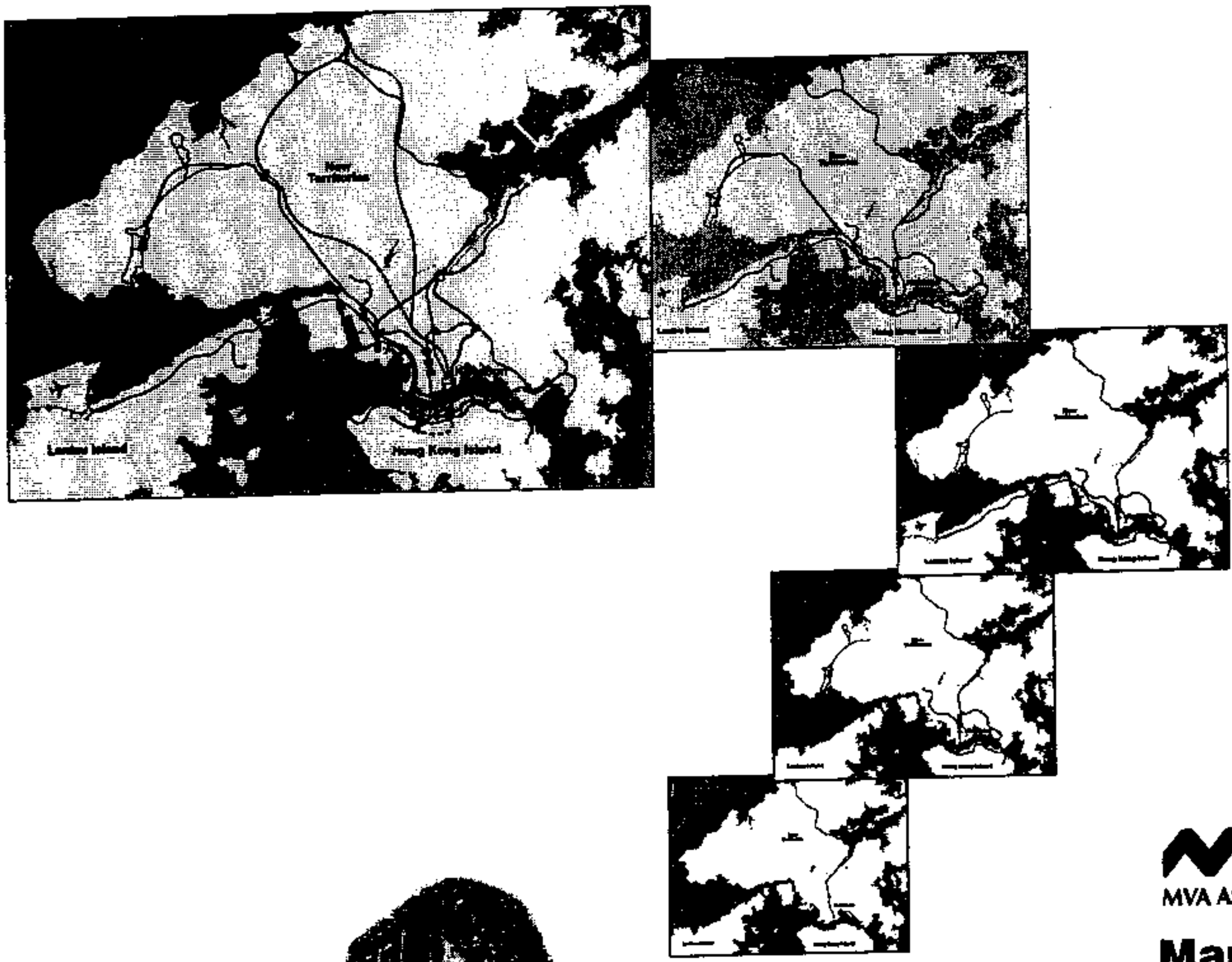
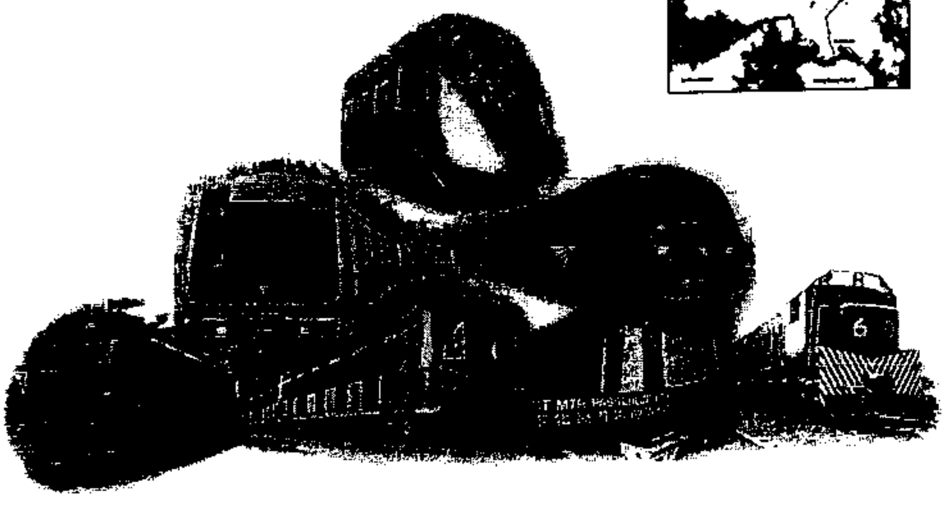
Annexe B

Comparative Assessment of Road Versus Rail





MVA ASIA LIMITED

Maunsell

in association with

Brooke Hillier Parker
Deutsche Bank
ERM Limited
FSDI of MOR
GHK (Hong Kong)
Kennedy and Donkin Ltd.
Murray Harrison Ltd.
Parsons Brinckerhoff (Asia) Ltd.

ANNEXE B COMPARATIVE ASSESSMENT OR ROAD VERSUS RAIL

1. INTRODUCTION

1.1 Background

1.1.1 The Study Brief for the Second Railway Development Study (RDS-2) made provision for a number of Key Issue Papers to be prepared as part of the Strategic Environmental Assessment (SEA) Study. The Papers were to address areas or issues of concern or interest arising from the SEA Study, in particular, the need for, and environmental justification of, new railways and associated infrastructure.

1.1.2 The first of these papers entitled "*Economic Appraisal of the Environmental Costs and Benefits of New Railways*", is included as Annexe A of this report. The paper introduced the concept of economic appraisal of new railway projects in a manner that allowed for their environmental costs and benefits to be explicitly considered during decision-making on whether to proceed or not with a new project.

1.1.3 Under the existing appraisal process, new railway projects which do not attain the desired financial criteria set by the Administration are not approved for construction; such a system does not allow for the consideration of the environmental "opportunities" which railways provide. On the basis of an international review, Annexe A presented examples of economic appraisal methods being applied for similar purposes in other developed countries and indicated the opportunities and constraints associated with applying such international experience to Hong Kong.

