Territory Development Department, Hong Kong
Urban Area Development Office

TECHNICAL PAPER NO. 19

Green Island Reclamation Feasibility Study

TRAFFIC NOISE IMPACT AND ASSESSMENT OF PLANS

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1 INTRODUCTION

The Design Brief for the Green Island Reclamation requires the reclamation site to provide housing for a large population. This, combined with the need to include strategic road links creates many difficulties. Noise from traffic within the development area is one of these concerns.

The purpose of this report is to give an overview of the traffic noise levels likely to be created and to review the noise mitigation measures that are likely to be necessary. As this report is being prepared as a result of a feasibility study, there is little detail available regarding the precise nature of the buildings to be constructed on the reclamation. The report has been based on the land uses shown in Figure 2 which will be presented as the Recommended Outline Zoning Plan (RODP) for the Green Island Feasibility Study.

This technical paper concentrates on the traffic noise aspects associated with the North Green Island Link options. An alternative routing of the Green Island Link (known as the South Option) has been discussed. The relative merits of the two schemes are discussed below in general terms.

2 NORTH AND SOUTH LINK OPTIONS

The north link option is shown in detail in Figure 2. The southern link option is broadly similar to that shown in Figure 2 except that the Green Island Link enters the reclamation to the south of Green Island itself and emerges to join Route 7 close to the western extremity of Kennedy Town. The two schemes are shown in Figure 1.

In noise terms, the south link option creates a number of difficulties. The most significant of these is the interchange required between the Green Island Link and Route 7. A large land area is required for the interchange and noise from the interchange will effectively 'sterilise' a significant area of land which could otherwise be residential. The interchange will also adversely affect areas of Kennedy Town.

By routing the Green Island Link to the north, it is possible for a much greater length of the Link to be located underground. It emerges close to the industrial and port areas which, combined with the local feeder roads in this area, provides a useful buffer between industrial and residential areas.

It can therefore be concluded that the North Link Option is more beneficial in terms of a reduced traffic noise impact. Other environmetal considerations referred to in TP23 *"Air Quality Impact and Assessment of Plans"* and TP26 *"Water Quality Impact and Assessment of Plans"* further support the choice of the North Link as the better option.

3 NOISE LIMITS

3.1 The Hong Kong Planning Standards and Guidelines (HKPSG) advise on maximum allowable noise levels *outside* buildings of different categories. The limits are given in terms of the L_{10} dB(A) level occurring during the peak hour. The 'L_{10} level' is defined as the noise level exceeded for 10% of the time. In effect, this is the 'average maximum' noise level.

The limits specified in the HKPSG are given below in Table 1

Development	L_{10} (1-hr)
Dwellings	70 dB(A)
Schools	65 dB(A)
Hospitals	55 dB(A)

TABLE 1: HKPSG Recommended Maximum Facade Noise Levels

Experience has shown that these limits are difficult to achieve without large set-backs from even lightly trafficked roads.

3.2 The HKPSG levels have been based on achieving acceptable internal noise levels with open windows and to maintain a reasonable level of noise in external areas close to buildings.

4 CALCULATED NOISE LEVELS

The level of traffic noise to be expected at the facades of NSRs has been estimated using the assumptions below. Calculation procedures used are those outlined in *Calculation of Road Traffic Noise* (HMSO, 1988). The resulting peak hour L_{10} noise levels are shown on Figure 2 with sample calculations given in Appendix A.

Traffic speeds:	Strategic and Primary Distributor Roads - 70kph Internal roads - 50kph
Traffic flow:	As shown in Technical Paper No 15 (*Local Network Studies*). As the traffic flow calculations are given in terms of PCUs, the data has been corrected by a factor of 1.25 to give the number of vehicles per hour. The data is valid for 2011 am peak flow.
Distance to facade:	10m from edge of carriageway and 1.5m above carriageway.
Angle of view:	180°
Percentage of HGVs:	50% on major roads, 30% on inner feeder roads
Gradient:	0%
Road surface:	Pervious

It should be stressed that the predicted noise levels shown on Figure 2 do not necessarily directly relate to those experienced outside the facade of buildings at that position. The design of the building, in particular the orientation of the windows, also influence the resulting noise levels. As these factors cannot be determined at this stage, a 'worst case' situation has been taken with a minimal setback from the road and a large angle of view.

5 ASSESSMENT

5.1 Calculations clearly show that, unless mitigation measures are taken, traffic noise levels are likely to exceed the limits given in the HKPSG.

