政府總部
發展局
工務科
香港添馬添美道 2 號
政府總部西翼

Works Branch
Development Bureau
Government Secretariat
West Wing, Central Government Offices,
2 Tim Mei Avenue, Tamar, Hong Kong

本局網址 Our Website: http://www.devb.gov.hk
本局檔號 Our Ref.: DEVB(CR)(W) 1-55/14
來函檔號 Your Ref.: CB1/PL/DEV

電話 Tel No.: 3509 8385
傳真 Fax No.: 2801 5620
電郵 E-mail: cheukholai@devb.gov.hk

香港中區立法會道 1 號
立法會綜合大樓
立法會發展事務委員會秘書
(經辦人： 鍾蕙玲女士)

鍾女士：

發展事務委員
於 2016 年 12 月 16 日舉行的會議
與擬議的"可持續大嶼辦事處"的工作有關的幾份研究報告

關於你 2016 年 12 月 19 日的來函，我們已就發展事務委員會的要求向相關的政策局及部門索取所需報告，現謹覆如下:

1. Green Island Link Preliminary Feasibility Study (負責部門：路政署)

現附上該研究的最後報告的摘要(只有英文版本)的複印本。此外，路政署現正整理該研究的最後報告，將於稍後提供。

2. 《鐵路發展策略 2000》(負責政策局：運輸及房屋局)

該發展策略的中文及英文版本可於以下連結參閱及下載：

http://www.thb.gov.hk/tc/psp/publications/transport/publications/rds.pdf

http://www.thb.gov.hk/eng/psp/publications/transport/publications/rds.pdf

3. 《第三次整體運輸研究》(負責部門：運輸署)

該研究報告的中文及英文版本可於以下連結參閱及下載：

http://www.td.gov.hk/tc/publications_and_press_releases/publications/free_publications/the_third_comprehensive_transport_study/index.html

http://www.td.gov.hk/en/publications_and_press_releases/publications/free_publications/the_third_comprehensive_transport_study/index.html

4. 《新界西南發展策略》(負責部門：規劃署)

該研究的最後報告(只有英文版)可於以下連結參閱及下載：

http://www.pland.gov.hk/pland_en/p_study/comp_s/swnt/final-report/final-report.htm

該研究的摘要的中文及英文版本可於以下連結參閱及下載：

http://www.pland.gov.hk/pland_en/p_study/comp_s/swnt/es/swnt-es-c.htm

http://www.pland.gov.hk/pland_en/p_study/comp_s/swnt/es/swnt-es-e.htm

基於上述各項策略及研究均已完成超過十五年或以上，大部分內容 (包括規劃及其他前設) 均可能已經不適用，故只能作參考。再者，上述策略及研究中一些未獲立法會財務委員會審批的工程項目估算亦會因多項因素的變化而更改，包括設計改動、推展計劃更改、建造價格水平變動等。因此，有關工程項目的最新估算有機會較上述策略及研究報告中提及的預算費用有大幅增加或減少。

發展局局長

(黎卓豪 黎卓豪 代行)

二零一六年十二月廿九日

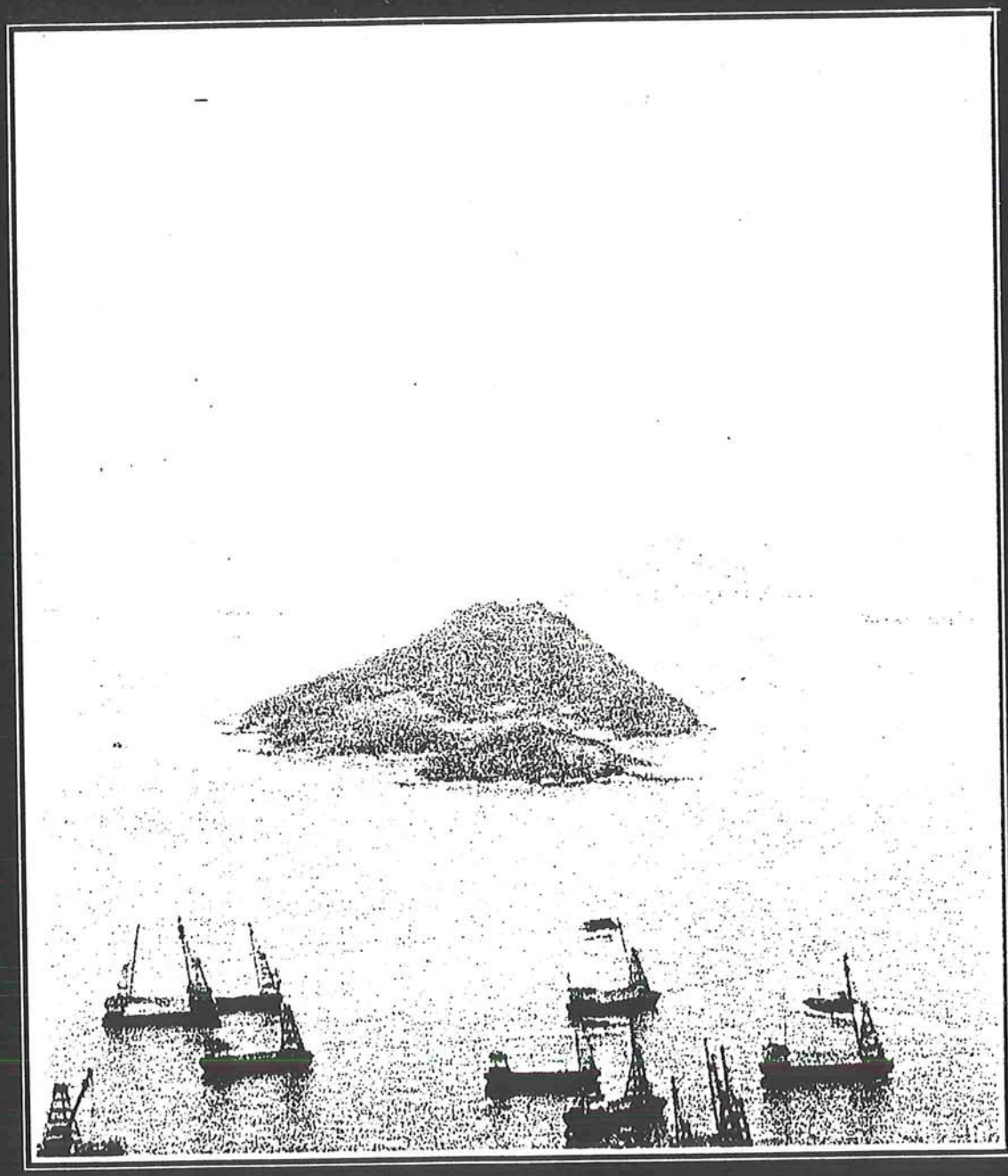
HIGHWAYS DEPARTMENT - WESTERN HARBOUR LINK OFFICE

GREEN ISLAND LINK

PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

EXECUTIVE SUMMARY



PAPM
CONSULTANTS

HIGHWAYS DEPARTMENT - WESTERN HARBOUR LINK OFFICE

GREEN ISLAND LINK

PRELIMINARY FEASIBILITY STUDY

FINAL REPORT

EXECUTIVE SUMMARY

PAPM
CONSULTANTS

A joint venture of
PYPUN-HOWARD HUMPHREYS LIMITED
OVE ARUP & PARTNERS HONG KONG LIMITED
PARSONS BRINCKERHOFF (ASIA) LIMITED
MAUNSELL CONSULTANTS ASIA LIMITED

in association with
MVA ASIA LIMITED
LLEWELYN DAVIES PLANNING
CREMER & WARNER LIMITED
HYDRAULICS RESEARCH (ASIA) LIMITED

SUMMARY

PAPM Consultants were appointed as Consultants for the Green Island Link Preliminary Feasibility Study under Agreement Number CE 21/90 of April 1991. The Study formally began on 30th April 1991.

The purpose of this Preliminary Feasibility Study has been to show the engineering feasibility and environmental acceptability of the proposed Green Island Link immersed tube road tunnel and its connections to the road systems on Lantau and Hong Kong Islands (in both dual 2-lane and dual 3-lane forms); to identify land and marine requirements for the project, including acceptable limits on dredging west of Green Island; and to prepare outline designs and phased programmes for a 2004 opening date. The Study is a preliminary feasibility exercise, to be followed later in the decade by a full Feasibility Study.

The Study boundaries, as shown in the attached Key Plan, enabled a realistic range of alignment possibilities to be investigated. These lie between the limits of the Study to the west at Siu Kau Yi Chau and to the east at Route 7 on the Green Island Reclamation.

The Study has assumed that the Green Island Reclamation, as envisaged in the earlier Green Island Reclamation Feasibility Study, is in place or under construction by 2001. An alternate arrangement of the Green Island landfall of the Link may be more appropriate if the reclamation is changed or is not required.

A Causeway connects the western landfall of the Link to Siu Kau Yi Chau, the assumed boundary of the Lantau Port Peninsula in 2001 as envisaged by the Port and Airport Development Strategy (PADS). In the event that the Lantau Port Peninsula Development Study changes these assumptions, appropriate modifications to the Green Island Link may be required.

The Study was carried out in two distinct phases. The first phase between May and August 1991 established and developed conceptual designs for alternate alignments. These alternatives were then ranked to select two options, one each for the dual 2-lane and for the dual 3-lane configurations. These two options were then carried forward and developed to outline design level during the second phase of the Study between September and December 1991.

