Highways Department
Western Harbour Link Office

Lung Cheung Road and Ching Cheung Road Improvements

EXECUTIVE SUMMARY

PHH / ARUP CONSULTANTS
潘衍壽－亨富利／奧雅納聯營工程顧問

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April 1992

3/F Asian House, 1 Hennessy Road, Wanchai, Hong Kong

AGREEMENT NO. CE 4/90
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INTRODUCTION

PHH/ARUP were appointed Consultants for the Lung Cheung Road and Ching Cheung Road Improvement scheme under agreement number CE4/90 in October 1990. The project area under the brief is split into two sections:-

- The section of Lung Cheung Road between Po Kong Village Road and Waterloo Road. For this section a Feasibility Study was required.

- The section of Lung Cheung Road and Ching Cheung Road between Lai Chi Kok and Waterloo Road. The Consultancy for this part of the route takes the form of a Preliminary Design stage, a Design and Contract stage and a Construction stage.

The project brief comprehensively dealt with the Government's requirements of the Consultant. As in all complicated undertakings however various parts of the brief have been re-interpreted as the design has developed. Particular instances are:-

- The design year was changed from 2006 to 2011. This had a number of consequences, not least being that the possible ramifications of a future Route 16 have had to be investigated.

- It was discovered that the traffic demands in some intermediate years (2001 has been specifically investigated) are likely to be greater than that in the design year. Although the scheme is still designed to accommodate 2011 traffic it has been checked against the requirements of the earlier year in order to ensure that the scheme performance is adequate throughout its life.

- Design standards have been redefined to a considerable degree. As a result of the publication of the Alignment Options Report the mainline has been designed to absolute minimum TPDM standards as a cost saving measure.

- The implementation year for the scheme has been changed from 1994 to 1997.

Another re-definition has been in the nature of the three stages of the consultancy, brought about by two peculiarities:-

- Although previous studies had suggested that the route be upgraded from dual two lane to dual three lanes no detailed traffic study had been carried out to verify this and no study into the feasibility of such a proposal had been carried out. Much of the early part of Preliminary Design stage was therefore devoted to first establishing capacity requirements by means of a detailed traffic forecasting exercise and then establishing the feasibility of various methods of providing that capacity.

- The difficult nature of the terrain is such that the level of site investigation required to precisely define all aspects of the scheme would be very extensive. It was considered that in this case, it would be preferable to accept a degree of uncertainty of detail at Preliminary Report stage, such that investigative work could be more precisely focused once agreement to the scheme had been reached. This approach minimised the risk of wasting resources on detailed investigations of areas which might subsequently prove impractical.

It remained necessary of course to define solutions sufficiently to establish all essential consequences of adopting the proposals. Wherever a lack of detailed information might have resulted in any uncertainty, a conservative approach has been adopted when considering cost or other consequences. In the event there have been very few such instances and the main consequence has been to assume for the moment a larger land take than might be the case when the design is refined further.

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PROJECT BACKGROUND

Lung Cheung Road and Ching Cheung Road are part of Route 4 which provides a vital link between Kwun Tong and Kwai Chung. The alignments of these roads are along the northern perimeter of the Kowloon Peninsular and generally constrained by the topography of the Kowloon foothills. The section of Lung Cheung Road from Lion Rock Tunnel interchange to Ching Cheung Road and Ching Cheung Road itself are essentially dual two lane carriageways whilst the remainder of Lung Cheung Road is a dual three lane carriageway. Grade separated interchanges are provided along the roads to provide direct ingress and egress to and from districts adjacent to the Route. Several grade separated pedestrian crossings are also provided along the roads.

Lung Cheung Road and Ching Cheung Road were designed and constructed to their present configurations in the 1960's and 1970's when the design standards were

less stringent than today. The capacity and configuration of the road and of several of the interchanges on Lung Cheung Road and Ching Cheung Road are inadequate for current traffic volumes and congestion frequently occurs.

The final report of the Second Comprehensive Transport Study (CTS-2) forecast that the traffic volume on Lung Cheung Road between Lion Rock Tunnel interchange and Ching Cheung Road would reach 142,000 pcu's/day by 2001. CTS-2 also forecast a traffic volume on Ching Cheung Road in year 2001 of 94,000 pcu's/day. The CTS-2 final report recommended that Ching Cheung Road and this part of Lung Cheung Road be upgraded to dual three-lane capacity by the mid to late 1990's.

Subsequent to completion of the CTS-2 final report, further traffic analysis has been carried out under the Port and Airport Development Strategy (PADS) Study, the West Kowloon Reclamation Transport Study, the Central Kowloon Traffic Study and the Metroplan Study. As a result of these further traffic studies and the decision to construct, and open in early 1997, a replacement airport at Chek Lap Kok it has become apparent that there is an urgent need to provide additional trunk road capacity between east and west Kowloon. This additional capacity can be made available only on Route 4 without having to resort to extensive land resumption. The Lung Cheung Road and Ching Cheung Road Improvements were accordingly scheduled for completion in 1994 before commencement of works to provide additional east-west capacity on other routes.

At a very early stage of the present design process an "Alignment Options Report" was circulated which dealt with the issue of design standards along the route. The outcome of the deliberations arising out of the Alignment Options Report was that the design of the improvement works for Lung Cheung Road and Ching Cheung Road should be based essentially on the design standards associated with the "Minimum Acceptable" scheme as defined in that report.

The essential outcome from the discussions surrounding the traffic forecasts was that the Consultant was instructed to make allowance for the future connection of Route 16 and to use the traffic forecasts for 2011 consistent with that decision, but that 2001 traffic figures would be used to provide guidance for intermediate years.

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SCHEME DESCRIPTION

Most of the project consists of taking an existing road layout and modifying it to accommodate future requirements. To enable a fuller understanding of the proposals to be reached therefore, much of the description of the scheme proposals is juxtaposed with a description of the existing situation. The road layout proposals are shown in Figures S1 to S9.

Highway design schemes were derived to suit various Route 16 scenarios as were traffic forecasts. These were presented to the Client in April 1991 and the outcome was that the Consultant was instructed in June 1991 to develop the Route 4 design on the basis of traffic from both Lung Cheung Road and Castle Peak Road having access to Route 16.

Road Provision

The existing road is primarily a dual two lane all purpose road running along the southern edge of the Kowloon hills. The terrain is such that gradients are often quite severe and long, and climbing lanes have been provided in some locations. The route is essentially free flowing with merge/diverge arrangements for all major connections, although there are a number of minor accesses which are not in keeping with the level of service of the road.

In general investigations regarding future provision have confirmed the conclusions of CTS-2, North Kowloon Traffic Study, and West Kowloon Reclamation Traffic Study. In essence the conclusion is that the existing dual two lane road be upgraded to a dual three lane road, i.e. one additional lane is required in each direction.

The proposed mainline alignment is severely constrained by the large existing cut slopes to the north of the road and the large steep natural and fill slopes to the south. Widening the road on the north side would require massive and expensive cutting of the slopes. Due to the constraints of the building line at the foot of the slopes, the options for widening on the south side are for the most part either retained fill or "open" structure. The relative costs, ease of construction and effects on adjacent land uses of these options were assessed for all locations before deciding on any particular form of construction.

At a great number of locations road widening at grade would result in excessive earthworks and/or land resumption. At such locations a structural solution has been adopted. These occur in Section 1, south of the existing road to provide for the new westbound

carriageway and in Section 2, on the "off line link". The key plan on Figure S1 shows the overall location of Section 1, 2 and the Off Line Link.

The "off line link" concept was developed because of limited opportunities for increasing capacity on the main line to meet future traffic growth, between the Tai Po Road interchange and the eastern limits of the Beacon Heights development and because of turning problems associated with the existing interchange. The concept was first raised in the "Alignment Options Report" and further developed in the "Alignment Report". There was general agreement to the concept and it has therefore been developed to Preliminary Design standard.

It has not been possible, within the given constraints, to achieve TPDM standards throughout. As agreed at the time of the Alignment Report, the main line meets the essential requirements of "absolute minimum" TPDM requirements whereas some of the approach roads fall short of this standard.

Pedestrian Provision

The pedestrian counts conducted for this report in 1991 indicate that the observed pedestrian flows at the grade-separated crossing facilities are very low. This is due to the fact that there are very few developments to the north of Ching Cheung Road and Lung Cheung Road. The provisions of footbridges and subways are largely for access to bus stops and the Country Park.

It is evident that pedestrian crossing facilities cannot be justified on the basis of pedestrian flows in this instance. The only basis for decisions on this matter are the amenity value of the bridges and issues of safety. This has led to two conclusions:-

- The existing footbridges, although carrying very small flows are located conveniently for specific purposes, for example adjacent to Country Park access points or to places of work to the north of the road.

- There are no pedestrian facilities at the Tai Po Road interchange. There is a bus stop on the south side of Tai Po Road and a Country Park access point to the north of the main route. There are also a number of squatter huts on the hillside adjacent to the Country Park access. This arrangement leads to people attempting to cross the southbound carriageway of Tai Po Road at the point where it passes beneath Lung Cheung Road, and thence across the northbound carriageway to the bus stop. This behaviour has been observed frequently and it is very dangerous. It was proposed therefore that an additional footbridge be provided to cross Tai Po Road at Chainage 30 and that a footway be provided adjacent to the southbound carriageway to pass beneath Lung Cheung Road. The footbridge and footway are illustrated on Figure S5.

Geotechnical Conditions

The southern side of the Kowloon Hills is dominated by low rounded thickly vegetated foothills with long convex upper slopes. The foothills are gullied as a result of weathering and several of these are deeply incised.

Much of the road alignment crosses land with "high" geotechnical limitation with regard to development. This is defined as terrain which is expected to require intensive geotechnical investigation, and the costs associated with site investigation, site formation, foundation and drainage works will be relatively high.

The geology of the road comprises coarse and medium grained granite with occasional outcrops of fine-grained granite. Along Lung Cheung Road the granite outcrops on the outer periphery of a 10km wide circular pluton which is centred on Victoria Harbour.

The hills are covered with debris flow deposits (colluvium) and this is thickest in the erosion gullies. The colluvium is poorly sorted containing boulders and cobbles in a gravelly clay matrix.

Four faults are mapped as crossing the alignment. Three are found west of So Uk Estate and the fourth crosses beneath colluvium near Beacon Heights. Several northeast trending photolineaments, primarily between Beacon Heights and Lion Rock Tunnel, also extend across the alignment. The dominant trend of joints in the area is conjugate NE/SW & NW/SE.

In order to supplement the record data and to provide sufficient information for preliminary design, a site investigation was carried out between January and July 1991. The investigation consisted of the following:-

- 22 boreholes with sampling and standard penetration testing;

- 8 trial pits on fill slopes with sampling, in situ density testing and GCO probing;

- 18 chunam strips;

- Laboratory testing.

One piezometer with Halcrow buckets was installed in each borehole for long term groundwater monitoring and this is continuing.

Road Pavement

This road will continue to cater for a relatively high traffic flow with a very high proportion of HGV's. The corridor will remain a main east-west artery and its usage will be enhanced in the future with PADs and WHC generated traffic and the influences of Routes 3 and 16. It is noted that the existing pavement has largely reached its design life in terms of standard axles, and this is evident from a visual inspection of the road.

The pavement should be designed to be as maintenance free as possible throughout its design life. The strategic importance of this road and the traffic volumes that will use it requires a pavement design that will minimise major recurrent maintenance and that a minimum of two lanes per carriageway remain open at all times. This particular requirement of the construction phase should be maintained as far as possible throughout the life of the road.

The preliminary pavement design has considered two pavement design options for the main carriageway:-

- flexible (bituminous) pavement
- rigid (concrete) pavement

and for minor access roads or off road areas, in addition to the above:-

- block pavement

Each of these options was assessed for suitability to best cater for the particular requirements of this road.

As excessive diesel spillage is expected due to the high proportion of HGV's and the steep gradient of the road, and as frequent maintenance should be avoided, it is recommended that the pavement be a concrete carriageway designed for a 30 year design life. As well as providing a longer life, the capital cost will be lower, based on current Hong Kong unit rates. The cost advantage will be further enhanced in this case as the existing subgrade level need not be changed for a rigid pavement as the pavement thickness would be similar to that already in place.

In view of the need to reduce capital expenditure as far as possible there is a case for carrying out a detailed condition survey of parts of the existing road and thus determining the remaining life expectancy of the road pavement.

There are three areas where the retention of the existing pavement should be considered during the detail design phase.

- Chainage 1160 to 1550 (see Figure S2)
- Chainage 3100 to 3600 (see Figure S5)
- Chainage 3850 to 4500 (see Figure S6)

Bridge Structures

There are some 124 existing structures that have been identified associated with the Lung Cheung Road and Ching Cheung Road corridor. Many are minor structures such as drainage culverts, minor retaining walls and water pipe culverts. There are, however, 18 major existing bridge and underpass structures.

It is proposed that the majority of the existing highway structures be retained in the new scheme. In accordance with our brief, preliminary assessments of the "As-built" structural drawings have been carried out to check their structural adequacy against the latest Hong Kong Civil Engineering Manual requirements and the Flint and Neil Report. Initial checks revealed that many of the structures would not satisfy the most recent Civil Engineering Manual requirements.

Discussions were held with the Highway Structures Department to determine the design standards that the existing structures must satisfy to allow their incorporation in the new works. The resulting criteria arising from these discussions is:

- where an existing structure is to be widened or significantly modified as part of this project, then both the new works and the existing structure are to be to current design standards in terms of strength and durability;

- where existing structures are to be retained in the new works without alteration, checks are to be carried out to assess their status against current standards and any deficit recorded. As long as the existing structures are not in danger of failure and they satisfy broadly their original design standards, no further work will be required on these structures.