1.2 Purpose of the Paper

1.2.1 This annexe was previously published as *Discussion Paper No. E10* and seeks to identify and outline the environmental benefits accruing from railway developments.

1.2.2 As stated in the Inception Report, the subject of the paper was to "*comprise an overview of the principles and criteria involved in the environmental comparison of road and railway developments with a view to presenting the environmental benefits of railways in terms of air and noise emissions and the constraints imposed upon railway developments through application of the statutory process in Hong Kong*".

1.2.3 Whilst the comparisons of air and noise constraints are considered in full (in *Sections 3* and *4* respectively), the SEA Study Team have also included the consideration of a range of other environmental aspects where rail development may offer advantage (or be disadvantaged) over alternative transport modes; the scope of the paper has been broadened, therefore, to include hazards, greenhouse gas/energy considerations, landtake issues and project appraisal procedures. These will be covered in successive chapters of this document, although to take up where Annexe A left off, the discussion will first centre on the ways in which the appraisal of road and rail projects differ.

1.3 Comments on the First Draft of Discussion Paper E10

1.3.1 The first draft of *Discussion Paper E10* was issued in August 1999 and was circulated to a wide range of Government Departments and Branches. As a discussion paper, it was not intended that the document would be revised in light of the discussion and comments provoked by its content. However, such was the interest in the issues raised, that the Paper has been revised with the intention of providing technical clarification, correcting factual errors and providing additional information in areas of particular interest.

1.3.2 It is not the Consultant's intention that each of the comments received on *Discussion Paper E10* is responded to individually in this revised version; to do so would, require detailed technical studies that lie outside the scope of the current RDS-2 Study. However, a number of general points regarding the basis of the comparison undertaken in this paper are provided in response to the issues that were raised by commentators.

1.3.3 *Discussion Paper No. E10* has considered only the present trends in the implementation and management of road and rail schemes in Hong Kong; similarly, current technology has been considered when assessing the comparative environmental performance of alternative transportation modes.

1.3.4 The potential benefits of future technological solutions have been largely discounted as the implementation of such solutions will require concerted political will if they are to be implemented at a scale sufficient to achieve the improvements offered. Whilst various improvements and mechanisms (such as cleaner fuel for road vehicles, improved road management, etc.) are available for immediate implementation, recent attempts to introduce controls in this area have foundered in the face of opposition from a range of interests, which collectively might be termed the "road-lobby". Such improvements (if and when implemented) may render future road-based transport services more efficient, reliable and environmentally friendly. However, it is unlikely that the environmental performance of road-based transport will be improved in absolute terms if the current trends in the expansion of vehicle numbers continue.

1.3.5 It should also be noted that, as with road transportation, current trends in the improvement of the energy efficiencies of railways and the introduction of technological solutions provide significant opportunities to further improve the environmental performance of railways. For example, the use of more efficient and cleaner fuels in power stations, safer and more efficient rolling stock and station design (e.g. reduced energy costs with the installation of platform doors). These factors will provide considerable improvements to the environmental performance of railways that may well, at least, match those achieved by road-based systems.

1.3.6 The Consultants' primary focus has been on strategic policy making and the intended purpose of the Discussion Paper was the stimulation of debate within the various departments of Government that hold responsibility for the strategic planning, implementation and management of transportation. It was not intended that the Discussion Paper provide a detailed prescriptive manual for shifting the Administration's priorities away from roads and towards railways.

1.3.7 The identification and implementation of solutions to the issues raised form part of the challenge associated with the Administration's stated intention to give preference to rail over road-based forms of transportation provision.

1.4 Structure of the Paper

1.4.1 The remainder of this Paper is structured as follows:

- *Section 2* describes the current methods of project appraisal and examines the different manner in which these are applied to rail and road schemes;
- *Section 3* presents a comparison of the air quality implications associated with road and rail schemes and the transportation of freight by these means;
- *Section 4* presents the results of an international review of operating railway noise criteria and compares the noise 'dose' emissions associated with road and rail schemes;
- *Section 5* examines the differences in the landtake between road and rail schemes and reviews the environmental implications of these differences;
- *Section 6* provides a review of the key differences between road and rail schemes in terms of hazard and risk management issues; and
- *Section 7* presents a summary of the findings and conclusions of the Paper.

2. PROJECT APPRAISAL OF TRANSPORT PROJECTS

2.1 Introduction

2.1.1 Given the demonstrable environmental advantages that arise from the development of new railways in preference to new roads, a review of the approaches that have traditionally been employed in Hong Kong for the appraisal of highway and railway projects has indicated that there appears to be a number of differences in appraisal which seem to favour road construction.

2.1.2 At a strategic transport planning level, CTS-3 looked into the economic return of strategic highway projects. At implementation stage, highway projects are normally funded out of the Public Works Programme (PWP) and "bid" for funding based on need and transport performance. Occasionally, projects are considered for privatisation such as harbour crossings or tunnels if they can be shown to be financially viable. If not, they are included for prioritisation in the PWP as Government infrastructure projects.

2.1.3 Railways are subjected to economic appraisal which takes into account the capital and operating costs and benefits to all affected users. Railway projects are also subjected to financial appraisal, initially to be funded from fare revenue. The guidance of operating railways under prudent commercial principles could often present financial hurdles for potential rail projects when the financial returns from the projects did not meet set criteria. The Government will need to provide support to less viable railway projects if the perception of promoting the environmentally friendly rail mode of transport is to be realised.

2.2 Economic Evaluation

2.2.1 Within a comprehensive framework such as that used in RDS-2 or CTS-3, the evaluation process applied to a proposed road and rail scheme includes mainly transport variables. However, in the wider context, the appraisal systems being used at the present time militate against rail investment because environmental factors are omitted from the quantifiable framework that is currently being used. An example of this relates to 'air quality benefits'. However, before the methodology for the assessment of these factors is fully established, they can only be estimated in rough orders. Nevertheless, the earlier discussion clearly demonstrates that railways are more efficient in terms of their emissions of Nox, RSP and CO_2. These lower emissions could have an effect on Hong Kong's overall air quality and thereby provide benefits in terms of reduced impacts to health, reduced damage to crops/agriculture and possibly even influence Hong Kong's attractiveness to tourist or businesses considering locating in Hong Kong. However, under the current evaluation systems that are being used, such environmental benefits are not considered, and as such, railways are being "undersold" in the evaluation. The inclusion of a wider economic appraisal, and in particular consideration of the environmental benefits, would allow a more holistic assessment of the proposed developments to be undertaken, and thereby provide decision makers with useful information to assist in the project selection process, minimise the negative environmental consequences that can be associated with transport provision, and assist with achieving broader environmental/sustainable policy goals.

2.3 Financial Evaluation

2.3.1 The financial evaluation of railways provides an assessment of the project internal rate of return from fare revenues, initially with no financial support from Government. The railway costs cover all infrastructure and recurrent costs.

2.3.2 As the principle road based mode of public transport, the bus operators pay no taxes for road usage, fuel or first registration. Therefore bus operators only have to cover vehicle supply and operations maintenance and depot costs and in effect have free "track" or infrastructure. This enables bus operators to hold down fares and capture a large market share. This meets a policy objective of promoting public transport, although it reduces rail patronage and revenues and worsens the railway financial position.