The Final Report of the Green Island Link Preliminary Feasibility Study contains proposals for the form and alignment of the Green Island Link at outline design level, and describes the impact of these proposals. Besides this Executive Summary, the Final Report is presented in four volumes:

- **Volume 1 - Engineering Feasibility**. The proposed alignment and form is described for both dual 2-lane and dual 3-lane configurations of the Link. It addresses the traffic, highway, geotechnical, structural, construction and operational issues. It also contains, as an appendix, a Design Standards Memorandum which sets out standards and guidelines for the development of the detailed design.
- **Volume 2 - Drawings**. This volume is complementary to Volume 1, containing engineering drawings of the layout, alignment and form of the Link.
- **Volume 3 - Site Investigation**. Details and results are described of land and marine based site investigations undertaken for this Study.
- **Volume 4 - Preliminary Environmental Assessment**. The probable effects of the Link on the environment during construction and operation are described, along with the monitoring and mitigation measures which should be implemented to minimize these effects.

The Study concludes that both a dual 2-lane and a dual 3-lane tunnel are feasible. Either can be constructed and operated by methods that will not impact unacceptably on the environment. The land and marine requirements for the tunnel are not unreasonable and can be met.

Subsequent to the completion of the Final Report, a Supplementary Investigation was commissioned to further develop the conceptual design for the Central Bypass, a new route on Hong Kong Island proposed by the study. An eight week investigation began in May 1992 and concluded with a Technical Note in July 1992.

STUDY BACKGROUND

On 11 October 1989, the Government announced its intention to proceed with the construction of a replacement airport at Chek Lap Kok with a target opening date in early 1997. The associated port development, as proposed in the Port and Airport Development Strategy Study, will be concentrated mostly in the Western Harbour. Initially, this will consist of construction of Container Terminals 8 and 9 at Stonecutters Islands and Tsing Yi respectively. Subsequent port development will be arranged along a proposed peninsula reclamation from south east of Tsing Chau Tsai to Kau Yi Chau.

Road access to the Port Peninsula development from Kwai Chung will be provided initially via Tsing Yi and the proposed Lantau Fixed Crossing. The Port and Airport Development Strategy Consultants in their Draft Final Report of July 1989 forecast that by about 2004, the increase in port and airport traffic would necessitate the provision of an additional road access from Hong Kong Island via Green Island known as the Green Island Link.

The Civil Engineering Department, assisted by the Territory Development Department, began a planning and engineering study, The Lantau Port Peninsula Development Study, on 12 August 1991. The purpose of the study was to determine the type, layout and timing of the proposed developments on North Lantau, including the Port Development. The scale and viability of these developments is contingent upon the feasibility of the Green Island Link.

The Metroplan Final Technical Report on Transport forecast traffic flows of 150,000 pcu/day using the Link in about 2011, with maximal development on Lantau suggesting that the Green Island Link may have to be of dual 3-lane capacity to meet ultimate traffic demand.

PROJECT DESCRIPTION

Traffic

Traffic design figures were used within the Study for both engineering and environmental impact purposes. The figures adopted were for the Green Island Link options operating at capacity, rather than the usual 5-yearly demand forecasts. This decision was made to ensure that the approach ramps, interchange and connecting roads do not pose a constraint on the ultimate tunnel capacity. To ensure consistency between ongoing Government studies, vehicle and person trip matrices were provided by Transport Department for the design year 2011. The trip data was produced by Transport Department in October 1990, and the forecasts were derived from land use planning data supplied by Planning Department in July 1990.

Strategic and sub-regional traffic models developed within the Study provided traffic forecasts for the year 2011. Design figures for both dual 2-lane and dual 3-lane tunnel configurations operating at capacity were derived from these, using a methodology agreed with Transport Department. Peak hour demand flows in 2011 were found to be reasonably close to the capacity of a dual 2-lane tunnel. For the dual 3-lane case, differential growth factors were applied to tunnel and together with background demand flows. This approach would allow for the predicted four to five year period beyond 2011 that it would take for a dual 3-lane tunnel to reach capacity.

Demand for additional capacity on the Green Island Link will be driven by two factors:

- Capacity constraints on the Lantau Fixed Crossing and Ma Wan to Sham Tseng bridge, expected to have reached capacity during peak hours by the year 2011.
- Demands from Lantau traffic using the Green Island Link together with a harbour crossing in order to reach the Kowloon Peninsula and the South East New Territories.

The vehicle mix assumed for the Study was directly output from the CTS2 model boundary conditions, namely a 40% private, 60% goods vehicle split. The goods vehicle flows using the Green Island Link are expected to be dominated by port traffic and air cargo related traffic.

Conceptual Designs

From the alignment and design possibilities considered, a range of conceptual designs were developed for both dual 2-lane and dual 3-lane tunnels. These took into account the criteria of the Preliminary Environmental Planning Assessment Paper, and the road connections on Lantau and Hong Kong Islands. The feasibility and environmental acceptability of these conceptual designs was established in broad terms.

Conceptual designs so identified were ranked against criteria which included environmental, highway, tunnel, geotechnical, land use, tunnel operation, marine and hydraulic, and cost standards.

Two options were selected from the conceptual designs for development to outline design. The two selected did not represent a preferred choice for the particular tunnel configuration. A dual 2-lane configuration could equally well follow the route of the dual 3-lane presented or vice versa. The final choice of options and configurations will need to take into account the conclusions of the Lantau Port Peninsula Development Study. The options selected were:

- A dual 2-lane N-C tunnel (from north of Green Island to the centre of Kau Yi Chau), which implied razing of the latter.
- A dual 3-lane N-N tunnel (from north of Green Island to north of Kau Yi Chau), which allows retention of the island.

The feasibility of a dual 3-lane Green Island Link was found to depend upon an increase in the capacity of the road network on the north coast of Hong Kong Island along the Route 7 corridor between the Hill Road and the Rumsey Street flyovers. Alternative ways of providing two additional lanes of capacity for the existing Route 7 corridor were explored within the main study only in sufficient detail to confirm the basis upon which a dual 3-lane tunnel option could be considered viable. A radical off-line solution, the *Central Bypass*, was presented in the Final Report to meet the shortfall in existing road capacity caused by a dual 3-lane Green Island Link.

A Supplementary Investigation to further develop conceptual design for the proposed Central Bypass was instructed by GE/WHL Highways Department. The principal objectives of the Supplementary Investigation were to:

- Identify the major issues associated with reservation of an alignment corridor for the Central Bypass between Green Island Reclamation and Central Reclamation Phase 1.
- Determine whether or not such a reservation is feasible.
- Identify any evident actions which need to be taken at this time in the interests of preserving such a corridor.

The Supplementary Investigation concluded that an alignment corridor can be reserved to permit future construction of the Central Bypass and thereby maintain the option of a dual 3-lane Green Island Link. This alignment corridor is shown in the attached Figure 3.3. The principal issues associated with the reservation of an alignment corridor for the Central Bypass between Green Island Reclamation and Central Reclamation Phase 1 were identified as relating to the layout of roads on the Central and Wanchai Reclamation Phase 1, and the planning of land use on the Green Island Reclamation, the Western Reclamation, and the Central and Wanchai Reclamation. A series of recommendations were made including that:

- A road reserve be identified on the appropriate Outline Zoning Plans.
- Appropriate changes to the proposed land uses and highway layouts be considered.
- the advanced tunnel works on the Central Reclamation allow for the possible widening to a dual 3-lane configuration.
- An assessment be made of the engineering and planning feasibility of widening the trunk road tunnel to dual 3-lane.
- The impact of a dual 3-lane tunnel on the highway network and adjacent land uses be included in the Trunk Road Tunnel Alignment Study.
- Consideration be given to ensuring Government access to part of the Western Harbour Crossing approach road area to enable construction of the Central Bypass in the future.
- The design of the Western Harbour Crossing southern vent building take account of the proposed Central Bypass and not preclude the construction of an elevated structure in the future.

It was also recommended that a more detailed feasibility study of the Central Bypass be undertaken at some later stage. It should develop an outline design for the Bypass, include an environmental impact assessment, and include a detailed marine study to consider marine and navigation implications of the proposal.

Marine & Navigation Considerations

The Green Island Link will be constructed across the Lamma Channel at a time when marine traffic densities are anticipated to be around 2½ times those of today (Port Development Strategy Review: April 1991). For these reasons, marine and navigation considerations have been regarded as an important aspect of this Study.

The total number of vessel movements through the tunnel site in the years 2001-3 have been estimated. Possible arrangements for marine traffic during construction of the Link have been identified on the basis that the width of the main part of the waterway occupied by construction plant will not exceed approximately 700 m. It is also anticipated that by the year 2001, Marine Department's Vessel Traffic Control will need to have moved towards more active traffic management, rather along the lines of air traffic control. It may be necessary to control the timing and routing of vessels into and out of the port to smooth out the peaks in traffic densities. Various measures which are available to control traffic patterns have been suggested and include those which are desirable in any case, such as relocation of the pilot boarding station to south of

Lamma Island. It is concluded that disturbance to traffic during construction of the tunnel, although inevitable, can be made acceptable.

Geotechnical and Marine Bed Conditions

Outline design work was based upon the considerable amount of existing geotechnical information assembled, supplemented where appropriate by sampling and testing carried out during the course of the Study. The Green Island Link corridor traverses an area where the geological succession is typical of offshore conditions in Hong Kong. The geological succession consists of marine deposits overlying alluvium, decomposed granite (soil) and granite bedrock.