5.2 Noise mitigation measures are therefore required and the options available are outlined in the following section.

6 REDUCTIONS IN TRAFFIC NOISE AT FACADES

6.1 General

Several measures can be considered to reduce the level of traffic noise affecting noise sensitive areas. These measures fall into three broad categories, namely:

- o Land use planning
- o Traffic measures
- o Road design
- o Architectural design

6.2 Land Use Planning

6.2.1 The combined use of distance setback, compatible land-use and the use of non-sensitive buildings as screens to sensitive areas are essential to achieving an environmentally acceptable development. The relatively slow decay of sound with distance limits what can be achieved simply by setting back roads from sensitive buildings. This strategy does, however, provide useful reductions in noise and should be followed wherever possible.

6.2.2 Large separations between roads and residential areas would be required if this were to be the only noise mitigation measure employed. A separation of 300m would normally be required between trunk roads and residential areas. Even secondary distributors with a traffic flow of 2000 Vehicles Per Hour (VPH) require a setback of 120m in order for the HKPSG limits to be met at residential properties.

It is not possible to achieve separations of these magnitudes and still incorporate the large amount of housing which is required on the reclamation.

6.2.3 The use of barrier buildings is by far the most effective way of controlling traffic noise. The Recommended Outline Development Plan will adopt this approach as far as is practicable in relation to overall strategic planning constraints.

6.4.4 Barriers have been successfully constructed from a variety of materials, including, prefabricated steel or aluminum panels, closed-boarded wood, precast concrete, cellular concrete, transparent plastics, earth berms and cuttings. The main criteria for selecting the materials to be used are:

- o Sufficient strength to withstand any wind load and vehicle impacts.
- o Do not shatter into dangerous fragments or represent a fire hazard.
- o Modular construction allowing panels to be easily replaceable if damaged.
- o Maintenance free.
- o Acceptable visual appearance.
- o Not adversely affected by sunlight and other climatic effects.

6.4.5 Use of a tunnel is a natural extension of the screening concept. In effect, a tunnel is a screen which is bent over the highway to ensure that no line of sight exists between the traffic and the Noise Sensitive Receiver. Substantial noise reductions (more than 10 dB(A)) can be achieved by such designs. The actual improvement is often governed by the length of the tunnel that can be built and the possible noise from the ventilation systems which may be required.

6.4.6 Visual screening by the tunnel of the noise source from the receiver also helps to reduce the subjective annoyance.

6.4.7 However, road tunnel design necessitates the provision of artificial lighting and forced ventilation. Noise levels inside the tunnel will also be much higher than for an open road. Noise from the tunnel ventilation system needs special attention and the air quality at both ends of the tunnel may not be acceptable.

6.5 Architectural Design

6.5.1 The level of noise at the facade of buildings can be reduced by minimising the 'angle of view'. In simple terms, reducing the length of road visible from a window reduces the level of incident noise. The cruciform design of many Hong Kong blocks is effective in this respect. Improvements can also be achieved by limiting the area of openable windows in a noise-affected facade.

6.5.2 Introducing non-sensitive rooms which act as buffers between the noisy facades and the sleeping areas is also beneficial. Careful location of corridors, stairways, lifts, bathrooms and kitchens can all help to improve the internal environment.

6.5.3 An example of this approach is known as 'Single Aspect Housing' where only one facade has windows. This calls for careful interior planning of the buildings and a sensitive architectural treatment to the windowless facades. Such buildings, whilst not common in Hong Kong have found widespread acceptance in Europe, particularly to guard against road and rail noise. Single Aspect Housing enables an acceptable environment to be achieved within the building and can also protect nearby developments which fall into the acoustic shadow created.

6.5.4 In certain situations, podia can also help to reduce noise levels on lower facades. The podium can cast an acoustic shadow on the lower storeys of a development. This requires the noise sensitive areas to be set back on a large podium which extends close to the road.

6.5.5 The addition of a centralised air conditioning system (or a 'split-type' modular system) will allow sufficient cooling to be obtained without the need for windows to be open. This will improve the level of noise within the buildings and thus raise the acceptable level of noise outside the building. However, as most flat dwellers would not wish to keep the windows shut at all times, this cannot be viewed as an ideal solution.

6.5.6 Once a centralised air conditioning system is added, the level of noise within a building is usually governed by the sound insulation of the glazing. Further reductions in noise within a building (and hence increases in the acceptable level of noise outside a building) can be achieved by using thicker single glazing (eg greater than 10mm thick). Double glazing can be used as an alternative where the panes are separated by an airgap of at least 100mm.

6.5.7 Whilst the use of architectural design as a form of noise control can be very effective, it should be a last resort where other methods - which limit noise outside the building - are not practicable or not sufficient in themselves.

