planting to some 20-30 seedlings/propagules.	K.c. ** Other Spp. *
B3	Very small bay just south of Yim Tin Tsai causeway on northern KSC. Suggested planting ratio Kc. 2 : A.m. 1 : B.g. 1.	All *
B4	Small bay beside B3. Kandelia hug the shore in dense thickets. Limited room for planting 20-30 propagules/seedlings.	K.c. ** Other spp. *
B5	Small bay c. 100m wide at landward end just south of B4 on N.W. coast of KSC. Rocky substratum with Kandelia and a few large Bruguiera gymnorrhiza trees. Limited 5x5m muddy planting site for 30-40 seedlings.	All spp. *
C1 and C2	Sites C1 and C2 are possible planting sites but sub-ideal because either special permission (Marine Dept.) or habitat modification may be needed before planting	All spp. *

Footnote : The need for class A and class B mangrove mitigation sites is reduced by selection of dam site number 2. However, these transplant sites may still be desirable in the interests of a broader concept of mangrove enhancement in Hong Kong generally.

Table 5.13 Attributes of mangrove tree seedlings suitable for transplantation.

Ideal Characteristic	B.g.	K.c.	A.m., A.c., A.i.
Stem height.	5 - 20	8 - 20	8 - 16
Leaf no.	4 - 6	6 - 8	4 - 6
Ideal internode no.	3 - 4	6 - 12	2 - 4
Total height (cm).	15 - 30	25 - 35	10 - 20
Mud depth for root system (cm)	10 - 15	10	10 - 15
Mud level diameter (cm)	10 - 15	10 - 14	8 - 12

B.g. : *Bruguiera gymnorrhiza.* K.c. : *Kandelia candel.* A.m. : *Avicennia marina.* A.c. : *Aegiceras corniculatum.* A.i. : *Acanthus ilicifolius.*

5.6.3 Potential Impacts to Marine Habitats

The primary potential direct impact to marine habitats due to construction of the project would be loss of habitat in Kwat Tau Tam inlet. As a result of this loss, there would be a corresponding reduction in the area available to marine and intertidal fauna. Although the inlet is no longer used by local fishermen for harvest of fingerlings for mariculture (fishermen pers. comm.), it does support a diverse fauna (Table 5.7). Loss of this habitat is to be addressed through the mangrove mitigation plan, as is translocation of representative samples of the Kwat Tau Tam intertidal fauna to mangrove sites to be constructed.

The primary potential indirect impacts to the coastal marine habitats of Kau Sai Chau, including the Fish Culture Zones (FCZs) to the east and the west of the site, arise from the possibility of sediment or chemical runoff during the construction and operation of the project. The primary potential sources of sedimentation would be the construction projects for the dam and the golf course fairways. Sedimentation from fairway construction could potentially augment that from dam construction as much of the golf course would drain to Kwat Tau Tam inlet.

If significant sedimentation should occur during the construction of the dam or golf course, several different types of impact are possible;

- Smothering of the seabed with silt could lead to clogging of the respiratory/feeding mechanisms of benthic invertebrates, such as bivalves, sedentary polychaetes and corals. Kills of benthic epifauna and infauna could in turn affect higher invertebrate and vertebrate predators, such as crabs and demersal fish.

- High levels of suspended solids in the water column could affect primary productivity due to decreased light available to phytoplankton for photosynthesis. This could result in reduced food availability to zooplankton and pelagic animals. Increased levels of organic matter associated with the sediment could lead to reduced concentrations of dissolved oxygen in the water.

- Negative impacts on the fish cultured at the FCZs could occur due to clogging of gills by fine suspended solids and reduced levels of dissolved oxygen in the water.

Potential for sedimentation during construction would be eliminated to a large extent due to construction of the golf course fairways during the dry season in the 1994-95 winter. This would eliminate the possibility of a major precipitation event occurring at a time before the fairways have been re-seeded and the turf grass has become established.

A second protection measure would be construction of temporary earthen berms surrounding the fairway construction sites in areas where runoff would be likely to occur. Berms would be constructed of rock and earth scraped from the fairway surface during the initial stages of ground clearance. They would be situated to serve as small check dams to slow runoff and serve as short-term stilling reservoirs during the construction project. They would be removed on completion of the fairway contouring, prior to preparation of the seedbed.

A third protection against sedimentation during fairway construction would be the coastal and interior vegetation which would remain intact during the construction project. Because these vegetated areas would not be disturbed, they would remain as protective buffers to slow or stop runoff which might escape the earthen berms around the fairway construction areas.

During construction of the dam control over sedimentation in the construction area would be achieved through use of temporary check dams above and below the reservoir dam site. The check dams would be build to de-water the dam construction area to facilitate rapid and safe completion of the project. The check dams would be constructed by dozing material from each side of the inlet across the channel to form a dike. The seaward check dam would be constructed first to block the tide from entering the channel. It would be faced with rocky material to preclude erosion by tidal action. The landward check dam would be constructed to impound fresh water which would otherwise enter the construction area.

During construction of the seaward check dam a silt curtain would be erected on the seaward side of the operation landward of the existing breakwater. This would contain sediments which could otherwise potentially escape Kwat Tau Tam inlet and degrade waters in the main channel.

The existing breakwater would also be used to control sedimentation by blocking the tidal flows. Use of this breakwater in the post-construction mangrove mitigation project requires addition of rock fill to close the gaps on either side through which the tidal flow is currently channeled. Completion of this measure at the outset of the dam construction project would reduce the force of tidal flows, and would aid in containment of sediments landward of the breakwater. This would complete a three part sediment containment strategy (check dam, silt curtain, breakwater).

It is expected that this system to control sedimentation during construction would be effective, and that the levels of sedimentation in the short term would not greatly exceed those currently experienced due to uncontrolled runoff from the erosive artillery shelling range on the island. In the long term it is anticipated that restoration of badly eroded sites on the island as part of the golf course construction would contribute to reducing sedimentation of marine waters around Kau Sai Chau to levels below those currently exerienced.

The potential source of impacts due to chemical contamination of marine habitats would be the golf course during the turf establishment phase and during operation of the course on a long-term basis. During the establishment phase the primary potential source of chemical contamination would be from surface runoff during and following storm events. Runoff could contain fertilizers which were applied to enhance turf establishment. This could include fertilizers suspended in runoff as well as those bound to soil which could be eroded from areas on which adequate turf cover had not yet become established. During the establishment phase of the fairway turf more intensive applications of fertilizers may be required to encourage quick development of a durable stand of grass (see Section 6 for details).

Potential long-term, or operational imacts from chemical contamination of marine habitats could result from runoff of fertilizers or pesticides from the golf course. Uncontrolled organic enrichment of the surrounding waters through the runoff of fertilizer could lead to faunal changes in the benthic environment. Algal blooms could also result, followed by bacterial breakdown, with subsequent depletion of the dissolved oxygen in the water. If depletion is severe, fish kills can result. Alternatively the alga may produce toxins that at high densities are lethal to marine life, and filter feeding invertebrates may concentrate the toxins in their flesh to levels dangerous to humans.

Marine life in coastal waters is susceptible to pesticide toxicity. The organochlorine pesticides (e.g. DDT) are highly persistent, readily concentrated by organisms and adversely affect many non-target species. As a result they are not registered for use. The organophosphate pesticides were developed to replace them. These are highly potent but less persistent in the environment as they hydrolyze in water. However, some formulations (e.g. diazinon, parathion) are highly toxic to aquatic organisms in the short term. Modern formulations are designed specially for use near aquatic habitats or to protect non-target organisms in terrestrial habitats. When applied and stored properly, these formulations present minimal danger to marine organisms due to their instant degradation on contact with water, or rapid degradation on land. These are discussed in the turfgrass management plan of this EIA (Section 6).

To control this potential source of contamination the turfgrass management system calls for use of foliar feeds which are rapidly absorbed by plant tissues, low toxicity pesticides which degrade rapidly and minimize threats to non-target organisms, spot applications in response to pest outbreaks which exceed action thresholds, complete avoidance of preventive use of pesticides, adherence to manufacturers' recommendations for chemical appication, and careful monitoring of weather conditions prior to chemical applications.

In addition, the drainage and water storage system in the upper reaches of Kwat Tau Tam inlet has been designed as a nutrient sink into which much of the course runoff would flow for removal of excess nutrients. The rough and out-of-bounds areas within the golf course and the coastal areas which retain native vegetation would also serve to take up nutrients removed from the golf course by rainfall. Areas which erode would be immediately repaired using erosion control matting, replacement of topsoil, and reseeding.

5.6.4 Impact Mitigation Measures for Marine Habitats

The loss of the faunal community and its habitat in Kwat Tau Tam is the most significant net impact of the project. This impact would be mitigated on site through the mangrove impact mitigation plan (Section 5.6.2) and through relocation of representative samples of the Kwat Tau Tam fauna to the mangrove transplant sites. Because many of the fauna species are typically found in mangroves, the measures taken to mitigate the loss of mangroves in the inlet would also include mitigation for the loss of the associated fauna.

The fauna translocation would involve the following groups, and must be conducted prior to disturbance of the inlet:

- Mud-dwelling invertebrate infauna and epifauna, especially the gastropod and bivalve molluscs;

- Epizoic gastropods on the adult mangroves, such as *Littorina melanostoma.*

It is recommended that the requirement for fauna translocation be included in the contract documentation.

5.6.5 Potential Impacts to Terrestrial Habitats

Construction of the proposed golf course would destroy some of the present habitats and the plants and animals associated with them on the upland portions of the island. Habitats most affected would be grassland and low shrubland. These habitats are extensive on the island, and the conservation value of the lost habitats is not significant. Considering the generally degraded nature of these habitats on the west and southwest extent of the proposed disturbance area, the opportunities for eventual enhancement are great.

Two protected species were recorded on the study area, *Enkianthus quinqueflorus,* a shrub, and *Arundina chinensis*, an orchid. Individuals of both species were recorded in proposed disturbance areas. Although neither species is considered rare in Hong Kong, possession or destruction of individual orchids is only allowed under authority of a permit issued by the Agriculture and Fisheries Department. A permit would be sought to transplant orchids from proposed works areas to secure sites such as a temporary golf course nursery prior to commencement of construction. This would ensure there is no loss of individual plants during the construction phase of the project. Where possible on-site preservation would be practised, by avoiding disturbance in such areas.

Some woodland and shrub-woodland habitat would be lost in the ravines which would be filled for fairway or lake construction. This habitat is richer in floral and faunal diversity, and is not as extensive as the grassland or shrub-grassland habitats. Within this habitat type there is considerable physiognomic diversity in the underlying landform and the vegetation. Due to the variety of slopes, slope aspects, ground cover, and above-ground plant forms, this habitat provides a diversity of niches. It has also been more protected from fire by virtue of the more mesic condition of the ravines. Therefore, its local conservation value is likely greater than that of the grassland or shrub-grassland. As described in Sections 2.1 and 2.8.2, the golf course has been designed to minimise site disturbance as much as possible, and in particular to retain these diverse habitat areas. Streams and wooded ravines will remain intact to the extent possible.

One small area of marshland habitat occurs on the east side of the island in the area proposed as the secondary or indirect catchment. This marsh area may have been used previously for agriculture, or it may be a natural feature. There are several paddies upstream from the marsh area which have been abandoned. The fairway for hole 23 parallels the marsh area on the northwest side, and there is to be no disturbance on the southeast side. Therefore, the marsh would remain intact. The only potential disturbance to the site would be construction of the weir and underground pipeline which would direct surface flow from the indirect catchment to the reservoir. The weir location would be downstream from the marsh habitat. The weir would be designed to avoid impact to the marsh, and to simply intercept surface flow which would otherwise runoff to the sea. The impact of the weir construction is predicted to be insignificant.

A potential benefit of the project to terrestrial habitats would be restoration of some of the badly eroded areas which are the site of the former artillery shelling range. Due to the combination of shelling and frequent wildfire these areas have not naturally re-vegetated, indeed, appear to have grown larger over time. Arresting the enlargement of the eroded area and restoring grass and/or shrub cover to these sites would compensate for past abuses of the land, enhance the appearance of the island, and provide some measure of habitat improvement. Restoration of eroded sites would take place in the vicinity of holes 2 through 5, in the southwest extent of the project area.

5.6.6 Impact Mitigation Measures for Terrestrial Habitats

To minimize the extent of habitat loss during construction habitats between or surrounding the golf playing areas would be clearly demarcated prior to construction. Equipment and personnel would be excluded from these areas during the construction process, and the areas would remain in their native condition. Following completion of construction these sites would provide native seed sources for revegetation of the roughs at the fairway edges, the fill sites, the peripheries of lakes, and other areas to be re-seeded.

The golf course design company responsible for the project recognized the importance of preserving the openness of the topography and the vegetation in the final course layout. Therefore, a natural blending of existing terrain and habitats with the golf course was sought as the design objective. To achieve this goal the undisturbed native plant cover would be the predominant feature of the rough and out-of-bounds areas on the course.

The coastal woodlands would be almost entirely preserved because the golf course fairways would not extend down slope below the 10m contour. There would be some loss of inland tall shrub and shrub-woodland habitat due to filling of the deeper valleys, particularly near the head of the Kwat Tau Tam inlet. Individual trees and shrubs would be transplanted from areas to be filled for later use in re-vegetation around the clubhouse, the water treatment works, and at the margins of lakes and streams. Only native species would be selected for transplantation.

Because the low vegetation cover on the open, rolling topography of northern Kau Sai Chau is considered to be a significant scenic resource which contributes to the suitability of the site for golf, one objective in the post construction landscaping process would be to retain this resource. Therefore, only very selective planting of trees near the two buildings would be undertaken. Trees and shrub species used for transplanting around the buildings would be those mentioned above which would be removed from the ravines to be filled during fairway construction. Species targeted for transplanting would be those listed in Table 5.9 which are known to be attractive to frugivorous birds.

Difficulties associated with use of native plants in re-vegetation are acknowledged. However, due to availability of wild seedlings from on-site sources, availability of cultivated seedlings from commercial nurseries in Guangdong Province and Hong Kong, and the generally greater ecological benefit which obtains from use of native plants, the optimum strategy is considered to be use of native plants to the extent possible.

It is anticipated that plants on undisturbed sites would respond quickly to protection from fire, and that natural growth would result in a rapidly maturing shrub and low forest canopy. Permanent photo points have been established to record this development, and permanent vegetation sampling transects would be established in sites to be undisturbed by fairway construction. These sites would be sampled according to the monitoring plan.

The site would be enhanced through repairing of eroded areas (which resulted from previous shelling damage), and elimination of wildfires. Wildfires would be eliminated due to the firebreak function served by the fairways. This would isolate potential fire damage to the northeast headland of the island where grave sites are numerous and no fairways would be constructed. These measures would lead to establishment of plant communities on undisturbed and revegetated sites which have greater species diversity than the communities which existed prior to the project (L. Chau, pers. comm.).

5.7 Habitat Enhancement

Construction and operation of the proposed golf course project offers two opportunities for enhancement of habitats on the island which are distinct from the proposed mitigation measures. These are (1) reduction of soil erosion through landscaping on those portions of the island which were degraded by artillery practice; and (2) creation of lakes as upland habitat features which double as water storage sites.

5.7.1 Artillery Range Restoration

The southwest corner of the proposed works area in the vicinity of golf holes 2, 3, and 4 has been badly degraded due to use of the area as an artillery shelling range (Photographic Plate 5.2). Due to the impermeability of the soil (which was determined through percolation testing), low content of organic matter, and susceptibility to erosion, many of the bomb craters on the island have expanded over time rather than naturally revegetating after shelling ceased in 1975. Because vegetation on these sites has not recovered from bomb damage, these sites have continuously eroded, thereby providing the supply of sediment which has filled the inlets on the northern half of the island.

The eroded areas which lie within the proposed works limit of the golf course project would serve as borrow areas for needed fill, and would be re-contoured and re-vegetated following completion of the construction project.

Reduced erosion from the restored sites and reduced sedimentation of the inlets on the north half of Kau Sai Chau would result from this project. Potential beneficiaries of reduced sedimentation are recreational users of the northern Kau Sai Chau waters and the mariculturists off the northwest and northeast sides of the island. This is a benefit from the project which does not accrue as a result of a mitigation plan, although it would to a large extent compensate for loss of grassland and shrubland due to construction of the proposed golf course.

During re-contouring of these sites erosion control measures would be employed including matting and earthen berms as needed. Soil amendments including sand and organic material may be required, as may be slow release fertilizers to ensure rapid establishment of a complete vegetation cover. Plant species to be used would be those naturally occurring on the site, all of which would be taken from areas to be defoliated due to reservoir construction or operation. Only native species would be used in the re-planting exercise.

5.7.2 *Lake Creation*

Thirteen lakes would be constructed to provide supplemental water storage and to serve as water hazards on the golf course. These lakes would be useful ecological features of the project because they would provide habitats which are lacking in the Territory. Because the irrigation demands of the golf course and the potable water supply are to be met from the irrigation reservoir, the upland lakes would not be subject to daily or seasonal fluctuations in water level. They would, therefore, simulate natural lakes and would not be characterized by a shoreline strip which is barren of vegetation due to constant water level fluctuations.

Water bodies on golf courses are often attractive to waterfowl and shorebirds. On some courses the combination of the turfgrass and permanent surface water availability is attractive to numbers of ducks and geese which eventually become a problem for the golf course manager. In such cases managers have sought non-toxic, organic, repellent compounds which reduce waterfowl populations on the golf course (G. Witmer, pers. comm.). It is planned that water birds would be attracted to Kau Sai Chau, and construction and management of the lakes would be directed specifically at providing water bird habitats.

Specific design features to ensure water bird use of the golf course lakes would be shallow and irregular shorelines, emergent shoreline vegetation, extension of marsh habitats from the lake to the adjacent shoreline habitat, and maintenance of water levels. These design features would be included in each lake during the detailed design stage of the golf course.

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Table 5.8 Plant Species List for Kau Sai Chau

Plant Species	Family	Local Abundance				Native/?	Remarks	
		WL/r	SL	GL	Coast	(n=native)		
TREES								
Acronychia pedunculata	RUTACEAE	F	O			N	BL	Frt
Antidesma ghaesembilla	EUPHORBIACEAE		R			N		
Aporusa diolca(A.chinensis)	EUPHORBIACEAE	O	O			N		Frt
Artocarpus hypargyrea	MORACEAE	R				N		Frt
Bridelia tomentosa	EUPHORBIACEAE	R				N	BL	Frt
Bruguiera gymnorrhiza	RHIZOPHORACEAE				C	N		
Casuarina equisetifolia	CASUARINACEAE	R				Exotic		
Cinnamomum porrectum (C.parthenoxylon)	LAURACEAE	F				N		Frt
Cratoxylum llgustrinum	HYPERICACEAE	F				N	BL	Ntr
Daphniphyllum glaucescens	DAPHNIPHYLLACEAE	O				N		Frt
Diospyros morrisiana	EBENACEAE	O				N		Frt
Eleaocarpus chinensis	TILIACEAE	O				N		Frt
Exoecaria agalloca	EUPHORBIACEAE				C	N		
Ficus superba var.japonica	MORACEAE	R				N	BL	Frt
Garcinia oblongifolia	OLUSIACEAE	O				N		Frt
Glochidion dasyphyllum	EUPHORBIACEAE	O				N		
Glochidion wrightil	EUPHORBIACEAE	R				N	BL	
Gordonia axillaris	THEACEAE	F	O			N		
Hibiscus tillaceus	MALVACEAE				C	N	BL	
Homalium cochinchinensis	FLACOURTIACEAE	F				N	BL	
Machilus ichangiensis	LAURACEAE	R				N		
Machinus velutina	LAURACEAE	O				N		
Mallotus apelta	EUPHORBIACEAE	O				N		
Mallotus paniculatus	EUPHORBIACEAE	O				N		
Ormosia emarginata	PAPILIONACEAE	C				N		
Pandanus tectoris	PANDANACEAE	F			C	N		
Pentaphylax euryoides	PENTAPHYLACACAEA	O				N		

Plant Species	Family	Local Abundance				Native/?	Remarks	
		WL/R	SL	GL	Coast	(N=native)		
TREES(Cont.)								
Phyllanthus emblica	EUPHORBIACEAE	F				N		Frt
Pinus elliotil	PINACEAE	O	O			Exotic		
Pinus massoniana	PINACEAE	O				N		
Rapanea nerifolia	MYRSINACEAE	O				N		
Rhus hypoleuca	ANARCARDIACEAE	O				N	BL	
Rhus succedanea	ANARCARDIACEAE	F				N		
Saplum discolor	EUPHORBIACEAE	F				N		Frt
Sapium sebiferum	EUPHORBIACEAE	O				N		Frt
Schefflera octophylla	ARALIACEAE	C				N	BL	Ntr
Schizostachyum dumetorum	POACEAE	O				N		
Scolopia chinensis	FLACOURTIACEAE	F				N	BL	
Symplocos sp.2	SYPLOCOCEAE	O				N		
Syzygium sp.(S.odoratum?)	MYRTACEAE	R				N		Ntr
Zanthoxylum avicennae	RUTACEAE	F	F			N	BL	Ntr
SHRUBS								
Acanthus ilicifolius	ACANTHACEAE				O	N		
Adinandra millettil	THEACEAE	O				N		
Aegiceras corniculatum	AEGICERATACEAE				C	N		
Antidesma sp.	EUPHORBIACEAE		R			N		
Ardisia quinquegona	MYRSINACEAE	O				N		
Atalantia buxifolia	RUTACEAE	F				N	BL	Ntr
Baeckea fructescens	MYRTACEAE		A	O		N		Ntr
Breynia fructicosa	EUPHORBIACEAE	O	F	O		N	BL	
Callicarpa integerrima	VERBENACEAE	R				N		
Clerodendrum fortunatum	VERBENACEAE		F			N		
Clerodendrum inerme	VERBENACEAE				C	N		
Desmodium heterocarpon	PAPILIONACEAE		O			N	BL	

Plant Species	Family	Local Abundance				Native/?	Remarks	
		WL/R	SL	GL	Coast	(N=native)		
SHRUBS (Cont.)								
Desmodium triquetrum (Pteroloma triquetrum)	PAPILIONACEAE		F	O		N	BL	
Diospyros vaccinioides	EBENACEAE	O	O			N	Frt	
Diplospora dubia (Tricalysia dubia)	RUBIACEAE	O				N		
Enkianthus quinqueflorus	ERICACEAE	R				N.Protected		
Eurya japonica	THEACEAE	O	F			N		Frt
Ficus stenophylla	MORACEAE		O			N		Frt
Ficus variosa	MORACEAE	O				N		Frt
Fortunella hindsii	RUTACEAE	O				N	BL	
Gardinia jasminoides	RUBIACEAE	C	F			N	BL	
Glochidium eriocarpum	EUPHORBIACEAE	O	O			N	BL	
Glochidium puberum	EUPHORBIACEAE		R			N		
Helicteres angustifolia	STERCULIACEAE			C		N		
Ilex asprella	AQUIFOLIACEAE		O			N		Frt
Ilex pubescens	AQUIFOLIACEAE	O	O			N		Frt
Inula cappa	ASTERACEAE			C		N		
Kandelia candel	RHIZOPHORACEAE				A	N		
Lantana camara	VERBENACEAE	O	O			Exotic		Ntr
Lasianthus chinensisi	RUBIACEAE	R				N		
Litsea rotundifolia var.oblongifolia	LAURACEAE	F	F			N	BL	Ntr
Lumnitzera racemosa	COMBRETACEAE				F	N		
Melastoma candidum	MELASTOMATACEAE	O	F			N		Frt
Melastoma sanguineum	MELASTOMATACEAE	O	F			N		
Phyllanthus cochinensis	EUPHORBIACEAE	F	F	O		N		
Premna integrifolia	VERBENACEAE				F	N		
Psychotria rubra	RUBIACEAE	F				N		Ntr.Frt
Rhaphiolepis indica	ROSACEAE	F	F			N		Ntr.Frt
Rhodomyrtus tomentosa	MYRTACEAE	F	A			N		Frt
Scaevola sericea	GOODENIACEAE				F	N		

Plant Species	Family	Local Abundance				Native/?	Remarks	
		WL/R	SL	GL	Coast	(N=native)		
SHRUBS(Cont.)								
Strophanthus divaricatus	APOCYNACEAE	O				N	BL	
Symplocos crassifolia	SYMPLOCACEAE	F				N		
Syzygium buxifolium	MYRTACEAE	O	O			N		
Urena lobata	MALVACEAE		R			N		
Wikstroemia indica	THYMELAECEAE		F			N		Frt
Zanthoxylum nitidum	RUTACEAE	O	O			N	BL	
CLIMBERS								
Alyxia sinensis	APOCYNACEAE	O	O			N		
Aspasaragus cochinchinensis	LILIACEAE	O				N		
Cassytha filiformis	LAURACEAE	O	F			N		
Dendrotrophe fructescens	SANTALACEAE	F	O			N	BL	
Embella laeta	MYRSINACEAE	O	F			N	BL	Frt
Gnetum montanum	GNETACEAE	O	O			N		Frt
Hypserpa nitida	MENISPERMACEAE	O				N		
Jasminum lanceolarium	OLEACEAE	O				N		
Millettia nitida	PAPILIONACEAE	F				N	BL	
Morinda umbellata	RUBIACEAE	O				N		
Mussaenda erosa	RUBIACEAE	O				N		
Mussaenda pubescens	RUBIACEAE	O				N	BL	Ntr
Paederia scandens	RUBIACEAE	O				N		Ntr
Psychotria serpens	RUBIACEAE	O	O			N		
Pueraria phaseoloides	PAPILIONACEAE	O				N	BL	
Rubus reflexus	ROSACEAE	O	O			N	BL	Frt
Scaevola hainanensis	GOODENIACEAE				F	N		
Smilax glabra	SMILACACEAE	O	F			N		Frt
Smilax lanceofolia	SMILACACEAE	O				N	BL	Frt
Tetracera asiatica	DILLENIACEAE	C	F			N		