At each end of the immersed tube tunnel where the vertical alignment rises towards the landfalls, the foundation will comprise a variable depth of marine deposits. The marine deposits are predominantly clay and silt, very soft to firm, exhibiting low shear strength and high compressibility. These materials are not a good foundation for engineering construction. On the approaches to Green Island and Kau Yi Chau, it is proposed that marine deposits be excavated and replaced with a granular fill material, both under the immersed tube tunnel and under the cut-and-cover tunnel lengths. The assumption of complete removal of marine deposits is conservative, as any marine sand underlying the marine clays and silts would not need to be excavated. The marine deposits are also susceptible to scour, should a change occur in the hydraulic regime at bed level.

The central 1700 to 1800 m of immersed tube for each of the tunnel options will be founded on alluvium or partly on decomposed granite soil (CDG). The alluvium consists of interbedded layers of silt/clay, sand and gravel deposits. The mantle of CDG varies in thickness along the proposed alignments. The alluvium and the CDG underlying the alluvium are both expected to provide a firm foundation for placement of immersed tube tunnel units.

An item of particular importance to the planning of the Link will be the future of the island of Kau Yi Chau, i.e. whether the Island is to be preserved as a landscape feature, or whether it can be razed. One of the two outline design alignments assumes the razing of Kau Yi Chau for the significant benefits it provides to the Green Island Link. The material excavated from the island would be suitable for use as rock fill or general fill. It could be used in the reclamation areas, general road embankments, and areas of landscaping. In some areas it may be possible to extract rock of a larger size, suitable for inclusion in the seawalls or as armour protection to the causeway. The future of Kau Yi Chau and the incorporation of the Green Island Link within the Port Peninsula should be considered by the Lantau Port Peninsula Development Study.

The total quantity of excavated material for disposal using the dual 2-lane configuration would be about 8.5 million m^3, of which about 85% is (uncontaminated) marine mud. The quantity of excavated material for disposal for the dual 3-lane configuration is about 10.8 million m^3. Disposal sites would be subject to the requirements of the Fill Management Committee. Requirements are about 12 million m^3 of fill for the dual 2-lane tunnel, and about 17 million m^3 for the dual 3-lane tunnel. Kau Yi Chau, if razed, would generate approximately 7.3 million m^3 of fill.

Hydraulic studies indicate that upon completion of the causeway and Port Peninsula, extensive scour of the marine clay and silt will occur across the route of the Link. This will have the effect of developing deep scour holes to the north and south of the tunnel. The depth of scour would be limited by the top of the underlying layer of alluvium and would result in increases in water depth of between 10 and 18 metres. Scour protection for the tunnel itself consisting of a blanket of small rocks and coarse gravel with a thickness of 1-1.5 m is proposed. Rates of erosion of the

seabed north and south of the tunnel are expected to be low, and bed level changes, and the need for dumping of additional armour, can easily be monitored.

Both alignments for the Green Island Link impact on the South Tsing Yi Borrow Area. The extent of the borrow area potentially sterilized represents only a small proportion of the sand resource in BP4, the southern-most borrow pit.

Alignment

The outline design layout for a dual 2-lane N-C alignment is shown at the top of the attached Figure E1.1, and for a dual 3-lane N-N alignment at the bottom of the same figure. Each layout, including the Green Island interchange, is designed for the tunnel operating at capacity for the respective configuration.

The dual 2-lane configuration for the Link consists of a 3 km long immersed tube tunnel which interfaces with cut-and-cover tunnels at each end. The position of the western landfall as shown for the dual 2-lane tunnel assumes the levelling of Kau Yi Chau. This provides fill for the project, a construction platform adjacent to the landfall site, and reduces the extent of reclamation and dredging with a corresponding reduction in water quality impact during construction.

The dual 3-lane configuration shows an alternative alignment which provides a western landfall to the north of Kau Yi Chau. The length of the immersed tube tunnel between interfaces with the cut-and-cover approach tunnels is 3.1 km. While the western landfall for this alignment does not require the razing of Kau Yi Chau, it does need a greater extent of reclamation than for the option through the island.

The best indication, at present, of the likely extent of the Lantau Port Peninsula in 2004 is the PADS 2001 layout indicated in the Brief. From either landfall location, the western landfall is linked by a causeway to the tip of the Lantau Port Peninsula as at the year 2004.

An eastern landfall north of Green Island was selected for both the dual 2-lane and the dual 3-lane configurations. This option allows better connections between the tunnel, Route 7 and the local road network in terms of geometry and traffic routing, and offers environmental advantages. The Green Island landfall, approach roads and interchange with Route 7 lie wholly within the new reclamation as proposed by the Green Island Reclamation Feasibility Study (GIRFS).

At the Green Island approaches, an approach tunnel of approximately 250 m length would be required for the roadway to rise up to ground level at an appropriate gradient. However, GIRFS proposed that the tunnel portal be located east of the landfall location in order to reduce severance, provide environmental mitigation and maximize land area for development. This arrangement, which necessitates a significant additional length of cut-and-cover tunnel, was maintained in this Study.

Highway Design

On Hong Kong Island, grade separated slip roads provide all movement connections between the Green Island Link and Route 7 at an interchange in the south east corner of Green Island Reclamation. All necessary other road connections as envisaged by the Green Island Reclamation Feasibility Study have also been preserved, including connections to the Kennedy Town Public Cargo Working Area, the primary distributor on Green Island reclamation, and the Belcher Bay Link. For a dual 3-lane Green Island Link, the interchange also allows for connection to the *Central Bypass*.

Horizontal alignment of the immersed tube tunnel is designed to be predominantly straight for ease of construction and maximum economy. Where landfall constraints have necessitated curves, these are accommodated principally within the cut-and-cover sections. Large radii have been chosen to avoid the need for transitions within the immersed tube and to maintain desirable sight distances without the need for widening of tunnel sections.

The link roads and slip roads on Green Island Reclamation are designed to meet the requirements of a 70 km/h design speed. The tunnel and Kau Yi Chau approach causeway have higher geometric standards and have thus been designed to at least meet the requirements of a design speed of 85 km/h.

The vertical profile is significantly influenced by the length and depth of the Green Island Link which will be greater than that of other tunnels in Hong Kong. The tunnel is over 4 km long and carriageways fall from portal elevations of +5.5 m PD to a minimum level of approximately -36 m PD in mid-channel. This latter level is dictated by Marine Department future clearance requirements within the limits of the East Lamma Channel.

Whilst principally controlled by marine clearance considerations, tunnel vertical alignment was also influenced by a number of other factors including geology, highway design parameters and immersed tube tunnel considerations. Upgrades can be expected to have an effect on the operational speed of the significant percentage of goods vehicles forecast to use the Green island Link, and hence possibly on tunnel traffic capacity. Analysis has enabled optimisation of the vertical profiles of the tunnel alignments to minimize any requirements for climbing lanes. Gradients have been selected to avoid climbing lanes within the immersed tube tunnel. Within the cut-and-cover tunnels, gradients increase to 4% and climbing lanes are provided where necessary.

Immersed Tube Tunnel

The dimensions of the immersed tube tunnel, the approach tunnels and the ventilation buildings are a function of the internal space requirements. These are in turn governed by the structural gauge for vehicular clearance, by space requirements above the structural gauge for signage and lighting, by the space needed for services and utilities, by ventilation duct requirements, and by electrical and mechanical plant considerations. It has been found feasible to design the immersed tube sections to meet all relevant criteria and to accommodate the necessary ventilation ducts.

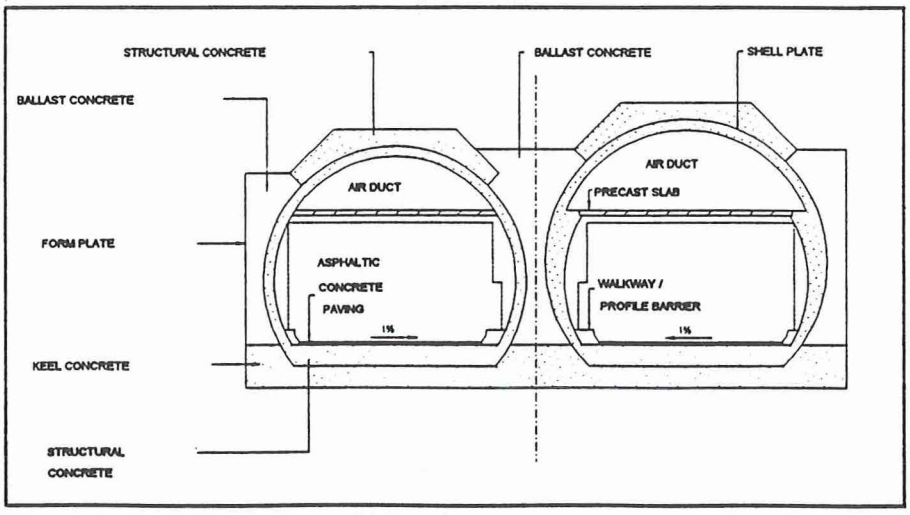


Figure 1: Steel Shell Immersed Tunnel

Immersed tunnels are made up of a number of units which are floated around to the desired location, lowered into position and joined underwater. Two forms of immersed tunnel unit are in common use, steel shell and concrete. The two forms are distinguished primarily by the methods used to construct the units, there being no significant difference in performance between completed units. The choice between the two forms is influenced by a number of factors which include the contractor's expertise and programme requirements, both of which can effect the project cost. Outline designs have been produced for both steel shell and concrete immersed tube units for a dual 2-lane tunnel, but for a dual 3-lane tunnel, an outline design has been produced only in concrete.