2.3.3 On the other hand, major railway projects are treated as public sector investment. Government flexibly seeks ways to implement railways through equity injections, property development rights, and supportive public works. Railways are funded from the Capital Investment Fund which has different criteria in its application than the Capital Works Reserve Fund for PWP.

2.4 Comparison of Road and Rail Appraisal Procedures

2.4.1 The inconsistencies between the evaluation of highway projects and public transport projects approaches are illustrated graphically in Figure 2.1. For the economic evaluation of highway schemes (as illustrated in Figure 2.1), the benefits are measured by the two shaded areas, the area to the left indicating the benefits to existing users, and the shaded triangle to the right indicating the benefits to new users from new vehicle trips. Although the balance between these two components varies according to the exact nature and location of the scheme being examined, typically in a busy urban area, the benefits to existing users would represent a large proportion of the total.

2.4.2 For public transport users, including rail passengers, the financial evaluation is based solely on the increase in revenues generated by the new project. Given a fixed tariff structure, this only arises in connection with new journeys, and for these it only represents a part of the overall journey cost. In the lower portion of Figure 2.1, this is reflected by the shaded area to the bottom right of the graph. Typically, this would be much smaller in comparison to that referred to in the preceding paragraph relating to the benefits to new users from highway projects.

2.5 Discussion

2.5.1 While a full-scale critique of the alternative approaches to evaluation, and the potential impact of these, is outside the scope of this study, it should be noted that the two approaches do give different results. It is therefore important that good railway schemes would not be militated by the differences in the evaluation approach.

2.5.2 Given the discussion above, it is suggested that, when considering railway proposals, greater emphasis should be placed on the potential environmental benefits. The overall adverse environmental impacts of railway developments are far less than those of roads. Coupled with the community benefits that can be demonstrated to be provided by railway projects and the Administration's desire to adopt more sustainable approaches to the future development of Hong Kong, placing emphasis and giving priority to railway projects would serve to fulfil a basic tenet of this philosophy. Including environmental and potential community benefits in the economic evaluation of railway projects would further enhance their economic returns. This will help to justify the investment in the new railway projects and their early implementation, hence meeting the Administration's goals of expanding the rail network and improving the environmental (and in particular air quality) conditions in Hong Kong.

3. AIR QUALITY IMPLICATIONS - ROAD VERSUS RAIL

3.1 Introduction

3.1.1 This section examines the principal air pollutants generated by road- and rail- based forms of transport and discusses the relative means by which controls on these sources are achieved.

3.1.2 A methodology to allow the comparison and evaluation of the emissions generated by road and rail sources in terms of the pollutants NOx, RSP and CO_2 has been defined and the results of a preliminary comparison are presented.

3.2 Differences in Pollutants and Regulatory Controls

3.2.1 Various international studies[1] have been commissioned to investigate and evaluate the comparative performance of different modes of transport in terms of environmental impacts. Differences in methodology, assumptions and the appropriateness of the information/data used have ensured that these previous studies have produced a range of conclusions, particularly in the reporting of performance data for air pollutants.

3.2.2 Road- and rail-based transport generate different types of air pollutants. Road vehicles are a major contributor to particulate matter (in Hong Kong known as Respirable Suspended Particulates or RSP) and nitrogen oxide (NO_X) emissions as well as a significant contributor to carbon dioxide (CO_2) emissions. Railway rolling stock on the other hand, result in very few (measurable) emissions at source, although indirect emissions of pollutants from power stations which provide the traction power required to operate the railway relate primarily to CO_2 emissions with lesser emissions of RSP and NO_X.

3.2.3 In addition to the different pollutants arising from the two modes of transport, there is also a different spatial distribution of the emissions as well as a difference in the numbers of sources. Emissions from the numerous types of road vehicles (there were 558,903 Hong Kong registered vehicles in 1997) are discharged at a low (street) level into the immediate surroundings and thereby directly contribute to local air quality conditions. By contrast, emissions from rail transport are indirect, and are discharged at the relatively few (four in 1997) power station locations in the Territory. As these emissions are discharged at a much greater height and away from urban centres, the emissions are generally considered to affect the Territory-wide or regional air quality rather than local air quality conditions.

3.2.4 The different sources of air pollutants as well as the vast differences in numbers of emitters in each case also gives rise to disparity in the manner and ease with which regulations can be enforced. For road vehicles, the Transport Department is responsible for the licensing and annual road-worthiness checks of vehicles (including air pollutant emissions for diesels) whilst between checks, the Police Department under the Road Traffic Ordinance have jurisdiction for the identification and enforcement of vehicles with excessive emissions. This is supported by the voluntary "smoky vehicle spotter" campaign co-ordinated by the EPD. The "visible" check on emissions provided by the smoky vehicle spotter programme is therefore limited to emissions of "black smoke or visible vapour" and therefore pertains primarily to particulate pollutants.

1 For example see: World Highways/Routes Du Monde Journal, "Green Light for Road Traffic", September 1995, p45

3.2.5 For power stations, air pollutants are much more strictly monitored and controlled. Stack emissions of CO_2, SO_2, NO_X and RSP from the newest power stations are continuously monitored by the EPD using telemetry equipment to provide a real-time readout of pollutant concentrations. In addition, a comprehensive operational monitoring and auditing of environmental performance is required. This is augmented by the formal publishing of environmental performance standards and achievements each year as part of a Corporate or "Green" Reporting Programme undertaken by companies.

3.3 Policy and Legislation

3.3.1 The principal legislation for the management of air quality is the Air Pollution Control Ordinance (APCO) which stipulates the Air Quality Objectives (AQOs) which must be met at all locations in the SAR. The AQOs outline the statutory limits on concentrations of a number of air pollution parameters; namely, SO_2, NO_2, CO, TSP, RSP, O_3 and Pb which are known collectively as the criteria air pollutants. The focus applied by the SEA team are the emissions arising from road and rail sources; those being RSP and NO_2.

3.3.2 Although the SAR is presently not a signatory of the Framework Convention on Climate Change (FCCC), the Government is investigating the potential for meeting the Kyoto Protocol which calls for the industrialised nations to reduce their average national greenhouse gas (GHG) emissions over the period 2008-2012 to 5% below 1990 levels. While carbon dioxide is not a controlled pollutant under the APCO, the Administration recently commissioned a study[2] to investigate the potential for GHG reductions in the SAR that will include CO_2.

3.3.3 Since 1992, the Hong Kong Government has been compiling a greenhouse gas annual inventory. Hong Kong is similar to other developed countries where emissions of CO_2 arising directly from the combustion of fossil fuels constitutes approximately 90% of the overall inventory. For the analysis being conducted within RDS-2 which focuses on the transport sector as a subsection of the wider economy, it is therefore considered appropriate to limit the determination of GHG emissions for railways to that of CO_2 alone.