A number of solutions have been proposed for the open structures on this project and as no one solution can be used for all situations, several different ones are proposed. Typical cross sections of these structures are shown on Figure S10.

Proposed Precast Beam and Slab Structures

This structural solution was brought into consideration in order to minimise the foundation work and in situ concrete works to be constructed on the constricted site and to minimise the temporary works required over the slopes. The decks would consist of pre-cast prestress concrete continuous T beams topped with an in situ concrete slab. The deck would be supported by a simple substructure of pairs of columns with an integral crosshead.

The columns would be effectively a continuation of the single caisson foundations which carry the decks loads down through the sloping ground to found on rock. In some cases it will be necessary to protect the fill slopes from lateral forces which might be imparted by the caissons. In such instances, the caissons will be sleeved forming in effect long columns integral with the above ground works.

A major advantage of this form of construction is that the number of movement joints and bearings has been minimised, thus reducing maintenance costs and improving ride quality, it is also very cost effective.

Proposed Mainline In Situ Concrete Structures

In some locations, the road alignment becomes very tortuous with horizontal curves of 90m radius. It is impractical to support significant lengths of high curvature road on a precast beam and slab type deck due to the difficulty of achieving the cantilever width variations caused by imposing a curved road on a straight beam, an in-situ post tensioned concrete box solution has therefore been derived.

To maintain visual continuity along the length of the scheme, the edge detail of these in situ bridge decks would be similar to the precast beam decks. The cellular deck would have vertical outer webs with a 1.75m cantilever, again with a featured edge beam.

Proposed Off Line Link Structures

Here the constraints are the layout of the ground level road network, the complex ground form and the alignment of the off line link itself. Conventional in situ construction has been chosen for this section because of high curvatures and the high visibility of the structures.

The steep slopes of the topography and the poor site access dictate that hand dug caisson foundations are the optimum solution.

The variations in road platform widths, to achieve the merging and diverging of the slip roads, has led to the choice of a multicell structural form with generally one or three cells, again similar to the in situ structures of on the main line.

The high visibility of these structures requires particular attention to detail to ameliorate their visual impact. This has led to a softening of the edge detail by using a concave "cantilever" design. In determining the visible edge detail of the structures, the main consideration was to maintain a constant form, irrespective of the width of the structure, to avoid a visual "jump" where structures of different widths are founded on the same substructure.

The abutment structures proposed for the off line link are similar to those of the main line; simple caisson supported structures with exposed deck support plinths. The concrete finish proposed for the abutments for both sections is similar to that proposed for many of the retaining walls on the project; this is a strong vertical feature rib.

Retaining Walls

A number of different types of retaining wall solutions have been proposed for this project. The choice of which solution is most appropriate for each location has depended on cost, ease of construction and visual impact.

The main types of wall proposed are:-

- Simple L-shaped reinforced concrete walls;
- Dead man anchored, hand dug caisson walls;
- Soil nailed, piled walls;
- Reinforced earth walls.

Drainage

The existing drainage along the road corridor is dominated by the natural topography and the man made features such as water reservoirs, residential areas and roads.

The road alignment is predominantly east-west along the foothills of the Kowloon hills and therefore bisects the natural north-south hillside drainage runoff. In the hills to the north the incised valleys have been dammed in several locations to impound the runoff and create reservoirs.

The drainage design has therefore to take into account the two main components of the surface drainage:-

- o surface runoff from the slopes to the north of the highway
- o highway runoff

The efficient drainage of both these elements is an important aspect to ensure the integrity of the natural and artificial slopes, the longevity of the highway and the safety of the road user and the population adjacent to the road corridor. Inherent within the design considerations will be measures to minimise the risk of pollutants accidently entering the outfall systems, especially in the vicinity of reservoirs.

West from Tai Po Road, because much of the proposed westbound carriageway is to be on structure, most of the existing culverts can be retained although many will require lengthening and/or headwall modification.

There is a history of silt runoff and consequent flooding along the existing road. Newly formed slopes along the north side of the road will include open lined channels incorporating silt traps. These will form a positive containment for the hillside runoff, especially flash flood runoff with a high silt content. The channels will be designed to be self cleansing and to be easily inspected and maintained.

The proposals to landscape and plant new cut faces will have the advantage of increasing runoff time assisting with vegetation naturally drawing down surface moisture and retaining both soil and water.

The general surface drainage will be isolated from the highway drainage. This has the benefits of maintaining the majority of the existing drainage patterns with the natural runoff operating independently of the highway system. Thus, the risk of overload and flooding with consequent contamination of the natural runoff is minimised.

Utilities

Along the existing Ching Cheung Road, Tai Po Road and Lung Cheung Road, there are a number of service reservoirs and electricity sub-stations where major watermains and electricity cables connect one district to another. Optical fibre transmission telephone cables also run along the length of the road. In order to provide a carriageway which results in minimum disruption to traffic flow due to any future maintenance of utilities, every attempt has been made to avoid placing utility services under the proposed carriageway. The proposed scheme will therefore, as far as possible, relocate these services into the verges of the carriageway.

Of the major utility service diversions identified in this Preliminary stage, there will be need to relocate 400kV, 132kV electricity cables, watermains of sizes up to 1350mm diameter, up to 12w telephone transmission cables and 400mm diameter gas mains.

Traffic Control and Surveillance

From the analysis of incidents on similar roads in the Territory, it is clear that there will be a significant number of incidents on Lung Cheung Road each day. Many of these will cause considerable traffic congestion.

It is proposed that at some stage provision be made for full coverage with CCTV and emergency telephones. This should enable incidents to be detected as quickly as possible. This provision could be allowed for in the design of the road itself in the form of ducting for cables, careful consideration of gantry design and location, and if considered appropriate sub-standard laybyes on the eastbound carriageway. A decision regarding actual installation could then be taken at a later date in conjunction with the wider requirements for North Kowloon.

It is suggested that consideration be given to the housing of control equipment for the CCTV system at the Argyll Street Police Headquarters initially, possibly within the same control room as the existing Kowloon ATC's CCTV system. The necessity of a separate control centre can then be reviewed when consideration is given to the implementation of CCTV on the Segregated Road Network on a territory wide basis.

Traffic Management

It is a requirement of the brief that two lanes of traffic be maintained on the main line at all times during construction. The proposed method of construction achieves this throughout the scheme with little difficultly. Where it is proposed to construct a new westbound carriageway over the slopes to the south of the route it might at some locations be necessary to remove the existing central barrier and reduce the main line to a four lane single carriageway, but this at least can be achieved at all such points.

Works Areas

There are very limited possibilities for the provision of works areas in the vicinity of the route. The proposed method of construction would necessitate the provision of a sufficiently large area to accommodate a casting yard for precast bridge beams as well as for the normal requirements for material storage, offices, Engineer's

facilities, plant storage and the like. Because of the need to transport the precast beams (Section 1 only) it is also important that access between the Works Area and Ching Cheung Road is particularly easy.

It is suggested however that no conclusions can be arrived at in the matter of works areas at present and that this should be pursued further during detail design stage.

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SCHEME COSTS

The Project Cost estimate has been completely revised to accord with the design as it has been developed through the Preliminary Design Stage. Throughout the design every effort has been made to optimise designs and thereby reduce costs. The result has been a considerable reduction in base costs since the start of the Preliminary Design.

Particular instances of cost savings are:-

- o The adoption of absolute minimum standards.
- o The deletion of the Waterloo Road Flyover.
- o The refinement of the alignment wherever possible to minimise cut and fill quantities.
- o The optimal location of bridge abutments.
- o The optimisation of structure designs.
- o The reduction of cut/fill quantities as a result of a greater degree of confidence in the design parameters available from the site investigation.

Set against these are a revision of the base date since the estimate contained in the Alignment Report. The current estimate is set at December 1991 rates. This masks a part of the savings achieved in the design.

The greater degree of confidence arising out of the more advanced stage of design has also allowed a more precise approach to Preliminaries and Contingencies. Whereas they had previously been set at 12% and 20% respectively, figures of 10% for Preliminaries and 15% for Contingencies are now employed.

A fully detailed cost estimate has been prepared for the scheme in two parts; to cover Section 1 and Section 2 of the scheme. Summaries of those estimates are given below.

Note that using a common base of August 1990 the cost of the scheme has been reduced from the agreed estimate of $950 million to $720 million during the course of Preliminary Design.

Scheme Cost - Section 1

Item	Cost (HK$m)
Cut Slopes	$5.37
Retaining Walls	$17.48
Bridge Structures	$118.87
Footbridges	$6.30
Carriageway	$61.61
Landscape & Noise Barriers	$4.61
Traffic Surveillance Equipment	$1.98
WSD Diversions	$1.70
Sub - Total	$217.92
Preliminaries (10%)	$21.79
Contingencies (15%)	$35.96
Total	$275.67

Scheme Cost - Section 2

Item	Cost (HK$m)
Cut Slopes	$58.88
Retaining Walls	$54.17
Bridge Structures	$152.34
Footbridges	$8.70
Carriageway	$104.94
Landscape & Noise Barriers	$16.87
Traffic Surveillance Equipment	$3.16
WSD Diversions	$14.30
Sub - Total	$413.36
Preliminaries (10%)	$41.34
Contingencies (15%)	$68.20
Total	$522.90

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IMPLEMENTATION

Construction

A Tentative Implementation programme for Sections 1 and 2 is given below. The programme would result in an average expenditure rate on each section in the range $8M to $14M per month. There is some scope for varying this by merely varying resource allocations. It is considered however that this range of expenditure rates is appropriate to this size and type of contract.

The implementation programme is based on the Client's instruction to re-schedule completion of the project to coincide with the expected airport completion of mid 1997.

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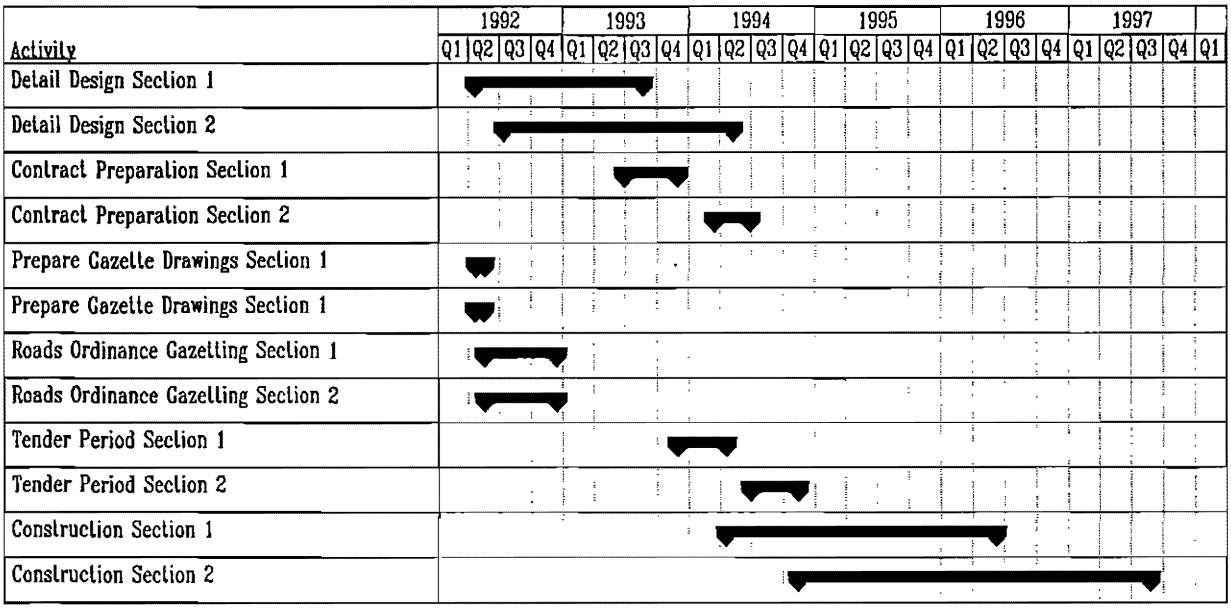


ENVIRONMENTAL IMPACT ASSESSMENT

A separate Environmental Impact Assessment was submitted at the same time as was the Draft Preliminary Report. Comments were received and responded to at a working group meeting on the 29th January 1992. The Executive Summary of the Environmental Impact Assessment given below reflects the outcome of the discussions on the comments received.

An important feature of this scheme is the fact that it is not proposed to construct a new road in a green field environment. The existing road already carries high traffic volumes, is visually intrusive and has a considerable noise impact on adjacent properties, many of which were constructed after the road was built. Therefore, as well as relating environmental impacts to the HKPSG as required by the brief, it is important to compare expected future impacts against those observed at present.

The road design has taken as fundamental the need to minimise adverse environmental impact in the vicinity of the road. This approach was put forward because it is evident that the existing LCR and CCR carry environmental disadvantages and areas of possible improvements can already be identified without first making a detailed appraisal of the proposals to improve the road.

For instance wherever cut slopes have been found necessary for engineering purposes, the Landscape Consultants have been closely involved in decisions regarding the form of cut slope and its treatment before a recommendation has been made. The same is true of decisions regarding the form of many of the structures. The effect of the scheme on noise sensitive developments has been taken to be a factor in the alignment and construction form at the outset. Where an option has existed to resolve traffic queuing and its associated noise and air pollution problems, then this has again been a factor in the decision to recommend any particular solution.