7 RECOMMENDATIONS

7.1 General

7.1.1 Calculations have clearly shown that traffic noise will be a major factor in the environmental acceptability of the developments within the completed reclamation. It would not be possible to incorporate the stipulated population and the necessary road links within the development without recourse to some traffic noise mitigation measures.

7.1.2 The projected roadside noise levels are relatively high in many areas. Recommendations on the zoning of the reclamation have taken account of the implications of this wherever possible but there are many constraints on the planning measures that can be taken to minimise traffic noise impact.

7.1.3 Some treatment should be applied to the roads themselves where this is effective. In other areas, architectural measures will be necessary to restrict the noise transmission through the building facades.

7.2 Specific Recommendations

Outline recommendations on noise control are given in the sections below. Figure 3 summarises the recommendations in relation to the affected areas.

7.2.1 As a general policy, it is recommended that a sound absorbing road surface be provided for:

- Strategic Links
- Primary Distributors
- District Distributors
- Local Distributors

7.2.2 Single aspect housing should be provided along the north of Route 7.

7.2.3 A roadside noise barrier should be constructed along the Green Island Link Tunnel access road. The optimum height of the barrier is estimated to be 6m above ground level. This will however depend upon the height and setback of the nearby buildings.

7.2.4 The primary distributor road within the reclamation should be located in a tunnel as far as is possible. Investigation of this option indicates that the maximum practicable tunnel length would be 300m and that this could be located in the centre of the reclamation.

7.2.5 A roadside noise barrier could be incorporated where the primary distributor road enters the tunnel. The depressed road would allow an effective roadside barrier to be incorporated.

7.2.6 The schools within the development must be located away from the strategic links and the primary distributor. Optimum setbacks and orientation of the schools is essential.

7.2.7 Maximum use should be made of non-sensitive buildings (eg commercial/ retail and sports halls) to screen sensitive areas located close to the strategic links. This is particularly recommended along Route 7.

7.2.8 Acoustic screens should be used along the Route 7/ Green Island Link interchange. Screens are particulary appropriate for this section of road. The nearest NSR is a 15 storey building located approximately 100m from the major noise source and thus a relatively low barrier can provide screening of the whole building.

7.2.9 As much of the Green Island Link as possible should be in tunnel.

7.2.10 Residential developments should be angled to major roads to reduce the 'angle of view' of the traffic noise.

7.2.11 Turning circles for trams be at least 75m in radius

7.2.12 Developers should be encouraged to incorporate the tram turning area within the podium of a development. A reduced turning radius would then be acceptable.

7.2.13 Tram lines should be installed as straight as possible and high quality rails be used.

7.3 Areas Exceeding HKPSG Guidelines

Implementation of all the above recommendations will not reduce noise to acceptable levels in all areas. It is therefore inevitable that some developments must incorporate noise mitigation within their design. In most cases, the provision of air conditioning and well sealed windows would suffice.

An indication of the zones where this is likely to be necessary is given in Figure 4. This must be regarded as being indicative because the actual facade noise levels will depend upon many factors which cannot be determined at this time (eg. building setback, angle of view, screening by blocks on other nearby plots). It has been assumed in drawing up Figure 4 that the setback would be at least 10m from the edge of the carriageway and that the design of the buildings would ensure that the angle of view was more than 60°. Mutual screening by blocks is likely to ensure that only the areas at the perimeter of the zone exceed the HKPSG guidelines.

8 CONCLUSIONS

8.1 The study brief requires that Green Island be zoned largely for housing. There is also a requirement for two major strategic links to be included within the reclamation in addition to the Primary Distributor links required for the reclamation itself.