3.4 Comparison of Passenger Related Rail and Road Air Quality Emissions

3.4.1 There are various approaches which have been previously used and could be adopted to compare rail and road-related emissions from the transportation of passengers. However, the methodology adopted should be chosen based on its appropriateness to the aims of the study and the information that is currently available. The two modes of transport are reported differently in terms of their performance and so a fundamental part of the methodology must be to identify a common unit in which performance can be expressed which does not compromise either of the two subjects.

3.4.2 The method adopted for this study and which will provide a common basis for the emissions comparison is the estimation on a per passenger-per kilometre travelled basis which, in other words, is a measure of the "pollutant efficiency" of each transport type. A note to be borne in mind is that this approach is heavily influenced by the assumed occupancy rate of both vehicles and trains, as well as the emissions technologies utilised for these modes of transport. However, to ensure the assumptions used are grounded on robust data, information on occupancy have been obtained from proprietary Government sources for the year 1997.

---

2 The Greenhouse Gas Emission Control Study

3.4.3 A particularly novel aspect of the proposed approach is to take into account the emissions generated by power stations in the calculation of emissions by railways. This has been achieved by obtaining data direct from the two railway corporations on historical energy usage as well as the published annual information provided by power companies in Hong Kong in order to determine the percentage of total power used by the railway sector and hence, derive appropriate estimates of emissions.

3.4.4 Further efforts to improve upon the proposed methodology could be attempted by perhaps addressing the additional emissions from power stations, which might result from the future additional energy that would be required to be generated if more railways were developed. However, the proportion of total power generated used for railway operation (around 5% in 1997) and the currently reported additional capacity being already generated would suggest that, even if this were able to be accurately calculated, the expected additional increases in pollutants would likely be very small.

3.4.5 The methodology and the assumptions used in the estimation of emissions from rail based transport are as follows:

- the consideration of rail share, the total numbers of stations and length of rail track in 1997;
- information on historical (1997) electricity usage obtained from railway operators;
- the magnitude of electricity consumed by rail as a proportion of the total electricity generated by a power company (CLP was used as a proxy for the whole Territory because the coal-gas fuel mix is considered more representative of future conditions in Hong Kong);
- the application of the percentage electricity used by rail to the annual emissions output measured by the power company to arrive at an estimate of those emissions generated by rail operations; and then,
- dividing the total rail emissions by the total number of passenger-kilometres travelled in one year, in this case 1997, based on information provided by the rail operators.

3.4.6 This approach provided emission estimates for each railway operator in Hong Kong; these were subsequently combined using a weighted average of the total rail trips (PKT) associated with each railway operator in 1997. The results are shown in *Table 3.1* below.

3.4.7 The methodology and the assumptions used in the estimation of emissions from road based transport are as follows:

- the consideration of total vehicle kilometres travelled (VKT) in 1997 and contribution by various vehicle types;
- EPD data for NO_X and RSP emissions per kilometre travelled for the various categories of vehicle type e.g. taxi, private car, public light bus, single and double decker air-conditioned bus (estimated based emissions in 1997);
- CO_2 emissions estimates were derived using fuel consumption data from Transport Department (TD), Kowloon Motor Bus (KMB), CityBus (CB) and USEPA's Fuel Economy Guide (Model Year 1999) with the general assumption of 2.4 kg CO_2 emissions arising per litre of fuel consumed;

- dividing emissions per kilometre travelled by average occupancy figures (number of passengers per vehicle) for various vehicle categories using data from the Annual Traffic Census 1997 to obtain pollutant emissions on a per passenger-per kilometre travelled basis;
- no allowance has been made for illegally high emissions from badly maintained road vehicles; and
- no allowance was made for emissions associated with the generation of electricity used to power night-time lighting of roads, traffic management facilities (traffic lights, electronic display boards, etc.) or road transport infrastructure or facilities such as tunnel ventilation, bus stations, public transport interchanges, toll plazas, etc.

3.4.8 As for rail, the emission estimates derived were unique to each vehicle category and were subsequently combined using a weighted average approach based on the contribution to total passenger kilometres travelled (PKT) in Hong Kong in 1997 (Traffic Census data).

Table 3.1 Road vs Rail Emissions Comparison (grams per passenger-per kilometre)*

Mode	Sub-Category	CO_2	NO_X	RSP	Split (%)
Rail	***Weighted Average***	***46.57***	***0.21***	***0.007***	
Road	Cars	213.92	1.25	0.029	16.36
	Taxis	147.57	0.82	0.342	13.03
	PLB	38.02	0.19	0.061	12.25
	SDB	76.99	0.87	0.107	7.98
	DDB	35.81	0.27	0.033	50.38
	Weighted Average	***83.07***	***0.54***	***0.082***	

Note: PLB = Public Light Bus
SDB = Single Decker Bus

3.4.9 Regarding the criteria air pollutants, it can readily be seen that weighted average NOx emissions from road transport are approximately 2.5 times greater than rail while RSP emissions from road are about 10 times greater than rail. In reality, the RSP emissions resulting from road transport should be even greater than shown above, as the emissions associated with vehicular trafficking of road surfaces, resulting from the wearing of the road surface as well as breakdown of ambient dust particles on the road, are excluded from this assessment. Regarding the adopted GHG indicator pollutant CO_2, rail transport is approximately twice as efficient as road based means.

3.4.10 From a disaggregated perspective, only NOx emissions from public light buses (PLB) and double decker buses (DDB) are comparable to that of rail. Regarding RSP emissions, the lowest road based emitter is the private car which is still more than 3.5 times greater than the maximum emission of RSP from rail sources while for CO_2 again only the PLB and DDB are comparable. The better performance of rail based means is likely due to a combination of high occupancy, cleaner fuels and the advanced forms of pollution control equipment applicable to power station installations while the performance of the comparable road vehicles, the PLB and the DDB, most likely result from their relatively high occupancy rates alone.

3.5 Generic Comparison of Air Quality Emissions from the Transportation of Freight by Road and Rail

3.5.1 The preceding sections have discussed the air quality implications of transporting passengers by road and rail. However, the scope of RDS-2 also covers the consideration of moving freight by rail. Therefore, an assessment has been undertaken to provide a generic comparison of the quantities of air pollutants that would be likely to be generated during the transportation of a defined quantity of freight a defined distance by means of road based transportation and by rail. For the analysis, it is assumed that a lorry carries, on average, 1.5 TUE, whereas a train can carry 64 TUEs. Consequently, it can be assumed that transporting 64 TUEs 1 km by train is equivalent to 42.7 lorries (with a load of 1.5 TUEs) travelling 1 km each.

3.5.2 Using the standard emission figures presented in Table 7.6 (for grams per kilometre travelled by Heavy Goods Vehicles) it was possible to determine the emissions that would result from the lorry transportation of 64 TUEs of freight over 1 km. The results are outlined in Table 3.2.

Table 3.2 Emissions from Heavy Goods Vehicles (kg/km)

Pollutant	Emissions per km (kg)	Equivalent per km Emissions from the Transporting 64 TUEs by Lorry (kg)
NOx	0.00384	0.164
RSP	0.00053	0.023
CO_2	1.033	44.109

3.5.3 In comparison the air quality emissions that would be associated with transporting 64 TUEs of freight 1km by rail were also assessed. This was determined by using emissions data from the CLP Annual Environmental Report for 1996/7 and data on the total kilometres travelled by KCR trains in 1996.