Thus an integrated design approach to all aspects of the engineering, involving the Environmental and Landscape Consultants has been adopted. As a result of this approach, the Landscape Strategy and Environmental considerations for noise, air and water are incorporated at design stage into the recommended scheme, rather than mitigating the effect of a road scheme which could be developed independently of environmental considerations.

Proposed Alignment

The proposals would bring the edge of the road closer to adjacent sensitive land uses in a number of instances and Figure 8.2.1 of the Preliminary Report drawings identifies various sensitive land uses. Most of the deterioration in environmental quality at sensitive uses surrounding LCR and CCR would however be due to the increase in traffic volume and in particular, the increase in the number of heavy vehicles which has been forecast. A part of this increase would take place in any event, even if the road were not improved. The consequences of this would be an increase in traffic delays along the route leading to a worsening of both the traffic and the environmental situation.

The proposed off line link would have implications for the air and noise environment of certain sensitive uses. For those sensitive buildings close to the proposed off line link, a new source of air and noise pollution would be introduced in their vicinity. On the other hand, the diversion of traffic from the mainline to the off line link would mean that certain sensitive buildings along the mainline would face lower increases in noise and air pollutants levels than would be the case if the link were not constructed.

Noise Impacts

Operational Phase

Currently, the NSRs close to the proposed road improvements are already affected by high levels of traffic noise. The noise monitoring programme carried out by the Consultants along the mainline indicate that the L_{10} (1 hr) levels recorded in all cases exceed the HKPSG level of maximum 70dB(A) for residential areas. The high noise levels of 74 to 80dB(A) recorded are attributable to the high traffic volume (4,000-5,000 v/h) along the existing corridor and the particularly high percentage of heavy vehicles, which is about 35%.

As road traffic noise already exceeds HKPSG levels along all of the route a number of noise reducing measures have been built into the design. Such measures include maximising free flow of traffic, maximising distance from NSRs where possible, minimising gradients and maximising soft ground where sound absorption could be expected to be significant. In addition, noise screens have been incorporated into the design in a number of areas where the noise levels already exceed HKPSG and their use would result in significant benefits. Therefore, the traffic noise impacts from the improved road will not be much greater than the "do-nothing" option. In a number of areas, the noise

environment will be improved to a significant degree.

Increase in traffic noise at NSRs along the mainline are largely due to increases in traffic volume, from about 5,000 vph to 7,500 vph, and the percentage of heavy vehicles, from 35% to 45%. The increase in noise level arising from this is predicted to be about 2dB(A). In areas where the improved road scheme will be closer to the NSRs, a further increase in the traffic noise levels will occur but will be slight due to the small distance involved. The new off line link will add a new noise source to certain NSRs, although some existing NSRs will benefit by such a re-routing. For the planned sensitive developments in close proximity to the proposed scheme, future traffic noise levels are predicted as far as possible based on the site layout and building plans. Table A summarizes the existing situation at the various NSRs juxtaposed with the expected noise levels in 2001 (worst case).

The effectiveness of noise barriers, to protect the NSRs exposed to high traffic noise, was modelled. Barriers of 2m, 3m and 4m high have been considered. In some instances, roadside barriers will be effective in screening traffic on the nearside carriageway but would be ineffective for screening traffic on the offside carriageway. As a result, the inclusion of additional barriers in the central reserve has been considered.

The standard CRTN calculation procedure cannot make allowance for barriers in the central reserve for this particular project as the central median is less than 5m wide; to take account of the possible effects of median barriers a departure from CRTN is necessary. EPD have accepted this need and instructed that the procedure should involve two noise source lines, one 3.5m from the nearside kerb, the other 3.5m from the farside kerb. As a result of this approach, the height of the barriers would in many cases become excessive, requiring heavy, intrusive support structures. The use of relatively lightweight transparent structures up to 3m in height show little benefit in the calculations as they are too far from the source line to be effective. Nonetheless, although the calculated benefits of the central reserve barriers are small, it considered that the actual effects will be greater because of the distribution of traffic between lanes. The recommendation for their inclusion therefore remains.

As most NSRs along the proposed scheme are highrise blocks, noise barriers are not effective at all in many cases. The proposed road scheme has nonetheless included barriers at the nearside and/or at the median strip for protecting the following sensitive receivers:-

- Nam Wah Middle School;
- Caritas main wards;
- Proposed school for mentally handicapped in Caritas Medical Centre;
- Fu Chak House, Chak On Estate;
- Wah Chak House, Chak On Estate;
- Wing Chak House, Chak On Estate; and
- Residential lots on Beacon Hill Road and Rhondda Road.

The barriers included in the scheme in front of Wah Chak House and the residential lots on Beacon Hill Road and Rhondda Road will not reduce the traffic noise levels lower than HKPSG, but the resulting noise levels are for the most part lower than those currently experienced.

In the early stages of detail design there will be minor variations of line and/ or structural form. During this early period the design, location and dimensions of the noise barriers will be refined. In some areas this will involve increasing the length and/ or height of barriers. Details will be worked out at that stage with constant reference to EPD.

Because of the lack of planning data associated with some future development sites it has not been possible to identify the most suitable noise mitigation measures in a number of cases. This also will be the subject of further investigation in the early stages of detail design and EPD will be consulted accordingly.

The Preliminary Report recommends the adoption of a rigid (i.e. concrete) pavement for the route on grounds of cost, pavement life and maintenance commitment. A number of locations were identified which might benefit, in noise terms, from the use of open textured wearing course materials. They are Chainage 2650 to 3220, Chainage 4000 to 44200 and Chainage 5300 to 5900 for protecting the receivers, Jockey Club Wai On Block and wards of Caritas Medical Centre, proposed Caritas School, Pine Hill, Park Mansion, So Uk Estate, Chak On Estate and Residential Lots on Beacon Hill Road and Rhondda Road. Even at those location however, it is considered that the capital cost would be too high and the maintenance consequences too onerous to include the material. The whole scheme is therefore assessed on the basis of a rigid pavement.

Table A Summary of Change in Noise Levels L_{10} dB(A), for the Proposed Scheme

NSR	Floor	Measured Noise Level	1991 Calculation		2001 Calculation			Noise Level Change due to the Increased Flow
			Traffic Flow, vph	Predicted 1991 Noise Level [1]	Traffic Flow, vph	Predicted 2001 Noise Level	Roadside Barriers	
Planned Kau Wah Keng Development Area Chainage 900 to 1100	1/F; lower	-	-	-	5500	80	Not Effective	-
Mei Foo Sun Chuen Chainage 1220 to 1450	21/F; top 13/F; mid	74	3300	76 74	5500	78 76	Not Effective	+2
Lai Chi Kok Hospital Chainage 1470 to 1550	2/F; top	-	3300	67	5100	69	N.A.	+2
Wai Man Tsuen - school - residential Chainage 1650 to 2050	1/F; top 1/F; top	- -	5300	63 65	7800	65 67	N.A.	+2
Nam Wah Middle School Chainage 2570 to 2620	6/F; top 3/F; mid	- -	5300	69 65	7800	69 65	2m barriers at nearside ($0.36 million)	+2
Jockey Club Wai Oi Block, Caritas Medical Centre Chainage 2650 to 2720	11/F; mid	79	5300	80	7800	82	N.A.	+2
Caritas wards and nurse quarters Chainage 2800 to 3100	8/F; top	-	5300	74	7800	72	2m barriers at separator and 3m barriers at nearside ($0.51 million)	+2*
Proposed Caritas School Chainage 3050 to 3150	3/F; top	-	5300	66	7800	64	2m barriers at nearside ($0.44 million)	+2*

(Table 8.3(a) of Preliminary Report)

Table A **Summary of Change in Noise Levels L_{10} dB(A), for the Proposed Scheme** (Cont'd)

NSR	Floor	Measured Noise Level	1991 Calculation		2001 Calculation			Noise Level Change due to the Increased Flow
			Traffic Flow, vph	Predicted 1991 Noise Level [1]	Traffic Flow, vph	Predicted 2001 Noise Level	Roadside Barriers	
Proposed Carlton Hotel Redevelopment Chainage 3000 to 3100	6/F; top	-	-	-	7800	78	N.A.	-
Park Mansion Chainage 3100 to 3220	3/F; top	-	5300	74	7800	76	N.A.	+2
Pine Hill Chainage 3000 to 3100	4/F; top	-	5300	70	7800	72	N.A.	+2
So Uk Estate Chainage 3050 to 3400	18/F; top 14/F; mid	74 -	5300	75 -	7800	77 75	Not Effective	+2
Fu Chak House, Chak On Estate Ramp C5 & C6	8/F; top	73	N.A.	N.A.	2600	70	2m barriers at nearside ($0.53 million)	N.A.
Wing Chak House, Chak On Estate Chainage 4000 to 4020	13/F; top 5/F; mid	- -	5000	73 70	5000	71 68	2m barriers at separator and 2m barriers at nearside ($0.96 million)	0*
Wah Chak House, Chak On Estate Chainage 4000 to 4150	13/F; top 9/F; mid	- -	5100	79 78	5000	77 73	3m barriers at separator and 3m barriers at nearside ($1.6 million)	0*
Planned Tai Wo Ping Residential Development Chainage 4000 to 4200	6/F; top	-	-	-	5200	78	N.A.	-
Proposed Private Hospital Chainage 4450 to 4600	3/F; mid	-	-	-	5200	80	Not Effective	-

(Table 8.3(a) of Preliminary Report)

Table A Summary of Change in Noise Levels L_{10} dB(A), for the Proposed Scheme (Cont'd)

NSR	Floor	Measured Noise Level	1991 Calculation		2001 Calculation			Noise Level Change due to the Increased Flow
			Traffic Flow, vph	Predicted 1991 Noise Level [1]	Traffic Flow, vph	Predicted 2001 Noise Level	Roadside Barriers	
Beacon Heights Chainage 4150 to 4420	13/F; top 9/F; mid	79 -	4400	80	5200	81 81	Not Effective	+1
Proposed School at Tai Wo Ping TIIA Ramp C5 & C6	6/F; top 3/F; mid	-	-	-	2600	70 65	N.A.	-
G/ICs on Kwong Lee Road Tai Po Road Interchange	6/F; top	-	4200	62	6500	64	N.A.	+2
Lei Cheng Uk Estate Tai Po Road Interchange	25/F; top	-	N.A.	N.A.	2600	68	N.A.	N.A.
Lung Ping Road TIIA Chainage 4600 to 4800	2/F; top	-	4400	69	6600	71	N.A.	+2
Beacon Hill Residential Chainage 5300 to 5900	13/F; top 10/F; mid	80 -	4400	81 81	6600	82 77	3m barriers at separator and 3m barriers at nearside ($5.5 million)	+2*

Notes :-

[1] The 1991 noise levels are calculated for comparison purposes to indicate the noise variations due to the traffic change. Other aspects, such as road geometry are assumed to be constant.

* Noise level change if without barriers

Construction Phase

Construction noise will be generated from road construction/ improvement activities including excavation, earthworks, piling, concreting, paving and earth moving activities. Based on a tentative list of dominant equipment items employed and the construction programme, the maximum noise levels at the facade of the NSRs for general construction works and piling have been predicted and presented in the EIA Report. Predicted noise levels for general construction activities, especially the roadworks, will exceed stipulated evening and nighttime criteria. The construction noise will also be perceivable in daytime even considering the high ambient noise levels. Based on the predicted noise levels, the Authorities would not grant restricted hours Construction Noise Permits to the contractor. An exception could be considered at Chainage 2000 to 2500 where industrial buildings are the only receivers and are not noise sensitive.

It should be appreciated that most of the bridge foundations are supported on caissons rather than piles installed using percussive piling. Noise impact from piling is therefore rarely a factor. For those cases where percussive piling is used, except for the schools in Wai Man Tsuen, the noise levels will not exceed the ANLs and thereby piling should be allowed between 0700 and 1900 of Monday to Sunday. The schools in Wai Man Tsuen are no longer in use and the impact from piling and general construction noise on normal teaching will not exist.

Chak On Estate is the nearest NSR to the Tai Woh Ping works area which would be used for the storage of precast beams and units. The transport of materials to various construction sites of the road alignment via Nam Cheong Street would add construction traffic to the roads. However, the additional traffic would not result in a perceivable increase in traffic noise as the number of truck movements would be small, especially when compared to the large traffic flow on Nam Cheong Street and LCR/CCR.

As most of the NSRs are already experiencing high traffic noise levels, noise impacts from construction activities, whilst important, need not be severe by comparison. With good on-site management, such as using silencer equipped plant and equipment, careful scheduling of activities, siting of the noisiest equipment or activities as far from the NSRs as practical, and with proper maintenance of plant and equipment, the noise impacts from construction activities can be minimized. The site management practices and noise mitigation measures should be enforced by contract conditions. 2m high temporary noise barriers in the form of noise panels are recommended to protect Caritas wards, Nam Wah Middle School and Beacon Hill residential buildings.

The construction site should be surveyed regularly to ensure that recommended site management measures are being practised and that the noise reduced powered plant quoted by the contractor is used. Noise monitoring should be carried out to check for effectiveness of the noise control measures being enforced in the contract. Compliance monitoring for construction noise should be carried out to evaluate the impacts on the NSRs concerned.