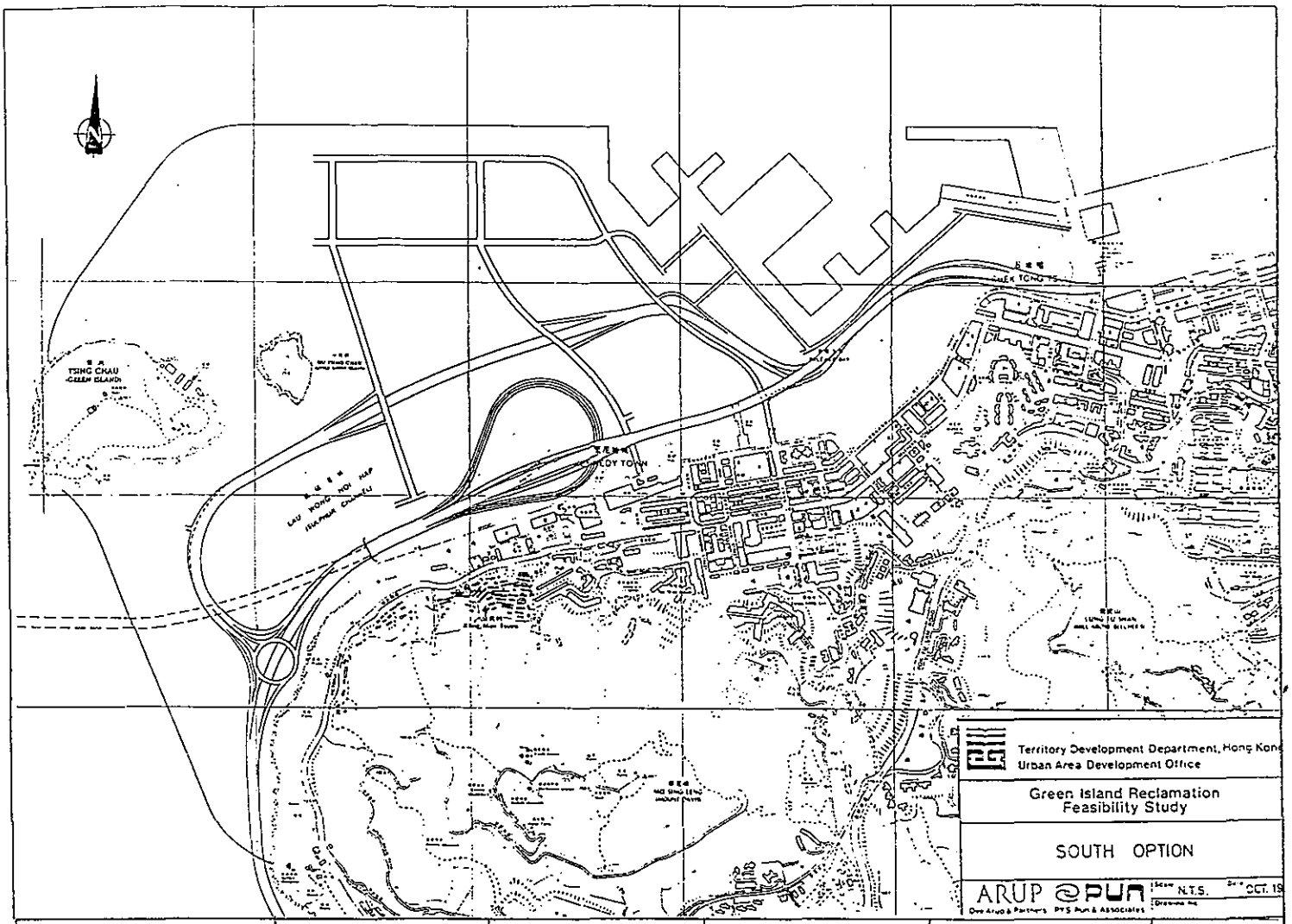
8.2 Precise determinations of the effects of traffic noise cannot be made at this stage because detailed drawings of individual buildings on the reclamation are not available. Estimates of the likely levels of traffic noise indicate that some areas close to strategic links will be badly affected by traffic noise.

8.3 Great efforts have been made to optimise the zoning of the reclamation to minimise the adverse affects of traffic noise. Other planning constraints are such that acceptable levels of traffic noise cannot be achieved at all locations with all possible building configurations. Some noise mitigation measures are therefore likely to be required and it is recommended that:

- o A sound absorbing road finish be used for all roads within the development with the exception of the local roads.
- o Single aspect housing be stipulated for all new developments along Route 7.
- o Sports halls and other non-sensitive buildings be used as acoustic screens.
- o Roadside acoustic barriers be included along the Route 7 / Green Island Link interchange.

8.4 Some restrictions on future developments in noise-critical areas of the reclamation will be required to ensure that acceptable internal noise levels are achieved. Good internal planning of the sensitive areas within the developments or the use of well-sealed glazing and air conditioning would be sufficient in this respect.