3.5.4 The CLP report detailed the total emissions from the generation of electricity. These are defined in Table 3.3.

Table 3.3 Total CLP Emission (Tonnes)

Pollutant	Total CLP Emission (Tonnes)
NOx	53,083
RSP	1,658
CO_2	11,551,000

3.5.5 The CLP report detailed the proportion of traction power that was consumed by KCR trains. From this data, it was possible to determine the CLP emissions that were due to the traction power requirements of the KCR trains. These data are defined in Table 3.4.

Table 3.4 CLP Emissions due to Energy Consumption for Traction Power (Tonnes)

Pollutant	KCR Generated Emissions (tonnes)
NOx	509
RSP	16
CO_2	110.750

3.5.6 As it is known that the total KCR train kilometres travelled in 1996 was 9,368,000 it, is possible to determine the KCR emissions per train kilometre travelled. These are presented in Table 3.5.

Table 3.5 KCR Emission per Train Kilometre Travelled (kg)

Pollutant	Emissions per Train km (kg)
NOx	0.054
RSP	0.002
CO_2	11.823

3.5.7 From the above calculations, it can be seen that, when comparing the transportation of an equivalent volume of freight over an equivalent distance, rail results in lower emissions of NOx, RSP and CO_2. Hence, in principle, the transportation of freight by rail represents a potential means of accruing air quality benefits.

3.6 Conclusions

3.6.1 This section of the paper has reviewed the predominant types of air pollutants generated by the two forms of transport, road and rail, and discussed the different means by which the two transport modes are regulated and controlled with respect to their emissions. Road vehicle sources are considered to have a direct impact on the local air quality conditions given their presence and discharge of emissions at street level. As such, road vehicle emissions have direct potential effect on urban residents. Power station emissions, by contrast, are more dispersed by nature of the height at which they are discharged and therefore typically regarded to affect the regional air quality.

3.6.2 The ability to regulate and control emissions from the various forms of transport has been reviewed. It is contended that the effective control of emissions from a wide ranging and large vehicle fleet is more problematic than the control of a much smaller number of sources as the power stations present. The disparity is brought into even greater focus by the current difference in methods used to achieve regulation in each case; random emissions checking of diesel vehicles augmented by voluntary assistance from the community in the case of road vehicles compared with the real-time information which the EPD is able to access from the newest of Hong Kong's four operating power stations.

3.6.3 The Section proposed a methodology for comparing the emissions from passenger related road and rail sources and it is suggested that a comparison based on pollutant "efficiency" or emissions on a per passenger-per kilometre travelled basis is the most appropriate unit of comparison. A novel aspect of the methodology adopted is that it takes into account the pollutant emissions generated (off-site) by power stations for the rail pollutant case.

3.6.4 The results of the emissions comparison indicate that rail transport is generally more efficient than road transport in terms of the analysed air pollutants of NOx, RSP and CO_2. It is evidenced that weighted average NOx emissions from road transport are approximately 2.5 times greater than rail, RSP emissions from road are about 10 times greater than rail and CO_2 emissions from road about two times greater than rail. Disaggregation of the weighted averages reveals that the performance of public light buses and double decker buses may be comparable to rail except for RSP emissions, although in all categories of pollutants, the better performance from these types of vehicles is substantially degraded by the poor performance of others including private cars, taxis and single decker buses.

3.6.5 Of the three pollutants studied, RSP stands out particularly as showing the greatest disparity between road and rail modes, even with the assumption that vehicular trafficked dust (which is expected to be a major source of RSP) has not been included. RSP is particularly prevalent in Hong Kong as indicated by a long term exceedance of the annual average AQO requirements and its control presents a serious challenge for the future of Hong Kong. Clearly, from the analysis presented, the provision and promotion of rail as a more sustainable form of mass transit has an important role to play in the curtailment of existing problems, although as intimated in the discussions in *Annexe A* and in the comparison of network options, a sustainable solution to the problem will require a strategic and cross-sectoral approach, rather than efforts focussed solely on one sector or another.

3.6.6 In addition to the passenger related assessment, and investigation was also undertaken into the generic air quality implications that are related to transporting freight by road and by rail. The assessment demonstrated that, in principle, the transportation of freight by rail represents a potential means of accruing air quality benefits; with NOx and CO_2 emissions from road related freight transportation being approximately 3 times greater than rail, and RSP emissions from road being about 11 times greater than rail.

3.6.7 However, as has been set out in the discussion on the PRL (see Section 7.5 of the main SEA Report), the actual situation is not so straight forward. There are economic and practical reasons why (especially reasonably localised) road based freight would not switch to using rail. In addition, road based transportation will probably be required to deliver and distribute the freight to and from the rail terminal. These road based movements will reduce the magnitude of any potential air quality benefits that could be accrued from transporting freight by rail.

4. NOISE PERFORMANCE CRITERIA - ROAD VERSUS RAIL

4.1 Introduction

4.1.1 This Section provides a comparison of noise criteria, which are applied to road and rail traffic noise within Hong Kong. The criteria are compared in two ways. First, the maximum acceptable noise levels for each source are expressed in the same units, and compared directly in terms of physical noise exposure; the unit used for comparison will be the maximum one hour A-weighted equivalent continuous energy level ($L_{Aeq,30min}$ (dB)). Secondly, the impact of each noise source, at a level equivalent to the relevant criterion, is compared using social survey data. In addition, each of the relevant criteria is compared with criteria applied internationally for the same noise source.

4.2 Comparison of Criterion Noise Levels

Road Traffic Noise Criteria

4.2.1 For road traffic noise, relevant noise level criteria are expressed in terms of an index of the A-weighted noise level which is exceeded for ten per cent of the time during the peak hour traffic ($L_{A10,peakhour}$ (dB)) and is enforced for new highways by the Environmental Impact Assessment Ordinance and its subsidiary Technical Memorandum (EIA O TM). These are shown in Table 4.1 below.

Table 4.1 EIA O TM Road Traffic Noise Criteria ($L_{A10,peakhour}$ (dB))

Resource Type	Criterion
Domestic Premises	70
Hotels and Hostels	70
Offices	70
Educational Institutions	65
Places of Worship and Courts of Law	65
Hospitals, Clinics and similar institutions	55

4.2.2 It should be noted that whilst these criteria apply to new highways, no statutory control exists for existing highways that have either been subject to an intensification of use or were constructed prior to the introduction of environmental assessment procedures and the *Hong Kong Planning Standards and Guidelines* which first promoted the above criteria. Whilst the above criteria are to be achieved at the facade of a sensitive resource, where restrictions exist in the placement of effective mitigation measures at the roadside noise insulation can be used to mitigate residual impacts.