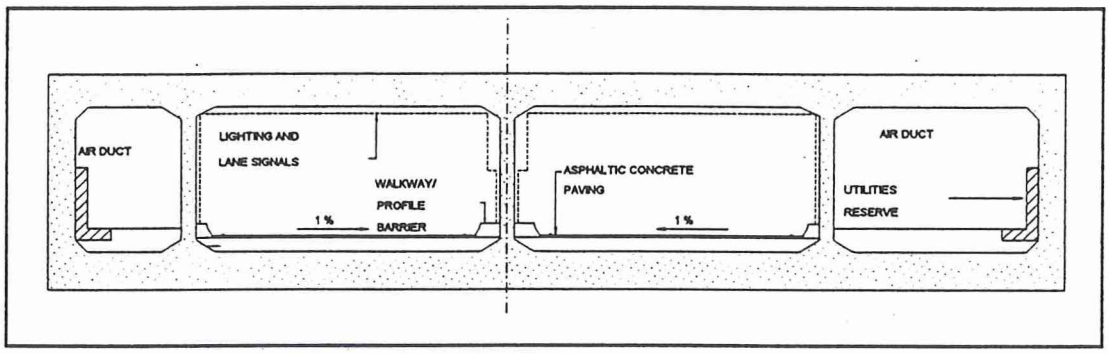


Figure 2: Concrete Immersed Tunnel

The concrete immersed tube unit is essentially a massive reinforced or prestressed concrete box structure which is too heavy to launch. The units must therefore be constructed in a casting basin, bulkheads placed across the ends, after which the basin is flooded and the units floated out. A steel shell immersed tube tunnel unit consists of a reinforced concrete structural ring within a continuous steel shell plate. Steel shell units are fabricated first as an independent steel structure. They are designed to be light enough and to have sufficient structural stiffness to be launched like a ship. The fabrication facility need not be a casting basin, reducing time and possibly costs. The concrete lining and any outfitting requirements are completed at fitting out berths in deeper water.

Approach Tunnels and Ramps

The principal factors which affect the design of the cut-and-cover approach tunnels and ramps are ease of construction, cost, and programme. It has been concluded that in-situ construction in the dry in open excavation will provide the simplest solution. If a casting basin for concrete units were to be provided in the area of the Green Island approaches, then the approach tunnel could be constructed within the casting basin excavation.

Tunnel Services

The purpose of tunnel ventilation is to maintain the air quality at an acceptable level. The tunnel is ventilated by supplying fresh air to dilute any pollutants present to a concentration less than the design level. The vitiated air is expelled at the tunnel portals and from the ventilation buildings. A semi-transverse ventilation system is generally proposed, with 3 km between ventilation buildings. Short lengths of fully transverse ventilation may also be required. Ventilation ducts are provided to deliver fresh air to the air grilles along the tunnel, and these can also, in times of emergency, be used for smoke extraction. The size of the ventilation ducts is governed by the total fresh air requirements to meet air quality standards in accordance with the design standards to be adopted. Haze criteria have been found to govern ventilation design, and

the system identified will both satisfy tunnel air quality standards put forward by the Consultant and meet EPD requirements.

Conceptual designs have been produced for power supply, lighting, drainage, fire protection, traffic control system, building services, and emergency cross adits.

Ventilation and Administration Buildings

A ventilation building is required near each of the landfalls. The primary functions of these buildings is to supply and extract air from the road tunnels, and to house the associated fans, plenums, ducts, power supplies and control equipment. The two buildings will occupy conspicuous positions on the waterfront, and they should be designed to make them as interesting and acceptable as possible. At the same time, they should be functional and meet the necessary environmental criteria. The building structure occupies a space above the tunnel, and can be constructed either integral with the approach tunnel structure, or as an independent structure floated into position above the immersed tube tunnel or approaches.

The administration and control building will be situated near the toll plaza on either Kau Yi Chau or new reclamation and will probably be of conventional reinforced concrete construction. It will contain office accommodation for tunnel staff, messing and locker facilities for operating staff, cash handling facilities, and the Central Control Room.

Causeway

Various forms of construction were investigated for the causeway that is required between the western landfall and the end of the Port Peninsula. An elevated viaduct structure was included as well as several forms of reclaimed causeway.

An elevated structure consisting of a simply supported deck on discrete marine pile supports would not restrict the flow of water from the western harbour. However, it might present construction difficulties for the necessary reclamation when completing the Port Peninsula, the end of which will be at Kau Yi Chau. If vessel collision protection is to be provided, costs are likely to be very much higher for a structure than for other alternatives. As an alternative to providing protection, the two carriageways could be constructed on separate structures. This could allow retention of one structure should accidental vessel impact demolish the other. As the risk of collision at the proposed location does exist, it is suggested that Government acceptance of the level of risk be obtained before adopting such a solution.

The reclamation type causeway would consist of two seawalls protecting a narrow strip of reclamation. The soft marine deposits beneath the causeway would be excavated to approximately -20 m PD. The provision of wick drains in the underlying marine deposits prior to reclamation could ensure early stabilization of ground settlement.

Given the limitations on subsequent filling operations for the elevated structure option, together with the cost disadvantage of providing vessel collision protection or accepting the associated risk, only the reclamation type causeway was taken to outline design level. It is not the intention of the Study to rule out an elevated structure, as this may have advantages if the extent of the Lantau Port Peninsula is modified by subsequent decisions. Nevertheless, in the context of the Brief, the reclamation option was considered to have several advantages including cost, resistance to vessel impact and flexibility for future adjacent reclamation.

Highway Structures

Highway bridge structures for the Green Island Link slip roads are envisaged as continuous post tensioned multicellular concrete decks supported on single central columns. The spans would vary depending on location but would be generally between 30 and 40 metres. The columns would be supported on pile caps on groups of end bearing large diameter bored piles or driven tubular piles.

By using a continuously pre-stressed box construction, deck expansion joints are only required typically every four spans. This would result in improved road riding quality, reduced road traffic noise and reduced maintenance as compared to alternative structural forms such as precast beam decks. In addition they will match the form to be used for adjacent Route 7 structures and thereby maintain continuity and compatibility resulting in an acceptable aesthetic appearance.

PRELIMINARY ENVIRONMENTAL ASSESSMENT

The Environmental work of the Study commenced with the production in June 1991 of a Preliminary Environmental Assessment Paper. The Paper reviewed the preexisting situation, identified the main environmental issues, and set out guidelines for reference by the Study Team. These guidelines helped in the identification, development, and choice between, conceptual schemes. Environmental input to the Study continued through outline design. As designs developed, so environmental impact and mitigation measures were identified, culminating in the Preliminary Environmental Assessment contained in Volume 4 of the Final Report.

At this stage, it has not been possible to identify specific sensitive receivers near the development, as both tunnel landfalls are to be located on land that now does not exist. In addition, the existing quality of the environment into which the proposals would be introduced is difficult to quantify, because the present proposals form a part only of the overall proposals for development of the area. The approach to this Study has been to consider the location and potential land uses to which the area may be put. Whereas the proposals for the Green Island Reclamation Feasibility Study identify land use as predominantly residential, it has been assumed that development at the Port Peninsula will be industrial in nature and therefore relatively insensitive to noise or air pollution. It will be important to continue to optimise the design and layout plans to reduce the impacts as far as possible.

Impacts of the proposals may be divided into two phases - those associated with the construction phase, and those associated with the operation of the Link. The impacts of the project cannot be dealt with in isolation. The pace of change in Hong Kong is rapid and the impacts of all the proposed development projects will interact to have cumulative effects throughout the region. It is important that at some appropriate stage in the integration of the individual projects the total impacts are assessed. During detailed design of the project, further information will become available, both for the project itself, and for the adjacent areas and land uses. This will enable production of a full Environmental Impact Assessment. It is recommended that means of auditing and monitoring the environmental performance of the project be included at all stages of design and construction.

The construction stage of the project will create the usual environmental impact in the fields of air and water quality, noise and visual impact. The activities at Kau Yi Chau will affect the flora and fauna of the island, and visual impact will be severe if Kau Yi Chau is razed. The phasing of the nearby projects will be a significant feature in nuisance prevention during construction operations. If occupancy occurs before completion of all construction related work, then the

opportunity for adverse impacts will be significantly higher than if all civil work were completed before occupation. Care will be needed in placing construction facilities if potential environmental impacts are to be minimized.

Increases in water column concentrations of suspended solids in a plume will be the most significant effect that will result from construction. Water quality impacts identified will affect sensitive downstream receptors despite phasing of developments. It is unlikely that contamination by heavy metals of marine deposits to be removed during the construction process will be a problem, though further tests will be necessary to confirm the absence of complex organic contaminants. However, the greatest impact on the water quality to the west of Victoria Harbour will result from the combined effect of the Lantau Port Peninsula, the Western Breakwater between Cheung Chau and Lamma, and the interim strategic sewage outfalls from Stonecutter's Island and Mount Davis at the west end of Hong Kong Island.

Once operational, the link will carry large volumes of traffic. Air quality and noise close to the road system will be adversely affected by traffic emissions. In worst case conditions, noise and air quality standards could be exceeded for short periods in some locations. It may not be appropriate to include sensitive land uses too close to these areas. It is recommended that pedestrians not be permitted to enter highways and that separate footways be provided as necessary. Careful planning at the design stage can eliminate potential severance problems by the adequate provision of walkways linking sections and access points. The impact on water quality caused by the finished tunnel is likely to be small.