8.5 Detailed traffic noise assessments should be made for new developments to be located within the reclamation. Such assessments can only be made once plans of the developments are available.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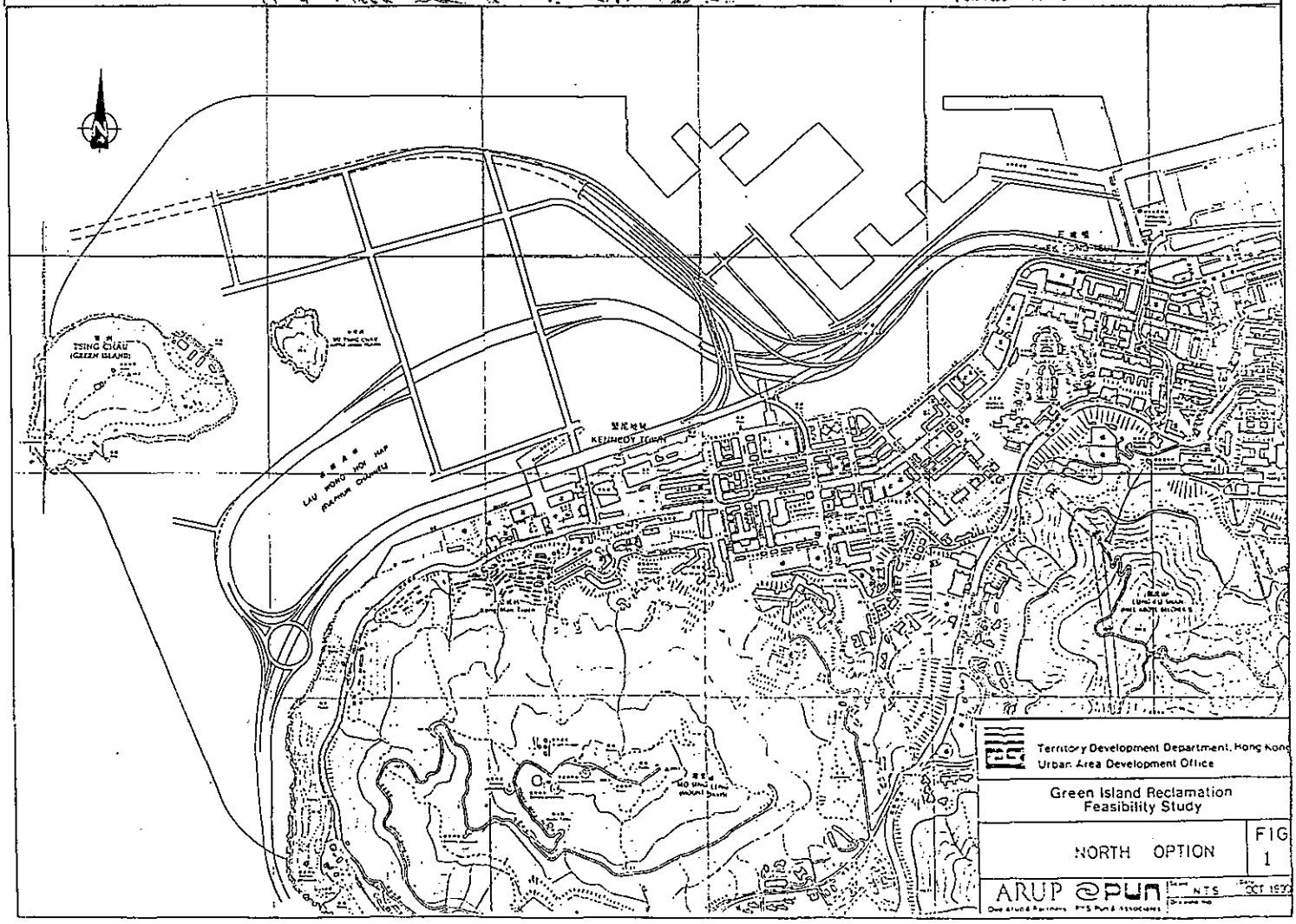
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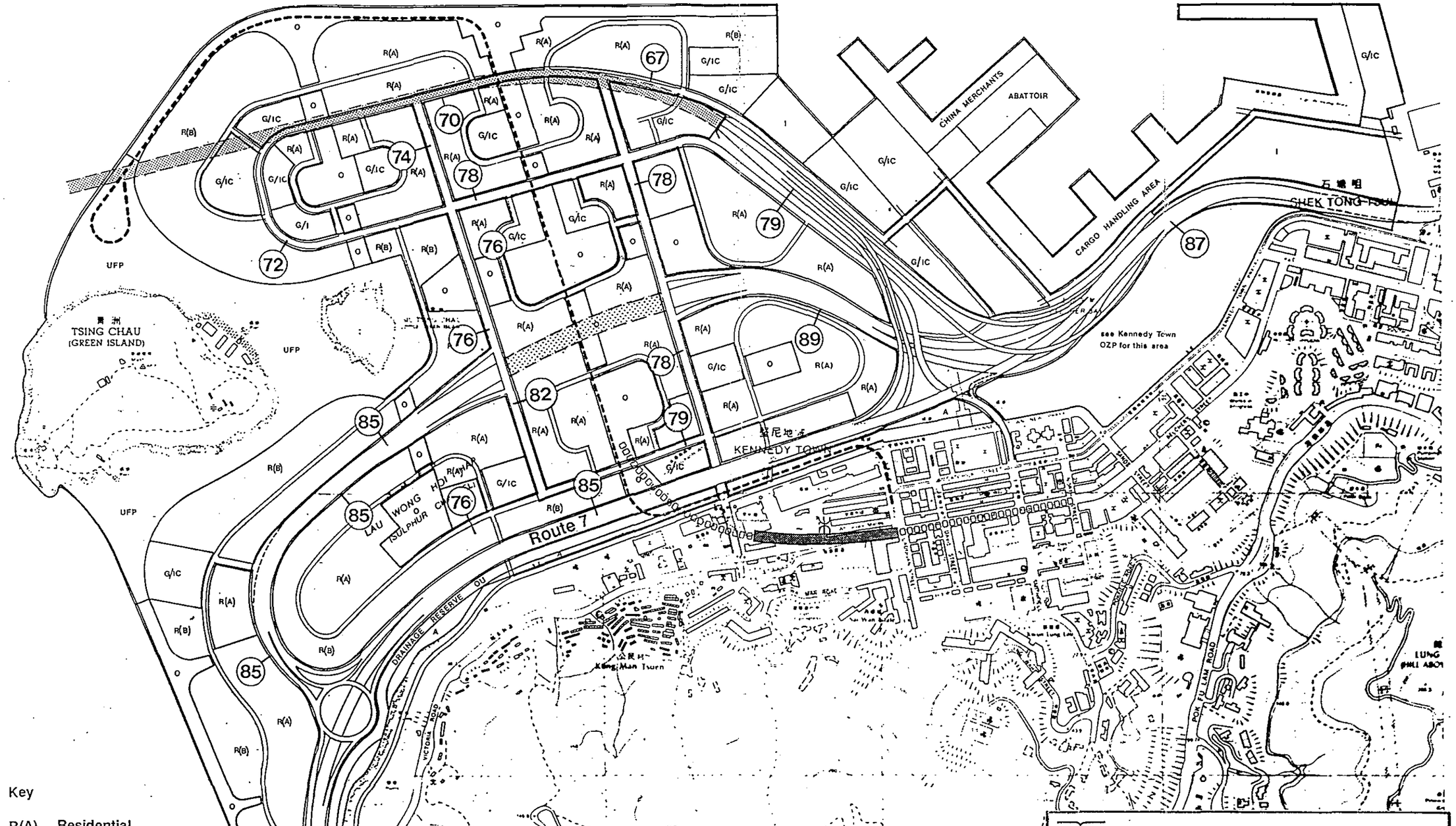