Air Quality Impacts

Operational Phase

As the existing LCR/CCR is within a developed area, a significant number of air sensitive receivers are in close proximity to the roads and are experiencing high levels of vehicle emissions. With the increase in the percentage of heavy goods vehicle from 37% in 1991 to 45% by 2001 together with the increase in peak hour traffic volume from 4,900 vph in 1991 to the predicted 7,200 vph for the year 2001, the pollutants emitted are expected to increase in quantity. However, the rate of increase in the total amount of pollutants emitted from vehicles is also dependent on the vehicle emission control strategy in Hong Kong, and the technological advances in vehicle emissions control. A set of emission factors was calculated based on the new Air Pollution Control (Vehicle Design Standards) (Emission) Regulation 1991, and the Compilation of Air Pollutant Emission Factors, AP-42, Third Edition, 1980 data for heavy goods vehicles.

The traffic-related air pollutant concentrations which would be experienced by the Air Sensitive Receptors (ASRs) during the operational phase of the improved road have been predicted using a mobile source dispersion model, CALINE 4 which is a gaussian dispersion model for line source emission. Table B summarizes the air quality impacts from the improved road at the sensitive receptors under their respective worst-case wind directions. It should be noted that the worst-case concentration of the pollutants for all sensitive receptors will not occur simultaneously.

Table B **Air Quality Assessment Results at the following Sensitive Receptors**

NSR	Height (mPD)	Distance (m)	Wind Direction (Degree)	Predicted Max Hourly Concentration ($\mu g/m^3$)			Estimated Daily Concentration ($\mu g/m^3$)
				CO	NO_2	Particulates	Particulates
Mei Foo Sun Chuen Chainage 1220 to 1450	28	63	84	809	245	405	162
Lai Chi Kok Hospital Chainage 1470 to 1550	45	118	358	194	59	97	39
Caritas Medical Centre Chainage 2800 to 3100	40	35	264	992	301*	497	199*
So Uk Estate Chainage 3050 to 3400	75	45	47	627	190	314	126
Wah Chak House, Chak On Estate Chainage 4000 to 4100	85	43	285	513	156	257	103
Fu Chak House, Chak On Estate, (Eastern & Southern Pt) Ramp C5 & C6	80	55	185	194	59	97	39
	100	43	73	205	62	103	41
Beacon Heights Chainage 4200 to 4400	95	15	250	1790	543*	896	358*
Residential Lots on Beacon Hill Road and Rhondda Road Chainage 5300 to 5900	110	20	38	1619	491*	810	324*

* Exceeding the Air Quality Objectives

(Table 8.4(a) of Preliminary Report)

In general, the predicted levels of 1-hour CO remain well below the air quality standard of 30 mg m^{-3}, whereas 1-hour NO_2 and the 24-hours RSP levels are likely to exceed the Air Quality Objectives (AQOs) standard within 40m of the carriageway. Depending on the background levels of NO_2 and RSP and the geometry of the alignment, air sensitive receivers located between 40m to 70m of the carriageway may experience NO_2 and RSP levels exceeding the air quality standard.

Traffic-related air pollution can only be tackled effectively at source. Alignment geometry could have some effect on the roadside pollutant concentrations. It can be seen from the prediction results that high levels of NO_2 and RSP will be experienced by the sensitive receptors within 40m of the alignment. The only effective amelioration measure against high levels of NO_2 and RSP is to control the pollution at source. This may involve some changes such as the introduction of reformulated diesel fuels and compressed natural gas, encouraging the use of technologies to improve combustion and the use of exhaust treatments such as particle traps. Long term commitment by the Government to progressively reduce vehicle emissions and the control in the growing number of vehicles (especially goods vehicles) is strongly supported, and would reduce NO_2 levels adjacent to the carriageway accordingly.

Future developments should where possible be at least 40m from the main carriageway in order to safeguard their air quality or be otherwise planned to accordance with HKPSG.

Construction Phase

Caritas wards and Beacon Hill residential buildings are considered to be the most sensitive to construction dust. Dust emissions are the main air pollution source arising from earth moving activities during the construction phase. With proper dust suppression measures used at the construction sites, dust impacts should be reduced and should not cause any nuisance to the sensitive receivers. The dust suppression measures recommended are regular water spraying of spoil and fill material, covering of stock-piles, provision of wheel washing facilities at works area exits and the provision of fence walls or dust screens where earth moving activities would be carried out in close proximity to sensitive receivers. No stockpiling of spoil should be allowed near Caritas wards and Beacon Hill residential buildings.

In order to assess the effectiveness of the mitigation measures adopted and the extent of the air quality impacts during the construction period, routine monitoring of air quality will be required. Hourly or daily dust measurements for TSP should be carried out at residential blocks on Beacon Hill Road and the Caritas Medical Centre. The results should be assessed according to the standards stated in the AQOs.

To ensure that proper site management is being practised by the contractor, it is recommended that regular site inspection should be carried out to ensure that the recommended mitigation measures are being put into practice.

Visual Impact and Landscape Strategy

The Landscape and Visual Impact brief for Lung Cheung Road and Ching Cheung Road Improvements required the preparation of a Visual Impact Assessment and Landscape Strategy.

A separate Vegetation and Tree Survey was also undertaken prior to commencing an assessment of the roadworks.

Objectives

The purpose of carrying out a tree survey and visual impact assessment is to identify the likely impacts associated with the road and where possible minimise the effect of these impacts during the design process.

The visual aspects of the proposed roadworks were considered as part of the ongoing design work and landscape proposals were incorporated as an integral element of the road improvement works. Where possible mitigation measures reducing the impact of the roadworks were incorporated during the design stage rather than in response to a complete scheme.

Specific areas where this approach was particularly successful included areas where planting was proposed as a form of slope stabilisation and areas where retaining walls were proposed in order to reduce the extent of a cut or fill slope. Reduction in extent of cut and fill slopes enabled retention of existing vegetation and natural countryside in adjacent areas.

Having assessed the visual impact of the proposed scheme, there are some areas of visual intrusion which still exist. Further recommendations for mitigation of these areas are then made as part of the Landscape Strategy.

Visual Impact

The visual impact assessment as described in the EIA involved an evaluation of the existing site conditions, the landscape character, visual quality and visibility of the site area.

The nature and extent of the roadworks was also assessed and graded. Determining the degree of visual impact for specific landscape character areas and identified sensitive receivers was the final step in the assessment of both site conditions and project characteristics.

In some areas the road improvement works would be occurring in areas which already have a visual clutter of road associated elements. The introduction of additional bridges, abutments, walls and other structures would not therefore have a significant visual impact on the overall area. In other areas the visual impact of elements of the highway improvements would be significant, and would remain so even after the maturing of the vegetation.

The mitigating effects of landscape proposals were also taken into account when assessing the overall effects of the roadworks.

There are a number of areas where visual improvement is the end result because works associated with the road works would necessitate the removal or upgrading of elements in the existing landscape which are identified as visually intrusive.

Generally the highest level of impact was identified in the Tai Po Road and Tai Woh Ping Area due to the extensive structures associated with the off line link and the close proximity of densely populated residential buildings.

The construction stage impacts were also found to be more severe than the operational phase impacts. This is largely due to the mitigating role of the landscape proposals which would not yet have been implemented or would not have had time to establish during the construction phase.

Landscape Strategy

Landscape proposals were developed both during and following the visual impact assessment, consequently the Landscape Strategy is the result of an ongoing design process determining the form of certain elements of the roadworks and responding to others.

For the length of the alignment the proposals incorporate a range of mitigation measures and landscape treatments which include street tree planting, roadside planting, screen planting, cut and fill slope planting and advice on structural finishes and forms.

The proposals are illustrated on the Landscape Strategy drawing figures 3.13.5 to 3.13.12 of the Preliminary Report.

Conclusion

Upon completion of the road scheme and once planting associated with the Landscape Proposals has matured there will be an upgrading in the existing visual quality for some areas. For other sections of the road areas of visual intrusion will remain and where possible additional mitigation measures have been proposed to help reduce the overall impact.

Areas where significant improvement over the existing situation is likely are described below.

- The appearance of existing cut slopes will be improved in areas where a slope will be affected by the roadworks, the chunam will be removed and the slope replanting with predominantly indigenous species to match the existing vegetation of the foothills.

- Street tree planting adjacent to the road will be strengthened wherever possible this will include planting in pits at the base of existing chunam slopes.

- The Lookout Area will be redesigned and upgraded during the detail design stage to allow for reprovisioning of a rest garden. Additional screen planting will be incorporated as part of the landscape proposals to minimise visual intrusion from the adjacent road.

- The appearance of existing chunam slopes to the south will be improved below Bridge B8 and above Lei Cheng Uk Swimming Pool Complex. Screen planting has been proposed for areas adjacent to Bridge B8 and individual trees in pits will be cut into the existing chunam above the swimming pool.

- Residential buildings along Beacon Hill Road will gain usable areas of space adjacent to the new Retaining Wall. The retaining wall will include a patterned finish and trees in planters will be planted at the base of the wall. The residential buildings in this area currently face a chunam slope to the north.

Areas where visual intrusion will remain or be increased will include the following:-

- Visual intrusion resulting from the very high structures associated with the off line link, this will affect the Tai Po Road and Tai Woh Ping Areas.
- All new slopes cut into areas of existing vegetation will result in visual intrusion, however these slopes will be planted and the degree of visual impact should be significantly decreased once the planting has established.
- Widening of the road adjacent to the Lung Cheung Road lookout area will result in the formation of fill slopes and construction of retaining walls. However, the fill slopes will be planted and screen planting will be included in front of the retaining walls minimising the overall impact.
- The removal of mature Bombax trees as a result of the road widening. Where possible these trees will be replaced.
- The removal of the existing vegetation and construction of retaining walls above Wai Man Tsuen, screening planting will be included in front of the walls and finishes have been proposed for surface of the walls.
- The playground at Tai Woh Ping will be affected by the new elevated structure associated with the off line link. The playground will require redesigning to allow for screen planting and relocation of play equipment, however reprovisioning of the playground would be preferable.

Recommendations

Potential improvements to the area which have not been included in the present project on cost grounds but which might be considered in the future include:-

Remaining chunam slopes

Removal of chunam and replacement with slope stabilisation methods which support vegetation would improve the visual quality.

- existing chunam slopes north of the road between Chainage 1950 and 2400
- existing chunam slopes above caritas Medical Centre
- existing chunam slopes north of the road between Chainage 2900 and 3200
- remaining chunam slopes above So Uk Estate
- existing chunam slopes at the Tai Po Road Interchange
- extensive areas of chunam on slopes south of the road between Chainage 3400 and 3900 above Kwong Lee Road
- existing chunam slopes above the reservoir playground
- existing chunam slopes above the Cornwall Street Temporary Housing Area
- existing chunam slopes surrounding Lung Ping Road Temporary Housing Area
- existing chunam slopes above residential buildings on Beacon Hill Road
- existing chunam slopes above the mainline between Chainage 4000 and 4180 west of Beacon Heights

Existing Structures

Some of the existing structures are badly stained. An applied finish to the structures would improve their visual amenity.

Screen Planting

Planting in front of existing structure and retaining walls.

- additional planting in the Roman Catholic Cemetery
- screen planting near buildings in Chak On Estate with views to the off line link
- additional planting in the grounds of the Tai Woh Ping Reservoir Playground to screen views of the off line link
- planting of trailing plants above the large retaining wall directly south of the WSD buildings

Planting species suitable for Amenity Areas will include the followings:-

- **Trees and Palms**

  Albizia lebbek
  Aleurites moluccana
  Archontophoenix alexandrae
  Bauhinia blakeana
  Bombax malabaricum
  Cassia siamea
  Cinnamomum burmanii
  Erythrina arborescens
  Grevillea robusta
  Livistona chinensis
  Melia azedarach
  Peltophorum pterocaspum
  Terminalia catappa

Water Quality Impacts

Operational Phase

The potential sources of water quality impacts would be from the accumulation of sediment, spillage of hydrocarbons or other contaminants from vehicles during normal operation and accidental spillage of hazardous materials following a road accident. However, as the proposed road improvement scheme is well away from the sea, there would not be any direct discharge of effluent to sea waters. Also it has been confirmed that none of the existing road drainage systems are close to any of the identified service reservoirs, thus no adverse water quality impacts should arise at any of the water pollution sensitive uses.

In order to prevent water pollution, appropriate drainage design with the installation of sediment traps and oil interceptors will be employed in the road scheme. Water quality impacts should then be minimized by frequent inspection and maintenance of the drainage system.

Construction Phase

No impacts to the water pollution sensitive uses are perceived during the construction phase. However, water quality impacts may arise due to contaminated runoff from the construction sites, impacts to the drainage system will be avoided by the adoption of good site practices such as wheel washing etc. This will be addressed in the contract documents.

Waste disposal

Spoil arising from the proposed cut slopes are not likely to be contaminated and there should not be any disposal problem. The spoil resulting from excavation or earthworks will be used as on-site backfill or for landscaping purposes as far as possible, the remaining should be used in the current reclamation works. Recycling of construction wastes is recommended if economically feasible. Only when all the recycling means have been investigated and found to be not possible, should the construction wastes be disposed of at approved landfill sites.

* * * * * * *

FEASIBILITY STUDY

Introduction

The brief requires that a feasibility study be undertaken to establish the need or otherwise for improvements to the section of Lung Cheung Road between the Lion Rock Tunnel interchange and Po Kong Village Road. Consideration is required of the present condition of the road, likely short term developments and possible long term developments associated with the future development of Upper Wong Tai Sin Estate.

Existing traffic flow patterns were identified by site survey carried out soon after the opening of the Tate's Cairn Tunnel and its approaches while future traffic requirements have been established from detailed 2001 and 2011 traffic models. These were derived for the main part of the present consultancy appointment and were extended to include a greater degree of detail in the area to the east of Lion Rock Tunnel.