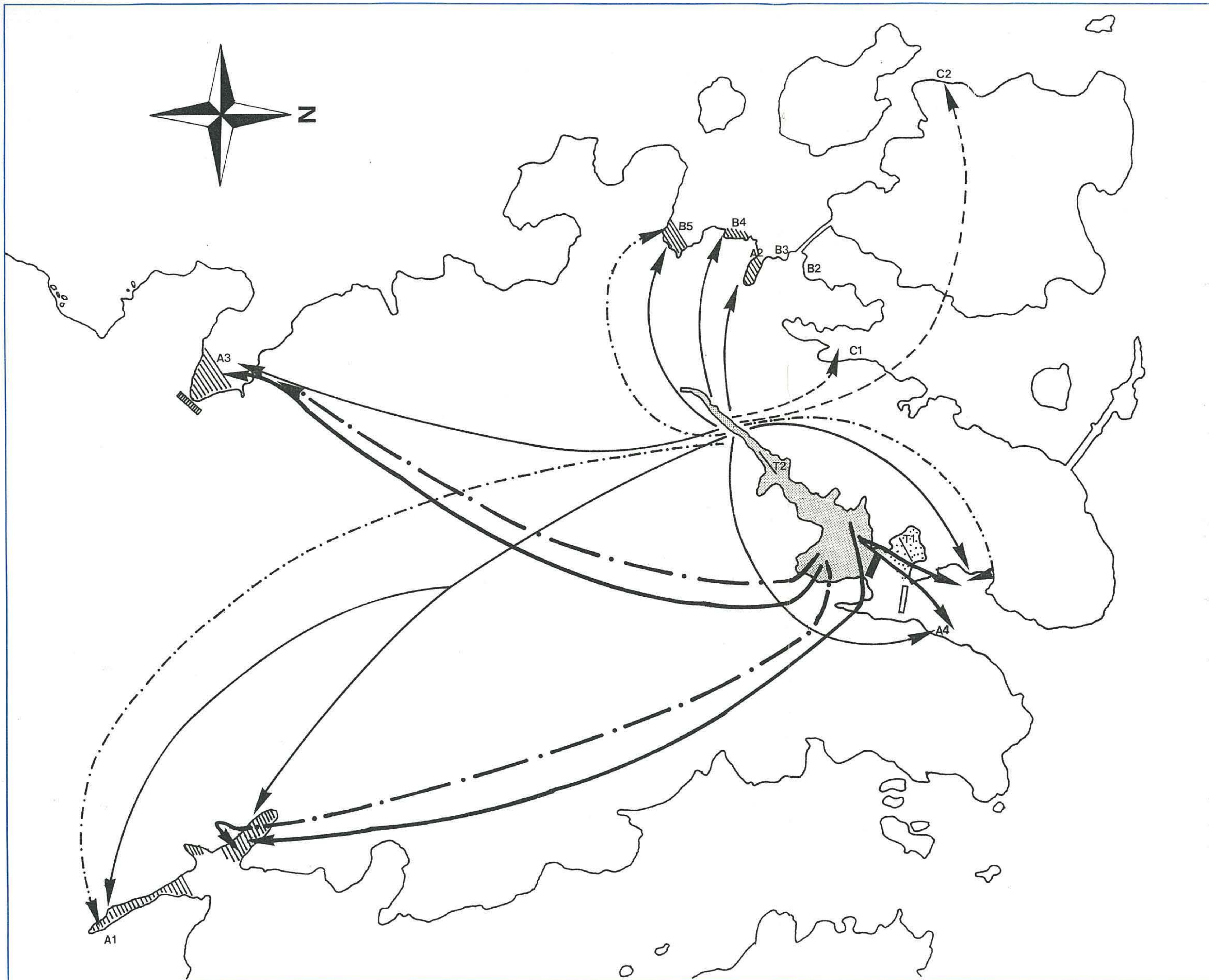
Plant Species	Family	Local Abundance				Native/?	Remarks	
		WL/R	SL	GL	Coast	(N=native)		
HERBS								
Adenosma glutinosum	SCROPHULARIACEAE	F	F			N		
Arundina chinensis	ORCHIDACEAE		O			N.Protected		
Aster baccharoides	ASTERACEAE		F	O		N		
Bidens pilosa	ASTERACEAE		O	O		Exotic		
Dianella ensifolia	LILIACEAE		F	O		N		Frt
Hedyotis acutangula	RUBIACEAE	F	F	O		N		
Melastoma dodecandrum	MELASTOMATACEAE		O	O		N		
Osbeckia chinensis	MELASTOMATACEAE		F	O		N		
Phylidrum lanuginosum	PHILYDRACEAE	R				N		
GRASSES & SEDGES								
Arundinella nepalensis	POACEAE		F	C		N		
Cymbopogon tortilis	POACEAE		F	A		N	BL	
Digitaria sp.	POACEAE			O		N		
Eleocharis atropurpurea	CYPERACEAE	O				N		
Eleocharissp.2	CYPERACEAE	O				N		
Eragrostis pilosa	POACEAE		F	F		N		
Eremochloa ciffaris	POACEAE				F	N		
Fimbristylis sp.	CYPERACEAE				F	N		
Ghania tristis	CYPERACEAE		F	C		N		
Ischaemum aristatum var.meynianum	POACEAE		C	A		N		
Ischaemum ciliare(I.indicum)	POACEAE		F	C		N	BL	
Lepidosperma chinense	CYPERACEAE		A	C		N		
Miscanthus sinensis	POACEAE	O	O			N	BL	
Neyraudia reynaudiana	POACAEA		O			N		
Paspalum thunbergil	POACEAE			O		N		
Rhynchospora corymbosa	CYPERACEAE	O				N		
Rhynchospora rubra	CYPERACEAE		F	C		N		

Plant Species	Family	Local Abundance				Native/?	Remarks	
		WL/R	SL	GL	Coast	(N=native)		
GRASSES & SEDGES(Cont.)								
Rhynchspora sp.3	CYPERACEAE	O				N		
Scirpus sp.	CYPERACEAE	O				N		
Scleria chinensis	CYPERACEAE		F			N		
Scleria levis	CYPERACEAE		O			N		
Setaris glauca	POACEAE		F	C		N		
Sporobolis fertilis	POACEAE		O	O		N		
Sporobolus virginicus	POACEAE				C	N		
FERNS & ALLIES								
Adiantum flabellulatum	ADIANTUM Group	F				N		
Blechnum orientale	BLECHNUM Group	C				N		
Brainea insignis	BLECHNUM Group		O			N		
Dicranopteris linearis	GLEICHENIACEAE	O	A	F		N		
Lycopodium cernum	LYCOPDIACEAE	O				N		
Lygodium flexuosum	SCHIZAEACEAE	O	O			N		
Lygodium japonica	SCHIZEACEAE	O	O			N		
Schizoloma heterophyllum	LINDSAEA Group	O				N		
Sphenomeris chinensis	LINDSAEA Group	O				N		

Legend :
WL/R = Woodland or ravine
SL = Scrubland
GL = Grassland

BL = Foodplant for Butterfly Larvae
Ntr = Nectar source for Butterflies and Wasps
Frt = Fruit for birds etc.

Local Abundance :
A = Abundant
C = Common
F = Frequent
O = Occasional
R = Rare



— T_1 (TRANSECT 1); T_2 (TRANSECT 2)

PROPOSED BRUGNIERA GYMNOSSHIZA TRANSPLANTATIONS

TENTATIVE BRUGNIERA GYMNOSSHIZA TRANSPLANTATIONS

PROPOSED AVICENNIA MARINA TRANSPLANTATIONS

PROPOSED KANDELIA CANDEL TRANSPLANTATIONS

PROPOSED OTHER MANGROVE SPP. TRANSPLANTATIONS A. CORNICULATUM, A. ILICIFOLIUM AND LUMNITZERA)

MANGROVES SAVED

MANGROVES TO BE FLOODED

MANGROVE SITES ENRICHED

PROPOSED DAM SITE #1

PROPOSED DAM SITE #2

PROPOSED DAM SITE #3

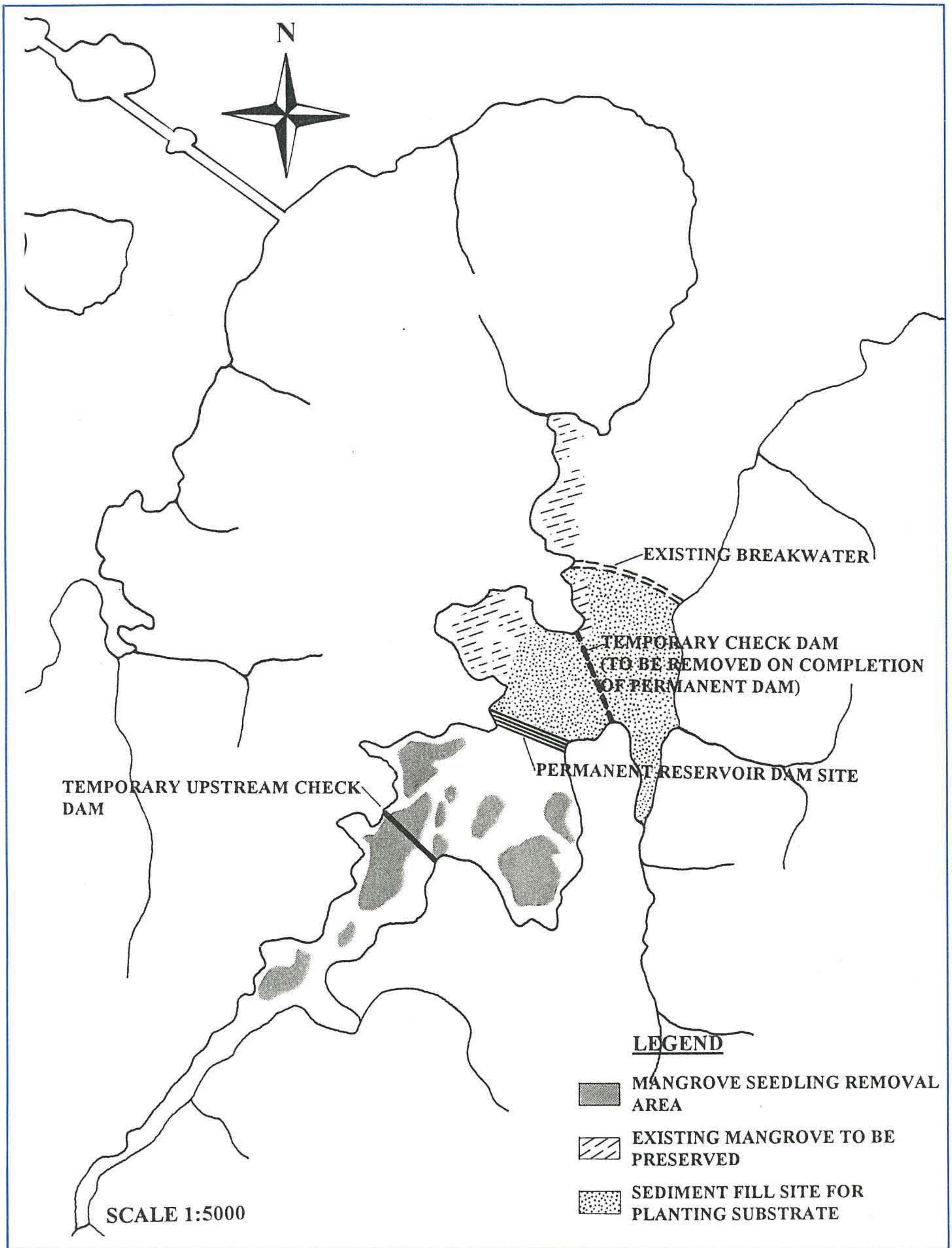
SCALE 1:10000

AXIS Environmental

Kau Sai Chau Project

Figure 5.1 Mangrove Impact Mitigation Plan (see Table 5.12 for details of mitigation sites)

076000/ December 1993



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Kau Sai Chau Project

Figure 5.2 Kwat Tau Tam Mangrove Mitigation Detail

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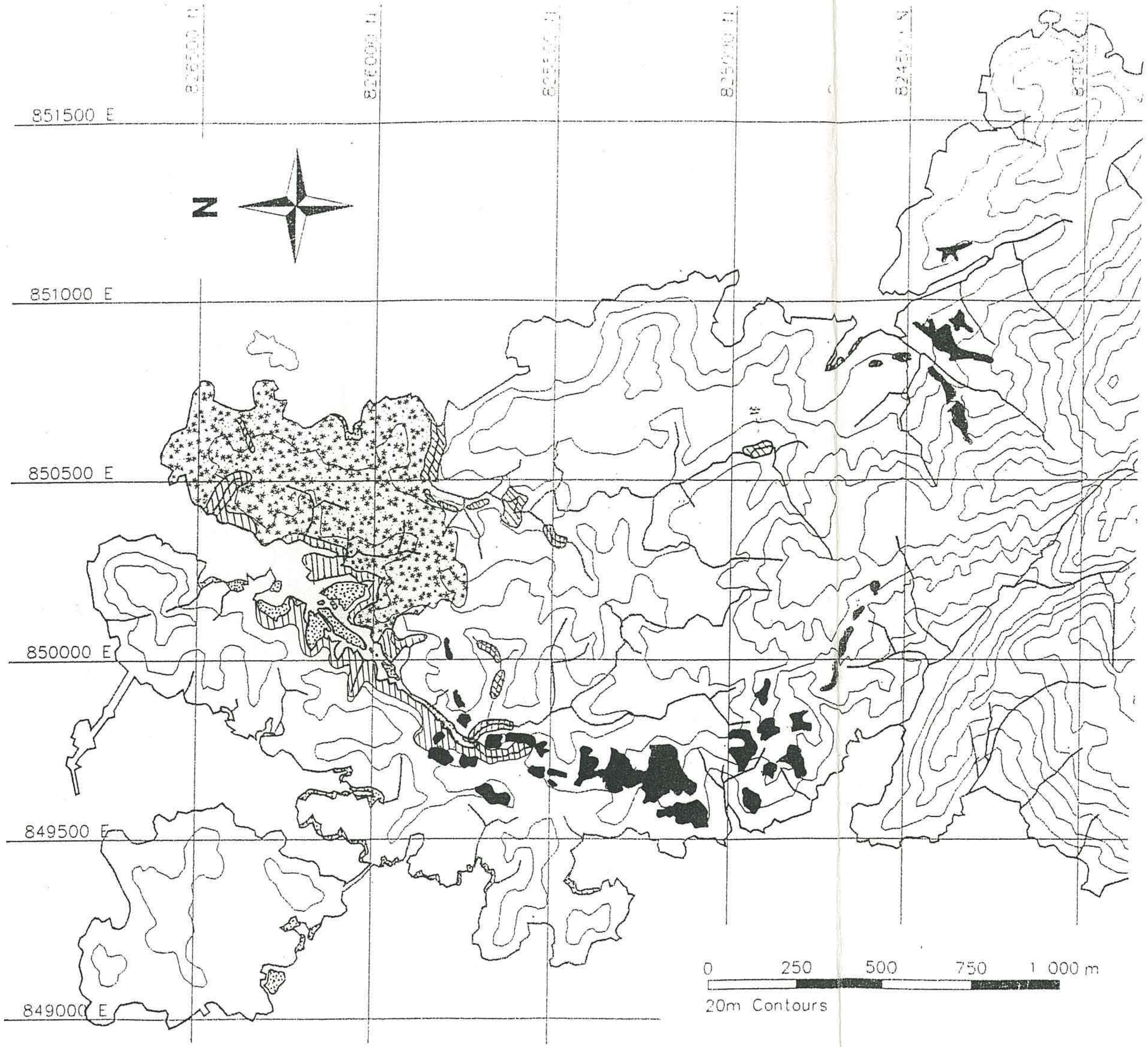

LEGEND

- MANGROVES
- TALL SHRUB/WOODLAND
- BOMB DAMAGE
- STREAM COURSES
- GRASSLAND
- SCRUBLAND

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Kau Sai Chau Project

Figure 5.3: Habitat Plan

076000/ September 1993

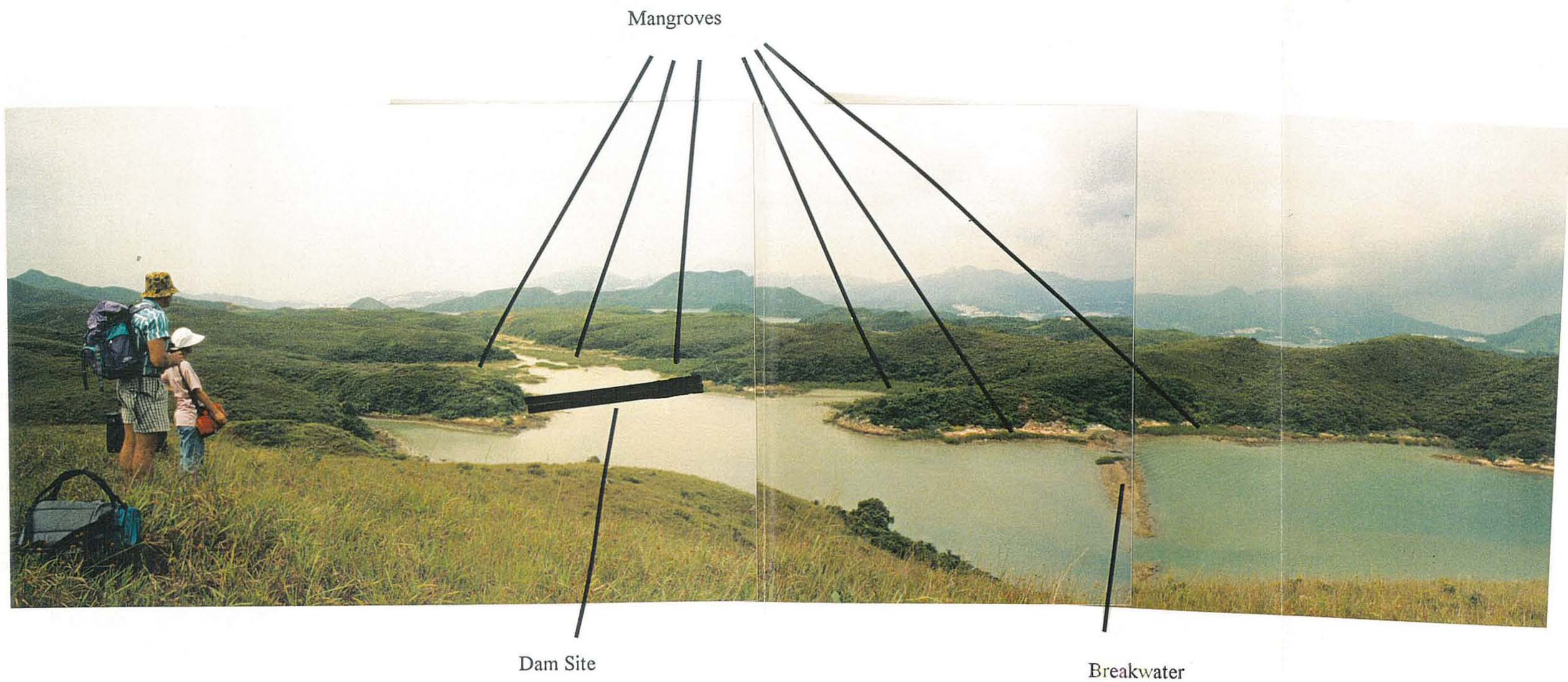

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Plate 5.1 Mangrove at Kwat Tau Tam inlet, Kau Sai Chau, Summer 1993.

Plate 5.2 Eroded former artillery range at Kau Sai Chau, summer 1993.

TURFGRASS MANAGEMENT PLAN

SECTION 6

6.0 TURFGRASS MANAGEMENT PLAN

6.1 Introduction

This Turfgrass Management Plan (TMP) is designed to provide management direction for the refinement of a Turfgrass Management System (TMS) for the planned golf course at Kau Sai Chau. The aim of the TMS will be to provide a managed turfgrass playing surface and to control non-point chemical contamination of surface, groundwater and marine waters and protect non-target organisms from contamination.

A TMS is required as part of the Stage 2 EIA as is a review and impact assessment of the candidate chemicals planned to be used on the golf course, their toxicity and impact on the surrounding environment and ecology.

A TMS has a number of fundamental components. At this stage of the study it is possible to define some of these components quite clearly. Others will require further work and liaison between the proponents and the Authorities to clearly define responsibilities of the different parties for operating the TMS. This TMS contains a Chemical Application Management Plan (CHAMP) and a Chemical Spill Contingency Plan (CSCP).

6.2 Trufgrass Management System Components

The following TMS components have been defined for Kau Sai Chau.

a) **System Component 1 = *Definition of Roles***

Definition of the roles of all people involved in the management of turfgrass assures understanding of goals and promotes communication. Important individuals in the development of TMSs on golf courses are the course superintendent, members of the green and golf committees, the golf professional, the golfers, and government departments which will eventually be responsible for management of Kau Sai Chau. There will also be more general concerns with respect to the statutory requirements enforced by EPD, WSD and AFD.

b) **System Component 2 = *Establish Objectives***

It is crucially important to establish objectives for realistic water, nutrient, and pest management on the course. These objectives will serve as the basis for establishing control methods and action thresholds.

Management of tees and greens will require different control strategies than for fairways and rough. Integration of irrigation, fertilization, pest and other cultural control methods is essential for effective TMS operation. The guidelines for the control strategies to be applied at Kau Sai Chau are based on current legislation in Hong Kong and on local and international practice and local knowledge.

c) **System Component 3 = *Establish Action Thresholds***

The action thresholds which will be established for implementing pest control procedures will be based on regulatory guidelines and baseline conditions. In TMS programs action thresholds are based on pest populations, turfgrass/soil nutrient tests, soil water conditions, soil and thatch physical properties, turfgrass playing conditions, and environmental conditions. All of these conditions indicate whether action must be taken to maintain the playability of the turf. No action, whether chemical, physical, or cultural, will be taken until the predetermined action threshold is exceeded. The thresholds will be determined and developed in the detailed design stages as local soil conditions and soil microclimate become apparent.

d) **System Component 4 = *Monitoring***

Monitoring the golf course for climatic conditions, irrigation water quality, soil condition, nutrient status, pest populations, and turfgrass quality will be undertaken on a regular and consistent basis to determine when the action thresholds are reached. Monitoring will also be used to determine whether a specific set of non-chemical control methods, or, in the last resort, the use of chemical controls has been successful, especially where these may effect local marine or freshwater resources.

e) **System Component 5 = *Specific Management Practices***

Specific management practices to suppress pest populations, reduce nutrient and water deficiencies, or maintain turfgrass quality for playability will be selected from a range of options. Depending on site-specific conditions, management options include physical, biological, or chemical treatment. Understanding the relationship of nutrients, water, and climatic conditions is especially important for control and prevention of conditions conducive to pest and disease infestations. Management practices will be subject to periodic review based on information from environmental monitoring and audit programmes. Particular emphasis will be placed on management review during establishment of the course and in the first few years of operation.

At Kau Sai Chau the use of natural non synthetic or organic alternatives for nutrient and pest control options have been investigated for preference and acceptability to the authorities. Alternative biological and cultural options have also been investigated.

The balancing of investment in green construction and a complex drainage system with a fully integrated irrigation regime will allow excellent control of these two basic management practices on the Kau Sai Chau course. The importance of good drainage in controlling pests and diseases cannot be overemphasised, particularly in the sub-tropical environment of Hong Kong. In general the United States Golf Association (USGA) system of construction will be used for the greens and tees.

f) **System Component 6 = *Chemical Usage***

The overriding principle which will guide chemical usage at Kau Sai Chau will be to **avoid** the use of any chemicals except where absolutely necessary to maintain the course in a suitably playable condition.

Before chemical usage, appropriate alternative controls will always be preferred to chemical control measures.

Preferred chemical practices would provide maximum contact with the intended pest (pesticide) or root system (fertilizer), while presenting the least possible hazard to non-target organisms or environment. Where pesticides must be applied measures will be taken to restrict the access of non-target organisms (such as by overnetting) if the chemicals have any residual period of potential toxicity.

Chemicals will only be applied on the basis of need. Calendar, global broadcast, and preventive applications **will not be permitted** since they are not consistent with integrated systems, environmental quality, or broader aims of the TMS.

g) **System Component 7 = *Maintaining Written Records***

Maintaining written records of course management objectives, monitoring methods, data collection, management actions, and the results of management practices is essential for evaluation of TMS and the iterative review and development of future plans. This component will allow long term audit of the performance of the TMS. Details of procedures are provided in section 6.11.

h) **System Component 8 = *Evaluation***

Evaluation of the results of integrated pest control measures, pest habitat alteration, pesticide application, use of alternate control options, fertilization, and water management (irrigation/drainage) will be conducted periodically to assess the success of the TMS program. Results of the evaluation will be used to modify the program to meet changing environmental, cultural, and pest conditions especially in the first four year of course life.

6.3 Factors Affecting the TMS

The development of the TMS for the management of water, nutrients, pests and diseases is essential for maintenance of the playing turf and the protection of the environment around the course. Many techniques can be used on golf courses to provide an adequate playing surface of turfgrass. The factors affecting the extent to which various design, cultural, and treatment techniques are implemented in an integrated management system for turfgrass are:

- The calibre of the course and the degree of excellence required in the turf;
- The choice of grasses to be used on different playing areas (greens, fairways, roughs, tees);
- The natural field resistance of the turfgrasses to diseases and pests;
- The suitability of non-chemical methods in maintenance of different grasses and playing areas;
- The extent to which some level of pest infestation can be tolerated in balance with natural predators;
- The design of the course and its effect on soil micro-climate;
- The desire to balance minimal use of chemicals against maintenance of a durable playing surface;
- The experience and skill of the golf course manager in integrating the mix of available technologies to achieve the golf course objectives.

6.4 TMS and the Significance of Potential Impacts

Potential environmental impacts have been identified and are associated with:

- contamination of surface water and groundwater with fertilizers and residual pesticides;

- contamination of surface water with sediment during construction and interface with natural drainage;
- perceived and actual health effects on humans, wildlife or other non-target organisms;
- development of resistant populations of pests and diseases.

Construction of new golf courses is often subject to widespread opposition. In some quarters the golf course manager (GCM) is perceived as being concerned only for maintenance of grass and course at the expense of other elements of the environment. In fact, the modern GCM uses a TMS to develop a balanced approach to course and pest management. This theme is developed in this section of the Stage 2 EIA.

The fate of chemicals applied to golf courses is often compared to that of similar chemicals used in agriculture. This comparison is based on the erroneous presumption that golf course chemicals are necessarily applied using similar methods and lacking effective controls. This ignores the fact that management practices for golf courses offer a much greater degree of potential control. The function of the TMP is to provide control through environmental monitoring, audit and review so as to allow effective protection of the surrounding environment. The trends in golf course management are toward minimization of environmental contamination through:

- corrective rather than preventive use of all chemicals;
- avoidance of the use of chemicals except where absolutely necessary;
- use of modern chemicals which break down quickly and have little residual effect;
- reducing application rates to reduce risk of any surplus chemical reaching water bodies;
- use of target-specific rather than broad-spectrum chemicals ;
- application of chemicals when pest species are at the most sensitive life stages;
- placement of legal restrictions on the types of chemicals registered for use on golf courses;
- allowing application only when there is a probability of serious loss of turf;
- encouragement of biological control of pest species by natural predators.

No reasonable GCM can expect to maintain a course without the use of some chemicals be they synthetic or organic. The nature of the turfgrass and the stresses caused by continual play dictate a requirement for fertilization. This will assist regrowth to withstand the wear and tear of play and trampling. Natural infestation of insect or fungal pests and unwanted plants will occasionally cause a need for use of insecticides or herbicides. This will maintain the playable condition of the golf course. However, the experienced GCM will use the natural attributes of the course to minimise the use of chemicals wherever possible in a TMS. The function of the TMS is to control management practices and chemical usage to a point where the environmental impacts are insignificant.

Whereas the broad scale and unfettered use of chemicals would certainly have effects in an area such as Kau Sai Chau, the use of a TMS and proper design of the course will give the GCM adequate scope to minimise chemical use. The range of management practices in the TMS includes:

- selection of turfgrass species and cultivars;
- soil management practices;
- mowing and cultivation practices;
- nutrient management;
- irrigation and drainage management;
- chemical, biological and cultural pest management.

Conservation of soil, nutrients, water, and other natural resources on and around the course is a fundamental objective of the TMS. The goal of the TMS is to balance environmental quality, costs, benefits and public health with acceptable levels of playability. The system will be refined over time through continuing review by the GCM to incorporate knowledge accumulated from operations. The initial system will be set by the course management in consultation with relevant departments of government (in particular WSD, AFD and EPD) at the detailed design stage of the course and subsequently fine tuned based on extensive monitoring.

6.5 Selection of Turfgrass Species and Cultivars

This section is intended to establish the broad strategy of selecting the grasses which will require minimal chemical maintenance and offer the highest tolerances to the range of pests likely to be encountered. The eventual selection of turfgrass species will be decided by the golf course designer and the developer.

Selection of species and cultivars with stress tolerance to regional and local weather patterns will minimise potential for decline in turfgrass quality and reduce the need to resort to artificial stimulants to keep the grass in good condition.