4.2.3 To provide an estimation of the $L_{Aeq,1hour}$ noise, the relationship with $L_{A10,1hour}$ follows the following approximate relationship:

$$L_{Aeq,1hour} = L_{A10,1hour} - 3\ dB$$

4.2.4 This relationship is generally accurate to within 0.5 dB for freely flowing traffic volumes greater than 200 vehicles per hour.

4.2.5 Noise levels from road traffic at other times (e.g. during evening and night-time periods) are not strongly related to the peak hour level. In contrast to the criteria for railways, the existing road traffic criteria provide no direct control over noise during these periods.

4.2.6 It should be noted that whilst there no specific noise trigger limits for legally defined enforcement abatement, or for imposing penalties for non-compliance, Section 11 (p) of the *Road Traffic Ordinance* does provide for the Commissioner for Transport to introduce traffic management schemes for environmental reasons. By the end of 1999, two such schemes had been implemented; both were local in application and related to heavy vehicle restrictions on particular sections of road.

4.3 Railway Noise Criteria

4.3.1 Railway noise criteria are expressed directly in terms of the L_{Aeq} noise level over the loudest 30-minute period during the daytime or evening (0700 - 2300 hours), and night-time (2300 - 0700 hours). Due to the generally regular nature of rail services, this can be assumed to be equal to the maximum value of $L_{Aeq,1hour}$ during these periods.

4.3.2 The railway criteria depend on the Area Sensitivity Rating (ASR) of a receiver, which is related generally to the level of noise from other sources, rather than the use of the receiver; except that the receiver must be a "Noise Sensitive Receiver", which includes all usage categories listed in Table 4.1 except offices. Table 4.2 below shows relevant criteria for rail traffic noise taken from the Noise Control Ordinance and EIA O TM.

Table 4.2 NCO and EIA O TM Railway Noise Criteria ($L_{Aeq,30min}$ (dB))

Area Sensitivity Rating	Daytime and Evening (0700 to 2300)	Night-time (2300 to 0700)
A	60	50
B	65	55
C	70	60

4.3.3 Unlike the EIAO TM criteria for road traffic noise, noise insulation is not a permissible form of mitigation. Accordingly, the railway operator must either limit his timetable or provide adequate "at source" mitigation measures to ensure the criteria are met at the external facade of the Noise Sensitive Receiver. Failure to comply will result in statutory abatement procedures being taken against the railway operator. No such statutory controls currently exist for the operation of highways.

4.4 Summary of Comparison

4.4.1 In comparing Tables 4.1 and 4.2, it can be stated in summary that in terms of $L_{eq,1hour}$ noise levels for the daytime period:

- the criteria for road traffic noise generally range from 62 to 67 dB(A), with the exception of a much lower criterion of 52 dB(A) for health-related institutions; and,
- criteria for rail traffic noise range from 60 to 70 dB(A), depending on factors related to the level of existing noise.

4.4.2 For a residential receiver in a location with an ASR of A, the daytime noise criterion for a new road development would be 67 dB(A), compared with 60 dB(A) for a new railway development. On the other hand, for a school in a location with an ASR of C, the relevant criteria would be 62 dB(A) for road traffic noise and 70 dB(A) for railway noise. However, in the latter case, the criterion for road traffic noise may in practice be higher, since existing noise levels may already be above the criterion.

4.4.3 Railways are also subject to additional criteria for night-time noise, which may result in much more stringent criteria than for road traffic noise, depending on the number of movements during this period.

4.5 Comparison of Noise Reaction

4.5.1 A number of studies have compared community reaction to road and rail traffic noise at the same L_{Aeq} noise level, the most comprehensive of which is by *Fields and Walker*[3]. The general conclusion of these studies is that railway noise is less annoying than road traffic noise at the same value of L_{Aeq}. This difference is generally expressed as a difference in L_{Aeq} noise level for the same level of noise reaction.

4.5.2 The extent of this difference cannot be stated precisely. The estimations given by *Fields and Walker*, using different studies and analysis methodologies, range from 4 to 15 dB(A). It is possible that the difference may be greater at higher noise levels, and may vary between countries[4]. However, a difference of 5 dB(A) in noise level to produce the same level of reaction can be taken as a conservative estimate.

4.5.3 Using this value, the Hong Kong criteria for railway noise are seen to be considerably more stringent than those for road traffic noise. The daytime criteria for residential resources, which would generally be numerically the most important receivers, are compared in Table 4.3 below.

Table 4.3 Comparison of Effective Daytime Noise Criteria for Residential Resources ($L_{Aeq,1hour}$ (dB))

ASR	Railway Noise Criterion	Rail Traffic Criterion Corrected For Lower Relative Reaction	Road Traffic Noise Criterion
A	60	55	67
B	65	60	67
C	70	65	67

4.5.4 For residential resources, the effective daytime rail traffic noise criteria in Hong Kong are 2 to 12 dB more stringent than road traffic noise criteria.

[3] Fields, JM and Walker, JG (1982) Comparing the relationships between noise level and annoyance in different surveys: A railway noise versus aircraft and road traffic comparison. Jnl Sound & Vibration 81(1), 51-80.

[4] Nelson, P (Ed) (1987) Transportation Noise Reference Book. London, Butterworths

4.5.5 For other land uses, the difference between criteria is less obvious. For instance, there is some indication that disturbance to speech communication may be similar for rail and road traffic at the same L_{Aeq} noise level, and hence for educational resources the two sets of criteria may be directly comparable. This would give effective criteria for educational institutions of 63 dB(A) $L_{Aeq,1hour}$ for road traffic noise and 60 to 70 dB(A) $L_{Aeq,1hour}$ for rail traffic noise. Given the other differences in criteria noted above, this may indicate a rough comparability in the stringency of these criteria for educational resources.

4.5.6 As stated above, there is a further night-time control in Hong Kong on noise from rail traffic; no such control is extended to road traffic. Whereas a review of night-time disturbances by *Moehler*[5] concluded that people are more tolerant to noise from railways than roads during sleep by 4 to 20 dB. The various studies reviewed by *Moehler* are shown in Table 4.4 below and indicate that people are around 10 dB more tolerant to railway noise at night than road traffic.

Table 4.4 Differences Between Levels of Road and Railway Noise for Equal Disturbance Reaction

Study	Disturbance Reaction	Noise Level Differential[1]
Holzmann (1978)	Interference at night	+6 to +11
Heintz et al (1980)	Interference with sleep	+4 to +20
PBO (1983)	Interference at night	+9 to +11
Vernet et al (1983)	Interference with sleep	+ ve
Knall et al (1983)	Disturbance to sleep	+12 to +14
Moehler et al (1986)	General disturbance Disturbance to sleep	+7 to +8 +12 to +14

Note: (1) Reported in $L_{Aeq,24hour}$ and $L_{Aeq,6hour}$ dB

4.6 Comparison of International Criteria

4.6.1 Table 4.5 below lists a selection of road traffic noise criteria in use in various other countries. These all represent daytime targets for residences, and various approximate conversion procedures have been used so that they are all presented here in terms of the $L_{Aeq,1hour}$ unit. From this table, it is clear that the least stringent criterion adopted in Hong Kong (for ASR C resources) of $L_{Aeq,30min}$ 70 dB is consistent with criteria adopted in a number of other countries, although toward the upper end of the range of criteria adopted in the European community.