Future development proposals for the Upper Wong Tai Sin Estate are not yet known but it is unlikely to be undertaken before mid 1994. When it is undertaken it is likely to reduce population density but increase car ownership. These two factors taken together are unlikely to result in a significant difference in overall trip generation from that given in existing Transport Department data and as a result strategic road traffic flows are unlikely to be significantly different from those forecast, although there might be localised differences. Traffic forecasts are therefore sufficiently reliable to make overall observations regarding the future performance of the main line.

The lack of detail relating to the Upper Wong Tai Sin development does not allow prediction of the effect of the estate on the road itself, but it is possible to do the reverse; i.e. it is possible to state limitations which might be imposed on the planning of the estate by the limitations of Lung Cheung Road.

Existing Situation

Lung Cheung Road

This section of Lung Cheung Road is approximately 1.8km long and has four grade-separated interchanges only one of which allows for all movements. In addition an at-grade junction allows left-in and left-out traffic movements.

The study section is a dual-three lane carriageway with a generally easy longitudinal gradient. Local widening to four lanes is provided at the weaving section of Lion Rock Tunnel Road interchange, where there is a 5-7% upgrade.

Pedestrian crossings are in the form of footbridges and subways with no at-grade pedestrian crossings provided. The central dividers outside Wong Tai Sin Estates are higher than the standard requirement to discourage illegal crossing.

Traffic Operation and Physical Constraints

Site observations and traffic counts were carried during the peak and off peak periods in July 1991, after the opening of the Tate's Cairn Tunnel. Traffic flows on Lung Cheung Road are in the order of 3,000 to 4,000 pcus/hour in each direction.

The key issues/problems regarding traffic operation and physical constraints on Lung Cheung Road are :-

- Merging Lanes
- Weaving Sections
- Bus Operations
- On-street Stopping/Parking
- Pedestrian Movements

Each of these issues was considered in turn and the problems with the existing situation identified.

Future Conditions

Traffic Forecasts

The forecast 2001 and 2011 peak hour traffic flows indicate that the link capacity of the existing dual three lane carriageway would be, in general, adequate in meeting the expected demands.

Planning Proposals

Redevelopment of the public housing estates along Lung Cheung Road have been taking place over the last few years and has resulted in limited scope for future road widening.

As stated above, the capacity of the dual three lane road is in itself adequate to cope with future needs, but the accesses to the road are critical and it is important that future developments take this into account.

Transport-Related Proposals

The Chuk Yuen Road interchange at Lung Cheung Road was constructed as an integral part of the public housing development in Chuk Yuen. A slip road for traffic from Lung Cheung Road westbound to turn right onto Chuk Yuen Road northbound was not implemented at that time. At present this slip road proposal is included in the Public Works Programme with estimated start and completion dates of April 1996 and September 1997 respectively. The proposal would improve access to Chuk Yuen developments from Lung Cheung Road westbound, but little improvement would be expected for the through movements on Lung Cheung Road.

The existing east-west road capacities across Kowloon are limited. At present, Lung Cheung Road is one of the few trunk routes serving these strategic east-west movements. A Central Kowloon Route Study is being undertaken by Government's consultants. The Central Kowloon Route is expected to be in operation by 2006. Any delay in the completion of this new link would undoubtedly result in additional pressure onto Lung Cheung Road.

Scheme Proposals

A number of scheme proposals have been derived to deal with the problems. The capacity of the existing dual three lane road would be adequate at least up to 2011 if accesses to the road could be properly controlled, illegal parking/ loading/ unloading curtailed, and if obstructions arising out of public transport requirements could be eliminated.

Most of the schemes being proposed are therefore relatively minor and do not for the most part entail the enlarging of the existing facility. They are mostly concerned with management and enforcement of existing provisions.

Table C below summarises the scheme proposals which are classified as follows:-

M* - Modifications to merge arrangements
B * - Modifications to bus stopping arrangements
S * - Modifications to signing or road markings
P * - Modifications to pedestrian facilities
W* - Modifications to road widths or layouts

Cost estimates associated with each scheme have been included in Table C. Note that these are construction estimates based on unit costs for highway works, generally as carried out by private sector contractors on individual large scale jobs. It is likely that such jobs carried out on a piecemeal basis, possibly by a Government term contractor, will vary significantly from the costs given here. They are however a useful guide as to order of magnitude expenditure which is associated with each improvement proposal.

The recommendations for implementation given in the tables is fairly subjective. The difference between "short term" and "long term" is as much related to cost of implementation as anything. In general it is considered that all of the schemes should be implemented as soon as practicable so that they are completed before further traffic buildup renders their implementation more problematical.

Conclusions

The section of Lung Cheung Road under study, between Lion Rock Tunnel Road and Po Kong Village Road, is currently dual three lane. Traffic forecasts indicate that the expected 2011 traffic flows on Lung Cheung Road would be approaching its link capacity given that there are no significant obstructions along the road. The proposals in this document are therefore predominantly intended to remove such obstructions.

At the present moment, there are a number of locations on the study section where the dual three lane capacity is restricted, the restrictions generally take the form of:-

- inadequate bus stopping facilities;
- inadequate length of merging lane;
- bus stop located at merging lane;
- poor roadmarkings, especially for the "no stopping" restriction lines;
- poor sightlines and inadequate pedestrian facilities.

It is anticipated that the situation will deteriorate with the increasing traffic volumes on Lung Cheung Road and hence the need for resolving these constraints will become more urgent.

Before submitting this report consultations were held with Traffic Engineering and Transport Operation Divisions of Transport Department and with Kowloon Motor Bus (KMB) in order to ensure that any proposals which might on the face of it resolve traffic problems defined purely as vehicle flows would not give rise to other insurmountable problems. In particular the siting of bus stops was seen as being of crucial importance in this exercise. Every effort has been made to retain existing bus user patterns but implementation of the proposals contained in this document will require further thought by the bus operators to minimise collateral problems associated with bus user patterns.

During the course of the consultations it was discovered that plans are currently being drawn up to re-surface much or all of this section of the road. It would seem prudent that any of the recommendations contained in this documents which it is determined should be implemented be considered in association with the re-surfacing work in order to avoid the possibility of reconstruction work being unnecessarily prolonged or of new work having to be disturbed.

* * * * * * *

Table C Summary of Feasibility Study Proposals

Scheme Solution	Description	Site Factors	Implementation	Cost HK$
M2 B1	Merging point from Ching Tak Street	- Undesirable bus stop location - Merging lane shortened by presence of bus stop - Conflict of bus/merging traffic	Short Term	885,000
M3	Merging point from Fung Mo Street	- Merging lane too short - Adjacent to bus stop - Sharp turning radius	Short Term	320,000
B2	Bus stop outside Upper Wong Tai Sin Estate	- No bus layby - Bus stopping on nearside lane - Reduce road capacity	Short Term	300,000
B3	Bus stop outside Lower Wong Tai Sin Estate	- No bus layby - Bus stopping on nearside lane - Reduce road capacity	Short Term	180,000
M1	Merging point from Po Kong Village Road	- Merging lane too short - Main road on curve - Poor sightline	Medium Term	660,000
S2	Parking of vehicles on footway near diverge point to Chuk Yuen Road	- Inadequate road markings and signs - Enforcement issue	Short Term	265,000
S1 P2	Green PLBs stopping and pedestrian safety at Ching Tak Street	- Poor sightlines - Obstruction by trees - Sharp turning radius	Short Term	150,000
M4 M5 W1 W2	Weaving and merging points at Chuk Yuen Road and Lion Rock Tunnel Road interchanges	- Inadequate length of weaving and merging distances - Obstruction by traffic queues from Lion Rock Tunnel Road - Main road on upgrade	Long Term	26,000,000
B5 S3	Bus stop near merging point from Ma Chai Hang Road	- Bus/merging traffic conflicts - Vehicles other than buses stop at bus bay - Inadequate road markings and signs - Enforcement issue	Short Term	100,000
B4 P1	Bus stop near Shatin Pass Road Inadequate footpath width near Shatin Pass Road	- Narrow footpath - Obstruction by footbridge and hawkers	Long Term	N/A
W3	New frontage road for the future redevelopment of Upper Wong Tai Sin Estate	- No direct access from Lung Cheung Road into Upper Wong Tai Sin Estate - Heavy bus stopping activities along Lung Cheung Road eastbound	Long Term	N/A

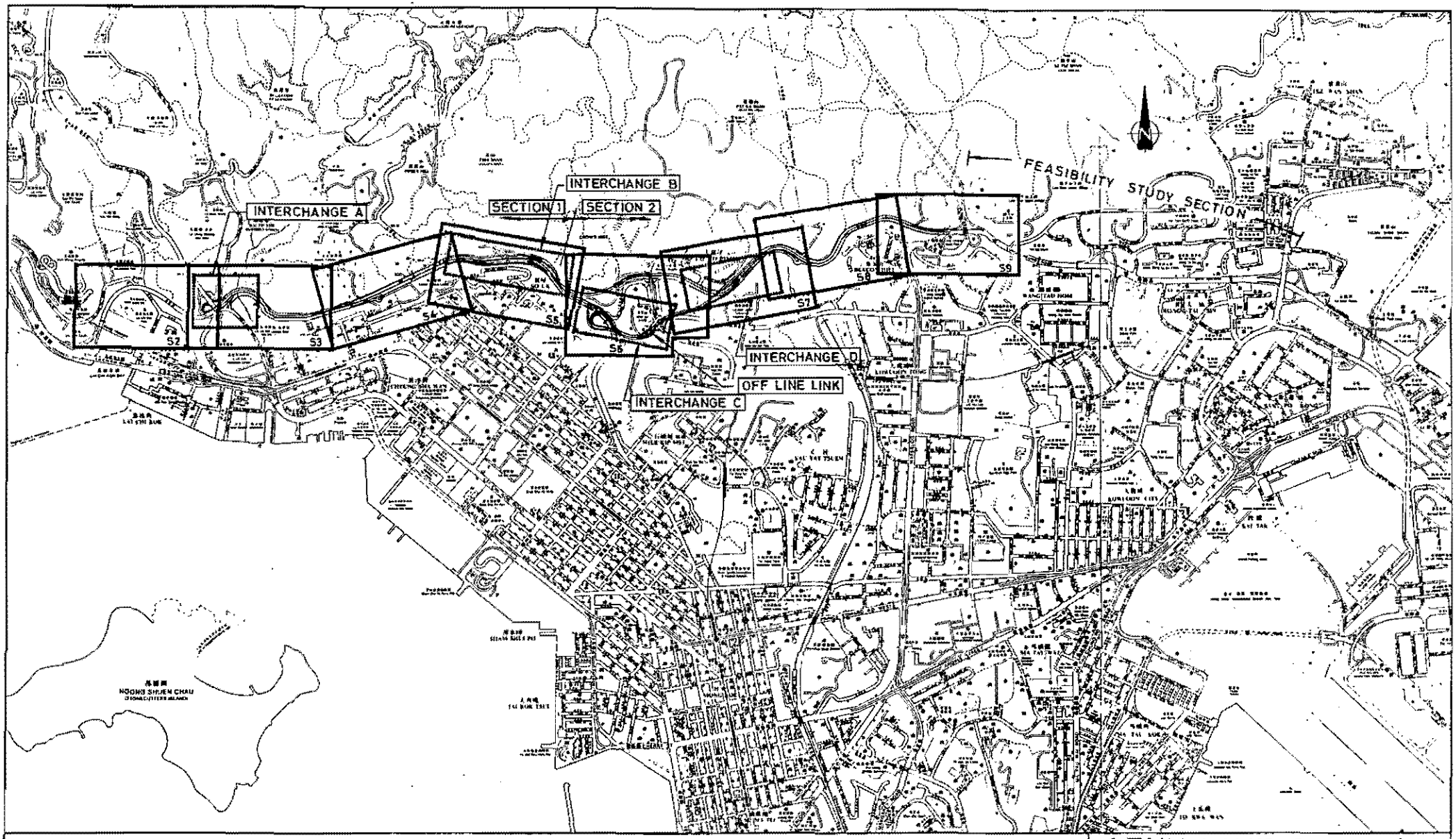
CONCLUSIONS

The scheme put forward in this report is the culmination of a detailed study of the problems of providing adequate traffic capacity across the north of the Kowloon peninsula. It has been developed in conjunction with the client department, Highways Department/ Western Harbour Link Office and with the co-operation of many other Government departments, Utility companies and others. Particular thanks are due to GEO for their assistance.

Since the inception of the project, expected scheme costs have consistently fallen. This was achieved firstly by the adoption of absolute minimum TPDM standards for the road, and subsequently by a combination of taking design standards to their limits and refining of the design. Throughout it has remained a fundamental that capacity has to be provided and that road safety has to be significantly improved.

The scheme therefore represents a balance between the ideal of constructing a road to meet the best possible design criteria and the physical and financial constraints surrounding it.

* * * * * * * *



NOTE:
1. INTERCHANGE REFERENCE LETTERS FOR IDENTIFICATION OF RAMP ALIGNMENTS.