6.5.1 *Fairways*

Nu Mex Sahara

Preference has been indicated by the golf course designer to use the commercially available Nu Mex Sahara throughout the course. This variety of bermudagrass (*Cynodon sp.*) has been used with success in other tropical and sub-tropical habitats in Thailand and throughout the world. It offers advantages in terms of pest and drought resistance, and can be hydroseeded, allowing rapid establishment and reduced chance of erosion. Under proper management it will out-compete weed species. Chemical pest and weed control methods are only recommended as a last resort. Performance of this variety has been substantiated since 1986 in national turfgrass evaluation programs in the USA. Nu Mex Sahara has a superior playing surface than *Zoysia spp.*

Zoisiagrass

Success has been achieved in Hong Kong with the Zoysia grasses of the genus *Zoysia spp.* A hybrid of *Zoysia japonica* has recently become available from the Jackland Seed Company, Oregon, USA although it is raised commercially in China. This grass is native to the region and tolerant of the ambient climate. The grass can be seeded and thus would be preferred to its relative *Zoysia machuka* which is only available as turf from China. However, Zoysia grasses require greater mechanical treatment and is slower to establish than Nu Mex Sahara.

Another species which could probably be used with success would be *Zoysia matrella*, often used in Thailand. The seed of *Z. japonica* has the added advantage of being relatively free from weed species whereas the turf available from China often contains broad-leaved weeds. *Z. japonica* would be a suitable candidate for the turfgrass on the fairways and roughs. It could also be used on most of the tees.

Z. japonica has a lower requirement for supplemental nitrogen than do grasses such as *Cynodon sp.* *Z. japonica* is naturally resistant to sod web worms and nematodes, which are common pests on Hong Kong courses. Retention of applied chemicals and resulting playing surfaces of Zoysia grass are superior to those of the more commonly used carpet grass.

6.5.2 *Greens*

The grass most commonly used for greens on Hong Kong golf courses is bermudagrass (*Cynodon spp*). This grass grows quickly under the local climate and provides a sufficiently tight turf for greens. It is also resistant to a number of local pests such as mole crickets, tropical sod web worm, bermudagrass mite, spittle bugs and nematodes. New hybrids and cultivars will be commercially available in late 1993. Although bermudagrass may require more nitrogen fertiliser during the growing season than Zoysiagrass, its superior ability to absorb nitrogen means that small applications of fertilizer will be rapidly absorbed for growth with little if any wastage. The proposed method of applying fertilizers is discussed later.

6.5.3 Tees

The option for choice of grass on tees is dependent upon the type of tee. On the par three holes the player will often elect not to use a tee peg to support the ball. The wear and tear on such tees is thus greater because of the divot taken in the playing stroke. This requires a fast growing grass on such tees to cover the small areas of damage. Bermudagrass would be one obvious choice.

On most par four and par five holes the damage to the tee is less and the requirement for fast growing grass is less critical. Zoysiagrass could be used on these tees although the option to use bermudagrass has no disadvantage.

It may be possible to substitute other turfgrasses with lower nutrient requirements on certain parts of the course or practice areas. This could further reduce the fertiliser requirements.

6.6 Soil Management Practices

Sound knowledge of the physical attributes of the course, drainage, soil type and nutrient status will be vital to good soil management. Management of the soil is the key to the success of the grass. This will be gained through close attention during course construction and through on-site experience of the local conditions.

6.6.1 Erosion Control

In a highly eroded area such as Kau Sai Chau it would be unreasonable to approach course construction without expecting some erosion problems. The choice of fast growing turfgrass varieties will allow rapid establishment of the main grass sward and the maturation of the turf areas will prevent major erosion problems. Early recognition of potential erosion, the phasing of main construction activities for the dry season and close liaison with the HK Royal Observatory for weather forecasting will enable potential problem situations to be identified and appropriate control techniques to be implemented prior to any mass erosion or wash out of established areas. Erosion control matting will be used wherever necessary to contain erosion and promote rapid and healthy seed germination. Totally organic blankets as straw and coconut fibre mixtures are commercially available and may be used extensively during course establishment. The phasing of course construction to coincide with dry weather periods is also a major contribution to erosion control.

6.6.2 Green and Tee Design

Greens and tees will be constructed to USGA specifications, and drainage will be provided for groundwater on each green. The USGA drainage system will be paramount in the success of soil management. Use of the USGA system will provide surfaces with excellent playing characteristics. Surplus water will be rapidly removed from the surface, reducing turf susceptibility to diseases and pests. Sufficient water will be retained in the root zones to minimise the need for irrigation. The growing medium for the grasses will be a sand soil mixture (the Root Zone Mix) which will be determined based on independent tests and recommendations and the specific properties of the local soil.

6.6.3 Irrigation Practices

Irrigation practices will be designed to maximise water use and minimise water wastage and the chance of disease proliferation. Irrigation will be provided little and often when required and never to the extent that the soil becomes saturated. Morning (dawn) irrigation will be preferred because temperatures will be lower and evaporation losses will be less. Watering at this time of day will tend to dislodge dew, exudates, and potential disease organisms from the leaves. Low pressure sprinkler heads will minimise drift away from target areas. Quantitative methods are available to determine the requirement for moisture and these will be used by the GCM to avoid human error which could lead to excessive watering or water wastage.

6.6.4 Nutrient Status

Prior to establishment of the golf course grass, and on a regular basis thereafter, the soil will be analysed. The analyses will include basic N:P:K determinations, pH, organic matter, and trace elements. The nutrient status of the soil will be balanced against the recommended nutrient requirements of the grasses in order to determine the optimum nutrient provision.

Most of the land which will form the main playing areas is former wilderness used as a firing range. During course construction any existing soil will be utilised in the regrading for the course coutours. Samples of the remaining soil will be sent for analysis and its use for the greens and tees will be as recommended by the USGA analyses.

The local soil appears to be poorly developed. As a grass growing medium it may require amendment with sand and organic material to improve tilth. Existing vegetation will be removed. Surplus vegetation will be retained and composted to add to the topsoil at a later date. Other soil amendment materials may also be required. These are discussed in section 6.7.

Because course construction will take place during the drier months (September - March) soil erosion during grass establishment should not be a major problem. The nutrient status is as yet undetermined and may well require little amendment. When the fairways have been constructed the seed bed will be prepared with the parent topsoil amended with composted material and a balanced mixture of proprietary organic fertilizers and soil amendment materials. Examples are presented in Attachment 1. These types of product used on all parts of the course will provide a sufficient supplementary, low base level of nitrogen and phosphorous for growth with adequate potassium and trace elements to establish the grasses and ensure that a strong and healthy sward is established. The soil for the root zone mixture will be balanced to USGA specifications as part of the green and tee construction.

Any further fertilizer applications will be based on soil analysis and nutrient requirements of the grasses so that nutrient supply is not excessive and potential for chemical runoff is minimal. Organic and slow release fertilisers will be used where possible but liquid nitrogenous fertilisers may be preferred particularly in the establishment phase. Bulk application of fertilizer will not be undertaken. Rather the grass will only be fed with small doses of fertilizer which can be utilised quickly, thereby ensuring the chemical goes to the plant and does not escape. Consideration will be given to foliar liquid feeding since this will maximise provision of nutrients to the grass in a readily available form and also minimise runoff.

6.7 Fertilizer Requirements

6.7.1 Principles

The scientific literature reveals that the chemical used most commonly on the golf course which is most likely to pose a threat to water quality is nitrogen, and more specifically, nitrate. This is the chemical most likely to impact on the water supply or water quality at Kau Sai Chau. Phosphorous will also be applied, but at a much lower rate based on soil tests. Phosphorous would normally be applied once per year on fairways and split over spring and autumn applications on greens. Recommended application rates for potassium are generally 50% to 70% of the rate for nitrogen. Other nutrients will be applied on an as needed basis. Chemicals other than nitrogenous fertilisers are also dealt with in principle. Details of cultural strategies for turfgrasses are presented in Attachment 2 to this chapter.

The requirement for and the use of fertilisers at Kau Sai Chau will be determined by the type of turfgrass chosen and the management practices. At present the turfgrass species have not been chosen and the TMS is also in development, however a preference has been shown for the use of bermudagrass (Nu Mex Sahara) which can be hydroseeded. Therefore at this stage the impact of chemicals on water quality is based on assumptions about turfgrass management practices and the use of Nu Mex Shahasa.

It is also important to recognise that turfgrass will grow more healthily when it is not overfed with surplus nitrogen or other nutrients and when is not over watered. This is a major factor in controlling fertiliser usage and controlling runoff. The stronger turf so produced will stand up better to mowing and trampling pressures and will resist diseases.

Nitrogen (N)

When applied with caution and in the appropriate formulation there would be minimal runoff losses. As a foliar liquid feed or in slow release form such as organically conjugated forms of urea (urea formaldehyde or isobutyledene diurea [IBDU], Brown *et.al* 1982) or an organic formulation a worst case scenario would predict losses of up to one per cent. This consistent with the literature on sandy soils which will prevail at Kau Sai Chau. Brown *et.al* 1982 also demonstrated less than 1% run-off losses with irrigation (12mm/day) greater than that proposed for Kau Sai Chau (3.5-7mm/day).

With appropriate management practices the losses of nitrogenous fertiliser will be minimal. Runoff from the fairways would most likely be taken up readily by the plants in the unfertilized roughs, that from the greens would be taken up in the green aprons. Thus the areas surrounding the fertilised areas will effectively act as a buffer.

Phosphorous (P)

Unlike nitrogen, phosphorous is not readily leached from soil. Although soils vary in their ability to retain or absorb phosphates, availability decreases exponentially over time (Anderson *et al.* 1989). Precipitation reactions, adsorption on mineral surfaces and retention by soil constituents will immobilise more than 50% of soluble phosphate within a few hours (Sample *et al.* 1980).

Rapid retention of initially soluble phosphates accounts for observed low concentrations in soil solutions (Frere 1976). Phosphorous is rapidly retained as insoluble inorganic compounds and sorbed to soil surfaces; therefore soluble losses in subsurface flow and runoff are much lower than for nitrogen. Offsite transport tends to be associated more with sediment erosion (Koehler et al. 1982b; Taylor and Kilmer 1980).

Highest concentrations and loss of phosphorous in runoff occurs in the first significant runoff after fertiliser application. The longer the time between runoff and application the less phosphorous is lost. Mass loss of phosphorous is associated with sediment transport, and is only of real consequence during the establishment of turfgrass, but not after establishment (Walker and Branham 1992). Long term release of P has been regularly observed at much less than 1% of the annual application regardless of the rate of application (Alberts et al. 1978). Thus, by avoiding application before storm events losses will be minimal. Losses can be even further reduced (0.35%) if the phosphorous is incorporated into the soil (Dunigan et al. 1976).

Potassium (K)

Turfgrass requires relatively large amounts of potassium. Added potassium fertilizers would be recommended since they would stimulate important root growth and enhance better resistance to drought, heat, cold and wear and tear. Disease resistance is also encouraged by potassium applications at about 60-70% of the nitrogen application rates. Excessive potassium losses from soils and deficient conditions tend to occur in similar conditions to that which favour losses of nitrogen.

Current trends are for lower fertilization rates and for N and K to be applied in roughly equal proportions or with K at 50% to 70% of N. Iron is also recommended to encourage rooting.

Nutrient Deficiency

The most common approach to preventing nutrient deficiency is through soil analysis. Establishing the nutrient status of the soil will enable the most efficient and economic use of fertilisers without excess (Turner and Waddington 1983). Since over fertilisation has been associated with non-point source pollution in agricultural systems (Anderson et al. 1989) fertilization will be based on soil and plant tissue analysis and fertilizers will only be provided sufficient to sustain healthy growth. This is widely regarded as the best management practice (Koehler et al.1982a).

6.7.2 Criteria

The natural process of eutrophication of waters has been identified as an appropriate criterion by which to evaluate the potential impact of the use of turfgrass fertilisers on waters on and around Kau Sai Chau. Threshold criteria for eutrophication in Hong Kong marine waters are generally regarded as nitrogen in excess of 0.3 to 0.5 mg/l. There is no equivalent criterion for fresh water but it is probable that levels of nutrients in the steams of Kau Sai Chau will be much lower than this.

Since potable water is to be derived from the same watershed it is also appropriate to consider impacts on the proposed water supply. WHO guideline values for nitrate nitrogen in drinking water are 10 mg/l.

6.7.3 Potential Impacts

The Kau Sai Chau course is designed to utilise the natural catchments for the provision of the irrigation and potable water supply. About half of the holes will drain towards the sea (Figure 6.1). Drainage from the remainder of the course will either naturally fall to the reservoir or will be directed to the reservoir via pipes and gulleys. The details of this drainage are reviewed in Section 2 and are shown in Figure 2.4.

The potential threat comes mainly from the possibility of nitrogen accumulating in the reservoir or from potential effects on the marine habitats should it leach from the course off site. Other nutrieuts are less critical but are also evaluated below. In the reservoirs and artificially created lakes and ponds elevated nitrogen or phosphorous levels could lead to eutrophication. Since this water is also to be treated for potable use the levels of nitrogen should also be within acceptable health standards.

Potential Runoff

It is important to recognise certain aspects of the behavior of nitrogen fertilisers in soil. If soluble nitrate is present in the soil in a concentration greater than can be utilised by the grass and there is surplus water to percolate through the soil then leaching may occur. Use of insoluble or slow release forms of nitrogen will reduce leaching. The release of phosphorous will not be significant once the course turfgrass is established.

Leaching is more likely to be a problem on exclusively sand greens. Increased applications of nitrogen to sand-loam greens, however, does not necessarily lead to a deterioration in water quality. This assumes the nitrogen applications are commensurate with the ability of the grass to take up the nitrogen. Excess nitrogen will therefore not be applied.

Turfgrass systems generally have high infiltration capacity and consequently the possibilities for surface runoff to lead to deterioration in water quality are significantly reduced. Several studies indicate that losses of nutrients in surface runoff from turfgrass are minimal.

The potential for the loss of subsurface nitrogen is greatly increased by irrigation in excess of that which can be successfully utilised by the grasses. Planned irrigation at Kau Sai Chau (Section 6.7.1) is lower than that which caused minimal (<1%) losses (Brown et al 1982).

If fertilisation of turfgrass does pose a threat to surface or ground water, there are many management options to minimise or avoid the problems. Limiting irrigation, use of slow release fertilisers, timing of applications, and use of less sandy soils will all contribute to limiting nitrogen losses.

There are four primary methods to be used at Kau Sai Chau which will act together to reduce non-point losses of nitrogen:

- Excessive irrigation will not be practised at Kau Sai Chau since water supply will be limited.

- Slow release fertilizers and foliar feeding will provide adequate nutrients directly to the areas of need and reduce nutrient surplus and losses.
- Realistic non-calendar applications based on soil testing to suit specific turf requirements will be the methods of choice.
- Organic matter will be mixed with the native soils to ensure nutrients are retained in the sod.

6.7.4 *Quantification of Impacts*

A preference has been indicated to use a bermudagrass (Nu Mex Sahara) for the greens and fairways at Kau Sai Chau. Fertilisation rates for Zoysiagrass would be much lower. Local knowledge suggests fertilization rates could be reduced by up to 50% with Zoysiagrass depending on prevailing conditions.

The following estimates of chemical usage have been subject to review but are based on the discussions above and typical nitrogen application rates for bermudagrass fairways and greens in order to assess the likely impact of nitrogen fertilisers on water quality (Attachment 2).

Since the chemical used most commonly on the golf course which is likely to pose a potential hazard to water quality is nitrogen, due emphasis is given to this nutrient in the following impact assessment.

Application rates are usually given in pounds per acre or pounds per 1,000 sq.ft. Where conversion is necessary 1,000 sq.ft is assumed to be approximately equal to 0.01 ha.

Nitrogenous Fertilisers

The two golf courses will consist of about 49 ha of fairways and 3.6 ha of greens (including practice areas). Application rates for the fairways range between 11 to 45 kgN/ha/growing month with irrigation (lower rates without irrigation.) Application rates for the bermudagrass greens range between 20 to 50 kgN/ha/20 to 30 growing days with water soluble carriers (slightly higher rates for slow release carriers).

Nitrogen applications per month to fairways are about 2205 kg (49x45). On greens the figure would be 180 kg (50x3.6). Total monthly applications of nitrogen during each growing month would be <2400 kg. Assuming six growing months the total annual application would be <14,500 kg.

Irrigation will be in the region of 3.5 mm/day on fairways and 7 mm/day on greens when there is no precipitation. Fertilisation will not take place immediately prior to a major storm event and the RHKO will be consulted for weather forecasting.

The literature indicates that good management practices can limit leaching losses of nitrogen to <1% (Brown *et al.* 1982 and Attachment 4). Therefore, assume approximately 145 kg of N leached. About half of the fertilised areas will drain to the reservoir, therefore about 73 kgN would enter the reservoir and a similar amount in diffuse form might runoff towards the sea.

The reservoir has a designed gross storage capacity of approximately 570,000 m^3. Thus if all the 73 kg nitrogen accumulated in the reservoir at full capacity the resulting concentration would be

73/570 = 0.13 mgN/l

The reservoir has a dead capacity of approximately 150,000 m^3. Thus if all the 73 kg nitrogen accumulated in the reservoir at minimum capacity the resulting concentration would be

73/150 = 0.49 mgN/l

Assuming fairways of zoysiagrass, much less nitrogen would be required annually for the fairways. Nitrogen applications per month to fairways are about 1500 kg (30x49) compared with 2205 kg for bermudagrass. On bermudagrass greens the figure would remain 180 kg (50x3.6). Total monthly applications of nitrogen during each growing month would be <1700 kg. Assuming six growing months the total annual application would be <11,000 kg.

About half of the fertilised areas will drain to the reservoir, therefore <55 kgN would enter the reservoir and a similar amount in diffuse form might runoff towards the sea.

If all the 55 kg nitrogen accumulated in the reservoir at full capacity the resulting concentration would be

55/570 = 0.10 mgN/l

Thus if all the 73kg nitrogen accumulated in the reservoir at minimum capacity the resulting concentration would be

55/150 = 0.37 mgN/l

None of the above estimated N concentrations exceeds 5% of the WHO health guidance levels. Nitrogen levels in the range of 0.3 to 1.0 mg/l have been recognised as encouraging natural algal bloomes in fresh water (Macan & Worthington 1972, Hynes 1960).

Phosphorous Fertilisers

The application rates for phosphorous fertilisers will initially be of the same order of magnitude as for nitrogen (70%) but thereafter applications are much less frequent (Attachment 2). However, as described above, the potential to leach P from the soils is much reduced (<1% annually and probably <0.5%, Dunigan et al. 1976) because P is much more firmly bound to soils.

It is reasonable to assume, therefore, that resultant P concentrations in runoff would be much lower (down to 50%) than nitrogen concentrations, as is commonly found elsewhere. Therefore the total losses of phosphorous could expected to be less than 100 kgP/year with half towards the reservoir.

Dissolved in the designed gross storage capacity of (570,000$m^{3.}$) all the 50 kg phosphorous would produce a concentration of

50/570 = < 0.09 mgP/l

Dissolved in the dead capacity of (150,000$m^{3.}$) all the 50 kg phosphorous would produce a concentration of

50/150 = < 0.33 mgP/l

Naturally occurring concentrations of phosphates in oligotrophic fresh water are generally much lower than 0.5 mgP/l. However, concentrations of up to 1 mgP/l have been reported as not bringing about excessive eutrophic conditions (Pitcairn and Hawkes1973). Phosphate concentrations are not likely to be excessive.

Potassium Fertilisers

The application rates for potassium fertilisers will initially be of the same order of magnitude as for nitrogen. The same arguments hold true for potassium as for phosphorus (Attachment 2), and the potential to leach K from the soils and produce excessive concentrations is likely to be negligible.

Ambient concentrations of potassium in oligotrophic fresh water will fluctuate depending on season and flow conditions between 0.5 and 5 mg/l. This dissolved metal is required for vigorous plant growth but is not generally limiting in freshwater systems.

Natural Nutrient Sources

If small amounts of nitrogenous or other fertilisers can escape from the fairways and greens to the lakes or reservoir the impact has to be balanced with that which may result from natural sources. If natural nutrient sources are significant the requirement for added nutrients may therefore be reduced.

Certainly some natural sources of nitrogen and nitrate will occur in the streams at Kau Sai Chau. Rainwater itself may contain considerable amounts of nitrate. Concentrations of 0.1 mgN/l as nitrate are not uncommon (Vollenweider 1970). The surface loadings attributable to precipitation are reported in the region of 2 kgN/ha/year (as nitrate). Rainwater will also contain equally significant amounts of nitrite and ammonia which will be converted to nitrate by nitrifying bacteria in the soil. Whereas these sources of nitrogen are not sufficient to reduce fertilizer requirements significantly they will be a positive contribution.

Reservoir

The reservoir will undergo natural eutrophication as do all man made and natural lakes but given the above fertilization rates it seems likely that the reservoir may only be subject to gradual eutrophication in the long term. Although nitrogen sources will be significant, phosphorous is more likely to be the limiting nutrient and P concentrations will not be excessively elevated so as to bring about rapid eutrophication.

If the waters of the reservoir are well oxygenated the effects of fertilizer sources should not cause eutrophication to accelerate to the degree where nutrient enrichment becomes a problem. The nitrifying bacteria will therefore not reduce oxygen levels significantly. We conclude that excessive runoff would be preventable, (Attachment 4) and would not cause deterioration of the water quality in the streams or reservoir of Kau Sai Chau.

Seaward

Given the current drainage regime, about half of the holes would eventually drain towards the sea creating a diffuse low level source of nitrogen. However the ambient levels of inorganic nitrogen in the surrounding waters are below the criteria for eutrophication and given the diffuseness of the source and the massive diluting effects much greater than that of the reservoir it is unlikely that any impact would be detectable on the water quality, at the nearby mariculture sites, or in the marine habitats and beaches in the vicinity.

Potable Water Supply

The concentrations of nitrogen in the reservoir water will not exceed the 10 mgN/l WHO criterion given the management practices above.

Mitigation

Despite the above argument which does not favour rapid eutrophication it is thought prudent to retain some mechanism to help control excessive nutrients should they begin to accumulate in the long term. Such mitigation is best introduced in the early stages to avoid later retrofitting of the designs.

In order to mitigate the possible long term effects of eutrophication it is proposed to remove as much of the nitrogen from the drainage as possible. The method currently in development has been discussed earlier in chapter 3. By introducing a weir or series of weirs at the head of the reservoir it is proposed that the dry weather flow from holes 1, 2, 7, 8, 9, 10, 17, 18, 19 and 20 could be intercepted. These wiers will form four medium sized ponds (adjacent to holes 7,10,18,19 & 20) which will act as a treatment reservoir (TR). Water in these ponds would be recirculated for irrigation purposes and monitored to determine nitrogen levels and the need for supplementary fertilisation. Thus the dry weather flow from these holes would be retained on this part of the course.

The ponding system would cross holes 10, 18, 19 and 20 linking the four smaller ponds previously proposed. Emergent macrophyte vegetation would be planted in the pond, creating a useful marginal habitat. Algal growth would utilise or mop up surplus nitrogen and phosphorous so reducing the load on the reservoir and providing the base for a food webb. Fish introduced to these ponds would crop off any surplus algal growth and provide an integrated tool for bioassay and biomonitoring (see also chapter 9). Local species likely to be suitable would be silver carp (*Hypopthalmicthys molitrix*) and bighead carp (*Aristichthys nobilis*) which are plankton feeders. The grass carp (*Ctenopharyngodon idellus*) could be used to control excessive growth of submerged plants and grasses.

Excessive vegetative growth could also be cropped off (scouped out) and composted at intervals to keep the system free flowing. The ponds adjacent to holes 9, 30, 33, 34 and tees 1, 10, 19, 27, could be similarly designed and could also provide habitat for waterfowl.

6.8 Weed Control and Herbicide Requirements

Principles

Weed Control

Weed control is mainly accomplished by mechanical methods on many courses in Hong Kong and throughout Asia. The techniques of choice are different from course to course but a team of up to as many as 25 staff are employed at many of the local and Guangdong courses and these teams are engaged almost exclusively in hand weeding of the fairways, roughs, and tees. In this way up to 80% of the weed species are controlled. This level of control will be sufficient for weed control on most areas of the course at Kau Sai Chau. Thus, the requirement for chemical control of weeds will be reduced to the absolute minimum.

Use of good quality seeds and turf in establishing the course will help reduce the possibilities of introducing weeds. Soil management practices will avoid weeds becoming established, as will light mowing on a frequent basis. Allowing a slightly longer grass length as is preferred with Nu Max Sahara will help to ensure that the turfgrass species dominate the weeds so that weed control requirements are minimised. In conjunction with hand weeding the weed species will be effectively controlled in most areas.

However in the event that all mechanical means fail it may be necessary to make spot applications of herbicides from time to time; probably only on the greens which are less amenable to hand weeding. In this case the material of choice would be specific to broadleaf species and readily translocated in the target plants.

Aquatic Toxicology

The freshwater and terrestrial habitats formed by the course at Kau Sai Chau also require consideration. The toxicity of the chemical to wildlife must be carefully considered. In order for the chemicals to bring about toxic effects in the biota the exposure must be:

- to the chemical in a chemically active/toxic form;
- to a sufficient concentration of the chemical;
- for a sufficient length of time.

The toxic effects may be acute or chronic and will depend on the dose and duration of exposure.

Candidate Herbicides

Glyphosate based preparations (e.g.Roundup® by Monsanto Chemical) would be a probable choice and is used at other courses in Hong Kong with considerable success. This chemical is chosen because of its broad spectrum of activity. It is translocated in the plant after spraying on to the leaves. It is strongly bound to the soil (Flint 1987; Wauchope *et al.* 1991), so minimising the chances of runoff. Glyphosate works best in conditions of high humidity and only requires six hours rain free weather after spraying to be effective. It breaks down quickly upon contact with the soil so minimizing the chance of runoff or of contaminating non-target species. Glyphosate is registered for use in potable water supplies in the USA.

Spot application of the herbicides on greens and tees would be to discrete areas of weeds. Thus in the unlikely event that for some reason the herbicides are not broken down in the usual way they would be retained in the area of application. Rapid chemical breakdown would take place once water contacted the chemical. Water in the streams, ponds and reservoir would be tested periodically as part of the soil management programme. In the event that they are detectable pesticide usage would be reviewed.

Quantification of Impact

Recommended application rates for glyphosate are around 8.0 l/ha, with about 40-50% (500g/l) active ingredient (depending on formulation). Spot applications of these chemicals would only be used in the event that all mechanical methods of weed control failed. Spot treatments would not require such high application rates and would only be required in small areas.

Probably much less than 20% of the total tee and green areas would require treatment and it is entirely probable that most of the weeds on the fairways and roughs could be controlled solely by mechanical means to maintain the necessary level of playability.

However, assuming a worst possible case and that for some unforeseeable reason 20% of all fairways greens and tees had to be sprayed once per year; the total active ingredient sprayed to the total playing area would be (1 x 500g x 41 x 10ha) = 20 kg active ingredient annually. Assuming even 1% of this material found its way to the water courses and remained chemically unaltered (unlikely because glyphosate is readily broken down and is well bound to the soil) 200 g of chemical would reach the reservoir waters over a year.

If this material still remained undegraded after contact with the water the possible concentration if it all arrived at the reservoir at once would be:

200/570,000 = <0.0004 mg/l at design capacity and

200/150,000 = <0.0014 mg/l at dead capacity.

At these levels it would most likely be undetectable because of the dilution rates involved and the gross overestimation of the resistance to degradation made in the above calculation.

It is quite clear that this chemical would not accumulate in the food chain and will not be detectable in the waters of the Kau Sai Chau catchment. Whereas there is no WHO drinking water quality guideline for this chemical, the USEPA have produced advisory limits based on a toxicological evaluation.

The Drinking Water Equivalent Level (DWEL) represents the concentration of a substance in drinking water that is not expected to cause adverse health effects in humans over a life time of exposure.