Key

R(A)	Residential
R(B)	Residential
O	Open space
UFP	Urban Fringe Park
G/IC	Government, Institutional, Community
(78)	Predicted sound pressure level during peak hour at 10m from carriageway edge (dB(A))

Scale
0 100 200 300m

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Predicted 'worst case' traffic noise levels

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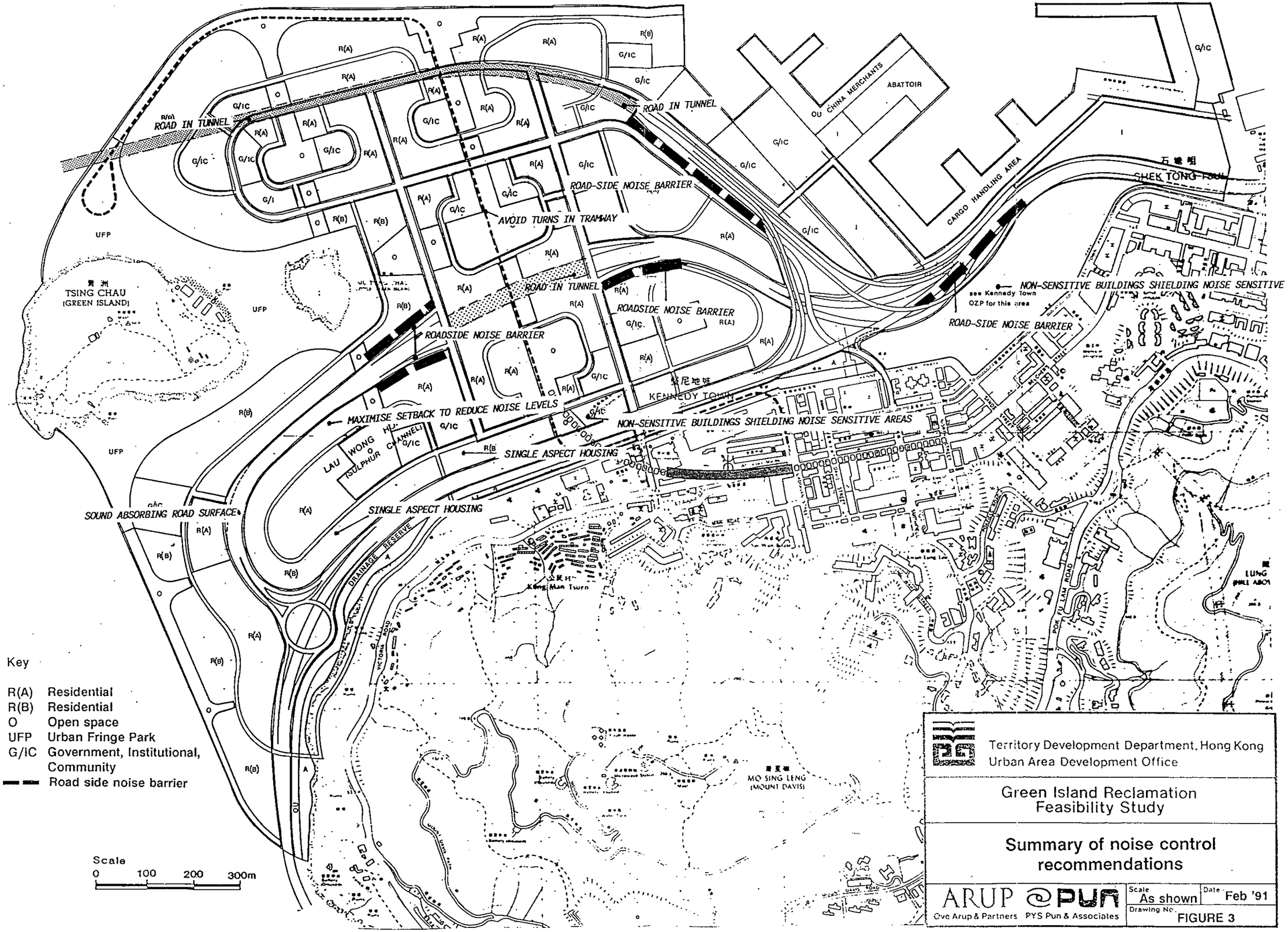