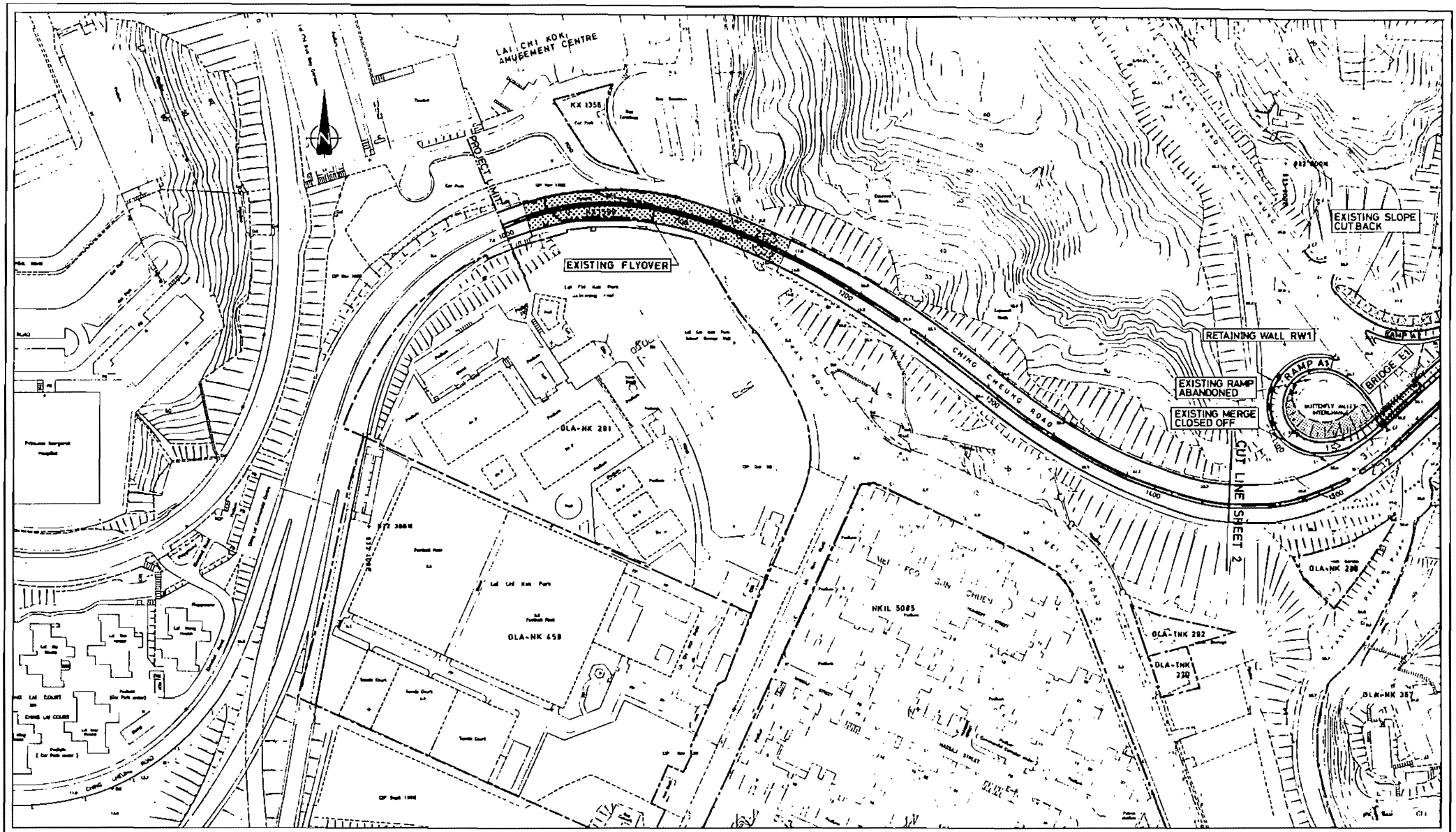
SCALE 200 0 200 400 METRES

PHH / ARUP CONSULTANTS
LUNG CHEUNG ROAD AND CHING CHEUNG ROAD IMPROVEMENTS
潘衍壽－亨嘉利／奧雅納聯營工程顧問

HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

KEY PLAN

DESIGNED	H. W. C.	DRG. NO.	FIG.
DRAWN	K. W. F.	PR/H622/100P/034	S1
CHECKED	H. K. L.		
APPROVED	R. B.		
DATE	DECEMBER, 1991	SCALE AS SHOWN	



NOTE :

1. ALIGNMENT FROM CHAINAGE 1000 TO 1500 UNALTERED.

KEY:-

1. Proposed carriageway edge
2. Proposed structure edge
3. Proposed retaining wall
4. Existing made slope
5. Proposed made slope
6. Limit of proposed earthworks
7. 3 No. of traffic lanes
8. Lot boundary
9. Open structure
10. Proposed noise barriers

SCALE 20 0 20 40 METRES

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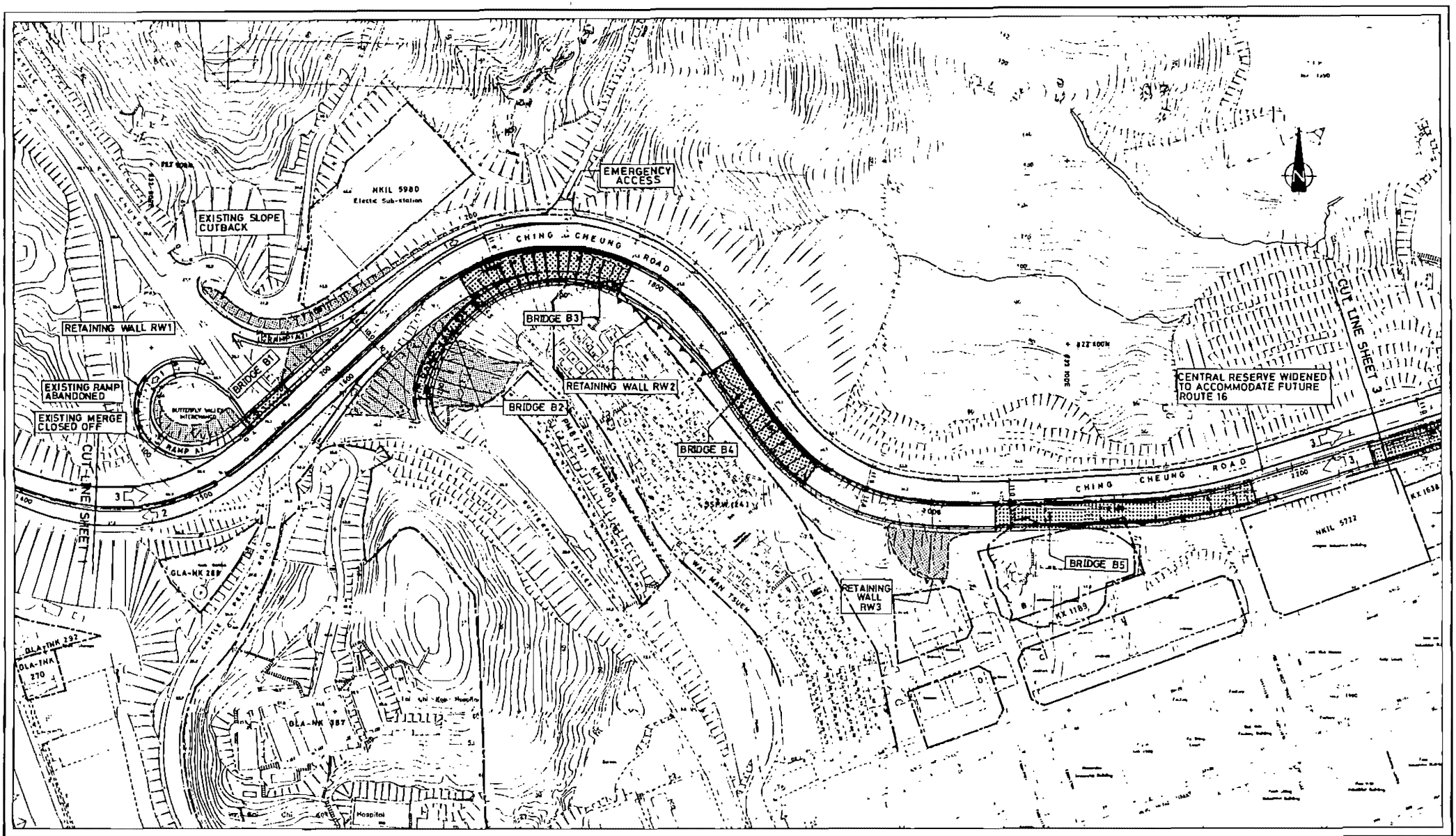
潘衍壽－亨富利／奧雅納聯營工程顧問

HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 1000 TO CH. 1450
SHEET 1 OF 8

DESIGNED	W. W. C.	DRG. NO.	FIG.
DRAWN	A. K.	PR/H622/101P/012	S 2
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991.	SCALE AS SHOWN	



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SCALE 20 0 20 40 METRES

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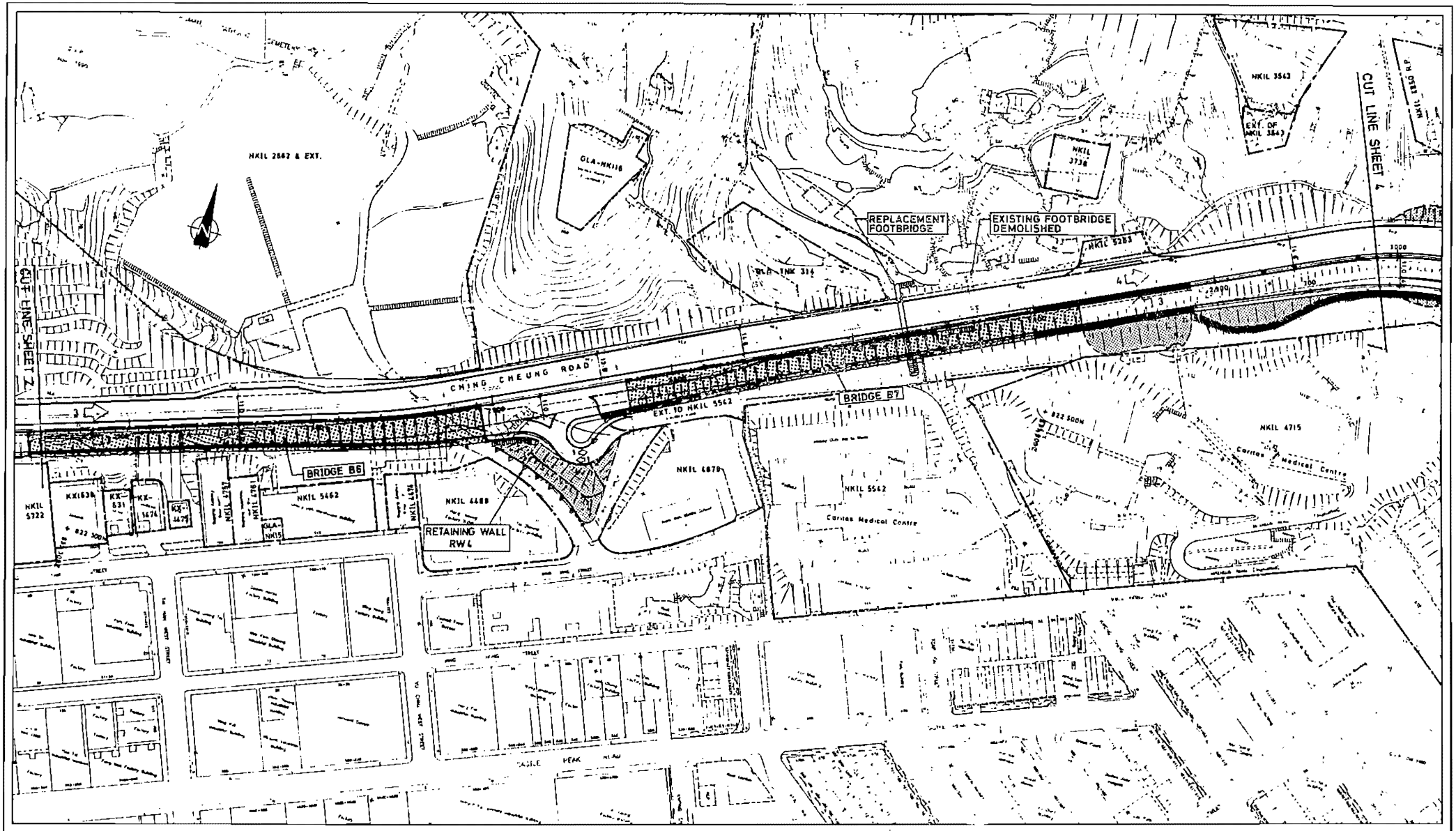
HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 1450 TO CH. 2250
SHEET 2 OF 8

DESIGNED	M. W. C.	DRG. NO.	FIG.
DRAWN	A. K.	PR/H622/101P/013	S3
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991.	SCALE AS SHOWN	



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5. Proposed made slope
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8. Lot boundary
9. Open structure
10. Proposed noise barriers