The DWEL is calculated assuming all exposure to the chemical comes from drinking water. The Lifetime Health Advisory (LHA) is calculated by reducing the DWEL in proportion to the amount of exposure from drinking water relative to other sources (e.g. food). The DWEL for Glyphosate is 3.5 mg/l. The worst case predicted level is therefore less than 0.04% of the lifetime DWEL. The LHA for Glyphosate is 0.7 mg/l. The worst case predicted level is therefore less than 0.2% of the LHA.

Attachment 5 indicates that after toxicological evaluation WHO standards are of the same order of magintude as the LHA. The USEPA LHA could therefore provide an appropriate standard for the pesticides not covered in the WHO list.

It is most unlikely that the controlled use of such a herbicide will have any detectable effect on waters or pose any risk at all water supplies given the TMS controls proposed for Kau Sai Chau.

The literature indicates that glyphosate is only acutely lethal to fish species in concentrations of >10 mg/l. Mature catfish are killed in a few days by concentrations exceeding 100 mg/l but the fry are more sensitive and lethal concentrations are >3 mg/l (Folmar *et al.* 1979). The literature on toxicity of glyphosate to insect species is limited but concentrations above 30 mg/l are known to be acutely lethal (Folmar *et al.* 1979; Holk and Meek 1987).

The controls placed on the application of herbicides and the type of chemical used mean that lethal concentrations of herbicides are most unlikely to escape from the golf course to the water bodies at Kau Sai Chau. The waters of the streams and irrigation lakes will be monitored regularly to check that no residues are finding their way off the playing areas. If residues become detectable then the use of the chemicals will be temporarily suspended subject to review of the TMS by the course management team in conjunction with the authorities. There will be no detectable effects on surrounding marine waters.

6.9 Fungicide Requirements

6.9.1 Principles

Disease Control

Turfgrass diseases are a significant problem on Hong Kong golf courses at certain times of year. Even under good management, close mowing, moist conditions at certain times of year, cool temperatures and constant injury due to trampling and divoting are conducive to fungal attack. Disease problems are more significant for the maintenance of the greens, but the bermudagrass to be used at Kau Sai Chau is naturally more resistant than other grasses. This is another reason to consider the use of bermudagrass on the tees.

Zoysiagrass, if used on the fairways, also has a natural resistance to diseases. The intensity of disease tends to be greater in the cooler months and problems tend to occur when temperatures fall below 18°C (local knowledge).

Preventive disease control with chemicals **will not** be permitted at Kau Sai Chau. Rather, an integrated approach to disease identification and treatment will be pursued. If diseases occur the proper fungicide will be selected and the application limited to the affected area.

Fungal pathogens of the grasses most commonly used on Hong Kong golf courses are *Fusarium* blight and *Pythium* blight. Occasionally an uncommon disease may be encountered and recent experience (pers. comm.) suggests that local professionals will cooperate to pool experience in dealing with unexpected infestations. This has great advantages in that the GCM in Hong Kong can draw on the pooled experience of his colleagues at other courses. Preventive disease control does not appear to be a strategy used by local GCMs. Some low levels of infestation of the sward can be tolerated in order to avoid the use of chemicals whenever possible.

Some control of fungal pathogens will be necessary at Kau Sai Chau, but many techniques and factors suggest that major problems with pathogens can be avoided. These will enable the GCM to minimise expenditure on chemical disease control. Examples follow:

- A balanced soil will enable the grasses to resist diseases;
- Resistant grasses such as bermudagrass and zoysiagrass will be chosen;
- Identification of the areas most prone to disease attack due to course and soil microclimate will enable the GCM to keep a close watch for diseases;
- The months when the temperatures and dew point will be below 18°C coincide with the periods of lower rainfall and lower relative humidity (RO data 1961-1990) therefore disease development is not favoured;
- The proposed drainage system and the resultant well drained soils will be less prone to disease attack.

Candidate Fungicides

Recently, organic forms of fungicide have been developed specifically for use on golf courses and organic fungicides will be used for any routine treatment of fungal pathogens. The materials involved are derived from sewage sludge and sawmill waste. The materials are first composted to

170°C which also kills any harmful bacteria. The material is then allowed to ferment or *brew* suspended in water barrels for 10- 14 days. The resultant soup is used as a natural fungicide which has been used in a diluted form effectively to control diseases on courses in USA and Germany. Natural turf tonics such as sea plant extract and fish emulsion may also be added (Attachment 3). A modification of this technique could be used at Kau Sai Chau as a first line of defense against fungal attack. The method will need attention in detailed design stages but it has the advantage of being totally organic and allowing the recycling of some waste, including solid paper waste from administrative offices (Section 2.9.7).

In the event that natural techniques prove unsuitable for use at Kau Sai Chau some synthetic preparations may be necessary as a last resort. The range of prospective candidate chemicals is large. Candidate chemicals would include Iprodione (Rovral®) for *Winter Fusarium, Brown Patch and Dollar Spot* and Etridiozole® for *Pythium.* Iprodione is used with success on courses in Hong Kong. Both chemicals are rapidly broken down with half lives of about 7 days to a few weeks (Wauchope *et al.* 1991) and are considered to be non-persistent.

6.9.2 Quantification of Impacts

Application rates for Iprodeone (Rovral) would be are around 8 to 9 kg/ha, with about 50% (500g/kg) active ingredient (depending on formulation). Applications of these chemicals would only be used in the event that alternative organic methods of fungus control fail. Spot treatments would not require high application rates and would only be required in small areas.

The need to use fungicides should not be a regular occurrence since the grasses chosen will have a natural resistance to disease and other cultivation practices will be geared to disease control. If needed, fungicide would most likely be required on the greens or occasionally on the fairways. If needed as a last resort the spot application of such chemicals could be at low application rates and most likely only once or twice in a year. The chemical and biological degradation of the fungicide is a natural process with a half life of a few days to weeks.

Iprodione is strongly bound to the soil so minimising the chance for runoff. Even if small fractions of these compounds were desorbed from the soil there would be ample time for them to breakdown before they could move over significant distances to enter the reservoir or sea water.

Assuming a restricted application to say 20% of the course on two occasions yearly (2 x 500g x 8kg x 10ha) the total applied would be approximately 80 kg per year.

If 10% of this material still remained undegraded after residence in the soil or contact with the water the possible concentration if it all transferred to the reservoir at once would be:

8000/570,000	= <0.015mg/l	at design capacity and
8000/150,000	= <0.05mg/l	at dead capacity.

Information on the toxicity of this family of chemicals generally indicates extremely low toxicity with lethal concentrations in excess of 10 mg/l for freshwater organisms. Mammalian toxicity is even less with lethality only occurring after doses exceed several grams/kg body weight. Use of this or similar fungicides would not result in contamination of waters or toxicity to non-target organisms.

As an precautionary measure small areas would be sprayed and covered at night to prevent animal species gaining direct access to concentrated material.

Iprodeone is permitted for use in Hong Kong.

USEPA standards for Iprodeone are under investigation but the low toxicity of this and related compounds indicates no significant health risk. If this candidate is unsuitable another less toxic alternative will be chosen.

6.10 Invertebrate Pests and Pesticide Requirements

6.10.1 Invertebrate Pest Control

The three most common invertebrate pests on golf courses in Hong Kong are armyworm, mole crickets and sod web worm. Nematodes can also be a problem on some courses. Discussions with some local course managers indicate that natural predators such as ground-feeding, insectivorous birds are allowed to control the pests such as the worms as far as possible. In the event that infestations become very heavy some pesticide treatment may be applied.

The trigger for the application of insecticide is the number of army worms or other pests in a given area of turf. As a rule of thumb up to 70 to 100 armyworms per square foot of turf will be tolerated. The GCM keeps a close eye on the behavior of the feeding birds and inspects areas where excessive numbers of birds congregate to feed. Turf is lifted and the worms counted in one square foot of the turf. If the birds cannot control the numbers below the trigger value after a few days then the area of infestation will be determined by more sampling and applications of an insecticide such as Chloropyrifos or Carbaryl will be considered, but only to the affected areas. Similar methods will be employed at Kau Sai Chau and **no preventive or prophylactic spraying of insecticides will be permitted.**

In the event that natural techniques prove unsuitable for use at Kau Sai Chau, there is a wide choice of insecticides available for the control of the above mentioned pests. If pest numbers cannot be controlled by natural predation, localised spraying would be considered, but only as a last resort and only as a priority on the greens. Army worms have been known to destroy a whole green in about 24 hours if uncontrolled (S. Templeton, pers.comm.). However, higher levels of infestation would be tolerated as far as possible on the tees and fairways of Kau Sai Chau. If greens have to be sprayed, then spot applications would be applied to affected areas which would then be covered over with a protective mesh to prevent access of wildlife until the chemical is given time to do it's work and undergo natural breakdown. Non-persistent organophosphates or carbamates are those most often selected in Hong Kong.

6.10.2 Candidate Pesticides - Carbamates

The carbamate pesticides appear to present a sound environmental choice since they have low phytotoxicity and can be used against a variety of insect pests including the species likely to be encountered at Kau Sai Chau.

Carbaryl in particular offers several environmental advantages because of its rapid breakdown to non-toxic intermediates (mainly 1-Napthol and carbon dioxide). Carbaryl is photolysed in the atmosphere (half life 12 hrs), and in soil (half life 3-30 days). Mobility in soil is only moderate (Hautala 1978) but leaching to groundwater has been noted. In soils previously treated with carbaryl breakdown is much faster due to the adaptation of soil microorganisms to use carbaryl and napthol as an energy source.

In natural waters carbaryl is broken down within a few weeks but even more rapid breakdown within a few days has been reported (Boethling *et al.* 1980). Alkaline pH favours hydrolysis but breakdown is also rapid at or near neutral pH (10 days, Karinen *et al.* 1967). Carbaryl in streams and rivers resulting from forest spraying has shown a half life of less than 30 hours (Stanley and Trial 1980).

Carbaryl has a known mode of action and toxicity studies indicate no mutagenicity, carcinogenicity or teratogenicity in humans. Acceptable doses for humans have been calculated at 0.082 mg/kg/day.

Lethal toxicity to fish is reported at between 5 and 50 mg/l (Geiger et al.1988) but lethal toxicity to invertebrates is much lower, at around 1mg/l (Hanazata and Yasuno 1989).

Carbaryl is permitted for use in Hong Kong.

6.10.3 Candidate Pesticides - Organophosphates

The organophosphate pesticides are relatively immobile in soil compared to the carbamates. Chloropyrifos in particular, has proven immobile in soils and is not readily available to surface runoff, and is not proven to be a groundwater contaminant. Breakdown is moderately fast, occurring in 30 to 80 days in all soil pH conditions.

However, the organophosphate pesticides are known to be toxic to aquatic life. Chlorpyrifos is acutely lethal to catfish at concentrations between 0.1 and 1mg/l (Phipps and Holcombe 1985). Aquatic invertebrates are more sensitive, being killed at much lower concentrations but no comparable published data for the local species could be identified (0.001mg/l is a lethal concentration to some invertebrates from similar classes (Carter and Graves 1972). Trichlorphon is equally toxic at concentrations of a few micrograms per liter.

Chlorpyrifos and Trichlorphon are permitted for use in Hong Kong and breakdown in 3 days to four weeks. These compounds are obviously toxic but a few grams of active ingredient would be sufficient for effective control and less active ingredient is required than for carbamates. If controlled spraying of greens were to take place it is unlikely that residues would persist for long. They are classified as moderately short lived (Chlorpyrifos) or very short lived (Trichlorfon).

6.10.4 Quantification - Carbaryl

Application rates for Carbaryl are around 8 to 14 kg/ha, with about 80% (800 g/kg) active ingredient. Spot treatments would not require high application rates and would only be required in small areas.

Assuming a restricted application at a rate of 12 kg/ha to say 10% (5 ha) of the course on two occasions yearly the total applied would be approximately (2 x 800g x 12kg x 5ha) < 96 kg per year.

If even 1% of this material still remained undegraded after residence in the soil or contact with water, the possible concentration if it all transferred to the reservoir at once would be:

960/570,000 = <0.0017 mg/l at design capacity and

960/150,000 = <0.006 mg/l at dead capacity.

The DWEL for Carbaryl is 3.5mg/l. There is therefore more than two orders of magnitudle safety margin between health advisory standards and possible concentrations in water. The LHA for Carbaryl is 0.7 mg/l. The maximum predicted concentration is less than 1% of the LHA.

6.10.5 Quantification - Chlorpyrifos

Application rates for Chlorpyrifos are even lower than for Carbaryl, at 7 to

10kg/ha, with about 50% (500 g/kg) active ingredient. Spot treatments would also not require high application rates and would only be required in small areas.

Assuming a restricted application at a rate of 10 kg/ha to say 10% (5 ha) of the course on two occasions yearly the total applied would be approximately (2 x 500g x 10kg x 5ha) 50kg per year. If 5% of this material still remained undegraded after residence in the soil or contact with the water, the possible concentration if it all transferred (from both applications) to the reservoir at once would be:

2500/570,000 = <0.005 mg/l at design capacity and

2500/150,000 = <0.017 mg/l at dead capacity.

If chlorpyrifos were used at Kau Sai Chau, the drainage water from the greens would be analysed for residues. If necessary the stream waters would also be monitored for assurance purposes but accumulation in stream waters is most unlikely. Trichlorphon is water soluble which would accelerate breakdown. Chlorpyrifos is not very water soluble but is strongly bound to the soil.

Acceptable daily intake (ADI) values for Chlorpyrifos is 0.003 mg/kg/day. For an adult the acceptable daily intake would be 0.21 mg/day. To exceed the ADI an adult would have to consume >12l/day of raw water at a concentration exceeding 0.17mg/l.

The possibility of these compounds reaching the watercourses of Kau Sai Chau in detectable amounts is not likely given the caveats pertinent to application methods. There is no possibility of contamination of public water supplies with controlled applications because of the small amounts of active ingredients involved and rapid breakdown.

It is also unlikely that any residual toxicity to freshwater organisms would result due to the low potential concentrations and rapid breakdown of the chemicals.

6.11 Chemical Application Management Plan

6.11.1 Draft Operations Manual

General

This section of the document is designed to be followed during the operation of the project. Each directive contained in this section shall be followed by all personnel providing services to the project. The rationale behind each directive has been explained elsewhere in the EIA. It is the intent that each employee working on the project receive a copy and understand, in principle, the contents of this document.

To help clarify some terms, the following definitions are given:

CHAMP - Chemical Application Management Plan. Its purpose is to provide technical public disclosure regarding the proposed fertilizers and chemicals to be used on the golf course, the methods of application, limitations on use, and potential health hazards of those chemicals.

Carbaryl - Carbamate insecticide for the control of armyworm, cut worm, sod web worm, pasture cockchafer and locusts.

Chlorpyrifos Organophosphate Insecticide (as found in Dursban®) used for the control of armyworm, mole crickets, sod webworm. It will only be used on greens. It is applied as a dilute spray in water.

Glyphosate - Glyphosate, (as found in Roundup® by Monsanto) is a herbicide used for spot eradication of weeds. It will only be used on maintained fairways and tees. It is applied as a dilute spray consisting of glyphosate, a detergent and water.

Golf Course Operator - The golf course superintendent or his appointed representative.

Pesticide - As used in this CHAMP, pesticide refers to the insecticides herbicides and fungicides approved for use on the project.

Project - The 36-hole golf course being constructed in connection with the Kau Sai Chau Development.

Spot Application - The area of application not to exceed 250 square metres (the average size of one green or tee area).

TRC - Technical Review Committee, a review panel formed from interested parties from the Golf Course management and any interested government departments.

6.11.2 Prohibitions and Mandates

1. All personnel involved in the management and application of chemicals shall receive initial site health and safely training regarding the storage, handling, application, decontamination and spill control procedures. All employees shall sign a statement acknowledging receipt of the prescribed training.

2. This document will be followed with respect to the type of herbicides, fungicides or fertilizers, or application rates approved

for use in the CHAMP.

3. The discharge of treated or untreated domestic waste water, garbage or other solid wastes, or any deleterious material to the surface waters of Kau Sai Chau is prohibited.

4. All discharge attributable to human activities of solid or liquid waste materials including soil, silt, clay, sand, and other organic and earthen materials to the surface waters of Kau Sai Chau is to be controlled such that the provisions of the Water Pollution Control Ordinance with respect to Water Quality Objectives for Port Shelter Water Control Zone are met.

5. The discharge of oil, gasoline, diesel fuel, or any other petroleum derivative is prohibited any where on the Project.

6. The discharge to surface waters or ground waters of any toxic chemical or hazardous waste is prohibited.

7. The use, storage, discharge, or stockpiling of any algaecides or rodenticides is prohibited.

8. Weed control will be accomplished primarily by mechanical methods. Only in the event all practical mechanical methods fail to produce sufficient weed control will the golf course superintendent apply herbicide. In the event of herbicide application, drainage from the treated area will be isolated from the surrounding environment. This isolation process should be in effect for a minimum of three days after herbicide application. If surface waters accumulate in the isolated areas, the isolation process should continue until there is no remaining impounded water.

9. All maintenance chemicals should be prepared, handled and applied by person(s) who have received training in such chemicals and application methods. Chemicals would be stored in a bunded chemicals store, and preparation will take place in a bunded area. Chemical preparation will not take place on the course.

10. Maintenance chemicals should not be used under any circumstances without the full knowledge and approval of the golf course Environmental Supervisor.

11. All accidental spills of any chemical shall be reported and cleaned up according to the chemical spill contingency plan.

12. Seeds to be used in the revegetation plan and for the

establishment of the golf course turf shall not be pretreated with any pesticide.

13. At no time stall fertilizers, fungicides or herbicides be applied to areas with standing water.

14. All waste chemical solutions and cleanup rinse water shall be retained in closed storage containers at the maintenance building in a protected area. Storage containers shall be labelled with date and contents. Containers shall be retained unitl after the breakdown period of the chemical, at which time the solution shall be re-used in diluting spray formulations.

15. Fertilizer, fungicide insecticide or herbicide application to pond, stream or wetland environments is prohibited. Any chemical application to a surface water area will be in direct violation of this CHAMP.

16. Under no circumstances will any rodenticides be used.

6.11.3 Fungicides, Insecticides and Herbicides

All fungicide applications will as far as possible be limited to greens. Fungicides will only be applied at the direction of the golf course superintendent. The only fungicides approved for use on the greens are the organic fungicidal soup (Attachment 3), Iprodione, or a product with similar breakdown and toxicity characteristics which is less environmentally threatening. No fungicide will be used on the fairways except in cases where written permission is given by the TRC or its nominated representative.

Fungicide in the form of Iprodione may be applied only once per year to the green areas. The manufacturer's prescribed application rate shall be strictly observed.

The only herbicide approved for use is Roundup® by Monsanto, containing <50% glyphosate, or a product with similar breakdown and toxicity characteristics which is less environmentally threatening.

Weed control will be accomplished primarily by mechanical methods. In the event all practical mechanical methods fail to produce sufficient weed control, the golf course superintendent may apply approved herbicide glyphosate (Roundup®) to maintained, fertilized fairway and tee areas only. At no time shall any herbicide be applied to any rough areas, any unfertilized play areas, any natural vegetation or wetland and surface water area. The golf course Environmental Supervisor shall check with RO Weather Service projected weather forecasts prior to use of pesticides. If adverse weather conditions are anticipated within two days of application, use of the pesticide shall be postponed. Adverse weather conditions would include a forecast predicting precipitation in excess of a trace amount with a probability of occurrence exceeding 10%.

The golf course superintendent must be notified if a weed infestation is observed. Herbicides can only be applied with the full knowledge of the golf course superintendent.

Roundup® application areas shall be as small as possible to complete the task. Individual or "spot" application areas should not exceed 250 m^2.

Roundup® shall be applied using a hand-held applicator equipped with a hand-trigger device. No fogger, aerial or hose application is allowed.

Areas treated with Roundup® shall be identified with markers at four points. No irrigation will be allowed on the treated area for at least 48 hours. Then areas shall be covered to prevent the access of wildlife.

Similar restrictions shall apply to fungicides and insecticides.

Records shall be kept on an ongoing basis of the use of insecticides, herbicides and fungicides. The records will include entries with the following:

Herbicide, Fungicide, Insecticide:

a. Herbicide, Fungicide, Insecticide Purchased

    (1) Each type of herbicide/fungicide/insecticide purchased

    (2) Amount of each type of herbicide/fungicide /insecticide purchased

    (3) Date of each purchase

    (4) Place of purchase/supplier.

    (5) Date of on site arrival of pesticides purchased

    (6) On site storage location of pesticides purchased.

b. Herbicide/Fungicide/Insecticide Application

    (1) Types of herbicide/fungicide/insecticide applied

    (2) Locations of application (with diagram/sketch or photograph)

    (3) Dates of application

(4) Amounts of application

(5) Method of application

(6) Name of person(s) responsible for application

(7) Weather before and three days after application.

At no time shall maintenance personnel transport active pesticide ingredients in excess of 11.4 kg (25 pounds).

All herbicides shall be applied in liquid form only. The "weed and feed" type granular products will not be applied. This is to protect wildlife species such as ground-feeding birds which might directly ingest such granular formulations.

In the event that all practical mechanical methods fail to provide sufficient weed control, the golf course Environmental Supervisor may apply Roundup ® to the infested area as directed by the CHAMP. If such application is necessary, the drainage from the treated area will be isolated from the surrounding environment. This isolation process should be in effect for a minimum of three days after herbicide application or until no potential drainage water remains. There is a potential for summer thundershowers to mobilize Roundup® shortly after application. To minimize the potential for Roundup® to impact the surrounding surface water, all drainages into and away from the treated area should be blocked. We envision this could be accomplished using sand bags to block the drainage and adequately sized sump pumps to divert runoff and recirculate runoff from the treated area. The golf course superintendent should be consulted in the event of rain.

6.11.4 Fertilizers

Fertilizers are considered to be any substance, either chemically processed or natural organic matter, that is applied to enhance and enrich the growth of the golf course turf.

Only fertilizers approved by the TRC shall be used on the golf course. The types required will probably include nitrogen, phosphorous, and potassium (N-P-K), and could include the following examples:

- A starter (19-26-5)
- A K-N fertilizer (19-0-17)
- A high K fertilizer (15-0-30).

Other fertilizer products likely to be approved for use are:

- Ferrous Sulfate ($FeSO_4$)
- Potassium Sulfate (K_2SO_4)
- Gypsum, Calcium Sulfate ($CaSO_4$)
- Dolomite Limestone.

All fertilizer applications shall be documented on forms available from the Environmental Supervisor. The record shall reflect the following:

1. Locations of applications (with photograph or diagram)
2. Type of fertilizer applied
3. Amounts of applications
   a. Total pounds/kg
   b. Pound per acre (or kg/ha)
4. Dates of application
5. Composition of the fertilizer
6 Weather conditions before and up to and including three days after application.

Application of fertilizers to areas of natural vegetation and roughs between the golf course tees, fairways, and greens is prohibited throughout the golf course. Fertilizers shall only be applied to maintained, groomed turf areas, tees and greens. All fertilizing will be done with the full approval and knowledge of the golf course Environmental Supervisor.

The greens should be fertilized in increments of not more than 0.2kg of nitrogen per 100 square metres per application. Total yearly nitrogen application to bermudagrass shall not exceed 5 kg of nitrogen per 100 square metres per year.

Fairways are to be fertilized not more than six times per growing season with not more than 3kg of nitrogen per 100 square metres per application. Tees are to be fertilized not more than once per month at a rate of 1kg of nitrogen per 100 square metres per application. Smaller applications will be preferred.

Fertilizer applications may be in the form of liquid foliar feeds to minimise nutrient losses. Slow release and organic forms (e.g. IBDU) will also be favored.

Fertilizer shall not be applied within 5 m of streams or 5 m of other water bodies. At no time shall fertilizers be applied to areas with standing water.

6.11.5 Fertilizer and Cultural Strategy

The proposed strategy is based on scientific documentation that turf is actually healthier when it is not fed as much nitrogen or watered as much as previously thought necessary. In combination with natural buffer zones and collection ponds to recycle irrigation water, the goal is not to affect the environment. Excessive nitrogen leads to disease susceptibility, depleted root structures, poor wear tolerance, and reduced tolerance to other stress factors such as heat, drought and cold.

More intensive use of potassium is intended to encourage deeper and more dense root structures and thicker, more resilient cell walls of the vegetative portion of the turf. Limited applications of iron will compensate for potential loss of turf colour.

6.11.6 Irrigation

Direct irrigation of natural vegetation will not be allowed. This will minimize the impact on natural vegetation and wildlife.

The irrigation system shall maximize the even distribution of water to all irrigated areas. No area should exceed the maximum application rate by more than 15 percent.

All irrigation practices shall be conducted in accordance with the following principles:

1. Irrigation can help stabilize newly graded soils. Light, frequent cycles help prevent wind erosion and serve to settle the soil. During seeding establishment, light, frequent cycles are necessary throughout the day to insure germination. At this time plant root structures are immature and deep watering is of no use. After the turf is established mid-day watering will give way to dawn cycles. Frequent, light irrigation will reduce run-off. Deeper penetration will be achieved in this manner to aid in root elongation.

2. The Environmental Surpervisor can adjust irrigation rates according to his assessment or by using soil tensiometers and evaporation pans.

3. An average dawn watering during peak periods would be less than 30 minutes. To prevent runoff this will be done in three cycles of ten minutes each. Soil and thatch are very often hydrophobic at first and initial wetting makes subsequent watering more effective.

4. Any variation from the routine irrigation methods shall be brought to the attention of the golf course Environmental Supervisor.

6.11.7 Drainage System Maintenance

Course management shall follow the practices outlined below.

Best Management Practices

There shall be no removal of vegetation nor disturbance of existing soil conditions except where adequate erosion control and storm water runoff control facilities are installed and operational.

Adequate erosion control and storm water runoff control facilities shall be installed, operated, and maintained to manage discharges from areas where existing ground surface conditions have been disturbed.

Placement of waste earthen materials in such a manner as to allow the discharge of such materials to adjacent undisturbed land areas or to any surface water is prohibited.

Disturbed areas shall be adequately re-stabilized or revegetated. Revegetated areas shall be continually maintained until vegetation becomes established.

Surface flows from the project site shall be controlled so as to not cause downstream erosion at any point.

All re-stabilization and revegetation measures on disturbed areas shall be completed prior to April 1 each year.

All surplus waste earthen materials shall be removed from the project site and deposited only at a legal point of disposal or adequately re-stabilized on site.

Storm water runoff handling and disposal facilities shall be periodically cleaned and renovated.

Any water from dewatering activities shall be discharged to a containment facility or area of adequate size to preclude a discharge to surface water.

An inspection of the project shall be made by the operator on a monthly basis. An inspection form shall be used during the inspection. Only employees designated by the golf course superintendent shall perform the inspections. The completed inspection forms shall be maintained in a file by the golf course Environmental Supervisor.

All drainage collection and installed treatment systems shall be inspected weekly throughout the year. The systems will be inspected for leaks, sediment buildup, clogging, and algae growth. The golf course Environmental Supervisor shall be notified immediately of any deficiencies. An inspection form shall be used during the inspection (Table 6.1). Only employees designated by the golf course superintendent shall perform the inspections. The completed inspection forms shall be maintained in a file by the golf course superintendent. It is essential that these systems remain in proper operation condition at all times to prevent unauthorized discharges.

Table 6.1. Sample Inspection Sheet

Hole No.	Algae Growth	Sedimentation	Clogging
1			
2			
3			
4			
5			
6			
7			
8			
9			
+ indicates no maintenance needed 0 - indicates maintenance needed before end of season - - indicates immediate maintenance required			

The irrigation system shall be inspected prior to use of any pesticide to assure the system will not affect the treated areas.

A programme of rodent control using mechanical methods will be implemented by the golf course operator as necessary.