CONSTRUCTION AND OPERATION

Immersed tube tunnels have been constructed in Hong Kong and throughout the world using a variety of construction, excavation and placement procedures. Construction of the Green Island Link will follow the general methodology adopted for other cross-harbour tunnels. This tunnel, however, is significantly longer and deeper than most, and requires construction across a relatively exposed section of water, crossing major shipping channels.

Marine Operations

The main operations which will require the use of marine plant are dredging, placement of units, foundation, and backfill. The site will be exposed to the open seas from the south, and weather induced conditions will have a much greater impact on this tunnel than on the previous cross-harbour tunnels which were placed in the relatively sheltered harbour environment. On the assumption that no breakwater to the west of Lamma Island is in place when the tunnel is being constructed, preliminary analysis indicates that two to three weeks of difficult conditions can be expected in any one year, with the worst conditions unlikely to persist for more than one week at any one time.

The tunnel site lies across a zone of current movement where surface water velocities of up to 1 m/sec may occur, and the line of the tunnel lies almost perpendicular to flow. Sinking operations must therefore take place within slack-current "windows". For placing the tunnel units in position in the prepared trench, it has been assumed that floating pontoons will be used from which the units are lowered from the surface. If it is found that insufficient weather windows are available to suit the derived construction programme, then consideration will need to be given to the use of marine plant which is less susceptible to the effects of inclement weather.

VICTORIA HARBOUR 維多利亞港

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POSSIBLE RECLAMATION TO PROVIDE P C W A RELOCATION

WESTERN RECLAMATION

WESTERN HARBOUR CROSSING

GREEN ISLAND RECLAMATION

HILL ROAD FLYOVER

ELEVATED DUAL 2-LANE TRUNK ROAD OVER SPINE ROAD

RUMSEY STREET FLYOVER

HK-MACAU FERRY TERMINAL TO BE RELOCATED

CENTRAL AND WANCHAI RECLAMATION

石塘咀 SHEK TONG TSUI

上環 SHEUNG WAN

卑路乍灣 BELCHER BAY

堅尼地城 KENNEDY TOWN

CONNAUGHT ROAD WEST

QUEEN'S ROAD WEST

QUEEN'S ROAD CENTRAL

DES VOEUX ROAD WEST

DES VOEUX ROAD CENTRAL

BONHAM ROAD

PARK ROAD

ROBINSON ROAD

CONDUIT ROAD

KENNEDY TOWN NEW PRAYA

BELCHER'S STREET

POK FU LAM ROAD

HOSPITAL ROAD

HOLLYWOOD ROAD

SEYMOUR ROAD

CAINE ROAD

ARGYLE STREET

MOSQUE STREET

GLOUCESTER ROAD

HARBOUR ROAD

UPPER ALBERT ROAD

ALBERT ROAD

Belcher Gardens

Hong Kong University

Sai Wan Estate

Kwun Lung Lau

龍虎山 LUNG FU SHAN (HILL ABOVE BELCHER'S) 266m

半山區 PUN SHAN KUI (MID-LEVELS)

Hong Kong Zoological and Botanical Gardens

269m

地契山 CHE KEI SHAN

KEY :

CENTRAL BYPASS

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	CONCEPTUAL CENTRAL BYPASS	FIG. 3.3
HIGHWAYS DEPARTMENT	DESIGNED K T P / DRAWN C P CHAN / CHECKED / DATE FEBRUARY, 1992	GIL/101/26
	DIMENSIONS ARE IN METRES	SCALE 1:10,000

Dredging

A combination of dredging plant will be required for excavation of the trench into which the tunnel units are placed. Dredging will be mainly in soft marine deposits, with the lower part of the trench in the underlying alluvium. The maximum excavation depth is to about -40 mPD, corresponding to a dredging depth of about 42 m. This is towards the upper limit of the operating range of suitable dredging equipment. High-capacity trailer-suction-hopper dredgers can possibly be modified for use at these depths. Cutter-suction dredgers, which are generally not able to dredge as deep as trailers, may be more suitable away from the main channels, in shallower water, and where harder materials need to be dredged.

Bulk pre-dredging carried out with more productive plant is likely to be followed by final trimming with grab dredgers. Ideally, any dredging carried out by grab dredgers in the busy part of the waterway should be done within the proposed marine works areas, just prior to tunnel laying, in order to minimize the number of times vessels using the existing channels need to be diverted.

Immersed Tube Units

The fabrication of steel shell tunnel units is a two stage process. The first stage, which is done on land, involves fabrication of the steel shell. The unit is usually constructed on or adjacent to a slipway, and is then side- or end-launched like a ship. The second stage involves placement of the main concrete keel and structural lining. This is done with the unit floating in deeper water.

The requirements for fabrication of concrete tunnel units are significantly greater than for steel units, due to the longer period required for construction of individual elements. Concrete tunnel units are massive structures and are therefore too heavy to launch in the manner of steel shells. Construction must therefore take place in a casting basin or dry dock, the floor of which is below sea level. When the units are completed the basin or dock can be flooded and the units floated and towed out.

North Green Island, Kau Yi Chau Landfall, Siu Kau Yi Chau, and the Port Peninsula itself, all constitute potentially suitable sites for a casting basin for concrete immersed tube units. Detailed planning for the period immediately subsequent to GIL (2004 to 2010) is sufficiently uncertain to preclude detailed investigation at this time. For the purposes of this preliminary study, the site for the casting basin has been assumed to be in the reclamation north of Green Island. Various areas have been identified as suitable for storing completed units in a floating condition which satisfy the criteria for a remote sheltered location with accessibility and adequate water depth and space.

Landfall Works

The landfall works at Green Island and Kau Yi Chau will be constructed within new reclamation. The cut-and-cover tunnels, ventilation shafts and approach ramps will be constructed within open excavation. The excavation has been assumed to be entirely within marine fill to facilitate the installation of the groundwater cut-off.

The causeway from Kau Yi Chau to the end of the Port Peninsula will consist of two seawalls protecting a narrow strip of reclamation. The core of the causeway is formed of pell-mell rubble or crushed rock placed by bottom dump barge up to approximately -3 m PD, with the remaining part placed either by grab, or by land based methods. The rock armour and underlayer would normally be placed from a barge.

The construction of the causeway will cause a significant increase in the currents in the Lamma Channel across the line of the immersed tube tunnel. It is considered desirable to delay completion of the causeway, in particular the construction works above the level of the surrounding seabed, until after all the immersed tube tunnel units have been installed and backfilled.

Tunnel Operation

The toll plaza includes full provision for the tunnel administration, main control room, and parking spaces for visitors and recovery vehicles. It will be located at Kau Yi Chau, making partial use of the razed island for the dual 2-lane option or located totally on reclamation for the dual 3-lane configuration. Remote end facilities would be provided at Green Island Reclamation, comprising suitable accommodation for several recovery vehicles and associated staff together with a secondary control centre. It is expected that by the year 2004, autotoll collection facilities will be feasible, and outline design of the toll plaza has assumed such facilities will be provided for the Green Island Link.

Traffic control and surveillance measures are essential to ensure safe and efficient operation of the tunnel. Consideration has been given in outline design to measures related to entrapment of overheight and overweight vehicles; to safety procedures in the event of fire, explosion and/or breakdown; and traffic control measures in normal operation and operation during maintenance. It is considered prudent to design traffic control and surveillance facilities to allow for possible future implementation of tidal flow.

Direction signs and warning signs both within the tunnel and on the approaches have been considered as part of the conceptual highway design development. Allowance has been made both in the tunnel headroom and the tunnel approach designs for signage requirements.

IMPLEMENTATION & PROGRAMME

The Study Brief required that the work of the Study proceed on the basis that the Green Island Link is operational in the year 2004; that Green Island Reclamation and Route 7 will be in place or under construction by the year 2001; and that a part of the Lantau Port Peninsula will be in place by the year 2001.

Liaison was maintained with the Lantau Port Peninsula Development Study (LPPDS) team during the concurrent months of the Studies, although the relative timing of the two studies meant that the work of this Study has had to be completed by reference to the PADS assumptions that the Port Peninsula construction will have reached Sui Kau Yi Chau by the year 2001.

The final outline of the LPPDS through to completion was chosen after completion of the Green Island Link Study. Nevertheless, the LPPDS team identified a range of conceptual outlines for development of the Port Peninsula. This range, which included landfalls located to the south of Kau Yi Chau as well as centrally and to the north of the island, is compatible with the provision of the Green Island Link within the Corridor examined in this (GIL) Study. The results of this (GIL) Study thus provide a satisfactory basis for future development of a preliminary design for the Link compatible with the final LPPDS landfall location wherever this is chosen to be on the Peninsula.

The work of the Green Island Reclamation Feasibility Study (GIRFS) was substantially completed before commencement of the Green Island Link Study. Liaison between the two

studies made it possible to ensure compatibility between the Green Island Link Final Report and the Draft Final Report of GIRFS, published shortly afterwards.

Steel shell and concrete immersed tube tunnel units have different construction programmes. It is generally considered that steel shell tunnels can be constructed in a shorter time than concrete tunnels. This is however very dependent on the facilities and resources available. Typical construction programmes and durations are shown in the attached Schedules 11.3 and 11.4. The construction programmes shown in the schedules have been prepared to indicate an opening date of November 2004. They can be adjusted to suit available resources, but are compatible with the achieved programmes of comparable projects. The Highways Department project programme is shown in the attached Schedule 11.5.