SCALE 20 0 20 40 METRES

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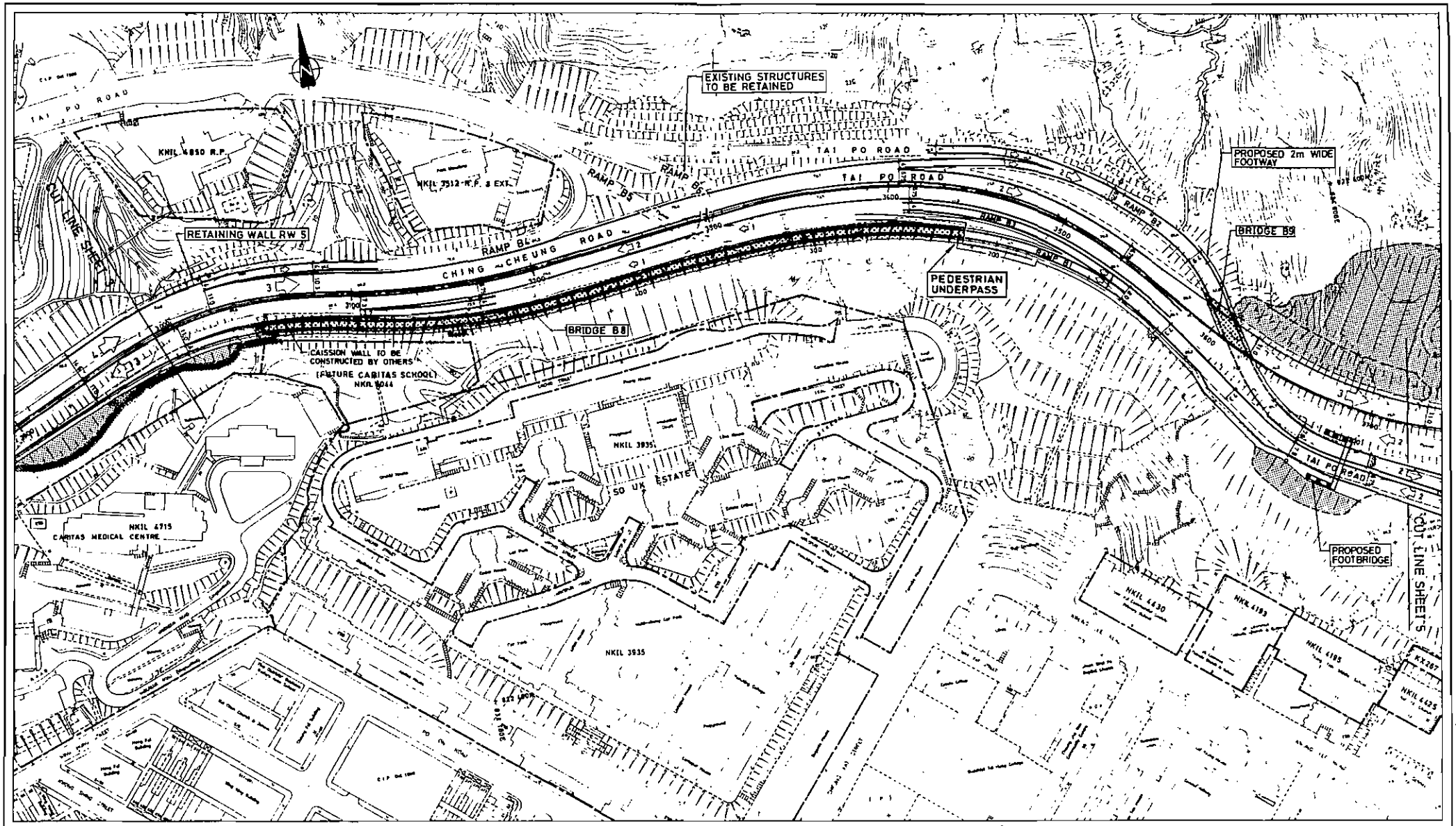
HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 2 250 TO CH. 3 000
SHEET 3 OF 8

DESIGNED	C. N. A.	DRG. NO.	FIG.
DRAWN	A. K.	PR/H622/101P/014	S 4
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991.	SCALE AS SHOWN	



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SCALE 20 0 20 40 METRES

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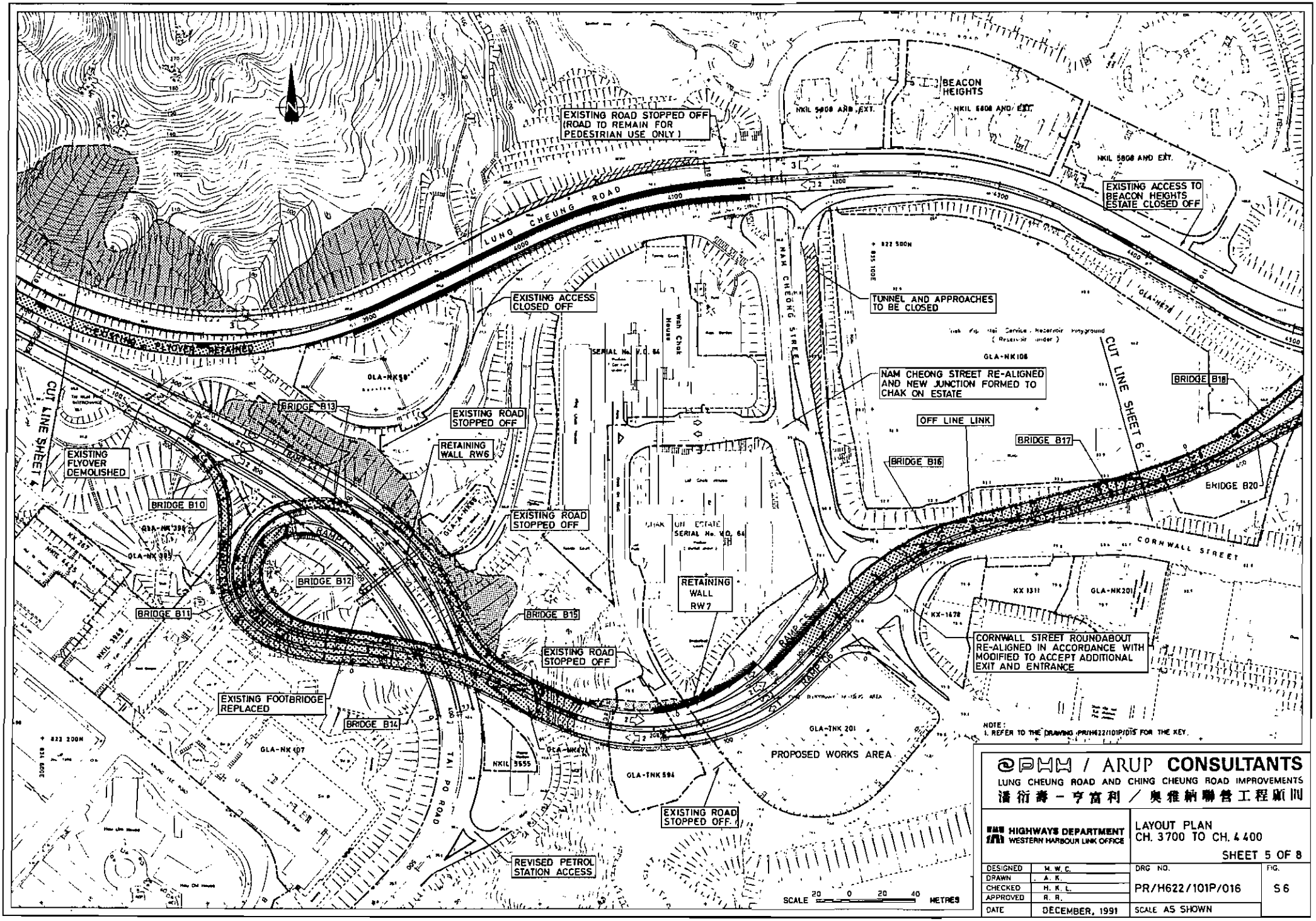
HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 3000 TO CH. 3700

SHEET 4 OF 8

DESIGNED	H. W. C.	DRG. NO.	FIG
DRAWN	A. K.	PR/H622/101P/015	S5
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991.	SCALE AS SHOWN	



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LUNG CHEUNG ROAD AND CHING CHEUNG ROAD IMPROVEMENTS

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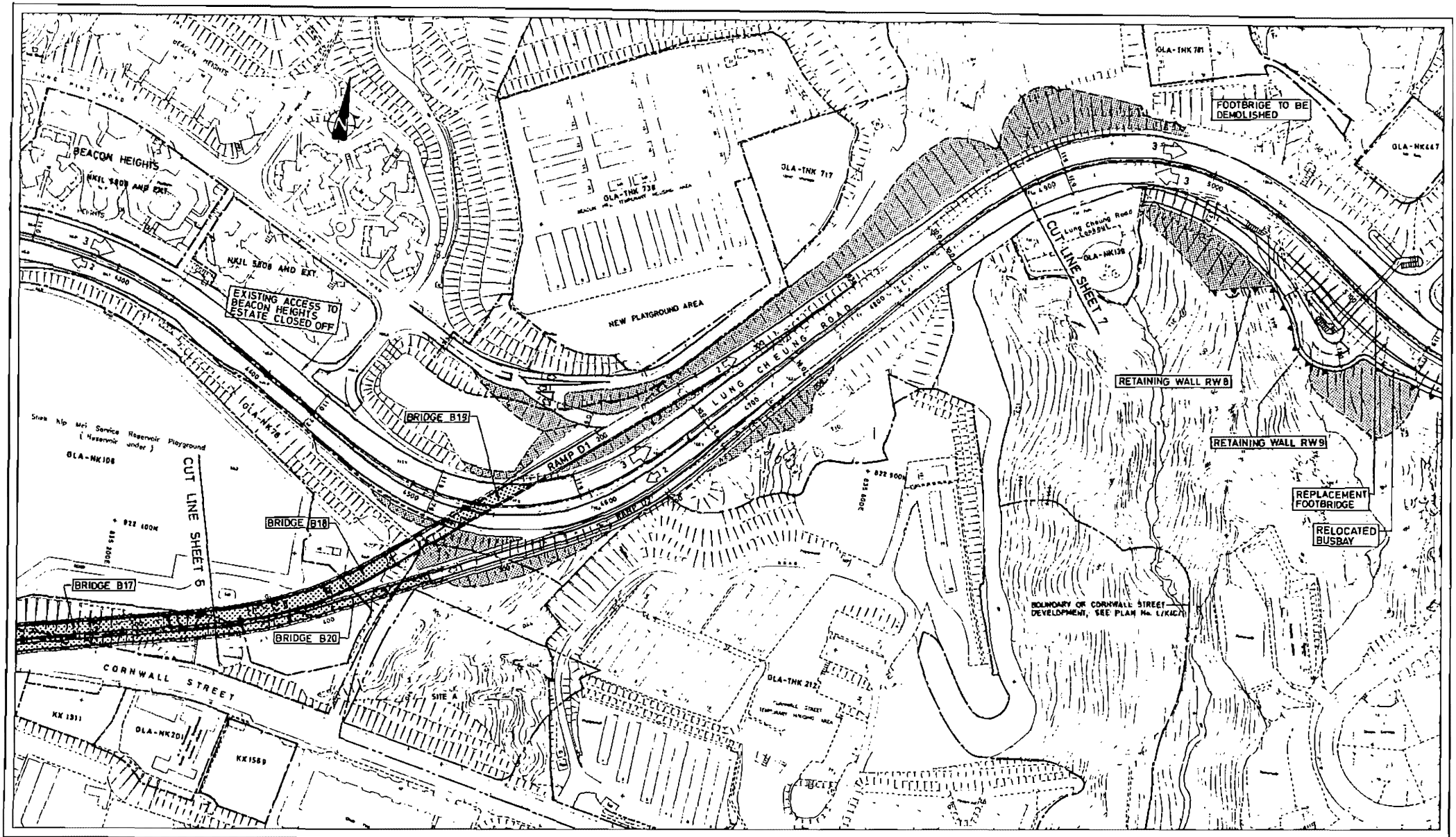
HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 3700 TO CH. 4400

SHEET 5 OF 8

DESIGNED	H. W. C.	DRG NO.	FIG.
DRAWN	A. K.	PR/H622/101P/016	S6
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991	SCALE AS SHOWN	



KEY:-

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2. Proposed structure edge
3. Proposed retaining wall
4. Existing made slope
5. Proposed made slope
6. Limit of proposed earthworks
7. 3 No. of traffic lanes
8. Lot boundary
9. Open structure
10. Proposed noise barriers