No chemical additives will be used to clean or maintain any portion of any drainage collection or water treatment system. All maintenance of the drainage system will be conducted with mechanical methods.

Every two months the discharge from three representative greens shall be sampled. The samples shall be taken from the catchpits and analysed for any pesticides used since the last sampling, nitrate as N, total nitrogen, pH and specific conductance. Samples shall be collected by a person with water quality sampling experience, preferably an employee of the accredited testing laboratory. Samples will be taken to an accredited laboratory for analysis. The analytical results will be submitted to the authorities (EPD), and will be permanently kept on file at the golf course.

Not less than once a year, management shall have nutrient and pesticide testing performed on at least three representative greens, tees, and fairways as a means of providing guidance for the fertilization and pesticide program. Results of the testing shall be submitted to the golf course superintendent and permanently maintained on file. Fungicide testing will be performed three times a year and will involve soil plugs from greens only.

Should fungicide or herbicide of testing greens show elevated levels of pesticide, application levels will be reduced in an amount sufficient to offset the residual amounts of these compounds.

Basket devices for catching grass clippings shall be used on mowers except for the first mowing after a green has been fertilized. All clippings will be composted. As far as possible, clippings should not be allowed to enter any surface water body.

Where maintenance tasks are specified to be performed on a scheduled basis (i.e. daily, every other day, etc.) management will not be expected to perform the task on the specified schedule if the performance of the task is precluded by weather or other unforeseeable or adverse conditions. The tasks shall be performed on the next available day on which weather or other conditions will not interfere with the reasonable performance of the task.

The project site shall be checked daily for fungus growth, insect infestations, weed invasion or any other pest problem. The appropriate mechanical controls for these conditions shall be applied as soon as necessary after their detection.

Pest control in rough areas will use mechanical methods only.

Pest control in sand traps will use mechanical methods only. When sand traps are constructed with drains, then herbicide shall not be applied within 3m of those sand traps.

6.12 Chemical Spill Contingency Plan

This section is provided as a guideline for necessary actions immediately following an accidental spill or discharge of chemicals. It is impossible to provide spill contingency plans for every conceivable accident scenario, therefore, the guidelines provided should be implemented as preliminary spill control measures after notifying the Environmental Supervisor, but prior to receiving any particular directions or advice from EPD.

Step 1

Immediately notify EPD and AFD of any spill, regardless of the size of the spill, date, time, day of week, or location. The notification phone numbers for EPD and AFD shall be posted near the spill response equipment (see below).

Spill response equipment shall be assembled and maintained at the project maintenance facility for cleaning up any chemical spills. The equipment shall be readily accessible. It shall not be used for any purpose except for chemical spill cleanup. The equipment shall include at least the following:

1. Approximately 50 sandbags for directing sheet flow.
2. A portable pump, pipes, and generator for removal and/or recycling of contaminated fluids.
3. Storage containers sufficient to contain approximately 500 gallons of either solid or liquid.
4. Several brooms and shovels.
5. Industrial vacuum of sufficient power to retrieve spilled solids and liquids.
6. Approximately 1000 square metres of sheet plastic to cover areas where chemicals have been applied.
7. Approximately 25 kg of chemical absorbent to contain liquids.

Step 2

The golf course Environmental Supervisor shall be immediately notified of any adverse condition. An adverse condition shall include, but not be limited to any chemical spills, losses or thefts of chemicals, excessive application of chemicals, or any unauthorised uses of chemicals. EPD shall also be notified whenever adverse weather conditions occur within fifteen days following application of chemicals or of any chemical spill. A written report shall follow the incident, detailing the reasons for the adverse condition and procedures to alleviate the adverse condition.

Step 3

If the spill consists of a solid on land, the material should be immediately collected by sweeping, shoveling, or using suction equipment to clean-up. The collected material may be reused or disposed of offsite.

Step 4

Should the spill of a solid material enter surface water of any kind, every effort should be made to immediately remove the material from the water and place it into a suitable container. Small surface water flows should be immediately blocked downstream. Upstream flows should be diverted around the spill site. The recovered spill materials should be transported to and stored offsite in a chemical holding area pending liaison with and any further instructions from EPD. If a chemical spill (liquid or solid) enters a surface water body, EPD shall be immediately notified. The water body shall then be immediately sampled downstream of the spill area, preferably within one hour from the time of the spill. The sample shall be submitted to the golf course superintendent or other authorised person or the next person in charge and should be analysed for parameters identified by EPD. If the discharge (spill) to the surface water continues, daily samples shall be collected until the discharge ceases.

Step 5

If the spill is a liquid on land, it shall be immediately isolated by berming the affected areas with sand bags or soil. Chemical absorbent shall be immediately applied. Every effort should be made to keep the affected area dry. Water shall not be applied to the spill area. If necessary, the affected area shall be covered with sheet plastic or other suitable water repellent material. When possible, the spilled liquid or solid should be collected using a portable, high-suction industrial vacuum. When a liquid spill occurs on soil and/or turf area, that area should be identified and isolated immediately. The soils may be removed if the size of the area is manageable. Further action will be discussed with EPD.

Step 6

If a remedial ground water investigation is deemed necessary it should be commenced within 72 hours of a large liquid spill as determined by EPD. Remedial activities should commence within ten days of the spill. Remedial action could conceivably consist of extraction well points down gradient of the spill. The water obtained in this method could be stored in portable tanks. Final treatment must be accomplished offsite.

Step 7

All circumstances leading up to the spill, action immediately following detection of the spill, notification procedures, all cleanup activities and waste disposal activities shall be careful documented and presented to EPD within 72 hours of the spill.

6.13 Attachment 1: Examples of Organic Products and Soil Amendment Materials

Manufacturer Rosenthal Chemtronics GMBH Margareten Strasse Oberhausen, Germany 46049D

1) Rosasoil Classic

Base : Organic slow release fertilizer derived from culture of Penicillium chrysogonium

2) Bio Mag

Base : Natural magnesite for magnesium deficiencies.

Manufacturer : FAS Austria c/o JVDB Wanchai Hong Kong

1) Fertinora 15/15/6+4

Base : Organically derived liquid foliar compound N.P.K. + Mg fertilizer for young turfgrass.

2) Fertinora P40

Base : Organic P-nutrient liquid foliar fertilizer

Other Fertinora products available for fill range of nutrient and trace elements.

Manufacturer : Dynaphos c/o JVDB Wanchai Hong Kong

1) Dynaphos Reactive Phosphate Rock
Base : Organic N P K + trace elements derived from sterilized manure.

Maunfacturer : Fisons Suffolk U.K.

1) Greenmaster Organic 1 and 2

Base : Wholly organic and natural mineral materials manufactured to U.K. Register of Organic Food Standards. Soild formulation N.P.K. 4:4:10 or 11:0:0.

2) Greenmaster Liquid

Base : High Quality Liquid feed for rapid uptake.

3) Seafeed

Base : Liquid seaweed extract for root development and regrowth.

4) Sportsmaster Organic 3, 4 and 5

Base : Wholly organic compound N.P.K. fertilizers for fairways and general recreation areas.

Manufacturer: Scotts : Marysvill Ohio USA

1) Scotts Pro Turf Nitrogen

Base : Methyleme Orea based slow release nitrogen fertilizer with lower leaching than IBDO.

Manufacturer : Gro Power E1 Monte California USA

1) Gro Power
Base : Humus base fertilizer and soil conditioner with bacterial "stimulators": for long term low level nutrient provision.

6.14 Attachment 2: Cultural System for a Bermudagrass Fairway

Mowing Height	0.5 to 1.0 in. (1.3 to 2.5 cm) (unirrigated common bermudagrass mowed at higher height).
Mowing Frequency	Two to three times per week, if irrigated: weekly to biweekly, if not irrigated.
Mowing Pattern	Mow longitudinally; cross mowing especially desirable if irrigated.
Clippings	Return.
Fertilization	
-Nitrogen	Apply 10 to 40 lbs. N/acre (11 to 45 kg/ha)/growing month; use lower rate if not irrigated.
-Phosphorus	Apply at rate based on soil rest, usually once per year.
-Potassium	Apply at rate based on soil test, usually at 50 to 70 percent of nitrogen pile.
-Iron	Apply only when visual deficiency symptoms appear. Deficiencies most likely on alkaline soils and following spring greenup.
-Other Nutrients	Apply if specific nutrient deficiency diagnosed (rare occurrence).
pH Correction	Maintain pH between 6.0 and 7.0. Apply limestone or sulfur materials based on soil test.
Irrigation	May or may not be irrigated. If irrigated, moisten to full depth of root zone prior to appearance of visual deficiency symptoms (foot printing stage).
Thatch Control	Vertical cutting may be needed if thatch problem develops. Best accomplished during first half of growing season. Thatch most likely to develop with improved bermudagrasses, especially at higher nitrogen and irrigation levels. Topdressing not normally practiced.
Cultivation	Core/slice as needed to correct developing soil compaction problem. Special attention needed on sites subjects to intense cart traffic. Best accomplished during first half of summer.
Weed Control	Apply herbicide only as needed to control developing weed problem. Best accomplished during first half of growing season. Control of winter annual weeds may be required after bermudagrass enters winter dormancy, assuming overseeding not practiced.
Disease Control	Fungicides used infrequently. Spring dead spot can be problem; thatch control and maintenance of moist soil conditions reduce severity. Nematode problems are infrequent occurrence, except in certain limited areas.
Insect Control	Insect problems are much greater threat on bermudagrass than on cool-season grasses.

Apply appropriate insecticide as needed when potentially serious insect injury symptoms first appear. Major problems include bermudagrass mites, sod webworms, armyworms and grubs.

Winter Dormancy Practices
Winter overseeding may be practiced on high-budget courses. Low seeding rates and Italian ryegrass used to control costs.

Cultural System for a Bermudagrass Putting Green

Mowing Height	0.19 to 0.31 in. (4.8 to 7.5 mm).
Mowing Frequency	Daily.
Mowing Pattern	Alter at each mowing in each of four directions.
Clippings	Remove.
Grain Control	Use vertical cutting as needed up to once per week for control of grain and variable growth. Adjust to produce very light combing effect. Combing or brushing may also be advisable.
Fertilization	
-Nitrogen	Apply 0.5 to 1.2 lb. N/1,000 sq.ft. (0.25 to 0.60 kg/are)/growing month. Use 0.2 to 0.5 lb. N/1,000 sq.ft. (0.10 to 0.25 kg/are)/10 to 15 growing days for water-soluble carrier or 0.5 to 1.2 lbs. N/1,000 sq.ft. (0.25 to 0.60 g/are)/20 to 30 growing days for slow-release carrier.
-Phosphorus	Apply at rate based on soil test. Spring or fall timing best. Usually part of complete analysis fertilizer.
-Potassium	Apply at rate based on soil test where fine-textured clay soils are involved. Coarse-textured soils require 4 to 8 lbs, K_20/1,000 sq/ft. (2 to 4 kg/are)/yr., usually split into four to six applications over growing season.
-Iron	Apply 2 to 4 oz. iron carrier/1,000 sq.ft. (0.06 to 0.12 kg/are) as needed to correct developing iron chlorosis symptoms; common occurrence following spring greenup.
-Other Nutrients	Apply if specific nutrient deficiency diagnosed (an infrequent occurrence).
pH Correction	Maintain pH between 6.0 and 7.0. Apply limestone or sulfur materials as needed based on annual soil test.
Irrigation	Moisten to full depth of root zone with each irrigation; time prior to development of visual deficiency symptoms.
Topdressing	Apply two to six times per years as needed for smoothing and thatch control. Minimum of twice per year suggested, with spring and late summer applications at 0.3 to 0.5 cu. yd./1,000 sq.ft. (0.25 to 0.41 m^3/are) Use as follow-up to cultivation whenever possible with higher application rate. May be applied as often as every three to four weeks during periods of rapid shoot growth at rate of 0.1 cu. yd./1,000 sq.ft.
Cultivation	Utilize two to six times per year. Higher frequencies needed on intensely trafficked greens grown on fine-textured soil. Core or slice a minimum of twice yearly in spring and late summer. Avoid cultivation within thirty days of scheduled winter overseeding.
Spiking	Practice as needed up to weekly to prevent developing surface compaction or impermeability problem.
Weed Control	Control broadleaf and annual weedy grasses as they appear with either preemergence or postemergence herbicide. Be sure to apply late summer treatments sufficiently early to avoid phytotoxicity to winter overseeded cool-season grasses.
Disease Control	Use corrective or preventive disease control program, former generally being preferred, especially in arid and semiarid climates.

Insect Control	Apply appropriate insecticide as needed to correct developing insect problem.
Winter Overseeding	Usually used in southern half of warm humid climate region. Accomplish adequate thatch control and soil compaction correction well in advance of scheduled winter overseeding. Follow overseeding procedures discussed in previous section.

6.15 Attachment 3: Fungicidal Soup

Organic fungicide details follow as quoted from the original publication (D.E. 1992. Recipe for compost soup. Golf Course Management. p75. Feb. 1992.)

At Stoneridge GC, we use a compost soup mixture for disease prevention. The compost base, which is produced in Missoula, Mont., is made of digested sewage sludge and wood wastes (sawdust, wood chips and bark fines).

During the composting process static aerated piles reach a working temperature in excess of 170 F [77^{o}C]. The heat of the composting process destroys any harmful bacteria or weed seeds that may be present in the raw materials.

Compost soup is made by filling burlap sacks with the product and suspending them in large plastic trash barrels filled with water. The soup is allowed to "brew" 10-14 days and then strained directly into our spray tank. Clogging of our spray nozzles was remedied with the use of panty-hose as a strainer.

Researchers at The University of Bonn used the soup full-strength, though we were successful with a 40:60 soup-to-water ratio. In the event of increased disease severity, we will experiment with stronger mixtures.

The researchers also concluded that any compost produced from both plant and animal wastes proved effective as a natural fungicide.

Approximately 40 gallons of soup is mixed with 60 gallons of water in a 100-gallon spray tank. Sea plant extract and fish emulsion are usually added. Approximately 100 gallons of this mixture is applied to 50,000 square feet of greens turf.

Whereas the use of such a "furgicidal soup" may offer an "organic" alternative, the composition of such a soup may not be consistent.

Liaison with AFD has indicated a preference for a more consistent chemical control such as with the candidate chemical suggested in Section 6.

6.16 Attachment 4

Selected Examples of Runoff Losses of Nitrogen from Treated Plots and Watersheds; Studies Represent Range of Soil and Management Conditions Associated with Nitrogen Fertilization

Catchment type/ moisture input	Duration of input/ variables investigated	General comments and conclusions	Ref.
30-60 ha watersheds/ rainfall	Surface loss of nutrients, season, conservation practices, 7-year study	Most of the average annual total loss of nitrogen occurred during the period of seedbed preparation, fertilizer application, and crop establishment from April through June. Seasonal discharges of runoff, sediment, sediment nitrogen, and total nitrogen were effectively reduced by a level terraced watershed compared to contour-cropped watersheds. Average annual soluble nitrogen losses never exceeded 1% of the annual application.	Alberts et al. (1978)
13.7 m^2 plots/ simulated rain	63.5 mm rain for 2 hr; compared levels of residue and fertilization, placement of fertilizer above or below residue; fertilizer incorporated on 0 residue plots.	Corp residue increased soluble N concentration in runoff insignificantly. Surface fertilization increased concentrations of N, especially NH_4, in runoff. Placement of fertilizer above or below residue did not affect concentrations in runoff. Increases in runoff losses of nitrate on fertilized plots were less than 1% of that applied. *Increases in surface runoff concentrations of soluble N with reduced tillage results from lack of fertilizer incorporation.*	Baker and Laflen Corp (1982)
4.5m^2 plots/ rainfall	2-year study comparing rate, placement, and type of nutrient element on millet and ryegrass.	Only small amounts of soluble N were lost in surface runoff when fertilizer was soil incorporated. Loss of soluble N did not exceed 1% of the total amount applied when soil incorporated regardless of application rate. Soluble N losses in runoff were directly related to application rate. Top-dressed fertilizer N losses ranged from 1.82 to 2.68% of N applied. NH_4 losses exceeded NO_3 losses in surface water in year with greater rainfall. Low intensity rain may have leached NO_3 beyond the surface mixing zone. Surface loss of soluble N ad urea N were greater for uncoated urea than sulfur-coated urea. *Large losses of nitrogen occurred (9.5%) from uncoated urea when heavy precipitation occurred soon after application.*	Dunigan et al. (1976)

Field size watersheds	3 year study on pollutant load in irrigation return flow from fields with continuous vegetation, pastured and unpastured.	No net loss of nitrate and total N from irrigated field of alfalfa hay and grass pastures in return flow was observed. Nitrate and total N concentrations were consistently lower in surface return flow than in irrigation water. The presence or absence of grazing animals did not affect soluble nitrogen concentrations in return flows. Statistical variation was attributed to variation in volume of return flow. Continual vegetation cover did not contribute to nitrogen loading via surface runoff and return flow. Nitrogen infiltrated into the soil rather than transported in surface runoff.	Miller et al. (1984)
7.2-11.6 ha watersheds/ rainfall	1-year monitoring of nutrients from cropland and grazed rangeland	Total N in runoff ranged from 2 to 15 kg ha^{-1} $year^{-1}$; flow weighted mean concentration of total N ranged from 1 to 6 ppm and nitrate-N ranged from 0.2 to 1.9 ppm. Runoff losses of soluble inorganic nitrogen were less than input by precipitation. Loss of fertilizer nitrogen did not exceed 5% of most recent application.	Olness et al. (1975)
Six 0.6 - 17.9 ha watersheds/ rainfall	5-year monitoring sediment and nutrients in runoff from cropland and rangeland.	Maximum annual nutrient losses were 13 kg ha^{-1} of total N and 4 kg ha^{-1} of nitrate-N. Nitrate accounted fro 10-30% of total N discharge in runoff.	Menzel et (1978)
Twelve 1.6-5.6 ha watersheds in OK, eight 1.1-122 ha watersheds in TX/rainfall	8-year monitoring of nutrients in runoff and groundwater wells on cultivated and native grassland.	22-93% of surface transported N was in the particulate form, sorbed NH^4 or organic N. The range of mean annual flow weighted concentration of nitrogen in surface water was 1.77-1.420 ppm for total N, 0.24-3.56 ppm for nitrate-N, and 0.02-1.72 for ammonium-N. Change from grassland to cultivation increased nitrate and total N in runoff; NH_4 losses decreased with cultivation due to increased conversion to nitrate. Nitrogen losses were greatest for fertilized wheat and rotational cropland, although total mass transport was small. Total N loss represented 3 and 9% of the amount applied in wheat and rotational cropland, respectively.	Sharpley et al. (1987)
Duplicate 4 ha watersheds/ rainfall	5-year study of nitrate in runoff on swelling clay soil, sorghum, cotton, and oats rotation.	At the recommended application rates, annual average concentration of nitrate-N in runoff ranged from 2.3 to 2.9 ppm. Mean total loss of nitrate-N was 3.2 kg ha^{-1} $year^{-1}$. Losses of sediment nitrogen were about 5 kg N ha^{-1} $year^{-1}$. Storm event concentrations of nitrate-N depended on timing of runoff event in relation to fertilizer application. *Concentrations of nitrate-N runoff were highest just after fertilizer application when soil was near field capacity. Concentrations of nitrate-N were lowest when large amounts of nutrients infiltrated dry soil prior to initiation of runoff. During runoff producing storms, immediately after fertilization, nitrate concentrations were lowest in initial runoff and highest near the end of the runoff event.*	Kisel et al. (1976)

Attachment 4 (continued) Fate of nitrogen in soils

The question was raised at the 2nd Steering Group Meeting of the eventual fate of the added nitrogen fertilisers and the validity of the runnoff or leaching rates quoted. This short review seeks to address this question and its implications for the water quality of the Port Shelter.

BACKGROUND

The Consultants recognise that leaching estimates for agricultural systems can be high but it has long been recognised that turfgrass and even pastureland systems retain much more applied nitrogen than arable crops, cereals etc. This is accepted in the horticultural/agricultural profession but there seems to be some reluctance to recognise this distinction environmentally. However, the consultants have attempted to clarify the situation by reference to nitrogen, the nutrient of major importance and the table in Attachment 4. A few key references are presented below but the general information can be found in any basic textbook on soil fertility and fertilizers of which there are many.

Concerns for drinking water are relevant to leachate which could reach the reservoir. Concerns for the water quality in Port Shelter are relevant to leachate, from holes adjacent to and draining towards the coast, which might pass beyond the broad area of buffer vegetation at the coast and reach the coast and beyond.

The quantities of nitrogen likely to leach from soils to the seaward will depend upon:

- the nitrogen status of the soils to begin with,
- the formulation of the fertilisers used,
- the ammount of additional (fertilizer) nitrogen supplied,
- the ability of the standing crop of playing surface grass to utilise the nitrogen supply,
- the ability of the suurrounding vegetation to utilise the remaining nitrogen not taken up by the turfgrass,
- other nutrient cycling, mineralisation, volatilisation, nitrification and denitrification mechanisms in the nitrogen cycle.

There issues have been addressed in Chapter 6.

The nitrogen status of the soil

The capacity of a soil to supply a nutrient over a peroid of time depends on the reserves of that nutrient in the soil and te rate at which it is converted into forms which can be readily absorbed by the plants. The reserves are drived from the mineral material of the soil and plant or crop residues, manures and fertilizers.

However, Nitrogen is a special case since there are virtually no reserves of nitrogen from the parent materials of mineral soils but it is contained in the organic matter residues of previous crops, manures, and the decaying remains of dead soil organisms such as fungi and bacteria.

Reserves of nitrogen in poor soils

Even the poorest soils will supply some nitrogen for the crop by virtue of the small amounts of nitrate, 3-10 kg/ha per year, which the soil receives in rainfall. This has been formed during electrical storms and from industrial pollutants. There are also nitrogen-fixing bacteria in the soil, both free living and in the root nodules to legumes, which convert atmospheric nitrogen to available forms. Other bacteria will release small amounts of nitrogen, even in very adverse soil conditions, by mineralization of complex nitrogenous compounds in the soil organic matter.

The atmosphere as a source of nutrients

The atmosphere supplies the water and carbon dioxide essential for photosynthesis by plants. Also, very variable amounts of gaseous nitrogen from the soil atmosphere can be converted to forms available to the plant by bacteria, living freely within the soil and contributing 10-40 kg N/ha each year.

Changes in the inorganic nitrogen in soils

Apart from the inorganic nitrogen released when soil organic matter and nitrogen-containing organic materials are decomposed by micro-organisms, the extra nitrogen that can be immediately used by plants only reaches the soil through rainfall and fertilizers. At Rothamsted the classical experiments from 1888 to 1916 indicated that about 2.9 kg/ha of NH_4-N and about 1.3 kg of NO_3-N (a total of about 4.5kg N/ha) reached the soil in rain. Most measurements in European countries show that rain provides between 2 and 12 kg N/ha each year. In addition, some ammonia may be fixed from the air by surface soil and little is known of such processes, but they are unlikely to provide more than a few kg nitrogen/acre in a year.

Thus in the absence of fertilisers nitrogen suplies in the order of (5 + 30 + 5) 40kgN/ha may be available to plants.

Nitrogen lossess

Nitrogen is lost from soil when it is taken up by crops, or standing vegetation. It is also lost as a gas from the soil surface, or it may be leached out (as nitrate) in drainage water. These processes are discussed below.

Losses of ammonia gas

Some nitrogen may be lost as ammonia from the soil surface. There is little information on the practical importance of this process under most conditions; but it is known that when ammonium salts are added to calcareous soils, and when urea, or organic manures are added to any kind of soil, ammonia is liberated, and it may be lost unless the manures are buried.

Losses by denitrification

Nitrogen present in soil as nitrate may be lost either as nitrogen gas or as oxides of nitrogen. Several mechanisms have been proposed to account for this loss; mostly it appears due to denitrifying bacteria which flourish in wet soils where oxygen is deficient and where there are remains of plants or organic materials that are not fully decomposed. Inorganic reactions that result in denitrification even in well-aerated soils are also possible. English soils with additions of readily decomposable organic materials, such as cellulose, caused rapid and extensive losses of nitrate from wet soils; straw and sawdust have similar but less marked effects.

Losses by denitrification are only important when the supply of air is limited; practically no loss occurs when the water content of soil is less than 60-70 per cent of the water-holding capacity, but when the soils are wetter the rate of denitrification increases rapidly.

Losses by other mechanisms

In agricultural systems harvesting of crops, erosion and leaching are about 44kg N/ha greater than the gains from fertilizers, manures, seeds, rainfall and biological fixation. American experiments have shown that crops recovered up to 75 per cent of the nitrogen which was available to them and a substantial proportion of the nitrogen "lost" was leached out in drainage water. This is not necessarily the case with all crops and turfgrass in particular will retain a greater proportion of applied nitrogen. About about 15 per cent of the total added was not accounted for, and it was assumed that it had volatilized.

Where grass is sown the grass is much more able to utilise the available nitrogen and grasses have been shown to take up all available nitrogen from fertilizer dressings supplying up to 125 kg N/ha within 6 weeks of starting active growth.

Losses by leaching

In the temperate European climate it has been shown that no fertilizer nitrogen is leached from the top 15cm of *uncropped* soil until the end of July, despite heavy rainfall in the two preceding months.

Moreover it is the prolonged wet weather at the end of July and in August washed nitrate into the subsoil, and by October the maximum nitrate concentration was found at a depth of 0.3 - 0.6m. Where grass was sown all fertilizer nitrogen was quickly removed as soon as the crop began to grow rapidly. By the time the grass was ready to cut for silage it had removed from the soil all the nitrate and ammonium from fertilizers supplying 112 kg N/ha. Applications of nitrogen to the grasses at Kau Sai Chau will be less than 50kgN/ha. The remaining nitrogen needed for growth will come from the mineralisation of organic matter, nitrogen fixation and atmospheric sources.

Therefore leaching of nitrogen is not necessarily likely to be a serious cause of fertilizer in-efficiency where dressings are applied in spring or at the time when turfgrasses are most able to utilise the nutrient. However, it is also conceeded that on very light soils or in wet areas, losses under those conditions could be be more serious. No leaching of nitrate can occur unless water drains through the soil. Therefore the risk of losses by leaching can be controlled if the drainage through the soil can be controlled. This may be done by comparing water lost by evapotranspiration with that falling as rain. This will be the case at Kau Sai Chau because the soil will be dependant on irrigation. Fertilizer applications will not be permitted before rainstorms (see Section 6).

QUANTIFICATION

The quoted percentages of nitrogen likely reach the Port Shelter from fertilisers getting into surface or subsurface runnoff is minimal. Any small ammounts of fertilizer lost from the fertilised greens, tees and fairways can be taken up in the unfertilised roughs or natural vegetation surrounding the playing areas.

The likely fate of the nitrogen applied to the soils ayt Kau Sai Chau will be consistent with that which occurs in other grassland and turfgrasses. Of the <73 tonnes / year applied to those holes which partly drain towards the sea we can assume that at least 75% will be taken up immediately by the grasses. (In reality this is a conservative estimate for the turfgrasses and the figure wil more likely exceed 85% since the soils will essentially be nitrogen deficient, at least to begin with). Use of foliar feeding can increase the uptake well above 90%. About 15% willbe volatilised and return to the atmosphere. Of the remaining 10% we assume most of this will be adsorbed on to the soil and about 1% may be lost in leachate.

It is clear that the golf course grasses have the ability take up all the proposed additions of nitrogen. This will depend on careful monitoring of the plants, soil and irrigation system and only supplying the nitrogen as needed. It will also be important to make sure that fertilisers are applied when meteorological conditions will allow time for the nutrients to be taken up. This is common practice in the golf industry.