It has been established that the programme for construction of Green Island Reclamation as identified by the Green Island Reclamation Feasibility Study (GIRFS) team in response to their Study Brief is compatible with completion of the Link by 2004. It has further been established that a latest possible start date for construction of the reclamation of 1997, 18 months later than the GIRFS start date, will meet the programme requirement for a dual 3-lane concrete GIL tunnel (the option with the longest programme duration). The consequence of this latest start date would be to delay the reprovisioning of the Abattoir and China Merchants Company on which the final completion of the reclamation is dependent.

An additional element to the phasing of the dual 3-lane configuration is the introduction of the possible Central Bypass to solve the capacity constraint presented to the dual 3-lane configuration by the limited capacity of the Route 7 corridor. It is envisaged that both the GIL and Route 7 will be constructed and operating for a number of years before the capacity of Route 7 east of the interchange is reached. Provision has therefore been made to allow the Central Bypass to be constructed at a later date when Route 7 has reached capacity and to enable the GIL to subsequently achieve full dual 3-lane capacity.

The Kau Yi Chau reclamation will be constructed as part of the Green Island Link project, and accordingly cannot be expected to commence before the project start date. Whilst it is accepted that work on the reclamation, including seawalls, and the bulk excavation of the island can easily by done with only marine access, work must also commence on the ventilation buildings and access tunnels, and these will be affected by the lack of land access.

The construction of the causeway between Kau Yi Chau and Sui Kau Yi Chau will be relatively straight forward, and completion of the causeway is not required until fairly late in the project. In order to minimize effects on currents, the construction works above the existing seabed is assumed to take place after installation of the immersed tube tunnel units.

COST ESTIMATES

Cost estimates for the project have been generated from historical data brought up to the valuation date of fourth quarter 1991 by application of the appropriate construction cost indices.

The capital costs include the cost of: the immersed tube tunnel; the approach tunnels; the causeway to the Lantau Port Peninsula as envisaged by PADS; reclamation for the Kau Yi Chau landfall; ventilation; lighting; drainage; control systems; toll plaza; administration building; and highways between the Study boundaries. The costs do not include reclamation at Green Island landfall, the construction costs of Route 7, the Central Bypass, escalation to the expected construction start date, nor do they include any element of escalation during the construction

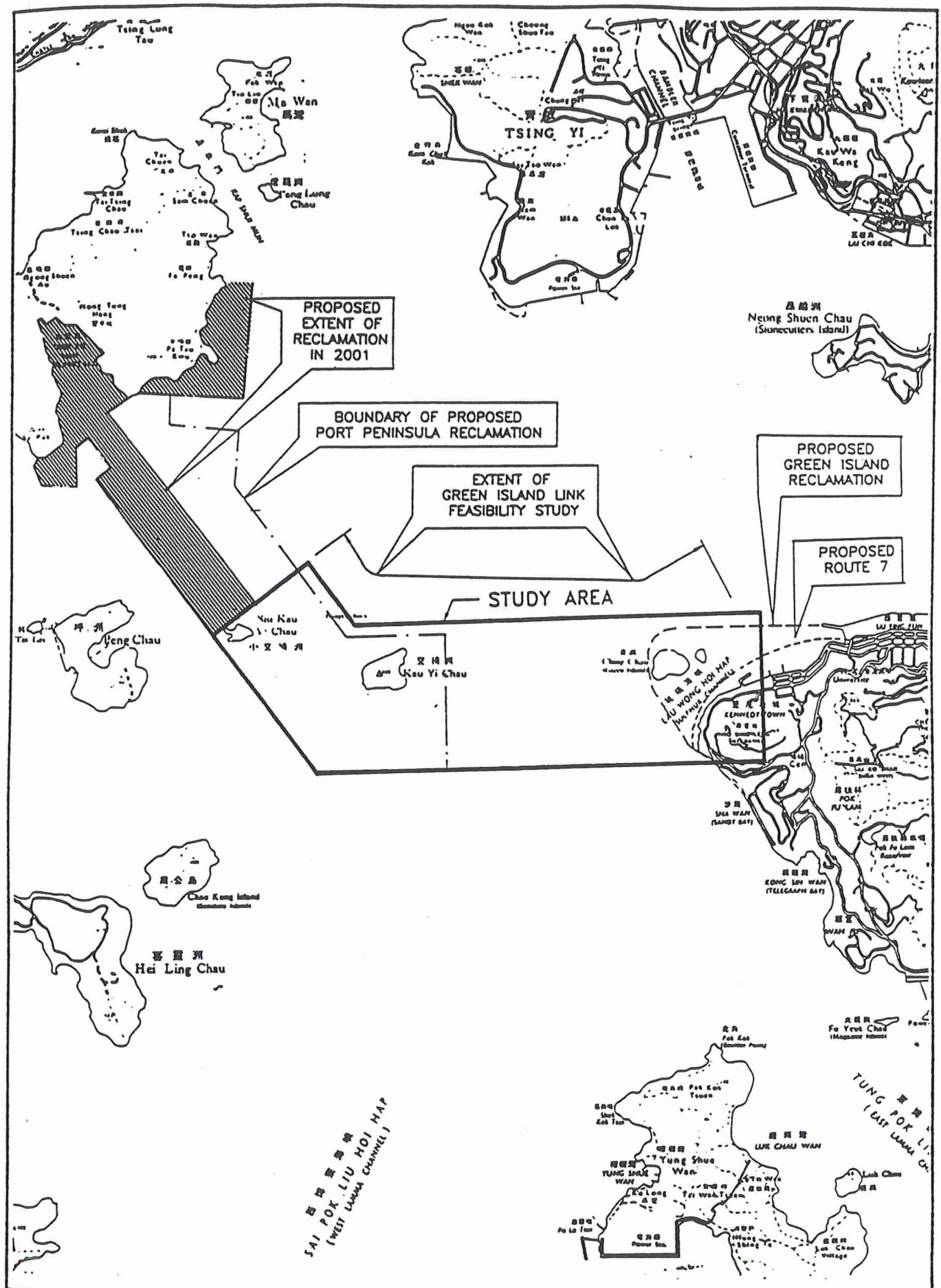
period. The capital cost estimates for each construction option are given in Table 1. Contract preliminaries of 15% are included and represent the costs of mobilization and demobilization and general site-based costs. A further 20% detail allowance is included to compensate for the omission of minor works and details which are not considered at this stage. Design and construction contingencies of 20% are included for additional costs arising from unforeseen changes or delays arising during detailed design and construction. A further allowance of 7% has been applied, external to the estimate, to cover costs of detailed design (3.5%), independent design check (1%) and project management (2.5%).

TABLE 1: Capital Costs

Description	Dual 2-lane (concrete)[1] $ millions[3]	Dual 2-lane (steel)[2] $ millions[3]	Dual 3-lane (concrete)[1] $ millions[3]
Road Pavement and Highway Structures	553	553	939
Approach Tunnels GIR	955	955	1169
Approach Tunnels KYC	570	570	665
Immersed Tube Tunnel	4,516	4,532	5,260
Reclamation - Causeway KYC	580	580	580
Reclamation - Landfall KYC	829	829	1,458
E & M - Ventilation, Lighting, Drainage, Fire	390	390	492
E & M - Control System & Toll Collect	426	426	512
Administration and Vent Buildings	197	197	210
Sub-Total	**9,016**	**9,032**	**11,285**
Design Checking and Project Management (7%)	632	633	790
Total	**9,648**	**9,665**	**12,075**

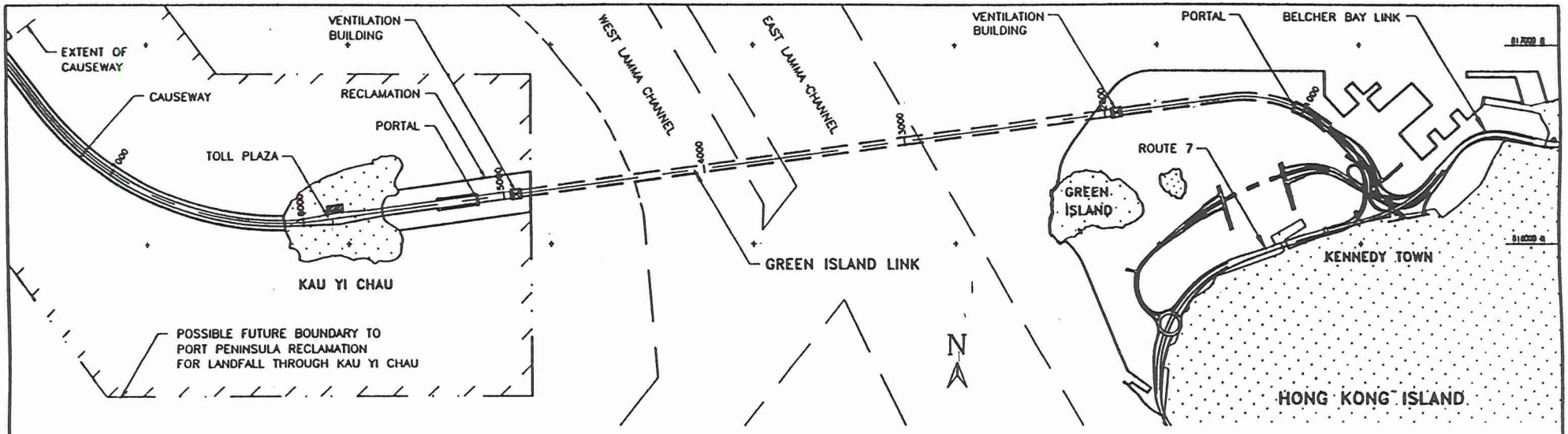
Notes: (1) (Concrete): Concrete unit immersed tube tunnel.
(2) (Steel): Steel shell immersed tube tunnel.
(3) All capital costs are estimated for fourth quarter 1991.
(4) GIR Green Island Reclamation;
KYC Kau Yi Chau;
E&M Electrical and Mechanical