Scale: As shown
Date: Feb '91
Drawing No: FIGURE 2



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Summary of noise control recommendations

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Scale: As shown
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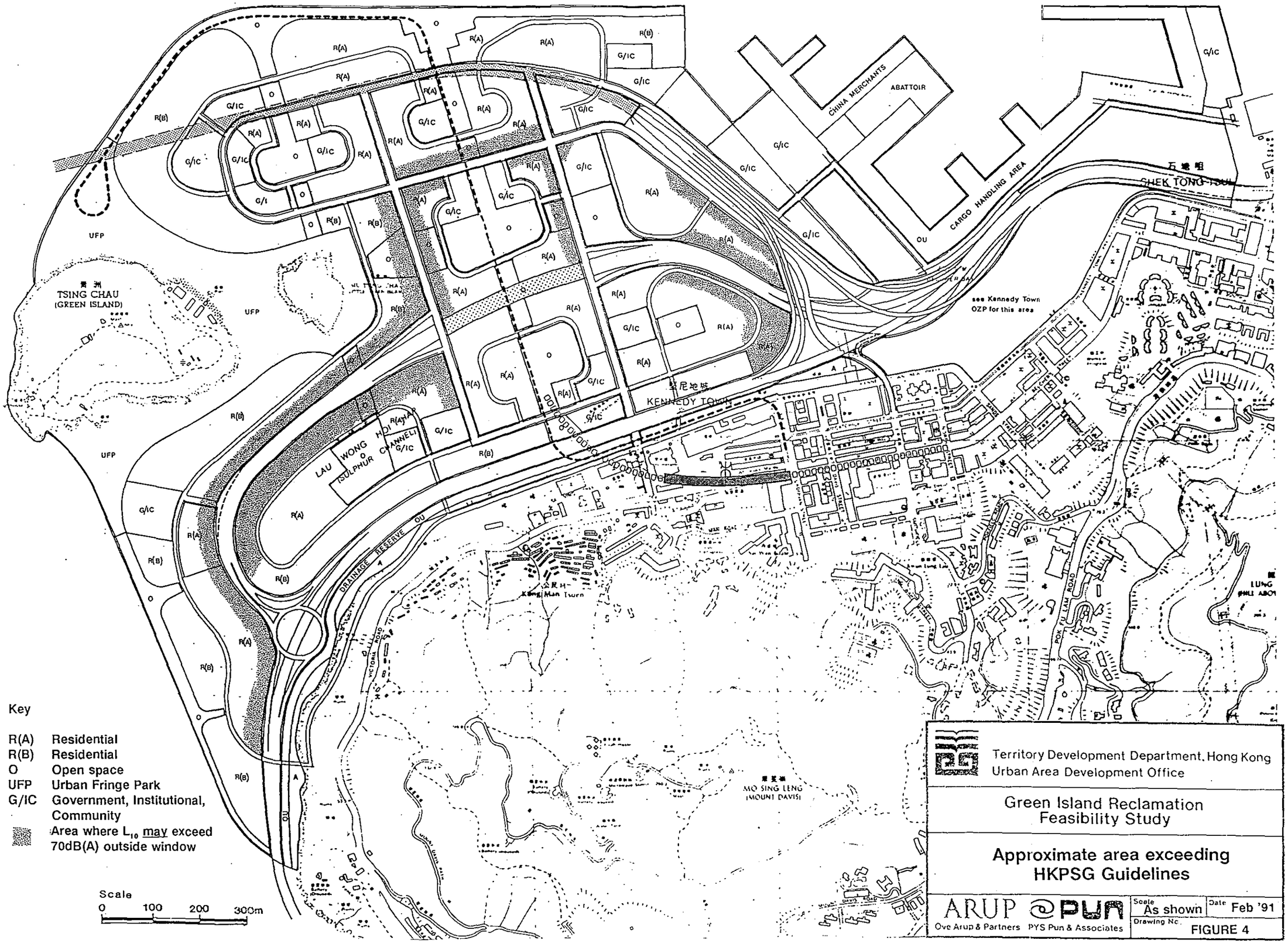
Drawing No.: FIGURE 3