When the grass is cut, the clippings are left on the ground to provide a slow release organic form of nitrogen for mineralisation. In this way the build up of organic matter will improve the tilth of the soil and the ability to retain applied nitrogen. Over time the nitrigen status of the soil will be improved and the requirement for added nitrogen will decrease to some extent. However, there will always be a requirement to add some nitrogen due to the losses to atmosphere.

Soluble nitrate may pass down into the lower portion of the soil but will remain essentially available in the deeper horizons and will migrate upwards during drier periods by capilary action.

In addition to the standing crop of grass on the course which will be the target for the nitrogen fertilisers, there will be a large reservoir of standing vegetation adjacent to the roughs. Given the exposed nature of these areas, they will be nutrient deficient due to wash out of material during extensive erosion. Once revegetated these areas will be well able to scavenge any nitrogen in the form of surplus fertilizer which is leached out from the playing area.

Once the course is established the mechanisms desribed above will continue to serve as a buffer to nutrient enrichment of the waters of the Port Shelter.

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6.17 Attachment 5

Drinking Water Quality Standards WHO Guideline Levels 1993

Table IV - Pesticides

Pesticide	1984 GV (ug/l)	Guideline Values (ug/l)	Comment
Alachlor		20	10^{-5} excess cancer risk
Aldicarb		10	10% ADI
Aldrin) Dieldrin)	0.03	0.03	1% ADI
Atrazine		2	10% ADI
Bentazon		30	1% ADI
Carbofuran		5	10% ADI
Chlordane	0.3	0.2	1% ADI
Chlorotoluron	0.3	0.2	1% ADI
Dichlorprop		100	10% ADI
DDT	1.0	2	1% ADI (includes metabolites)
1, 2-dibromo-3-chloropropane		1	10^{-5} excess cancer risk
2, 4-D	100	30	10% ADI
2, 4-DB		90	10% ADI
2, 4, 5-T		9	10% ADI
1, 2-dichloropropane		20	Provisional, 10% ADI
1, 3 dichloropropane			No adequate data
1, 3-dichloropropene		20	10^{-5} excess cancer risk
Ethylene dibromide		30	Provisional, 10^{-5} excess cancer risk
Heptachlor) Heptachlor epoxide)	0.1	0.03	1% ADI
Hexachlorobenzene	0.01	1	10-5 excess cancer risk
Isoproturon		9	10% ADI
Lindane	3	2	1% ADI
MCPA		2	10% ADI
MCPB			Inadequate data
Mecoprop		10	10% ADI
Methoxychlor		20	10% ADI
Metolachlor		10	10% ADI
Molinate		6	10% ADI
Pendimethalin		20	10% ADI
Pentachlorophenol	10	9	10% ADI, Provisional
Permethrin		20	10% ADI
Propanil		20	10% ADI
Pyridate		100	10% ADI
Silvex		9	10% ADI
Simazine		2	10% ADI
Trifluralin		20	10% ADI

EC Regulation standards : 0.1 µg/l individual substances
0.5 µg/l sun of detected concentrations of individual substances

Not based on a toxicological assessment

USEPA : Standards and Health Advisories

Pesticide	DWEL	Lifetime HA	Comment
Atrazine	200 μg/l	3 μg/l	WHO 2 μg/l
Bentazon	90 μg/l	20 μg/l	WHO 30 μg/l
Carbaryl	4,000 μg/l	700 μg/l	NO WHO VALUE
MCPA	50 μg/l	10 μg/l	WHO 2 μg/l
Glyphosate	4,000 μg/l	700 μg/l	NO WHO VALUE
Simazine	200 μg/l	4 μg/l	WHO 2 μg/l
Trifluralin	100 μg/l	2 μg/l	WHO 20 μg/l

<u>WHO Guideline Values</u> are based on a review (1988 onwards) of toxicological data on chemicals deemed to pose a threat to public health. None of the candidate chemicals proposed for use at Kau Sai Chau warranted inclusion by WHO as a priority. The WHO list does however include certain notoriously persistent chemicals such as simazine and atrazine.

<u>USEPA Health Advisories</u> are derived for water contaminants based on toxicological review (to 1986). The health effects are used to estimate no effect concentrations of a chemical over specific exposure durations. The Lifetime Health Advisories (LHA) are of the same order of magnitude as the WHO guidelines. DWEL and LHA are defined in Section 6.8.

<u>E.C. Directive Regulations</u> are not based on a toxicological review of chemicals or likely health effects. The values were chosen prior to 1980 in the absence of data on or any review of available toxicological data. In the absence of data the values were set deliberately low. The individual pesticide criterion of 0.1 μg/l does not stand up to scrutiny in the light of known lack of toxicity of chemicals such as Carbaryl or Glyphosate. This standard may be inappropriate.

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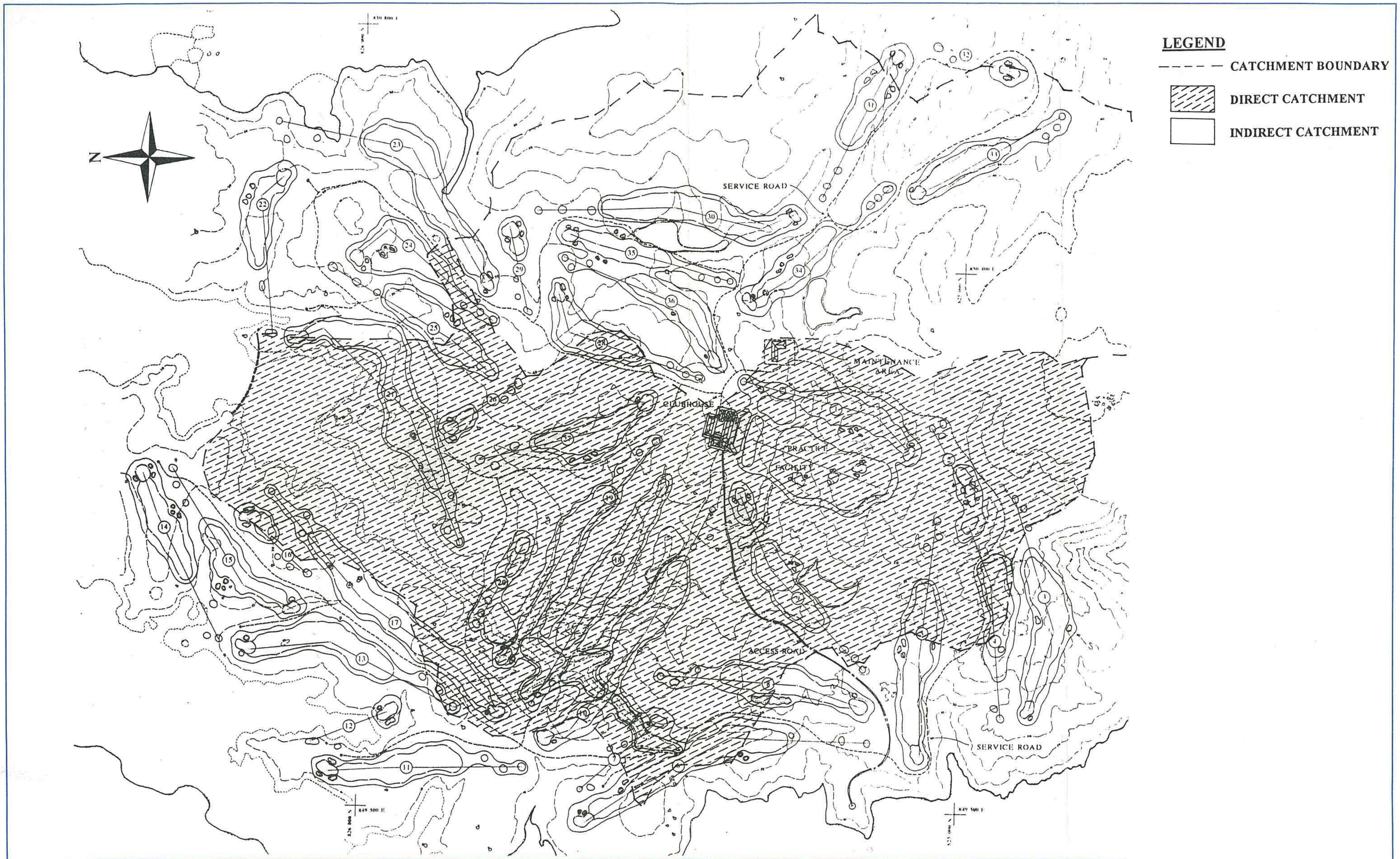

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Figure 6.1 Direct and Indirect Reservoir Catchment and Seaward Runoff

076000/January 1994

RECREATION AND CULTURE

SECTION 7

7. RECREATION AND CULTURE

7.1 Existing Recreational Opportunities

Kau Sai Chau is currently used for hiking, orienteering, recreational boating. Most of the visitor use observed during this study was for day-trips only. No overnight use was observed on Kau Sai Chau. Due to the presence of unexploded ordnance remaining from the period from 1936 through 1975 when the island was used as an artillery shelling range, there are numerous signposts on the island advising of the danger and warning away prospective visitors. Hikers and orienteering groups are presumably aware of the risks of visiting the island, and are not deterred by the potential danger.

Although there are no scheduled ferry services to the island, it is relatively easy to arrange transport from the Sai Kung pier at any time during daylight hours. Numerous small vessels are available, and the trip from Sai Kung to the island requires approximately 15-20 minutes.

There are currently no permanent facilities for recreation on Kau Sai Chau, but there is a Hong Kong Girl Guides facility, the Louisa Lansdale Camp, on the nearby island Yim Tin Tsai. There is a permanent pier at the Louisa Lansdale Camp, and there are facilities for overnight stay. Use of this facility is mainly by small groups, and is relatively infrequent.

Hiking trails on the island are not actively maintained,. and many have become obscured by the growth of vegetation. However, some trails receive enough use to remain readily passable.

Boating use of the island is most frequent on weekends and holidays during the summer months. There are many shallow moorings around the island which are sheltered, and are favorite spots for recreational use by groups on private or chartered junks. Because of the typically quiet waters within Port Shelter, the area is popular for water skiing, wind surfing, and sailing.

The six gazetted beaches in Port Shelter are shown in Figure 3.2. None of these beaches are located on Kau Sai Chau, and the nearest to Kau Sai Chau are on Sharp Island.

7.2 Proposed Recreational Improvements

7.2.1 Golf Course

The proposed golf course is described in Section 2.2 of this report. The planning justification for the course is demonstrated by comparison of available facilities in Hong Kong versus those in other regions of the world.

In UK, Australia, and USA golf facilities are available at a ratio of one 18-hole golf course per population of 10,000 to 33,000 persons (Murdoch and Marsden 1992). Hong Kong currently has the equivalent of 7 18-hole courses divided among 4 clubs at 5 sites. This provides one 18-hole course per roughly 860,000 residents, less than one twentieth of the recreation provision accepted as a standard in other countries. Following opening of the Kau Sai Chau golf course, this ratio would change to about one course per 670,000 population.

The Hong Kong Golf Association estimates that there are approximately 10,000 golfers in Hong Kong whose access to golf facilities is limited because they are not members of a golf club (Tatlow 1993). The facilities to be provided at Kau Sai Chau would address this group as well as much of the youth of Hong Kong who have not yet had the opportunity to be introduced to the game.

It is anticipated that the golf course will be open for play 365 days per year, and would only be closed during adverse weather conditions. The practice and teaching facility would also be open throughout the year, and would offer individual and group lessons in addition to practice tees.

Greens fees would be modest in comparison to those for non-members at private clubs, as would be the cost of the ferry trip from Sai Kung to Kau Sai Chau. To preclude excessive use of the course by non-residents of Hong Kong, it is anticipated that greens fees for non-residents would be set at or above prevailing market rates for non-member play at local golf clubs.

7.2.2 *Club House*

The clubhouse is described in detail in Section 2.2 of this report. It will be open to use by the public, and it is anticipated that there will be some use of the facility which will be unrelated to golf. There will be an informal restaurant, and it is expected that this will attract some visitors to the island.

7.2.3 *Jetty and Ferry Service*

The jetty on Kau Sai Chau may be used by visitors to the island who arrive by the scheduled ferry service, or by private or chartered boat. Although most use of the jetty will likely be related to golf, it is anticipated that some visitors will use the jetty for access to the island for hiking or visiting the clubhouse. Non-golfing visitors will be allowed use of the ferry service, and this is predicted to increase general recreational use of the island.

7.3 Potential Impacts on Recreational Resources and Impact Mitigation

Recreational opportunities will be enhanced by construction of the proposed project. Four aspects of the Project are expected to benefit recreational use of the island irrespective of the proposed golf course:

- clearance of unexploded ordnance on the island by the Police Explosive Ordnance Disposal Team (Section 2.10) which will remove the threat of serious accident;
- construction of the jetty on the island which will improve access for deeper draft vessels;
- operation of a scheduled ferry service to the island at frequent intervals which will facilitate public visitor use of the island by easing the logistics and lowering the costs of access;
- construction of the clubhouse and restaurant, which will make food and drinks more readily available to visitors.

Hiking and orienteering over the south half of the island will not be precluded by operation of the golf course. Although the total area available for hiking or related activities would be reduced, the more scenic, higher elevation areas on the south half of the island would be retained undisturbed for public use.

Operation of the Hong Kong Girl Guides Louisa Lansdale Camp would not be affected by the proposed project. There may, however, be an increase in requests for visitor use of the facility on an overnight basis due to increased intensity of public use of Kau Sai Chau for recreational activities.

Because none of the gazetted beaches are on Kau Sai Chau, and the nearest in terms of travel distance is some 2.5 km from the jetty location, it is anticipated that there will be no adverse impact of the Project on use of gazetted beaches. Water quality issues related to Port Shelter waters are discussed in Section 3, and measures to ensure minimal risk of chemical contamination of marine waters from golf course management are discussed in Section 6.

Private boating use of the island will be unaffected by the Project. It is anticipated that most golfers and visitors will arrive by the scheduled ferry service to the island, and that there will be little change in the number of private or charter vessels in the vicinity of Kau Sai Chau due to opening of the golf course.

7.4 Archaeology

Kau Sai Chau is known to be a site of archaeological and historic interest. There are three points of interest on the island, two relating to archaeology and one to religious history. Records of these sites were furnished for this report by the Government Secretariat, Recreation and Culture Branch, Antiquities & Monuments Office. The following information is provided from those records.

7.4.1 Kau Sai Rock Carving

On the northwest coast of Kau Sai Chau a rock carving has been located and preserved as a declared monument. The carving consists of zoomorphic patterns which resemble those on Bronze Age stamped pottery and bronze vessels in the region. The carving can be dated from the Bronze Age of Hong Kong, approximately 3000 years ago.

The rock carving is now protected within a stainless steel cage which is permanently fixed to the surrounding rock. The location of the rock carving is shown on Figure 7.1.

7.4.2 Kau Sai Archaeological Sites

Three sites on Kau Sai Chau have yielded late Neolithic stone implements. These were discovered during previous surveys on the site, and reported by Welch (1962). The locations of the three sites are shown on Figure 7.1. One of the three sites lies within the disturbance boundary of the proposed golf course. The remaining two lie south of the proposed disturbance area, and there is no predicted impact to these sites.

Although implements have been recovered, there has, to date, been no discovery of strata or deposits suggesting long-term occupation of the site. The fragments found to date have been located in the vicinity of the bomb craters and eroded areas caused by use of the artillery shelling range.

7.4.3 Historical Building

At the southern tip of Kau Sai Chau the Hung Shing Temple is located. This temple is now surrounded by the village of Kau Sai. Relics inside the temple have been dated to the 9th year of the Guang Xu, roughly 1883 A.D.

This temple is outside the proposed disturbance area, and no impact of the proposed project is predicted.

7.5 Potential Impacts to Archaeological Sites and Impact Mitigation

The Project could affect the archaeological site number 3 (Figure 7.1) which lies at the upper end of Kwat Tau Tam inlet. This area would be affected by construction of golf holes 18, 19, and 20, and by the lakes between them.

To avoid loss of important archaeological artifacts from this area a three-stage study has been commissioned by the developer. Stage One of this study is an archaeological survey of the northern extent of the disturbance area to be conducted during winter 1993-1994. The purpose of the survey will be to locate archaeological deposits within the project area through intensive survey and trial trenching.

Stage Two of the study will consist of an assessment of the potential impacts of the Project on the discovered resources. This will include mapping the location and extent of all finds. Based on the results of this stage of the study appropriate adjustments will be made to the final golf course routing and layout plan. Areas which cannot be avoided in construction of the course will then be subjected to a rescue and salvage operation (Stage Three) to remove artifacts from the sites to be disturbed.

All aspects of the survey, assessment, and any required salvage operation will be coordinated by the Antiquities and Monuments Office. The project began in December 1993.

Additional mitigation measures will involve education and training of the golf course construction workers. They will be advised of the existence of the archaeological site, and will be informed in detail regarding the nature of the artifacts to be expected and their potential locations. Should additional finds be made during the construction process, workers will be advised to notify the environmental monitoring supervisor who will request additional input from the Antiquities and Monuments Office in identifying and removing artifacts.

7.6 Grave Sites

Both northern Kau Sai Chau and the nearby island to the northeast (Urn Island) have been used to site a large number of graves. The northeastern headland of Kau Sai Chau has, for this reason, been excluded from the area of potential disturbance of the golf course project. However, there remain many graves located throughout the northern half of the island within the proposed golf course area.

All grave sites on the island have been identified and mapped to avoid potential disturbance to them during the golf course construction project. All grave sites will be maintained as part of the original landscape, and foot access to them will be provided. Many will become landscape features of the finished golf course, as is common on other courses in the region.

The grave site survey has indicated only one grave site that might be affected by the development. This site may be affected by the reservoir construction, and thus may need to be relocated prior to the outset of dam construction.

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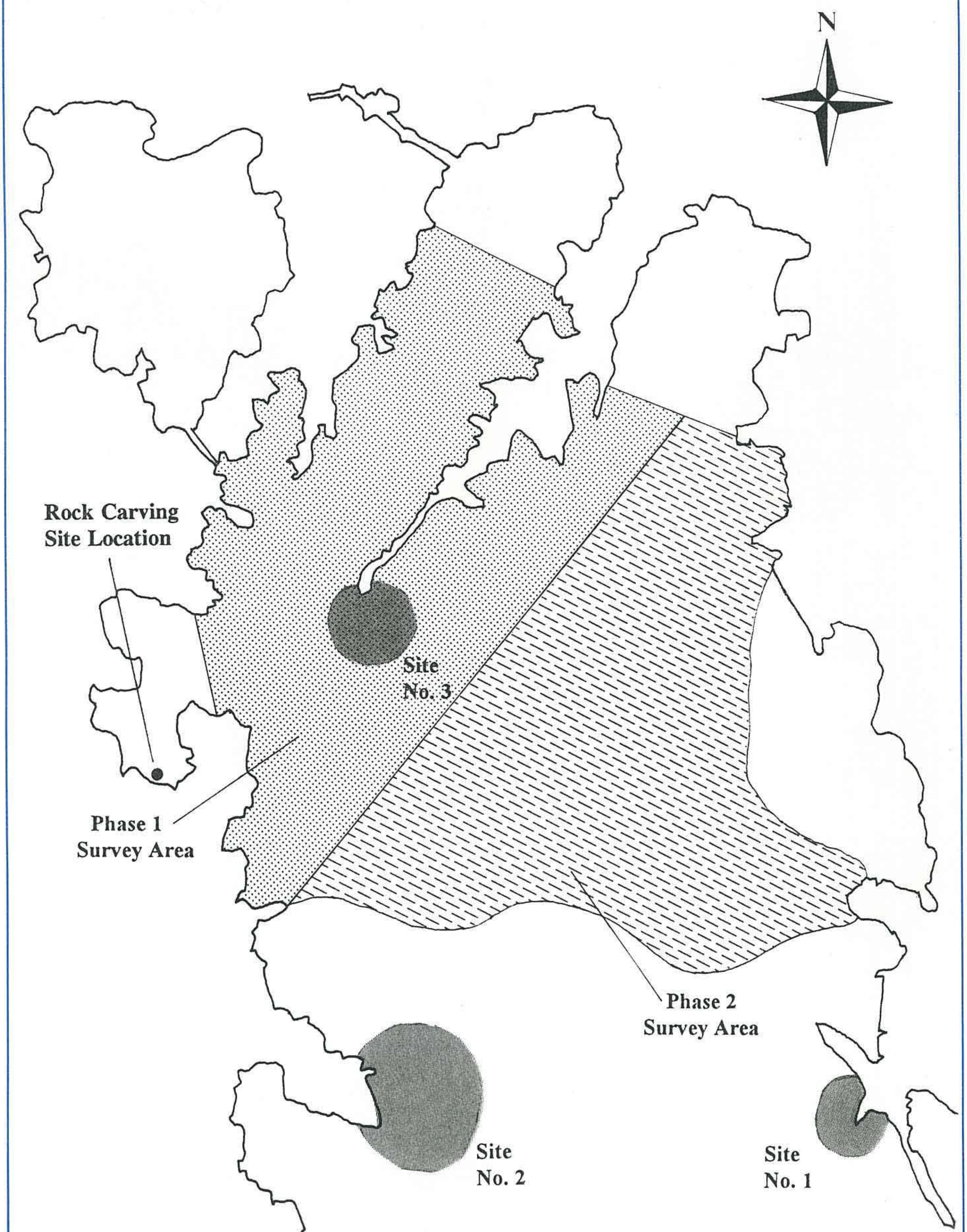

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Figure 7.1 Archaeology Survey Sites

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TRANSPORT AND INFRASTRUCTURE

SECTION 8

8.0 TRANSPORT AND ASSOCIATED INFRASTRUCTURE

8.1 Transportation and Access Options

A transportation study has been carried out for the project by MVA Asia Limited (MVA). This study is only reproduced in brief here, however it has been provided in full to Transport Department. The MVA study evaluated:

- the existing transportation infrastructure to the Sai Kung area and connections to Kau Sai Chau, including public transport, taxis, private transport, and the public accessibility to this transport;
- the demand that would be generated by the proposed project;
- the future transport conditions, and options for access to Kau Sai Chau, both in regard to transport to the Sai Kung area, and then from the mainland to Kau Sai Chau.

The transport access options included ferry access from Sai Kung, ferry access from other points in the Sai Kung area, and a bridge. The possible bridge location was from the promontory between the Yim Tsin Tsai typhoon shelter and Kwat Tau Tam inlet, to the nearest mainland point (near the AMS Canoe Centre, Figure 2.3), involving a 650 m cable stayed bridge with 350 m central span.

The principal findings of the MVA study were:

- 2.9 million people or some 50% of Hong Kong's population will be within one hour of the facility by car, and 1.3 million will be within one hour by public transport;
- the bridge option was shown to be expensive, detrimental to the quality of golf courses which can be developed, and incompatible to the aim of minimising environmental impact;
- of the pier options, the Sai Kung pier is the preferred access point from the mainland, because Sai Kung is well served by public transport, and other access points have the problem of access to buses and taxis on the return trip;
- most golfers are likely to use private cars for transport, owing to the hours of operation of public transport, travel times and the inconvenience of carrying golf clubs. However it is expected that most staff working at the golf course would be drawn from the Sai Kung area, and would not tend to use private vehicles;

- the provision of scheduled or on-demand shuttle buses operating on the hour or half hour from public transport nodes such as Choi Hung MTR and Sha Tin KCR stations is likely to be more attractive than existing public transport services, but not as convenient as private car or taxi;

- a fast motorised launch service capable of at least 15 Knots (28km/hr) and of capacity 75 to 100 golfers and equipment plus staff will need to be provided. The service should operate every 10 to 15 minutes.

8.2 Transport Impacts

The MVA study was based on an analysis of the expected pattern of demand for both users and staff. This has resulted in an assumed pattern of arrival and departure, which is provided at Appendix 2. The MVA study also provided a detailed analysis of expected car occupancy and usage, and a breakdown of usage by time period, which is also provided in Appendix 2. The study evaluated traffic flows along Hiram's Highway, and in particular on the junction with Clearwater Bay Road, as this is the most important relevant intersection.

A traffic survey for Hiram's Highway has been undertaken by MVA for the peak periods on a typical summer Sunday (6 June 1993) and Thursday (3 June 1993). There were no abnormalities to affect traffic demand on these days, and the counts are considered to be representative of peak summer weekend and weekday use.

The data obtained were converted to passenger car units (PCUs) per hour, and the results of the survey are shown in Figure 8.1. An assessment of expected car usage for the project was undertaken by MVA, and is summarised in Appendix 2. Based on the analysis of expected pattern of usage of the golf course, the numbers expected to arrive by car and the car occupancy rates, high and low car usage rates were estimated.

The MVA study noted that during weekdays the generated traffic demand along Hiram's Highway towards Sai Kung will be heaviest in the non-peak direction. An analysis has been undertaken on the reserve capacity of the Hiram's Highway/Clearwater Bay Road intersection, and these figures are provided in Table 8.1. The figures indicate the project would thus have minimal impact on the peak traffic flows on weekdays.

Table 8.1 : Summary of Clearwater Bay Road/Hiram's Highway Reserve Capacity-Weekday Peak

Period	Intersection Reserve Capacity			
	1993 Existing Conditions	1996 No Development	1996 With Golf Centre	
			High Car Usage	Low Car Usage
AM Peak	44%	21%	20%	20%
PM Peak	106%	43%	39%	41%

The critical traffic impact of the project in the study area will be on weekends and public holidays during the summer months. At such times, particularly Sunday afternoons, traffic flow along Hiram's Highway can be hampered by occasional congestion.

The high usage figures in Appendix 2 show a peak morning arrival figure of 47 cars/hour, and a peak afternoon departure figure of 77 cars/hour. The corresponding low usage figures are 28 and 45 cars/hour respectively. For the assessment it was assumed that 70% of this golf traffic is to the west (to Hong Kong/Kowloon), and 30% to the east (to Shatin). If the assumed split were changed to say 60% to/from Hong Kong and 40% to/from Sha Tin, this would have litte effect on the assessment, owing to the low volumes being generated.

Based on the observed peak Sunday movements towards Sai Kung on Hiram's Highway west of Sai Kung (542 PCUs/hour), the golf course would give rise to an increase in traffic flow in the Sunday morning peak of an estimated 33 vehicles/hour (about 6% of existing flow) for high car usage, and 20 vehicles/hour (about 4% of existing flow) for low car usage. For the Sunday afternoon return traffic peak (847 PCUs/hour), the corresponding figures are 54 vehicles/hour (6%) and 32 vehicles/hour (4%).

These figures indicate that the project would cause a minor increase in traffic along Hiram's Highway during the golfer peak use periods. However, these flow levels would be below the peak levels observed on weekdays. The MVA study concluded that the traffic demand caused by the Project will therefore only marginally affect traffic conditions, and will be within existing capacity limits.

In regard to the possibility of shuttle buses operating from Choi Hung MTR and Sha Tin KCR stations, these stations would represent the ideal potential terminii for shuttle services. However, should these terminii be determined unsuitable because of existing capacity problems, other locations could be used. These terminii locations should preferably be close to MTR or KCR stations.

8.3 Car Parking

An assessment of car parking was undertaken by MVA. Based on the analysis of expected pattern of usage of the golf course, the numbers expected to arrive by car, and the car occupancy rates (Appendix 2), car space requirements have been estimated. It was concluded that the car parking demand is about 254 spaces where car usage is a maximum (85% car usage), and about 147 spaces where car usage is a minimum (50% car usage).

The figure of 254 spaces is considered to represent the peak demand for parking. It is expected that the utilization of the Golf Centre will normally be below this peak day demand, for example during weekdays and during days of inclement weather (high temperatures, rain or high wind).