FIGURES

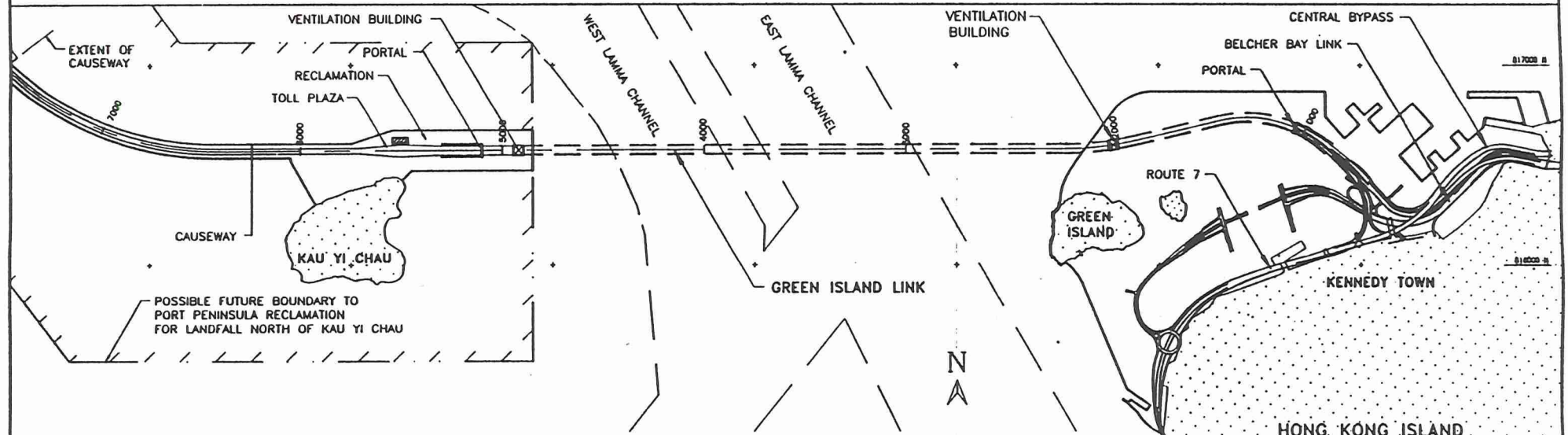


GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

HIGHWAYS DEPARTMENT	KEY PLAN	PAPM CONSULTANTS



DUAL 2–LANE TUNNEL – CENTRAL OPTION



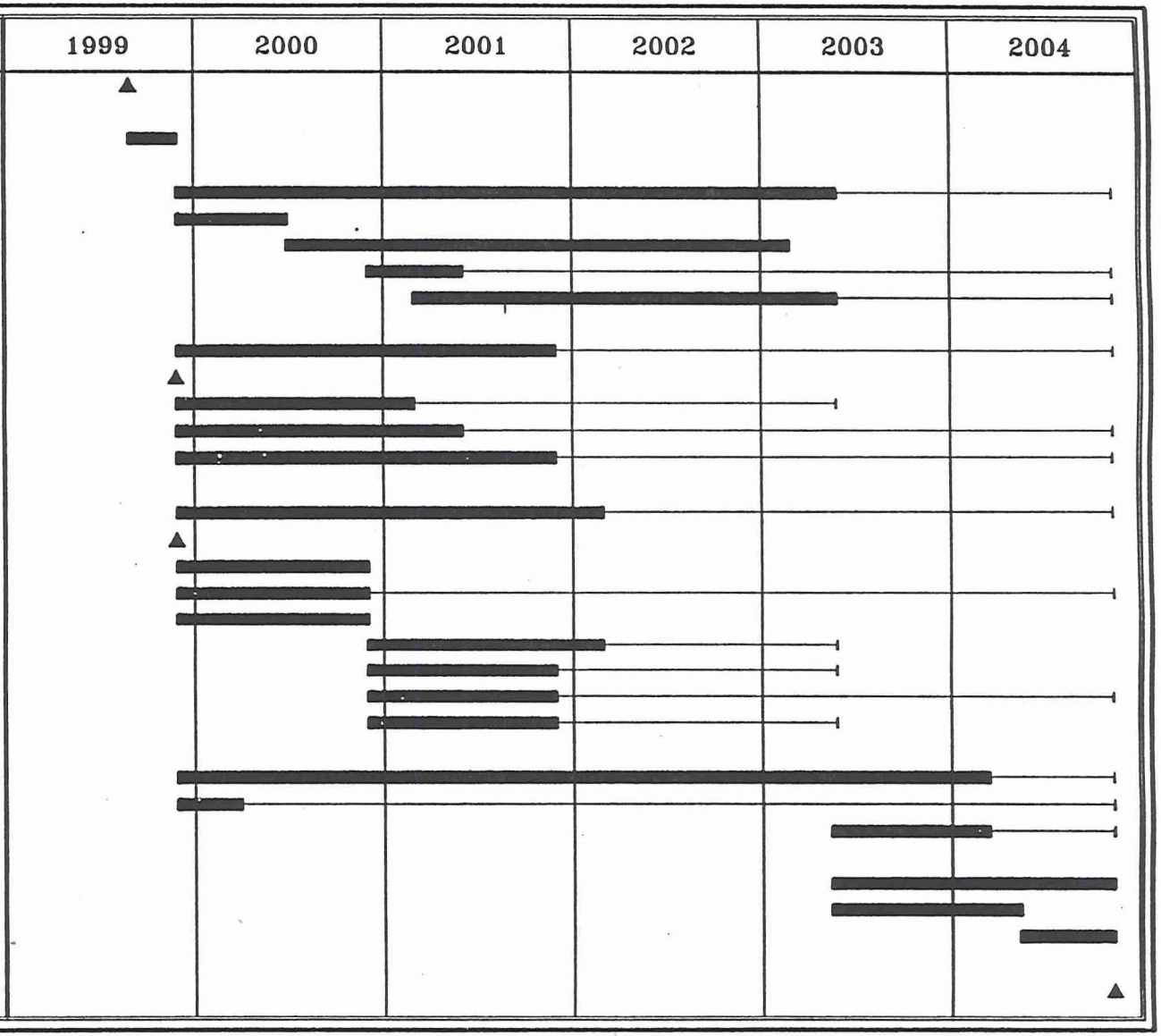
DUAL 3–LANE TUNNEL – NORTH OPTION

Note: Two options are reversible.

GREEN ISLAND LINK PRELIMINARY FEASIBILITY STUDY

PAPM CONSULTANTS	OUTLINE DESIGN ALIGNMENTS	FIG. E1.1
HIGHWAYS DEPARTMENT	DESIGNED: E I P DRAWN: C P CHAN CHECKED: DATE: FEBRUARY, 1992	GIL/101/40 DIMENSIONS ARE IN METRES SCALE 1:20,000

Task Name	Duration (Months)	Start Date
Contract Award	0	1-Sep-99
Site Mobilisation	3	1-Sep-99
Immersed Tube	42	30-Nov-99
Casting Basin	7	30-Nov-99
Construct Units	32	27-Jun-00
Bulk Dredging	6	2-Dec-00
Place Tunnel Units	27	2-Mar-01
Green Island Landfall	24	30-Nov-99
Reclamation Handover	0	30-Nov-99
Ventilation Building	15	30-Nov-99
Approach Tunnels	18	30-Nov-99
Highway Structures	24	30-Nov-99
Kau Yi Chau Landfall	27	30-Nov-99
Kau Yi Chau Handover	0	30-Nov-99
Bulk Excavation	12	30-Nov-99
Seawalls	12	30-Nov-99
Reclamation	12	30-Nov-99
Ventilation Building	15	2-Dec-00
Approach Tunnels	12	2-Dec-00
Toll Plaza	12	2-Dec-00
Administration Building	12	2-Dec-00
Causeway to Port Peninsula	52	30-Nov-99
Dredge & Fill to Seabed	4	30-Nov-99
Construct to +5.5mPD	10	23-May-03
E & M Systems	18	23-May-03
Installation	12	23-May-03
Commissioning	6	17-May-04
Start Revenue Service	0	13-Nov-04