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Approximate area exceeding HKPSG Guidelines

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Scale: As shown | Date: Feb '91

Drawing No. FIGURE 4

APPENDIX A

SAMPLE TRAFFIC NOISE CALCULATIONS

ARUP ACOUSTICS

Traffic Noise Calculation to CRTN 1988
using hourly flows

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date: 20-Feb-1991
Job ref: 20406/70
Description: GREEN ISLAND TRAFFIC NOISE
PRIMARY DISTRIBUTOR - TO ADJOINING RESIDENTIAL AREAS

Segment No: 1 Basic noise level:	Comment	Data		Correct. Fact	
vehicles per hour		5775		79.82	
mean speed (kph)		70			
% HGV		50	6.07		
gradient		0		.00	
change in mean speed			0		
corrected mean speed		70		6.07	
Comment		ok			
Road Surface Type	Pervious	4		-3.50	
Texture Depth (Concrete only)		2			
View angle (deg)		180		.00	
TOTAL BASIC NOISE LEVEL					82.4
ADD FACADE EFFECT				2.50	84.9
UNOBSTRUCTED PROPAGATION: HARD SURFACE					
HORIZ. DIST. TO RECEIVER (EDGE OF CARRIAGEWAY)		10			
RECEIVER HEIGHT ABOVE ROAD		1.5			
SLANT DISTANCE TO RECEIVER		13.54		-.01	
NOISE LEVEL INCLUDING FACADE EFFECT					84.9

ARUP ACOUSTICS

Traffic Noise Calculation to CRTN 1988
using hourly flows

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date: 20-Feb-1991
Job ref: 20406/70
Description: GREEN ISLAND TRAFFIC NOISE
NORTHERN LOCAL DISTRIBUTOR - TO ADJOINING RESIDENTIAL AREAS

Segment No: 1 Basic noise level:	Comment	Data		Correct. Fact	
vehicles per hour		368		67.86	
mean speed (kph)		50			
% HGV		30	3.22		
gradient		0		.00	
change in mean speed			0		
corrected mean speed		50		3.22	
Comment		ok			
Road Surface Type	Pervious	4		-3.50	
Texture Depth (Concrete only)		2			
View angle (deg)		180		.00	
TOTAL BASIC NOISE LEVEL					67.6
ADD FACADE EFFECT				2.50	70.1

UNOBSTRUCTED PROPAGATION: HARD SURFACE			
HORIZ. DIST. TO RECEIVER (EDGE OF CARRIAGEWAY)	10		
RECEIVER HEIGHT ABOVE ROAD	1.5		
SLANT DISTANCE TO RECEIVER	13.54	-.01	
NOISE LEVEL INCLUDING FACADE EFFECT			70.1

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