On the rare occasion of an international tournament or special event being held at Kau Sai Chau (Section 2.2.1), it is expected that special transport arrangements would be required. Such arrangements could include special ferry services from Central or other locations, and/or special shuttle bus services from MTR stations or distant parking stations. It is not considered warranted or practicable to design can parking at Sai Kung to cater for such special events.

As noted in Section 2.3.3, discussions are taking place between RHKJC and Government on the possible integration of this car parking requirements and potential sites in Sai Kung. Two principal options have been identified, one to the northeast of the Sai Kung Pier, and another at Tin Min Hoi. Details on the car park are thus not available at this time.

8.4 Pier Options and Usage

The MVA study considered eight pier options, including five utilising existing piers in Port Shelter, and three which would require the construction of new facilities.

As noted in Section 8.1, of the pier options, the Sai Kung pier is the preferred access point from the mainland, because Sai Kung is well served by public transport, and the other access points have the problem of access to buses and taxis on the return trip. If the Tui Min Hoi site were chosen for the car park, the ferry would either stop at the Sai Kung pier en route to Tui Min Hoi, or separate ferries may be scheduled, depending upon demand.

An assessment of usage of the Sai Kung pier was undertaken by MVA. There is considerable activity at the pier at weekends, particularly Sunday mornings. During weekdays activity is relatively light. A Sunday morning survey indicated that the peak activity period is from 9.30 am to 10.30 am, when vessel arrivals and departures peak, and all loading points are occupied.

MVA concluded that the capacity of the Sai Kung pier is generally adequate to cater for an additional arrival and departure each 15 minutes. At peak times some minor delays in berthing may be experienced, but this is likely to occur only for short periods at weekends and on public holidays during the summer months. The pier would only be used for boarding and alighting by golf course vessels, and would not be used for waiting or mooring.

If demand were to grow it could become necessary for extension of the existing pier, or creation of a separate dedicated pier for the Kau Sai Chau ferry service.

8.5 Ferry Service

The options for ferry services considered by MVA are:

- the establishment of a new dedicated ferry fleet;
- utilization of existing *kaito* services;
- other combination options.

The *kaito* option has the problem of the capacity of the operators to meet the demands of passengers wanting to travel to the golf course and those wanting to travel to other locations. Under these situations a reliable and frequent service to Kau Sai Chau cannot be assured. It was therefore recommended that total reliance on *kaito* services not be pursued.

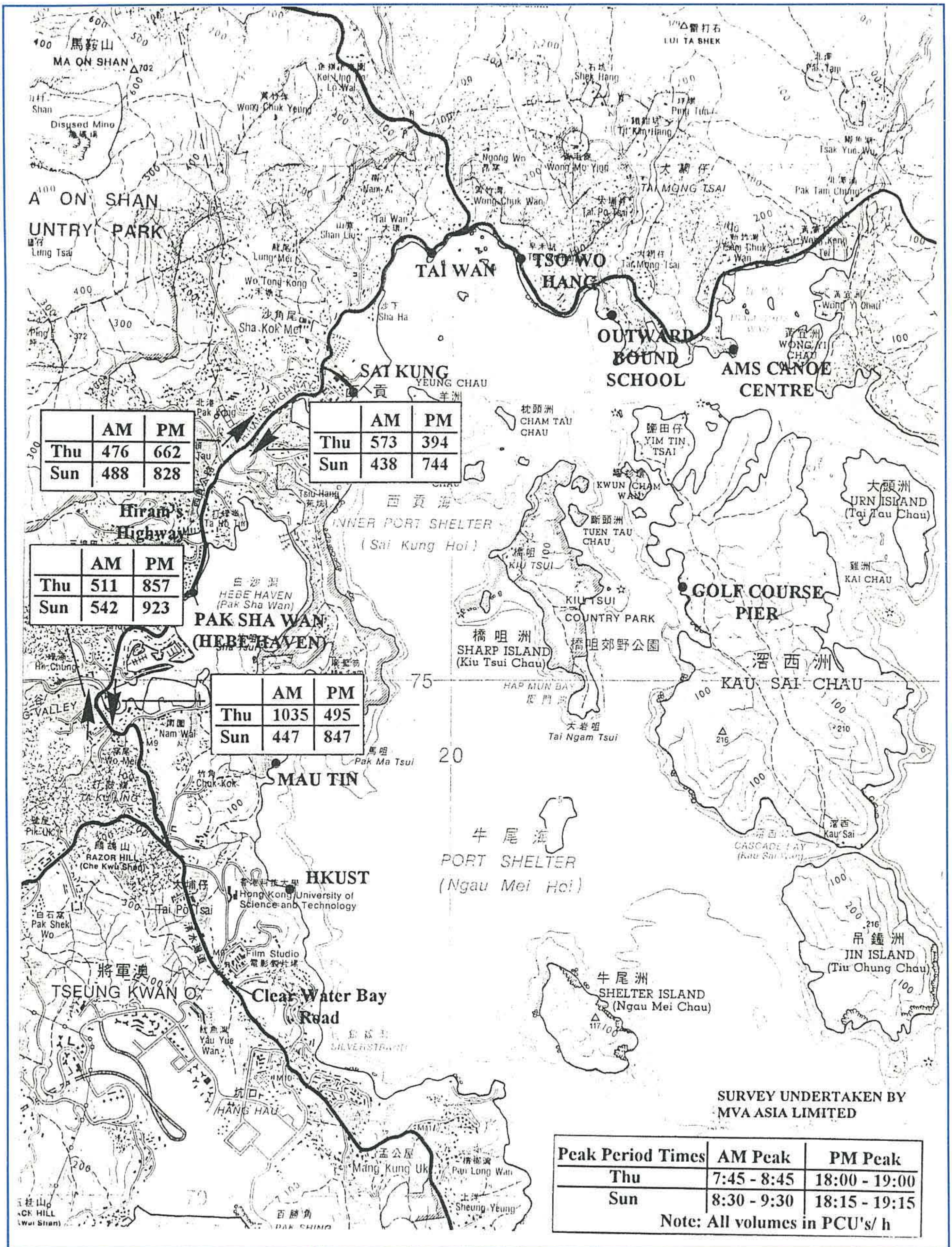
A dedicated ferry fleet has the key advantage of a high degree of control over the provision of transport to the golf course. MVA estimated a round trip cost of around $15 to $16 (1993 prices).

A combination service offers the possibility of allowing *kaito* operators to cater for the peak demands on weekends, and could be implemented on a trial basis. This option is however still subject to the ability and willingness of *kaito* operators to provide the peak service at a rate that is consistent with the dedicated fleet. A combination *Kaito* and dedicated service could present an increased workload for the Marine Police.

Overall a dedicated service is preferred, and is the proposed option. In particular the dedicated ferry option would provide a regular, reliable, safe, efficient and comfortable standard of service. This service is subject to the approval of the Commissioner of Transport for a transport licence. Licences are granted for periods of three years at a time. The Commissioner of Transport may have input on the maximum fare levels to be charged, and operating frequencies, depending on the nature of the service.

The options for a dedicated service are for Golf Centre owned and operated vessels, Golf Centre owned vessels operated by an experienced operator, and a totally contracted service to the Golf Centre. No decision has been made on which option is to be adopted, however Transport Department have noted that as demand for the ferry service is expected to be low, a contracted service to the Golf Centre is preferred.

The distance from the Sai Kung pier to the proposed jetty on Kau Sai Chau is about 4.5 km. For vessels capable of carrying 75 passengers and 15 knots (28 km/hr), three vessels would be required, operating on a service frequency of 10 to 15 minutes.



	AM	PM
Thu	476	662
Sun	488	828

	AM	PM
Thu	573	394
Sun	438	744

	AM	PM
Thu	511	857
Sun	542	923

	AM	PM
Thu	1035	495
Sun	447	847

Peak Period Times	AM Peak	PM Peak
Thu	7:45 - 8:45	18:00 - 19:00
Sun	8:30 - 9:30	18:15 - 19:15

Note: All volumes in PCU's/ h

AXIS Environmental

Kau Sai Chau Project

Figure 8.1 Hiram's Highway Traffic

Survey Time Thursday 3rd June 1993
Sunday 6th June 1993

076000/ December 1993

ENVIRONMENTAL MONITORING

AND AUDIT

CHAPTER 9

9 ENVIRONMENTAL MONITORING AND AUDIT

This Section sets out the framework for environmental monitoring and audit programme for the Project.

9.1 Introduction

An effective environmental monitoring programme for the Project is essential to:

- ensure that any environmental impacts resulting from construction and operation of the development are minimised or kept to acceptable levels;
- establish procedures to ensure that mitigation measures have been implemented and are effective, and that the appropriate corrective action is undertaken if and when required;
- provide a means to ensure compliance with environmental objectives, proper recording of anomalies, and documentation of corrective actions.

This section outlines monitoring requirements in relation to water quality, ecology, landscape and archaeological resources, and sets out monitoring schedules for the necessary environmental parameters. Monitoring schedules and audit requirements should be incorporated into the construction contract(s) and lease conditions.

9.2 Technical / Personnel Requirements

9.2.1 Responsibilities and Staffing

The Resident Engineer would be responsible for ensuring compliance with all environmental protection measures required of the Project during construction. This responsibility would be transferred to the Golf Course Manager for the operation of the Project.

During construction, an Environmental Monitoring and Audit Team should be appointed by the RHKJC, comprising the following:

- an Environmental Manager with overall responsibility for environmental performance, to oversee the Monitoring activities and to Audit compliance with contract environmental conditions;
- environmental specialists in mangrove ecology, water pollution technology and environmental monitoring, and specialists in

archaeology and landscape restoration. These specialists would undertake the monitoring activities for the project.

The Environmental Manager would report direct to the Resident Engineer.

During operation of the golf course, an Environmental Supervisor should be appointed to lead day to day work. This person should have the support of specialist staff on an as-needs basis.

The Environmental Supervisor would report directly to the Golf Course Manager, and be responsible for implementation of the environmental monitoring programme, and signing off operations required as part of the environmental protection programme.

9.2.2 *Monitoring and Audit Manual*

The Environmental Manager would prepare an environmental monitoring and audit (EM&A) manual for both the construction and operational phases, the content of which would be agreed with EPD. The contents should include the following:

- site detail and a description of the Project, including a summary of the key issues identified in the Environmental Assessment;
- A organisation flow chart showing internal and external liaison;
- programme for construction and the required EM&A actions;
- the location, frequency and type of environmental monitoring and audit requirements to assess environmental impacts of construction;
- the form/content of event/action plans (including any emergency plans) for water quality, ecological, landscape, and archaeological impacts;
- review of pollution sources and working and mitigation practices/procedures required as a result of the findings of this EIA, and to be implemented in the event that environmental pollution levels are exceeded. These measures would be summarized in a schedule;
- the content/presentation of monitoring data, procedures for their audit, and the actions to be taken in response to non-compliance with environmental protection levels;
- appropriate report formats/frequency of submission/special event reports, etc.;
- complaints/consultation procedures ;

- locations of sensitive receivers.

9.2.3 Reporting and Review

A periodic monitoring and audit report would be prepared and submitted simultaneously to the senior management representative and to EPD. The frequency of reporting should be agreed with EPD but is recommended to be monthly during construction, quarterly during the first 2 years of operation and half yearly thereafter.

The report would be a concise account of environmental monitoring and restoration programme during the previous period and would include:

- Summary - A concise summary of major incidents and performance during the period and recommendations for the coming period;
- Project Data - A synopsis of the project organisation; project programme; management liaison structure;
- Monitoring/Audit Requirements - Summary of parameters to be monitored;
- Trigger/Action/Target Levels, Action Plans, environmental protection requirements in contract documents, and engineering conditions, and performance criteria for ecological works and landscape restoration;
- Monitoring Methodology - Monitoring equipment used, locations, duration/frequency;
- Monitoring Results - Parameter, data, date, time, environmental conditions, location, etc.;
- Audit Results - Review of pollution sources, working procedures in the event of non-compliance with environmental monitoring levels, action taken in the event of non-compliance, follow-up procedures for earlier non-compliance actions;
- Complaints - Liaison and consultation undertaken, subsequent action, database of telephone/written complaints, location of complaints, action plan and follow-up procedures etc.;
- Appendices - Appropriate drawings/tables of monitoring locations, sensitive receiver locations, environmental monitoring and audit requirements, etc.

The monitoring programme for both the construction and operation phases would be subject to periodic review in consultation with EPD. At these periodic review meetings, the monitoring results would be reviewed to consider:

- any changes to the monitoring methodology, or changes to the parameters being monitored;
- the need to increase, or the ability to relax the frequency of monitoring;
- the need to upgrade, or relax any mitigation measures.

9.3 Monitoring and Audit Schedules

9.3.1 Environmental Monitoring

General

Environmental monitoring falls broadly into two categories:

- baseline monitoring which has been or is being undertaken to establish the existing conditions in the Study Area (this makes it possible to set limits for the construction and operational phases); and
- compliance monitoring which should be carried out during both the construction and operational phases to achieve the following general objectives:
    1. to assess the performance of construction/operation activities in environmental terms;
    2. to obtain early warning of potential problem areas, permit timely remedial action and identify any environmental impacts;
    3. to comply with appropriate standards and environmental objectives; and
    4. to provide reassurance to local communities.

Three quantitative levels would be set to monitor compliance with environmental objectives and to provide early warning of potential problem areas. This system of compliance monitoring will permit implementation of mitigation before the regulatory standards are reached. The three levels are described below:

1. **Trigger Level** is a reference value to be used as an early warning of deterioration in environmental quality. Achievement of this level may stimulate increasing the frequency of monitoring and undertaking preliminary investigation (for example to identify any obvious causes) and possibly remedial action if appropriate;

2. **Action Level** indicates that deterioration is significant and that urgent corrective action is required;

3. **Target Level** is the maximum permissible level which will achieve compliance with the appropriate regulatory standards, or other standards such as construction noise criteria outside restricted hours, and is therefore the upper boundary/limit which is acceptable in terms of environmental quality. Consequently, achievement of this level is undesirable. Compliance monitoring schedules are, therefore, devised such that remedial action is taken to prevent this level being attained. The Target Level should not therefore, be considered as the desired level.

In the case of ecological works these levels may need to be qualitative.

The monitoring programme will be required to ensure compliance with the construction sequence and methods, and to monitor ecological effects, water quality, landscape restoration, general site working practices and site hygiene, and compliance with the various control and mitigation measures also identified in this report.

9.3.2 Environmental Auditing

General

The purpose of environmental auditing is to review effectiveness of the overall environmental protection programme (both construction and operation) in terms of monitoring, mitigation and corrective action. The audit process should not be divorced from general management activities, and should promote a pro-active approach to environmental protection and Project management.

Construction Phase Auditing

Construction phase auditing should be carried out in conjunction with the construction monitoring programme. Audits should be conducted monthly during the construction period. Records of environmental monitoring should be maintained by the Environmental Manager and the Contractor, and the audit should seek to check:

- records of monitoring procedures;
- records of monitoring results;
- records of exceedence of any regulatory requirements;
- details of control and mitigation action taken in response to unacceptable impacts;
- effectiveness of overall environmental protection programme.

The audits should be conducted monthly and should cover the four key areas of engineering works including:

- dam and reservoir construction;
- internal access road and clubhouse site formation and utilities;
- golf course site formation;
- jetty construction.

Where possible audits should coincide with major construction activities. The audits should ensure that the activities/measures specified in the EM&A Manual and in clauses in the contract documents are adhered to. In addition the audits should examine whether any unanticipated impacts are being addressed and if any improvements are required for future monitoring programmes.

Operational Auditing

An operational audit should be completed as each key engineering activity becomes operational. This audit should focus on the operational aspects of the golf course, but also consider the dam, reservoir, and associated drainage facilities, water treatment works, clubhouse and maintenance building, and jetty. A post-project audit should be undertaken for at least the first 3 years of operation.

Post project auditing should verify the findings of the EIA and provide a mechanism for:

- reviewing the effectiveness of, and requirement for the on-going monitoring programme;
- reviewing environmental management practices in terms of achieving environmental objectives;
- reviewing the effectiveness of environmental mitigation;
- recommending improvements in environmental controls in the event that environmental objectives are not achieved and environmental impacts are unacceptable.

A post-project audit report and executive summary should be submitted to EPD and the operator(s) within 5 weeks of completing the audit.

9.4 Water Quality Monitoring

During the period following the Stage 2 Environmental Statement approval and prior to the commencement of civil works, baseline water quality monitoring would be undertaken. The frequency of monitoring would be agreed with EPD in order to ensure that sufficient baseline data is obtained.

Results would be reported to the Developer, EPD and AFD, and reviewed on a regular basis.

Due to the fishing interests either side of the development a programme of water quality monitoring is proposed. The monitoring would be divided into the following activities:

a) Baseline marine water quality monitoring;
b) Construction marine water quality monitoring during dam construction and dredging, and at the FCZs during the construction period.
c) Operational marine water quality monitoring;
d) Reservoir water quality monitoring.

9.4.1 Baseline Monitoring

The proposed locations for baseline monitoring are shown in Figure 9.1 and the monitoring schedule is given in Table 9.1.

9.4.2 Construction Phase Monitoring

The only construction activity which may have a significant impact on marine water quality is considered to be the dam construction. The parameters to be tested reflect the potential pollutants from this activity (Table 9.1).

There are no permanent running streams flowing to outside the Project area that would be affected by the site construction works. There is a marshy area below hole 23, however this area would also not be affected by construction activity. The overall drainage of the Project area would be substantially altered as part of the project works, and this is described in Section 2.5. Freshwater monitoring is therefore not required during the construction phase.

9.4.3 Operational Phase Monitoring

Marine Environment

Monitoring is proposed to detect any impact the operation of the golf courses may have on the marine environment (Table 9.1). Given the comprehensive environmental controls adopted in the design stage of the Project the impact on the marine environment is anticipated to be insignificant. This should be confirmed by the monitoring programme and it is likely that the frequency of monitoring can be reduced after the first year of operation.

Reservoir Water Quality

Routine reservoir water quality monitoring would be required throughout the life of the Project. The Environmental Supervisor would prepare a check list through consultation with EPD and other interested Government Departments to identify water quality parameters of concern. Together with environmental clauses in the contract documents, this check list will form the basis of a proforma for the future reservoir water quality monitoring programme.

Table 9.1 Marine Water Quality Monitoring Schedule

PARAMETER	OBJECTIVE	TRIGGER LEVEL	ACTION LEVEL	TARGET LEVEL	LOCATION	FREQUENCY/TIMING
Aesthetic Appearance SS, DO Salinity Ammoniacal Nitrogen Inorganic Nitrogen Nitrate Orthophosphate *E.Coli* Turbidity	Baseline assessment	N/A	N/A	N/A	5 Designated monitoring stations and control - 1m below surface - mid level - 1m above sea bed	Prior to commencing construction, 3 times/week for 4 weeks, at mid-ebb and mid flood.
Aesthetic Appearance Turbidity, SS, DO	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	Designated monitoring station positions 1 to 5 and control station 6 - 1m below surface - mid level - 1m above sea bed **	Weekly during the construction period, at mid-ebb and mid-flood.
SS, DO	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	Designated monitoring station positions 2 and control station 6 *** - 1m below surface - mid level - 1m above sea bed	3 times/week during marine dredging works and marine works associated with construction of the dam, and once weekly at other times at mid-ebb and mid flood.
Aesthetic Appearance SS, DO Salinity Ammoniacal Nitrogen Inorganic Nitrogen Nitrate Orthophosphate *E.Coli* Turbidity	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	5 designated monitoring stations and control - 1m below surface - mid level - 1m above sea bed **	Monthly during the operation of the golf course at the 5 designated marine monitoring stations and control station.

Note : N/A Not applicable
* In the event that the running background level is in excess of the WQO, the Target Level = a deterioration from the running background level of 30%

SS = Suspended Solids
DO = Dissolved Oxygen
WQO = Water Quality Objective

** The frequency of sampling would be reduced if no impacts are recorded, as agreed with the EPD.
*** Monitoring marine works is initially limited to position 2 and control site 6. If problems are detected this monitoring would be extended to include all the proposed monitoring positions.
Turbidity is measured by turbidity meter.

Table 9.2 Water Quality Event Contingency Plan

EVENT	FREQUENCY	ACTION	
		Monitoring Personnel	*Contractor/operator*
Breach of Trigger Values	One sample	Inform contractor/operator	Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary
	Two consecutive samples	Inform EPD, AFD, contractor/operator; resample to confirm result	
Breach of Action Level	One sample	Inform EPD, AFD, contractor/operator; resample to confirm result	Check working methods/practices to identify any immediate causes; take approate remedial action if necessary
	Two consecutive samples	Inform EPD, contractor/operator; resample to confirm result	Undertake detailed chech of working methods and practices
		Increase frequency of monitoring	Carry out appropriate remedial action and inform EPD of remedial action
		Propose remedial action	Ensure corrective action has been undertaken and is effective
		Continue monitoring after completion of remedial action to confirm action is effective	Amend method statement, if appropriate
		Record event in monitoring report for submission to contractor/operator and EPD	
Breach of Target Level	One sample	Inform EPD, AFD, contractor/operator;	Undertake immediate check of activities and employ any appropriate mitigation
		Confirm result & increase monitoring frequency	Ensure immediate implementation of remedial action and in extreme cases cease activities
		Propose remedial action	
		Undertake monitoring at nearest water quality SR	Ensure corrective action has been undertaken and is effective and inform EPD of remedial action
		Continue monitoring after completion of remedial action to confirm action is effective	Amend method statment, if appropriate
		Complete Monitoring Report and submit to contractor/developer and EPD	

9.4.4 Event Contingency Plans

An Event Contingency Plan would be followed by the contractor to facilitate appropriate and immediate response by relevant personnel in the event that the Action Levels are attained or exceeded. The requirement for an Event Contingency Plan would be contained in the contract and lease conditions and suitable plans should subsequently be submitted by the developer/operator to EPD and AFD. An example of a Water Quality Monitoring Event Contingency Plan is given in Table 9.2.

9.5 Air, Noise and Waste Monitoring

9.5.1 Construction Phase

As noted in Section 2.8.4, there are no identified Sensitive Receivers that would be affected by noise or dust from construction activities.

It is therefore not proposed that regular noise or dust monitoring be undertaken. However it is proposed that a short baseline study of noise and total suspended particulate levels would be undertaken, in order to provide a baseline reference.

If complaints of noise or dust were made, the EM&A team would advise on mitigation measures, and undertake any monitoring as required.

In regard to waste, all marine muds and spoil generated will be fully utilized on site, as described in this EIA. Other wastes would be disposed of to Government landfill.

9.5.2 Operational Phase

Air and noise are not issues for the operational phase. As noted in Section 2.9.6, the wastes generated by the operation of the golf course, restaurant and staff quarters would be of a household/commercial nature, and would be disposed of to a Government landfill. Sewage sludge would be disposed of to the Sai Kung sewage treatment plant (Section 3.5.4). It is not proposed that any monitoring of these wastes be undertaken.

9.6 Ecological Monitoring

Before commencement of any works on site, baseline ecological surveys would be thoroughly checked against final development proposals to ensure minimum potential for damage to existing vegetation. This will be particulary important in Kwat Tau Tam inlet where mangroves to be preserved in the final scheme are located, or in areas near the works for the dam construction project.

Procedures for coffer dam construction landward and seaward of the dam site would be carefully monitored to ensure minimal damage to mangroves and coastline vegetation.

9.6.1 Construction Phase

During construction the primary tasks of the Environmental Team will be:

i) briefing and training of construction crews in the importance of confining construction and related activities to permitted areas ;

ii) marking special areas and features to be avoided by personnel and equipment;

iii) liaising with survey and construction crews to modify layout as needed to avoid sensitive areas;

iv) monitoring and reporting performance of construction crews;

v) carrying out the mangrove mitigation plan;

v) immediately correcting situations which violate the intent of the ecology impact mitigation plans;

vi) working with the detail design and construction teams to ensure that water bodies are designed for maximal ecological utility;

vi) ensuring minimal adverse ecological effects of construction.

Ecological monitoring will be directed at protection of all native vegetation which does not occur on sites scheduled for features of the final project layout. The Environmental Supervisor would be responsible for advising survey and construction crews of the protection status of these areas, marking them so they are readily identifiable, and ensuring that no damage is done. Should activities appear likely to cause damage to identified vegetation or other habitat features, the Environmental Supervisor would formally advise the Site Engineer to cease or modify the works concerned.

The mangrove impact mitigation plan calls for creation of a planting substrate immediately seaward of the reservoir dam. Because this type of project is relatively new to Hong Kong, it will require close supervision to ensure that an appropriate substrate is provided to ensure success of transplants. Therefore, it will be important that special attention is paid to selection of sediments for the substrate, construction methods, and the transplanting operation. Survival of seeded and transplanted mangroves will be monitored, and plants which fail to survive will be replaced by seedling transplant or seeding by propagules. Such replacement will occur throughout the construction stage and through year 2 of the operation stage of the project.

Equally important is protection of existing mangroves located seaward of the dam site which may be impacted by dam construction operations. These areas must be carefully marked to avoid accidental encroachment by construction personnel or equipment. Also, appropriate irrigation measures must be undertaken to ensure that the dewatering process to facilitate dam construction does not result in loss of those mangroves lying seaward of the dam site.

An additional concern will be design and supervision of erosion control measures during the construction phase.

The measures to be adopted would include:

- i) inspection of layout of erosion control matting as required;
- ii) inspection of erosion control berms built to contain runoff from golf course construction sites.
- iii) regular checks of temporary drainage works;
- iv) inspection of dam construction procedures including sedimentation controls
- iii) programming and supervision of mulching on exposed areas;
- iv) programming of early hydroseeding and planting works.

The effectiveness of these works will need to be closely related to the water quality monitoring programme. Suspended solid concentrations seaward of the dam construction site will be quantified and reported as part of this programme. Tolerance limits will be set for levels of suspended solids according to those established for Port Shelter waters.

9.6.2 Operational Phase

A concern during the early years of operation will be sedimentation of coastal marine waters or the reservoir from erosion of recently revegetated fairways. This will be monitored visually following storms, and corrective measures such as supplementary planting and erosion control matting will be implemented as required. Sediment loads will be quantified as part of the water quality sampling program.

A concern throughout the life of the project will be the potential for contamination of surface and ground water by chemicals applied to the golf course (Section 6). Monitoring of ground and surface water quality will be conducted on a periodic basis following application of fertilizers or pesticides. The monitoring schedule and list of target parameters will be developed through liaison with EPD.

General site housekeeping will be monitored during operation to ensure safe, handling, and use of all chemicals on site. The monitoring programme for the water treatment works and the golf course equipment depot will be particularly strict as these areas are the potential point sources of pollutants such as chemicals, fuels, and oils.

Golf course operations will be audited to ensure that chemical treatments are applied as specified in the management plans. Chemical formulation, frequency and quantity of chemical applications will be reported to EPD for use in developing water quality monitoring schedules.

Success of upland and mangrove tree and shrub transplants will be monitored. Because of the importance of mangrove restoration to the success of the overall ecology impact mitigation plan, special care will be taken to ensure that areas where planting has failed are re-planted as needed. All transplant sites will be monitored monthly during the first year following transplanting. During the second year monitoring will be conducted quarterly. Mangrove and upland trees and shrubs which have not survived transplantating will be replaced with new seedlings or propagules. The Environmental Supervisor will be responsible for sourcing and transplanting seedling or propagule stock as needed.

New mangrove stands or enhanced stands should be sampled using the point-centre-quarter method beginning six months after transplanting is completed. Sampling should be repeated at six month intervals thereafter for a period of two years (five total sample periods). Results of the transplant and enhancement programmes should be compared with sampling results obtained during baseline studies to determine and assess the effectiveness of the mangrove mitigation project.

All mitigation measures should be audited to ensure effective implementation and to review the effectiveness of mitigation and monitoring programmes. Monitoring data and reports should be supplied to AFD and EPD for review.