SCALE 20 0 20 40 METRES

PHH / ARUP **CONSULTANTS**

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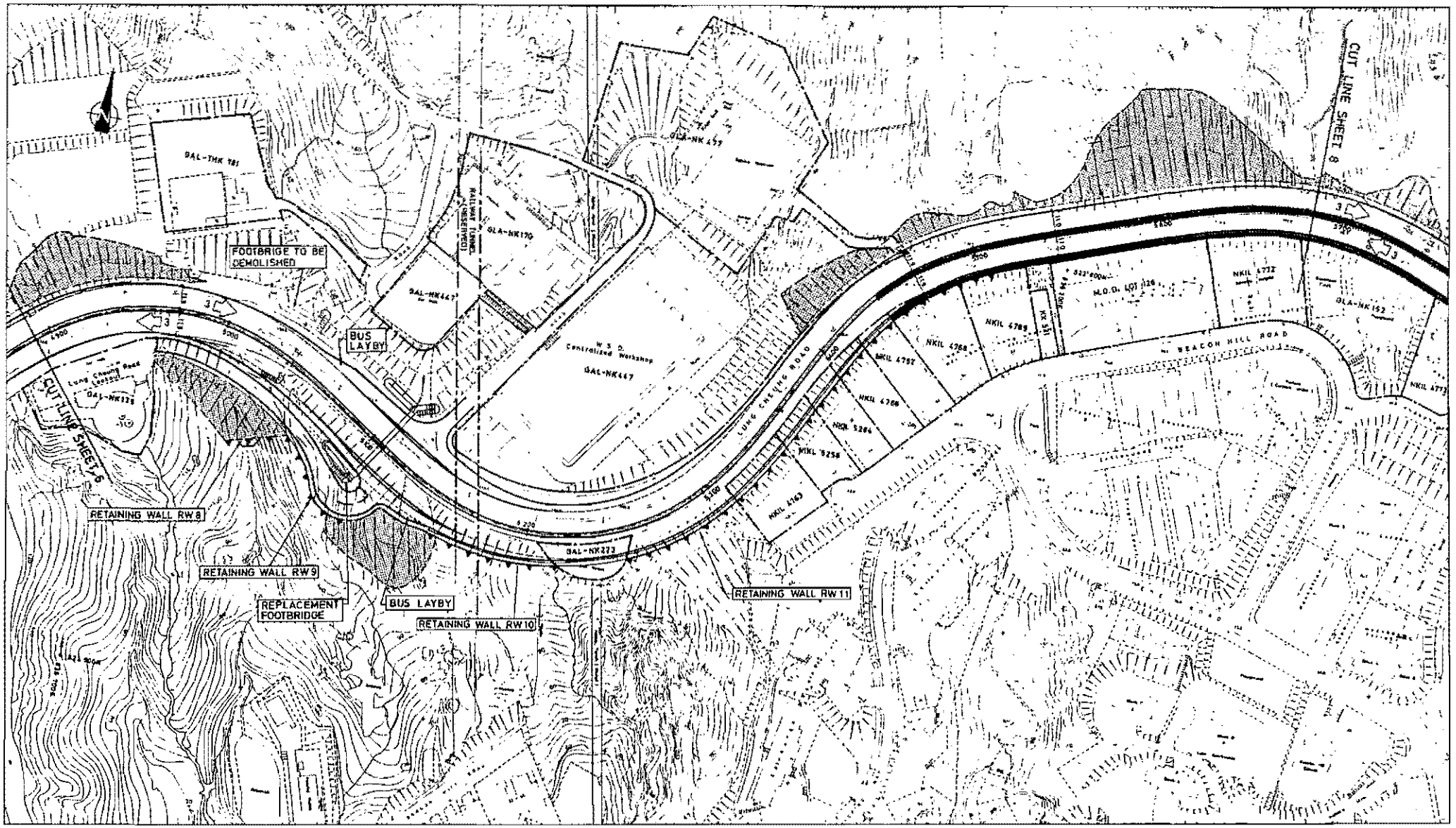
HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 4400 TO CH.4900

SHEET 6 OF 8

DESIGNED	M. W. C.	DRG. NO.	FIG.
DRAWN	A. K.	PR/H622/101P/017	S 7
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991	SCALE AS SHOWN	



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SCALE 20 0 20 40 METRES

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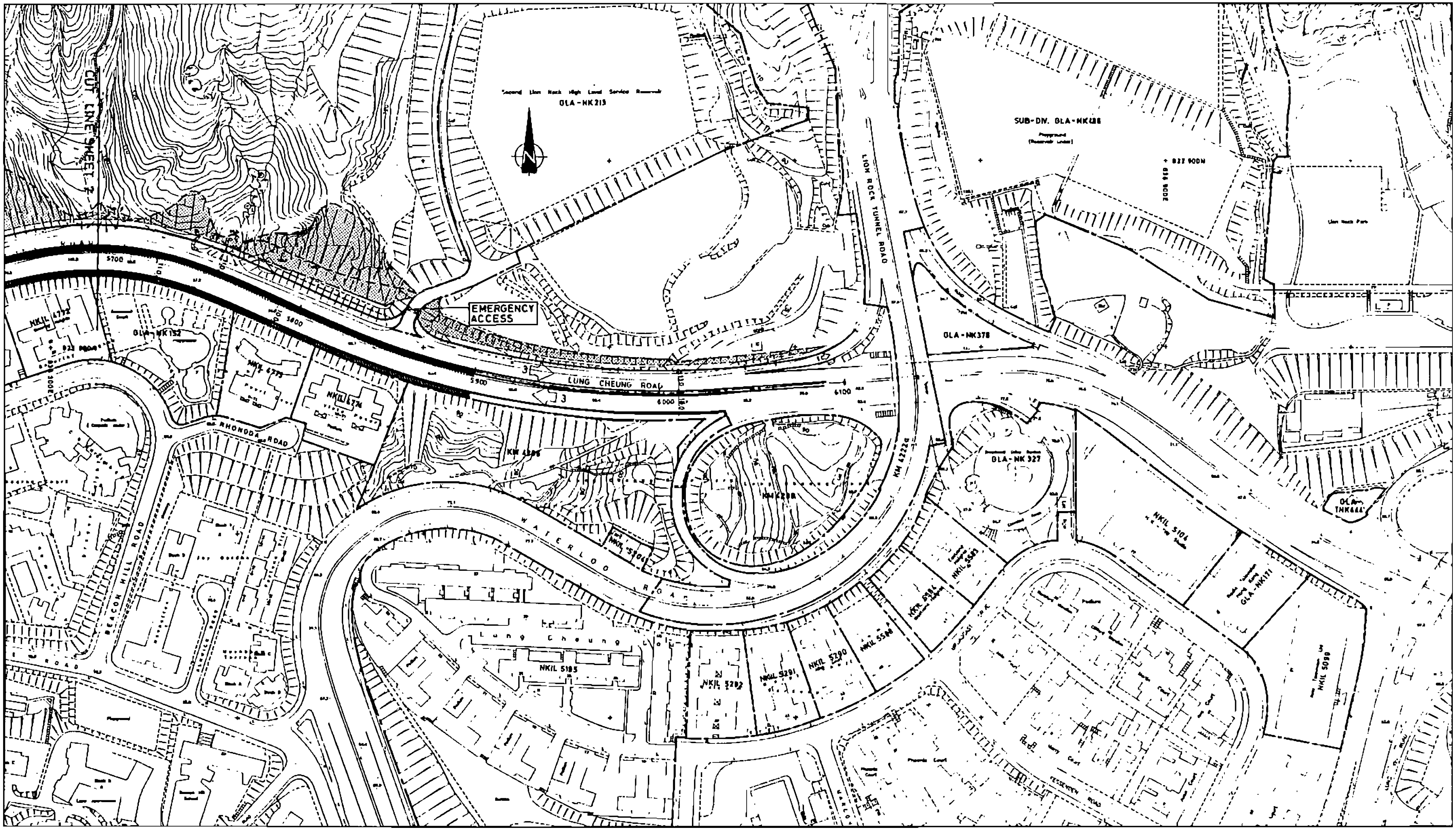
潘衍壽－亨富利／奧雅納聯營工程顧問

HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH. 4900 TO CH. 5700

SHEET 7 OF 8

DESIGNED	H. W. C.	DRG. NO.	FIG
DRAWN	A. R.	PR/H622/101P/018	S8
CHECKED	H. K. L.		
APPROVED	R. H.		
DATE	DECEMBER, 1991.	SCALE AS SHOWN	



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SCALE 20 0 20 40 METRES

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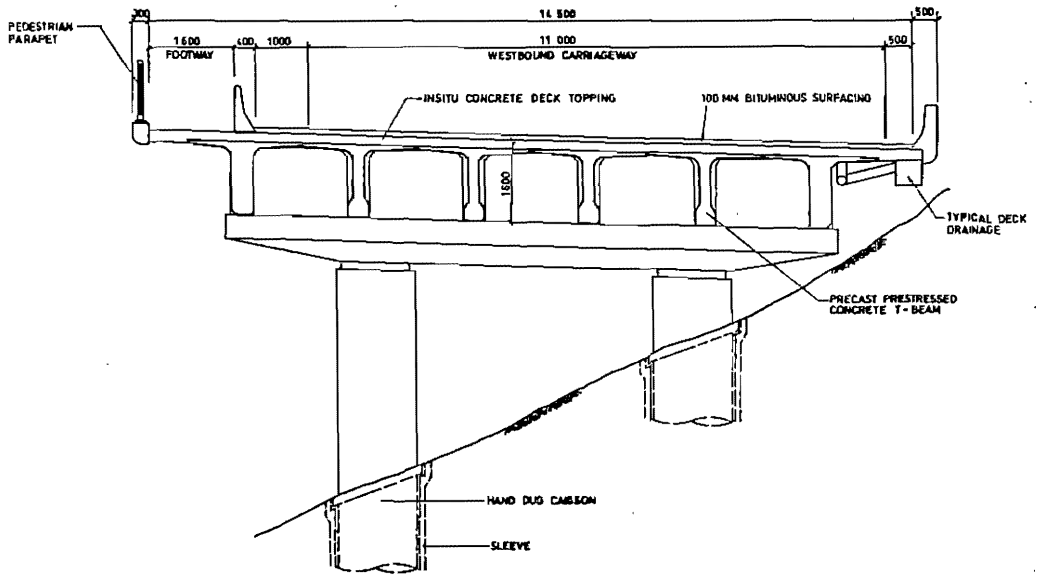
HIGHWAYS DEPARTMENT
WESTERN HARBOUR LINK OFFICE

LAYOUT PLAN
CH.5700 TO CH.6100

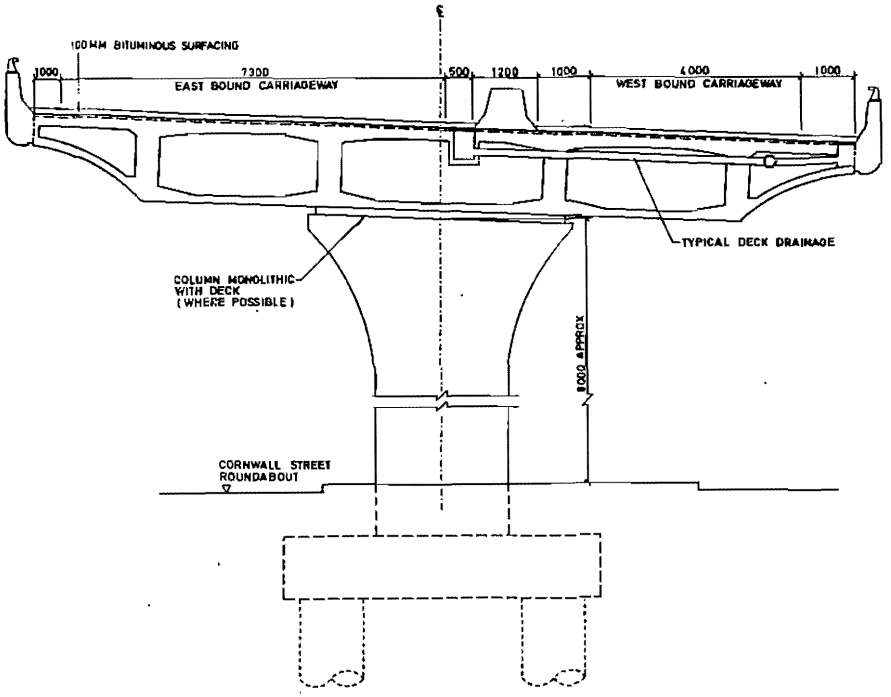
SHEET 8 OF 8

DESIGNED	M. W. C.	DRG. NO.	FIG.
DRAWN	A. K.	PR/H622/101P/019	S9
CHECKED	H. K. L.		
APPROVED	R. R.		
DATE	DECEMBER, 1991.	SCALE AS SHOWN	



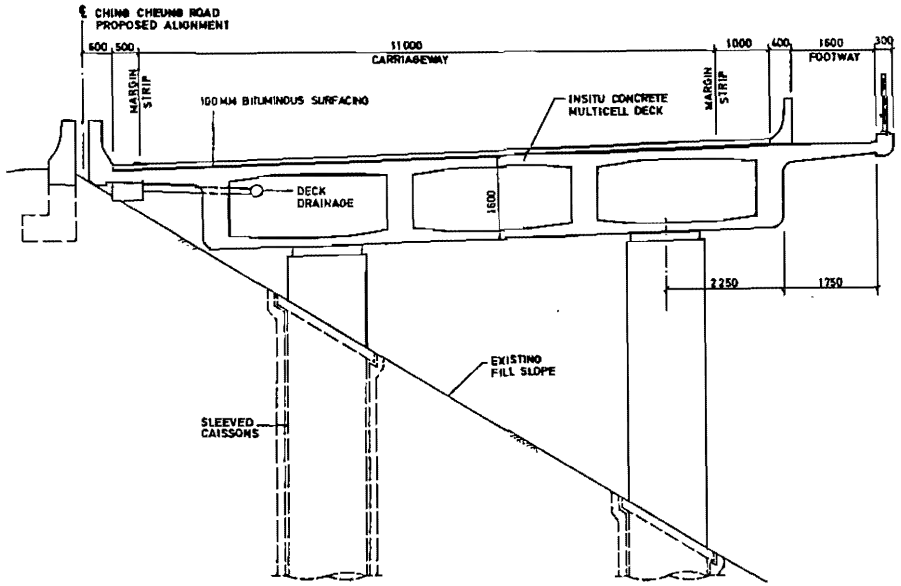
TYPICAL PRECAST BEAM AND SLAB BRIDGE STRUCTURE

(BRIDGES B5, B6, B7 & B8)



TYPICAL OFF LINE LINK BRIDGE STRUCTURE

(BRIDGES B10, B11, B12, B14, B15, B16, B17, B18 & B20)



TYPICAL INSITU CONCRETE BRIDGE STRUCTURE

(BRIDGES B2, B3 & B4)

SCALE 1 0 1 2 METRES

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HIGHWAYS DEPARTMENT WESTERN HARBOUR LINK OFFICE	TYPICAL BRIDGE STRUCTURE
DESIGNED W H F	DRG. NO. PR/H622/300P/035
DRAWN S L	FIG. S10
CHECKED D W	
APPROVED R R	
DATE APRIL . 92	SCALE AS SHOWN