5 Moehler U (1988). Community response to railway noise: a review of social surveys. Journal of Sound and Vibration, Vol. 120, Academic Press, London.

Table 4.5 Road Traffic Noise Criteria for Residential Resources in Other Countries ($L_{Aeq,1hour}$ dB)

Country	Status	Criterion
Australia (NSW)		62
Australia (Queensland & Western Australia)		67
Austria		67
Canada (Alberta)		70
Canada (Ontario)	Objective New Housing Prohibited	60 76
Denmark		60
France		70
Finland & Sweden	Objective New Roads	60 66
Japan	Environmental Standard Maximum Level	64 78
Netherlands	Objective Maximum Level	60 76
United Kingdom		70
Singapore		72
Switzerland	Planning Level Desirable Level Absolute Level	60 64 74
United States		69
WHO & OECD	Environmental Target	60

4.6.2 Table 4.6 below shows a comparison of criteria for rail traffic noise adopted in other countries[6]. This demonstrates that the railway noise criteria in Hong Kong are significantly more stringent than those operating in most other modern countries.

Table 4.6 Railway Noise Criteria for Residential Resources in Other Countries ($L_{Aeq,30min}$ (dB))

Country	Status	Criterion
Denmark	Design Guideline	63
Germany	Noise Insulation Trigger	54
Japan	Design Guideline	62
Norway	Recommendation	63
The Netherlands	Noise Insulation Trigger	54
Sweden	Noise Insulation Trigger	63
United Kingdom	Noise Insulation Trigger	65
United States	Design Guideline	68

Notes:
(1) The Netherlands criteria will be 3 dB more stringent after 1 January 2000.
(2) Comparison based upon the West Rail timetable relative to the "ASR B" night-time criterion of $L_{Aeq,30min}$ 55 dB.

6 J R Pyke and R Bullen, Prepared For KCRC West Rail, West Rail Initial Assessment studies by ERM-Hong Kong Ltd, 1997.

4.6.3 The British, Dutch, German, Japanese and Swedish criteria are understood to be trigger limits for noise insulation, much in the same manner as the Hong Kong EIA O TM criteria for road traffic noise. However, Hong Kong's railway criteria are absolute design limits that must be achieved by the railway operator and, from *Table 4.5* above, the "ASR B" limit is much in line with the most stringent criteria applied in countries where noise insulation would be provided. Whereas in comparison with countries where design guidelines are specified, the Hong Kong "ASR B" criterion is 8 dB more stringent.

4.6.4 While the medium sensitive "ASR B" category is in line the most stringent criteria reviewed, it can be considered the most restrictive to Hong Kong's railway operators since noise insulation cannot be offered in lieu of insurmountable impacts.

4.7 Conclusions

4.7.1 It can be concluded from the above analysis that residential noise criteria for road and rail traffic which operate in Hong Kong are not consistent in terms of stringency:

- Criteria for road traffic are relatively consistent with those operating in comparable countries, being a little less stringent than average for western countries, but within the generally accepted range;
- Criteria for rail traffic noise at residential resources are significantly more stringent than those for road traffic, and are more stringent than those adopted in other modern countries.

4.7.2 The current inequitable noise performance criteria placed upon railway operators have direct implications for both the financial feasibility of new railways and the travel costs to rail passengers as discussed in other sections of this report. By contrast, the costs associated with the attenuation of road noise (to less stringent requirements) are borne by the wider Hong Kong community due to Government funding of the road building and maintenance programmes.

4.7.3 Such inequities act as a barrier to encouraging the transportation of passengers and freight by rail in favour of road transport.

5. LANDTAKE AND LANDUSE IMPLICATIONS - ROAD VERSUS RAIL

5.1 Introduction

5.1.1 This section examines the comparative environmental implications arising from the physical occupation of land by roads and railways and the potential effects on existing and surrounding environmental resources. The theoretical landtake requirements for new road and rail developments are compared in terms of potential impacts to landuse, landscape, ecology and heritage resources.

5.2 Methodology

Overview

5.2.1 In order to compare and contrast the landtake requirements for typical new road and railway infrastructure developments, it is first necessary to determine the essential dimensions and hence landtake of the new infrastructure. The calculation of the landtake requirements of road and rail infrastructure has been estimated on the basis of guidance from Government design manuals and supplemented, where necessary, by discussions with design engineers and personnel involved with the infrastructure construction.

5.2.2 The implications of the differences in landtake are then examined in terms of the likely impacts to a range of surface environmental resources.

5.2.3 For the purposes of a road and rail landtake comparison, a theoretical new road and railway alignment of ten kilometres in length has been defined. In order to determine the features and design form of the theoretical 10 km development, standard design specifications have been reviewed and the relevant information extracted.

Definition of an Indicative New Railway

5.2.4 In order to derive a set of representative features for new railways, the study team has reviewed the alignments and facilities associated with three new railways: West Rail Phase I, the Tai Wai to Ma On Shan Extension to East Rail and the Sheung Shui to Lok Ma Chau Spur Line. These surface railways have been selected in favour of currently planned underground railways (such as the MTRC's Tseung Kwan O Extension) as surface railways represent the "worst-case" scenario in terms of potential impacts to landuse resources.

5.2.5 Following discussions with KCRC and MTRC personnel and a review of the Corporations' internal design standard manuals, the following assumptions have been made:

- For at-grade sections of alignment, landtake calculations are based upon 4.5 metre track centres which define an overall width of nine metres plus an additional "set-back" assumed to be two metres either side of the tracks. Although landtake would increase in areas of cross-overs and on the approaches to stations, these have been discounted from the comparison for simplicity.

- The new generation of surface railways are built, for a significant proportion of their length, on elevated structures. Rail viaducts are typically supported by columns at 30 metre intervals with landtake limited to column support footings of between 2 m^2 and 3 m^2 each. As land beneath rail viaducts may be utilised for a range of uses (including landscaping, conservation, recreation and agriculture), the indicative railway does not include lengths of viaduct. However, it is acknowledged that the development of land is constrained by railway viaducts.
- For sections of railway alignment on embankment or in cutting, it is assumed that, in addition to the 9 m at-grade width, the "footprint" of the embankment or width of the cutting would require additional landtake to accommodate an assumed 45° cutting or embankment slope. For the purposes of the comparison, it is assumed that a five metre high embankment or five metre deep cutting is required resulting in an overall formation width of 19 metres.
- In addition to rail formation and permanent way, the development of new railways will also typically require the construction of stations; on the basis of the dimensions of stations on currently planned new railways, an area of 30,000 m^2 each has been assumed as representative for an indicative ten kilometre railway.

5.2.6 On the basis of the indicative railway definition given earlier and assumptions on formation width and ancillary facilities, the landtake of an indicative new 10 km railway has been derived and is presented in Table 5.1 below.