9.7 Landscape Restoration Monitoring

The upland landscape restoration measures to be implemented following construction of the golf course will require monitoring to identify areas of subsequent erosion, and to implement corrective action. The badly eroded portions of the island in the southwest corner of the works boundary will serve as a borrow area and a part of the golf course. Some re-contouring and reseeding will be required to obscure the transition from the restored areas to the native topography.

The Environmental Supervisor will be required to work with the construction supervision team to plan and implement the restoration project and to monitor the progress of revegetated sites on a periodic basis. It is suggested that monitoring of the restored areas be conducted on a bi-weekly basis.

Shrub and tree plantings around the clubhouse and maintenance building should also be monitored to identify transplants which have failed and require replacement. This monitoring should be conducted continuously by the golf course staff.

The Environmental Supervisor will be responsible for locating and arranging transplanting of shrubs and trees from areas to be disturbed during the construction process. In the event that a temporary (or permanent) shrub and tree nursery is required to provide transplant stock, the Environmental Supervisor will be responsible for planning and implementing a nursery project.

9.8 Archaeology and Grave Site Monitoring

An archaeological survey was underway at the time of submittal of this report. Upon completion of the survey and subsequent rescue operation it will be important to develop a monitoring plan for archaeological resources during the construction phase of the project.

Due to the number and historic importance of the artifacts found to date on the site, it is probable that fairway and lake construction in the upper reaches of the Kwat Tau Tam inlet may unearth additional finds. A monitoring plan will be required to identify, salvage, catalog, and preserve any artifacts found during construction of the golf course.

Although the details of the plan must be agreed with the Antiquities and Monuments Office (AMO) of the Recreation and Culture Branch, a general protocol can be put forward as follows:

> Steps to be taken to ensure preservation of archaeological artifacts found during the construction process at Kau Sai Chau.

1. Works in the area should be halted, and the equipment and personnel reassigned temporarily.
2. The AMO should be contacted by the Environmental Supervisor and notified of the nature of the find, and given an opportunity to respond.
3. The AMO should have the option of delegating a salvage operation to the Environmental Supervisor should staff commitments so dictate.
4. A salvage operation should be conducted, the artifacts should be properly identified, cataloged, and removed from the site.

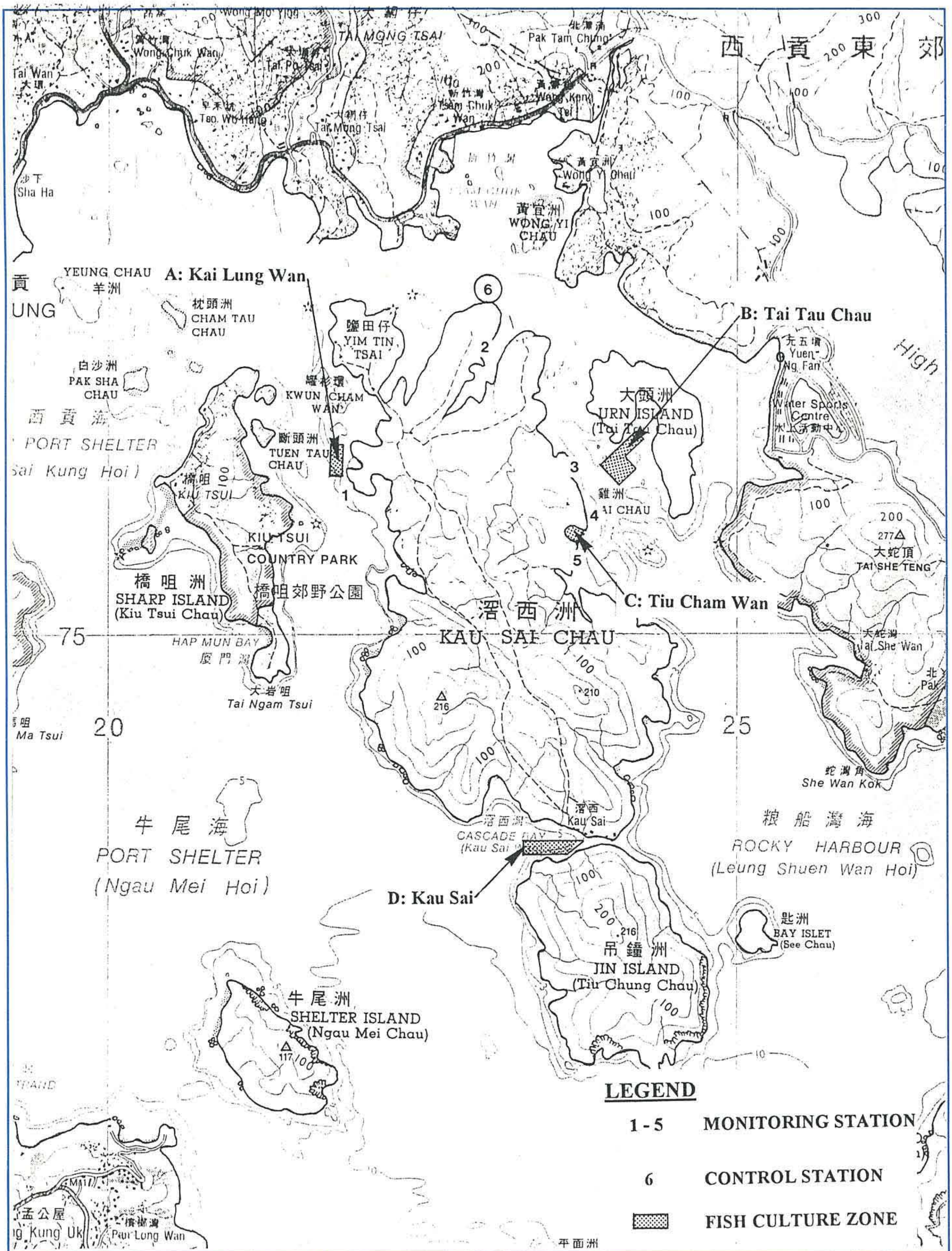
5. The AMO should then authorize resumption of works on the site.

Grave sites in the Project area have been identified and mapped. However, during construction it is possible that additional sites could be found.

The AMO and the District Lands Office, Sai Kung, would be advised of any such finds. Should the grave site be possibly affected by the Project construction or operational activities, this would be discussed with AMO.

9.9 Schedules of Implementation

A detailed schedule of implementation incompassing all the environmental mitigation measures recommended in this Final Environmental Impact Assessment Report, will be incorporated in the EM&A Manual for Construction of the Kau Sai Chau Project. A draft schedule of implementation is included within this report as Appendix 4.



AXIS Environmental

Kau Sai Chau Project

Figure 9.1 Marine Water Quality Monitoring Locations

076000/ December 1993

ABBREVIATIONS

APPENDIX 1

APPENDIX 1 : ABBREVIATIONS

Measurements

Technical units of measurement in this report are based on the International System of Units (SI) wherever possible. These technical units may be broadly grouped as prefixes and measurements. A prefix applies to the unit of measurement that immediately follows it - for example microgram is abbreviated as μg. Superscripts ^{2} and ^{3} following a linear unit indicate area and volume - for example m^2 (square metres) and m^3 (cubic metres). Different units are combined by a full stop (.) to differentiate units of the same exponential sign, and a solidus (/) to indicate 'per'. For example, kilometres per hour is abbreviated as km/h, while megalitres per day per square kilometre is $Ml/d.km^2$.

The prefixes used in this report are:

k	kilo	1,000
c	centi	0.01
m	milli	0.001
μ	micro	0.000,001

Units of measurement which have been used are:

yr	year
are	$100m^2$
°C	degrees Celsius
g	gram
hr	hour
ha	hectare
Hz	hertz
l	litre
m	metre
pH	degree of alkalinity/acidity
%	per cent
s	second
t	tonne

Miscellaneous

AFD	Agriculture and Fisheries Department
AMO	Antiquities and Monuments Office
AXIS	AXIS Environmental Consultants Limited
BOD	Biochemical Oxygen Demand
BOD_5	Biochemical oxygen demand (five-day test)
CCA	Countryside Conservation Area
CHAMP	Chemical Application Management Plan
CSCP	Chemical Spill Contingency Plan
DO	Dissolved Oxygen
DSD	Drainage Services Department
DWEL	Drinking Water Equivalent Level
EIA	Environmental Impact Assessment
EM&A	Environmental Monitoring and Audit
EPD	Environmental Protection Department
E.coli	*Escherichia coli*
FCZ	Fish Culture Zone
GCM	Golf Course Manager
IBDU	Isobutyledene diurea
K	Potassium
KCR	Kowloon Canton Railway
KSC	Kau Sai Chau
KTT	Kwat Tau Tam
LCA	Landscape Character Area
LHA	Lifetime Health Advisory

MLWS	Mean Low Water Springs
MTR	Mass Transit Railway
MVA	MVA Asia Limited
N	Nitrogen
N/A	not applicable
NTU	nephelometric turbidity units
P	Phosphorus
PCU	Passenger car units
PD	Principal Datum
PO_4-P	Orthophosphate
ppt	parts per trillion
®	registered trade name
RHKJC	Royal Hong Kong Jockey Club
RBC	Rotary Biological Contactor
Redox	Reduction - oxidation
RO	Royal Observatory
SMG	Study Management Group
SS	Suspended Solids
TM	Technical Memorandum
TMP	Turfgrass Management Plan
TMS	Turfgrass Management System
USEPA	United States Environmental Protection Agency
USGA	United States Golf Association
WHO	World Health Organization
WPCO	Water Pollution Control Ordinance

WQCZ	Water Quality Control Zone
WQO	Water Quality Objective
WSD	Water Supplies Department
ZVI	Zone of visual influence
<	less than
>	greater than

PATTERNS OF ARRIVAL AND DEPARTURE

APPENDIX 2

APPENDIX 2 : PATTERNS OF ARRIVAL AND DEPARTURE

Table A.1 Assumed patterns of arrival and department at Kau Sai Chau Golf Centre

Source : MVA Asia Ltd

60 Minute Time Period Beginning	Arrival Pattern At Course								Departure Pattern At Course							
	Golf Players	Golf Practice	Golf Visitors	Golf Caddies	Admin	Grounds	Catering	Total	Golf Players	Golf Practice	Golf Visitors	Golf Caddies	Admin	Grounds	Catering	Total
05:00 AM	0	0	0	0	5	30	10	45	0	0	0	0	0	0	0	0
06:00 AM	64	20	0	64	0	0	0	148	0	0	0	0	0	0	0	0
07:00 AM	64	20	0	64	0	0	0	148	0	0	0	0	0	0	0	0
08:00 AM	64	20	0	64	0	0	0	148	0	0	0	0	0	0	0	0
09:00 AM	64	20	16	64	0	0	20	184	0	0	0	0	0	0	0	0
10:00 AM	64	20	16	64	0	0	0	164	0	20	0	0	0	0	0	20
11:00 AM	64	20	16	64	0	0	0	164	0	20	0	0	0	0	0	20
12:00 PM	64	20	16	0	5	20	0	125	64	20	16	0	0	0	10	110
01:00 PM	64	20	16	0	0	0	10	110	64	20	16	0	5	30	0	135
02:00 PM	64	20	16	0	0	0	0	100	64	20	16	0	0	0	20	120
03:00 PM	64	20	16	0	0	0	0	100	64	20	16	0	0	0	0	100
04:00 PM	0	0	0	0	0	0	0	0	64	20	16	64	0	0	0	164
05:00 PM	0	0	0	0	0	0	0	0	64	20	16	128	0	0	0	228
06:00 PM	0	0	0	0	0	0	0	0	128	20	16	192	0	0	0	356
07:00 PM	0	0	0	0	0	0	0	0	128	20	0	0	5	20	10	183
08:00 PM	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
09:00 PM																
TOTAL	640	200	112	384	10	50	40	1436	640	200	112	384	10	50	40	1436

Table A.2 Maximum and minimum private car usage

Source : MVA Asia Ltd

Group	Maximum Private Car Usage		Minimum Private Car Usage	
	% by car	Car Occupancy	% by car	Car Occupancy
USERS				
Golfers Playing	85%	2.0	50%	2.0
Golfers Practising	85%	1.5	50%	1.5
Golfers Visiting	85%	2.0	50%	2.0
STAFF				
Administration	10%	1.2	5%	1.2
Catering & Services	5%	2.0	2.5%	2.0
Maintenance & Grounds	5%	2.0	2.5%	2.0
Caddies	5%	2.0	2.5%	2.0

Table A.3 High and low car usage private car generation rates

Time Period	High Car Usage (85%)			Low Car Usage (50%)		
	Arrive (cars)	Depart (cars)	Accumulation (cars)	Arrive (cars)	Depart (cars)	Accumulation (cars)
5:00 - 6:00	12	0	12	7	0	7
6:00 - 7:00	40	0	52	23	0	30
7:00 - 8:00	40	0	92	23	0	53
8:00 - 9:00	42	0	134	25	0	78
9:00 - 10:00	47	0	181	28	0	106
10:00 - 11:00	47	11	217	28	7	127
11:00 - 12:00	47	11	253	27	7	147
12:00 - 13:00	47	46	254	27	27	147
13:00 - 14:00	45	47	252	27	27	147
14:00 - 15:00	45	46	251	27	27	147
15:00 - 16:00	34	45	240	20	27	140
16:00 - 17:00	0	47	193	0	28	112
17:00 - 18:00	0	49	144	0	28	84
18:00 - 19:00	0	77	67	0	45	39
19:00 - 20:00	0	67	0	0	39	0
20:00 - 21:00	0	0	0	0	0	0
TOTAL	446	446		262	262	

MARINE OUTFALL DISPERSION CALCULATIONS

APPENDIX 3

APPENDIX 3 : MARINE OUTFALL DISPERSION CALCULATIONS

Kau Sai Chau Golf Course Development
Sewage Effluent Discharges

Population:

Day	Peak Week	Average Week
Mon	976	758
Tue	976	758
Wed	976	758
Thu	1091	847
Fri	1206	938
Sat	1379	1070
Sun	1436	1115
Total	8040	6244

Note: Population figures include caddies, ground staff, etc. (50 assumed)

1.Treatment to Technical Memorandum:

Effluent Standards

Determinand	Level
Flow	
-Resident	370 l/h/d
-Visitor	70 l/h/d
BOD*	20 mg/l
SS*	30 mg/l
Total N*	20 mg/l
E. coli*	1000 /100ml

* - Based on Technical Memorandum; Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland Waters and Coastal Waters

Discharge Flows and Loads

Average Week:

Day	Popn.	Flow* (m3)	BOD (kg)	SS (kg)	Total N (kg)	E. coli (No.)
Mon	758	81.3	1.6	2.4	1.6	8.13E+08
Tue	758	81.3	1.6	2.4	1.6	8.13E+08
Wed	758	81.3	1.6	2.4	1.6	8.13E+08
Thu	847	89.0	1.8	2.7	1.8	8.90E+08
Fri	938	97.0	1.9	2.9	1.9	9.70E+08
Sat	1070	108.5	2.2	3.3	2.2	1.09E+09
Sun	1115	112.5	2.2	3.4	2.2	1.12E+09
Total	6244	650.8	13.0	19.5	13.0	6.51E+09
Average Day	892	93.0	1.9	2.8	1.9	9.30E+08

* - includes an allowance for restaurant discharges

Peak Week:

Day	Popn.	Flow* (m3)	BOD (kg)	SS (kg)	Total N (kg)	E. coli (No.)
Mon	976	100.3	2.0	3.0	2.0	1.00E+09
Tue	976	100.3	2.0	3.0	2.0	1.00E+09
Wed	976	100.3	2.0	3.0	2.0	1.00E+09
Thu	1091	110.4	2.2	3.3	2.2	1.10E+09
Fri	1206	120.4	2.4	3.6	2.4	1.20E+09
Sat	1379	135.5	2.7	4.1	2.7	1.36E+09
Sun	1436	140.5	2.8	4.2	2.8	1.41E+09
Total	8040	807.8	16.2	24.2	16.2	8.08E+09
Average Day	1149	115.4	2.3	3.5	2.3	1.15E+09

* - includes an allowance for restaurant discharges

2. Treatment for Irrigation:

Effluent Standards:

Determinand	Level
Flow	
-Resident	370 l/h/d
-Visitor	70 l/h/d
BOD	15 mg/l
SS	15 mg/l
Total N*	45 mg/l
E. coli#	100 /100ml

* - assumed treatment level without denitrification
# - minimum level of treatment

Discharge Flows and Loads

Average Week:

Day	Popn.	Flow* (m3)	BOD (kg)	SS (kg)	Total N (kg)	E. coli (No.)
Mon	758	81.3	1.2	1.2	3.7	8.13E+07
Tue	758	81.3	1.2	1.2	3.7	8.13E+07
Wed	758	81.3	1.2	1.2	3.7	8.13E+07
Thu	847	89.0	1.3	1.3	4.0	8.90E+07
Fri	938	97.0	1.5	1.5	4.4	9.70E+07
Sat	1070	108.5	1.6	1.6	4.9	1.09E+08
Sun	1115	112.5	1.7	1.7	5.1	1.12E+08
Total	6244	650.8	9.8	9.8	29.3	6.51E+08
Average Day	892	93.0	1.4	1.4	4.2	9.30E+07

* - includes an allowance for restaurant discharges

Peak Week:

Day	Popn.	Flow* (m3)	BOD (kg)	SS (kg)	Total N (kg)	E. coli (No.)
Mon	976	100.3	1.5	1.5	4.5	1.00E+08
Tue	976	100.3	1.5	1.5	4.5	1.00E+08
Wed	976	100.3	1.5	1.5	4.5	1.00E+08
Thu	1091	110.4	1.7	1.7	5.0	1.10E+08
Fri	1206	120.4	1.8	1.8	5.4	1.20E+08
Sat	1379	135.5	2.0	2.0	6.1	1.36E+08
Sun	1436	140.5	2.1	2.1	6.3	1.41E+08
Total	8040	807.8	12.1	12.1	36.3	8.08E+08
Average Day	1149	115.4	1.7	1.7	5.2	1.15E+08

* - includes an allowance for restaurant discharges

Implications of Effluent Discharges

Discharge Dilutions at edge of 100m mixing zone:

Current (m/s)	Dry Season	Wet Season
0.1	28,500	25,000

Note:
Plume widening for low currents under quiescent wind conditions has been calculated using the Brookes Method.

Concentrations at edge of mixing zone

Determinand	Effluent Quality		Concentration at edge of mixing zone			
			Dry Season		Wet Season	
	Outfall	Irrigation	Outfall	Irrigation	Outfall	Irrigation
BOD (mg/l)	20	15	0.0007	0.0005	0.0008	0.0006
SS (mg/l)	30	15	0.0011	0.0005	0.0012	0.0006
Total N (mg/l)	20	45	0.0007	0.0016	0.0008	0.0018
E. coli (No/100ml)	1000	100	0.0351	0.0035	0.0400	0.0040

SCHEDULE OF IMPLEMENTATION ENVIRONMENTAL MITIGATION MEASURES

APPENDIX 4

APPENDIX 4 : SCHEDULE OF IMPLEMENTATION ENVIRONMENTAL MITIGATION MEASURES

SCHEDULE OF MITIGATION MEASURES
KAU SAI CHAU GOLF COURSE REQUIREMENTS ON ENVIROMENTAL PROTECTION MEASURES

Ref.	Environmental Protection Measure	Implementation Programme	Implementation Status
	Kau Sai Chau Mitigation Measures Water Quality Construction Phase		
EIA Sec 3.3.1	1. Activities involving substantial earth moving will be undertaken during the dry seasons 1993/94 and 1994/95.		
EIA Sec 3.3.1	2. Earth berms will be constructed, marking out the golf holes. This serves to identify vegetation to be retained and also to reduce and control surface water run-off.		
EIA Sec 9.4.1	3. Baseline Water Quality Monitoring will commence one month prior to the commencement of any construction works.		
EIA Sec 3.3.4	4. A silt curtain will be placed in the Kwat Tau Tam inlet north of the dam construction. This will control the release of sediments and allows for the use of sediment in mangrove transplanting.		
EIA Sec 9.4.2	5. Compliance monitoring will be undertaken throughout the construction period, at six monitoring locations. Monitoring in Kwat Tau Tam inlet will be intensified during marine works for the dam construction.		
EIA Sec 3.3.4	6. Temporary ditches would be provided to facilitate runoff discharge into the appropriate water courses, via a silt retention pond;		
EIA Sec 3.3.4	7. Sediment traps would be regularly cleaned and maintained by the contractor. Daily inspections of such facilities would be required of the contractor.		
EIA Sec 3.3.4	8. Exposed soil areas would be minimised to reduce the potential for increased siltation and contamination of runoff.		

KAU SAI CHAU GOLF COURSE REQUIREMENTS ON ENVIROMENTAL PROTECTION MEASURES

Ref.	Environmental Protection Measure	Implementation Programme	Implementation Status
EIA Sec 3.3.4	9. The Constructor shall ensure that no visible foam, oil, grease, scum, litter or other objectionable matter is present on the water;		
EIA Sec 3.3.4	10. Dredgers would be fitted with a closed seabed grab, with tight seals, and the dredged material loaded onto a split barge with a water tight seal. No barge overflowing would be permitted.		
	Mitigation Plan for Impact to Kau Sai Chau Mangroves		
EIA Sec 5.6.2	1. Preserve mangroves outside the dam and reservoir locations through protection during construction;		
EIA Sec 5.6.2	2. establish replacement mangroves on Kau Sai Chau and immediately surrounding islands to compensate for the losses caused by the project;		
EIA Sec 5.6.2	3. enhance the spatial distribution of B. *gymnorrhiza* in the Kau Sai Chau area through transplanting.		
EIA Sec 5.6.2	4. transplantation of mangrove trees from the sites to be disturbed to existing mangrove habitats which are secure from disturbance;		
EIA Sec 5.6.2	5. creation of new substrate suitable for mangrove establishment immediately seaward of the proposed dam location;		
EIA Sec 5.6.2	6. transplantation of mangroves from disturbance sites to newly created substrates;		

KAU SAI CHAU GOLF COURSE REQUIREMENTS ON ENVIROMENTAL PROTECTION MEASURES

Ref.	Environmental Protection Measure	Implementation Programme	Implementation Status
EIA Sec 5.6.2	7. enhancement of existing mangrove propagule survival and distribution potential;		
EIA Sec 5.6.2 EIA Sec 5.6.2	8. plantation of mangrove propagules collected from other Hong Kong sites into new substrates at Kau Sai Chau. 9. Monitoring existing and transplanted mangrove survival.		
EIA Sec 5.6.4	**Impact Mitigation Measures of Marine Habitats** 1. fauna translocation would involve the following groups, and must be conducted prior to disturbance of the inlet: Mud-dwelling invertebrate infauna and epifauna, especially the gastropod and bivalve molluscs; Epizoic gastropods on the adult mangroves, such as *Littorina melanostoma*.		
EIA Sec 5.6.6	**Impact Mitigation Measures for Terrestrial Habitats** 1. To minimize the extent of habitat loss during construction habitats between or surrounding the golf playing areas would be clearly demarcated prior to construction. Equipment and personnel would be excluded from these areas during the construction process, and the areas would remain in their native condition.		

KAU SAI CHAU GOLF COURSE REQUIREMENTS ON ENVIROMENTAL PROTECTION MEASURES

Ref.	Environmental Protection Measure	Implementation Programme	Implementation Status
	Archaeology		
EIA Sec 7.5	1. A 3-stage study has been commissioned. Stage 1 is a study of the northern extent of the disturbed area Stage 2 is an assessment of the potential impacts of the project on discovered resouces, resulting where appropriate in design changes to the project plan. Stage 3 rescue and salvage operation to remove artifacts from the sites to be disturbed.		
	2. Education and training of the golf course construction workers.		
	Safety		
EIA Sec 2.11	1. Clearance of unexploded ordnance prior to commencement of construction on-site.		

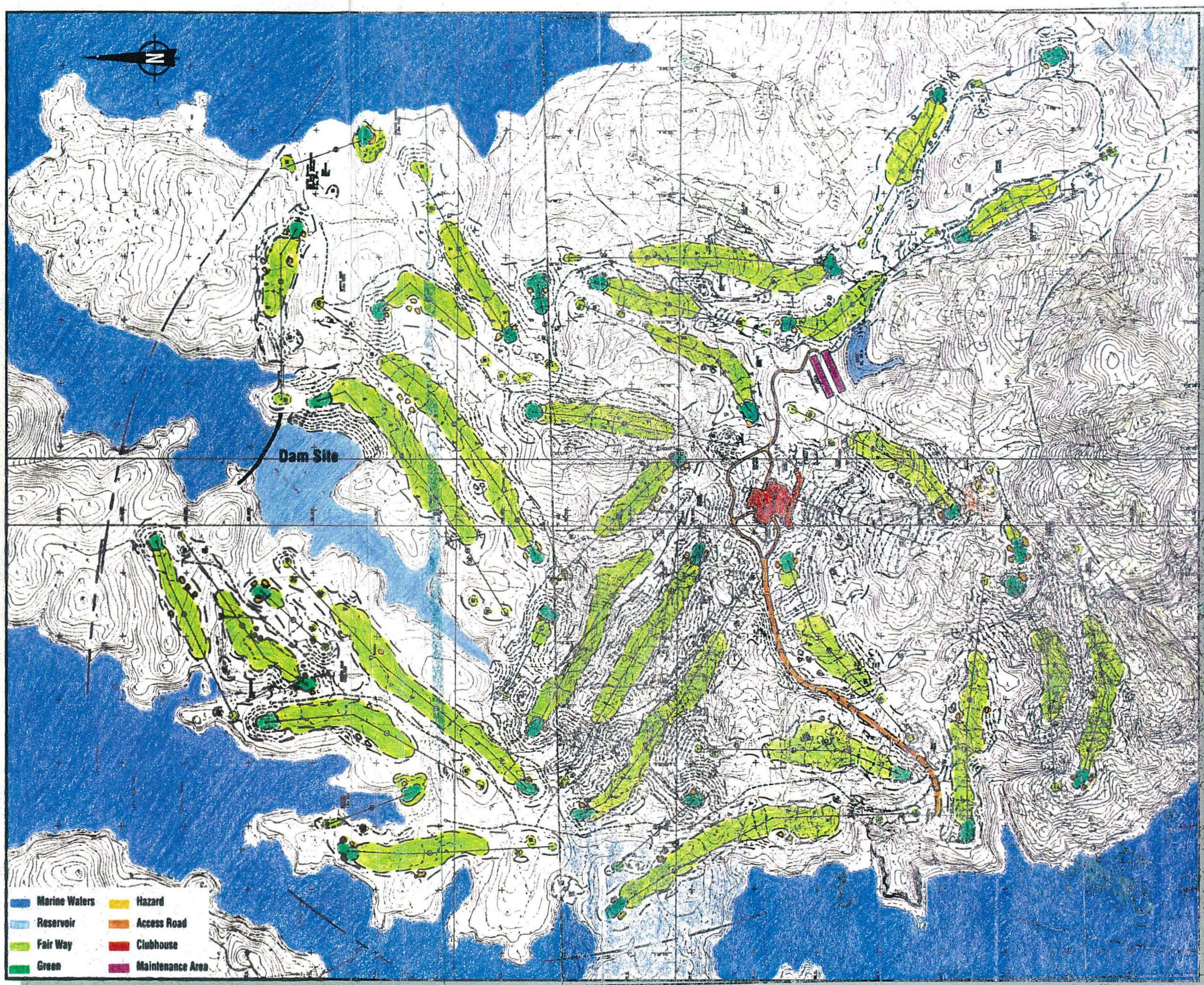


Figure 2 The Hong Kong Golf Centre – *Kau Sai Chau*
Master Layout Plan April 1994

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