Legend

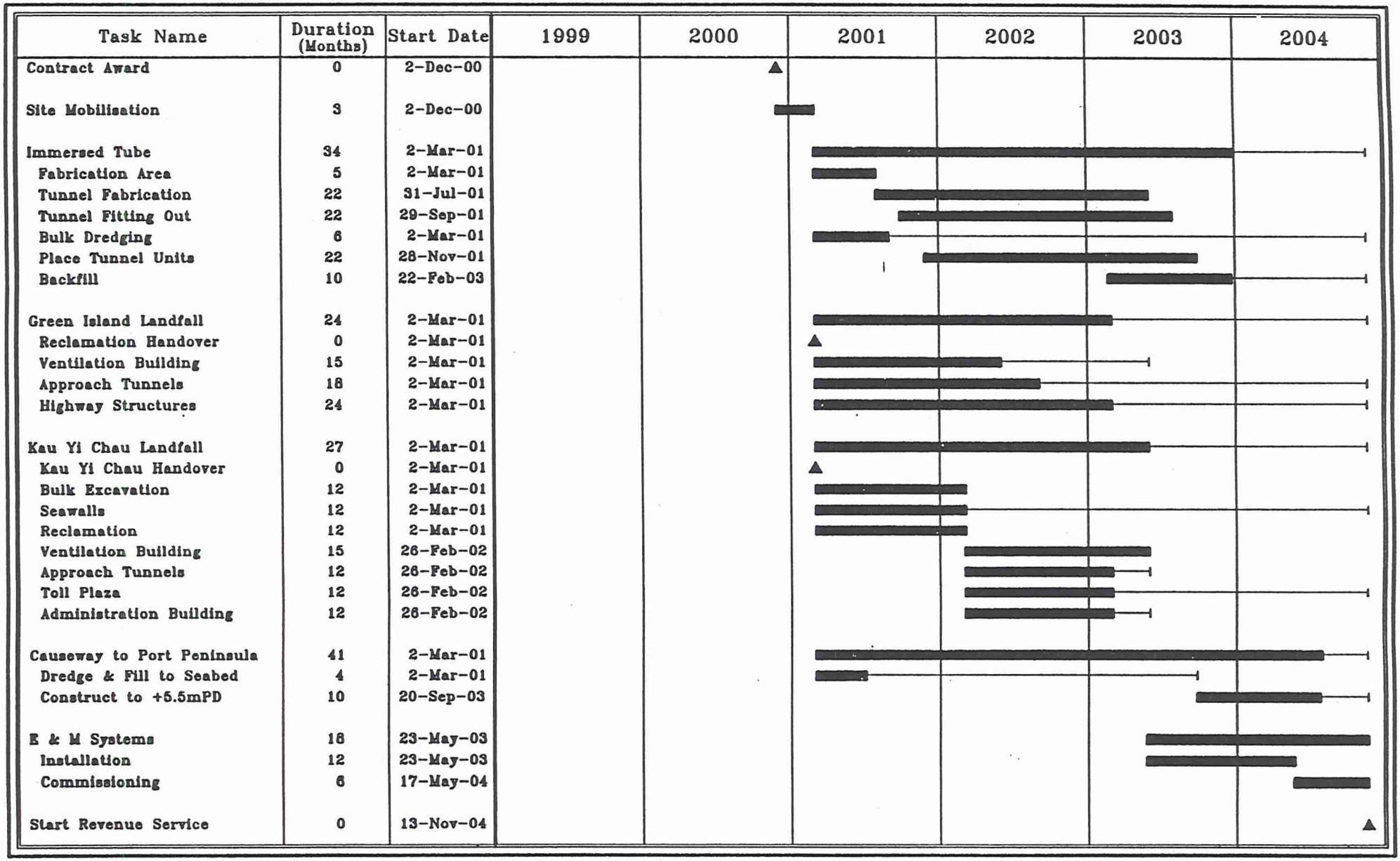
- Activity
- Float
- Milestone

CONSTRUCTION PROGRAMME

DUAL 3-LANE CONCRETE TUNNEL

SCHEDULE 11.3

Task Name	Duration (Months)	Start Date
Contract Award	0	2-Dec-00
Site Mobilisation	3	2-Dec-00
Immersed Tube	34	2-Mar-01
Fabrication Area	5	2-Mar-01
Tunnel Fabrication	22	31-Jul-01
Tunnel Fitting Out	22	29-Sep-01
Bulk Dredging	6	2-Mar-01
Place Tunnel Units	22	28-Nov-01
Backfill	10	22-Feb-03
Green Island Landfall	24	2-Mar-01
Reclamation Handover	0	2-Mar-01
Ventilation Building	15	2-Mar-01
Approach Tunnels	18	2-Mar-01
Highway Structures	24	2-Mar-01
Kau Yi Chau Landfall	27	2-Mar-01
Kau Yi Chau Handover	0	2-Mar-01
Bulk Excavation	12	2-Mar-01
Seawalls	12	2-Mar-01
Reclamation	12	2-Mar-01
Ventilation Building	15	26-Feb-02
Approach Tunnels	12	26-Feb-02
Toll Plaza	12	26-Feb-02
Administration Building	12	26-Feb-02
Causeway to Port Peninsula	41	2-Mar-01
Dredge & Fill to Seabed	4	2-Mar-01
Construct to +5.5mPD	10	20-Sep-03
E & M Systems	18	23-May-03
Installation	12	23-May-03
Commissioning	6	17-May-04
Start Revenue Service	0	13-Nov-04

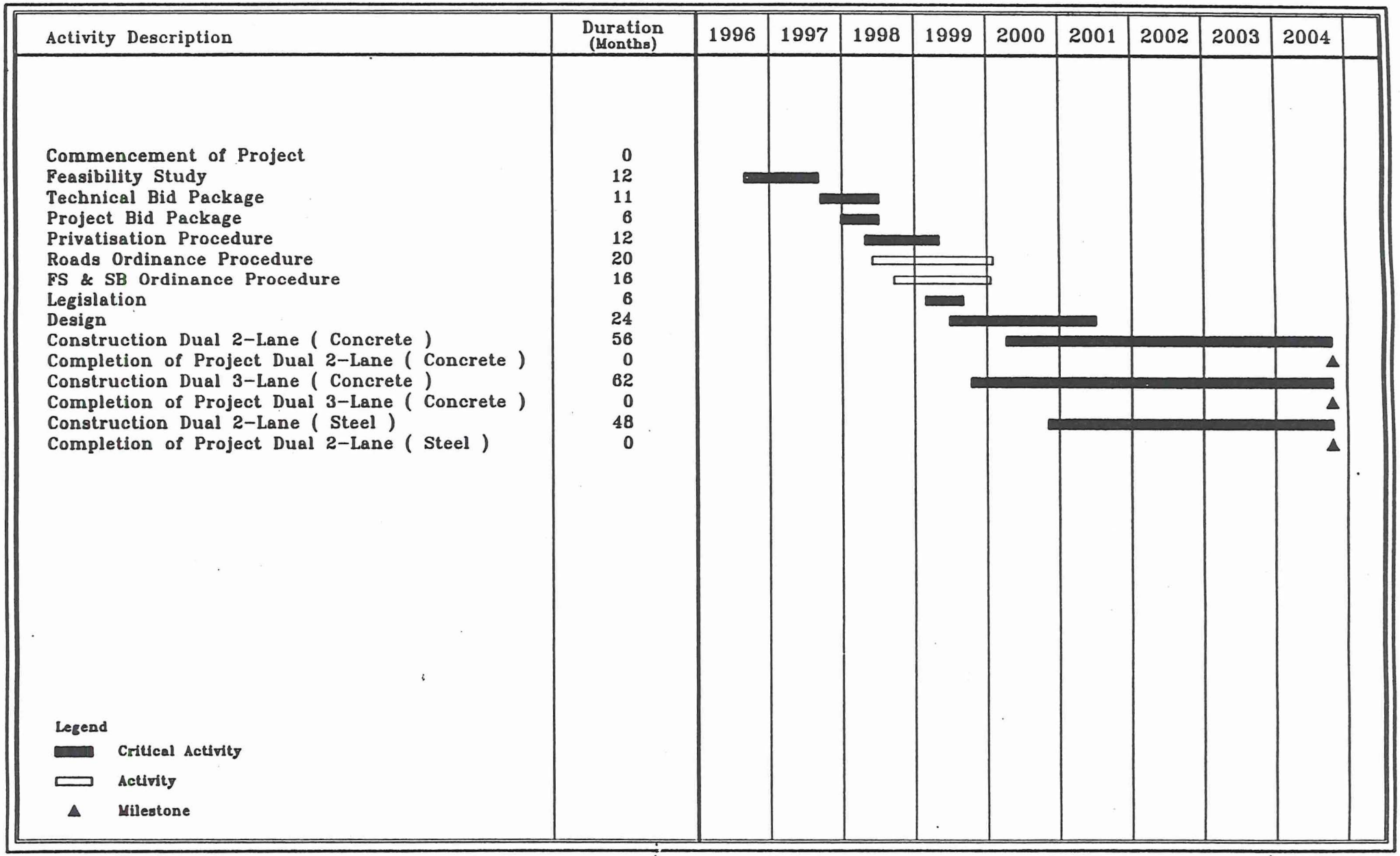


Legend

- Activity
- Float
- Milestone

CONSTRUCTION PROGRAMME
DUAL 2-LANE STEEL TUNNEL

SCHEDULE 11.4



HIGHWAYS DEPARTMENT PROJECT PROGRAMME

SCHEDULE 11.5

PAPM
CONSULTANTS

A joint venture of
PYPUN-HOWARD HUMPHREYS LIMITED
OVE ARUP & PARTNERS HONG KONG LIMITED
PARSONS BRINCKERHOFF (ASIA) LIMITED
MAUNSELL CONSULTANTS ASIA LIMITED

in association with
MVA ASIA LIMITED
LLEWELYN DAVIES PLANNING
CREMER & WARNER LIMITED
HYDRAULICS RESEARCH (ASIA) LIMITED