Table 5.1 Landtake of an Indicative New Ten Kilometre Railway

Feature	Notional Dimension	Length	Area (m^2)
Formation:			
At-Grade Railway	13 m (width)	5 km	65,000
Embankment / Cutting	19 m (width)	5 km	95,000
Associated Facilities:			
Four Stations	30,000 m^2 each		120,000
TOTAL			280,000 m^2

Definition of an Indicative New Road

5.2.7 The definition of the landtake requirements for new highways has been derived on the basis of information presented in the Hong Kong Government's design standards for new roads[7], supplemented by a review of the characteristics of recently constructed and currently planned major highways.

5.2.8 For the purposes of this paper, it is assumed that a road with a similar capacity to a new mass transit railway would be a three-lane, dual carriageway road with each carriageway comprising a width of 11 metres plus a separation of two metres and a set-back of ten metres. This provides for an overall width of 34 metres.

5.2.9 These dimensions are based upon the highway standards established by the Hong Kong Highways Department, a summary of which is presented in Table 5.2 below.

7 Based on: Transport Department's Transport Planning & Design Manual, Volume 2.

Table 5.2 Standard Road Widths

Road type	No. of Lanes	Carriageway Widths	Separation & Set Backs	Total Width
Dual Carriageway	2	7.3 metres (X2)	2+10 metres	26.6 metres
	3	11 metres (X2)	2+10 metres	34 metres
	4	14.6 metres (X2)	2+10 metres	41.2 metres
	2	7.3 metres (X2)	10 metres	24.6 metres
	4	13.5 metres (X2)	10 metres	37 metres

5.2.10 On the basis of this information, the following landtake assumptions for roads are made:

- For at grade sections, a three-lane, dual carriageway has been selected with a width of 34 metres. The landtake would increase to 41.2 metres in areas where an additional lane is added to accommodate junction feeder lanes or in particular areas of expected congestion, although these type of complexities has been ignored in the current assessment for simplicity. Similarly, it is assumed that the dual carriageway is designed to expressway standard; were this not the case the provision of hard shoulders could be omitted.
- Highway viaducts are significantly larger than those designed to support railways. A 34 metre wide deck would typically be supported by larger and more column supports. The width of the highway deck limits the use of land beneath road viaducts in terms of the range of uses that might be established beneath rail viaducts (including landscaping, conservation, recreation and agriculture) which is due to the shadowing effect. The development potential of such land is also constrained by the presence of the road viaduct and, possibly, by concerns regarding air quality or noise which would typically result in even larger setbacks.
- As for rail, an assumed 5 metre embankment with a 45° batter slope, in addition to the 34-metre at-grade width, would require a 10 metre width resulting in a total formation width of 44 metres.
- Grade-separated junctions vary in size and complexity. However, for indicative purposes it is assumed that each highway junction would have four, two-lane slip roads of 150 metres in length plus a roundabout that would require a landtake of 1500 m^2 in addition to the highway width. Each indicative junction would have, therefore, the following characteristics:
  - Slip Roads: width of 7.3 metres plus 5 metre set-backs; and
  - Roundabout: notional landtake of 1500 m^2.

  On this basis a junction may be assumed to occupy 9,000 m^2.
- In addition to the carriageway, new highways will also require the construction of junctions, breakdown lanes and feeder roads. Furthermore, if the highway is to be tolled a toll-plaza will need to be accommodated.

5.2.11 For the purposes of comparison, on the basis of the indicative highway definition given earlier and assumptions on formation width and ancillary facilities required, the landtake of an indicative new 10 km highway has been derived and is presented in Table 5.3 below.

Table 5.3 Landtake of an Indicative Ten Kilometre Highway

Feature	Notional Dimension	Length	Area (m^2)
Formation:			
At-Grade Road	34 m (width)	5 km	170,000
Embankment / Cutting	44 m (width)	5 km	220,000
Associated Facilities:			
Six Junctions			54,000
TOTAL			444,000 m^2

Comparison of Landtake

5.2.12 As can be readily seen from the total landtake figures presented in Tables 5.1 and 5.3 above, the landtake required of an indicative new railway is 40% less than that for a new road of similar capacity.

5.2.13 It is acknowledged that the figures derived for the purposes of this comparison are purely indicative. Railways currently under construction or being planned tend to be built either primarily underground (such as the MTRC's Tseung Kwan O Extension) or on extensive lengths of viaduct (such as the KCRC's West Rail, Ma On Shan Extension and Sheung Shui Spur Line); the landuse implications for these railways would be considerably less than is suggested by the landtake derived from the indicative railway presented in Table 5.1.

5.3 Discussion of Landuse /Environmental Resource Implications

Introduction

5.3.1 The following sub-sections examine the implications for Hong Kong's surface environmental resources of such a contrast in landtake requirements between rail and road infrastructure. This discussion has been informed by the Consultants' experience of conducting environmental impact assessments (EIA's) of road and rail schemes both in Hong Kong and internationally.

Impacts to Land Use

5.3.2 In Hong Kong, land is a scarce and valuable resource. In the past, the management of land availability has relied upon extensive coastal reclamation to ensure that the economy and community of Hong Kong is provided with land sufficient for its needs. However, recent shifts in public attitude have rendered reclamation increasingly unacceptable and a more sustainable approach to the management of land is being adopted.

5.3.3 Clearly, the additional landtake associated with the construction of new highways reduces the amount of available land that might otherwise be developed for the provision of housing, commercial/industrial premises or recreational uses. Furthermore, in addition to the direct loss of land, the greater noise and air quality impacts associated with operational highways (see *Sections 4* and *3* respectively) act as a constraint upon the uses to which land alongside a highway may be put.

5.3.4 By way of contrast, the higher noise performance standards imposed upon railways have ensured that the next generation of surface railways will be designed to control noise to extremely low levels that will allow the construction of residential development to within 10 metres of the new railway alignment. Furthermore, railway stations frequently act as a focus of, and catalysts to, the development of residential, commercial, retail and leisure facilities. In Hong Kong, such opportunities have been successfully exploited at a number of railway stations and direct linkage to the railway network has been a key factor in the success of many of Hong Kong's prime retail locations including Pacific Place, Festival Walk, Times Square and The Landmark.

Impacts to Landscape Resources

5.3.5 The likely impact to landscape resources of linear developments, such as roads and railways, will be strongly influenced by a range of factors including:

- the size and scale of the road or railway;
- the value of the landscape resource through which the alignment passes;
- the landform and topography of the surrounding area;
- the extent of the visual envelop for the alignment;
- the numbers and sensitivity of surrounding receivers; and
- the extent and effectiveness of measures taken to mitigate the predicted impacts.

5.3.6 By virtue of the comparatively larger scale of a highway "footprint", the disruption to the existing landform and topography will be significantly greater for the indicative highway than would be the case for the indicative railway. In areas of high landscape value, the extent to which impacts to the landscape resource may be effectively mitigated will be constrained by the greater "bulk" of a new highway.

5.3.7 The size and scale of the wider highway will also result in greater numbers of impacted sensitive receivers; the foreground and mid-distance views of those in close proximity to the highway will be dominated by the highway to a far greater extent than would be the case for a new railway.

Impacts to Ecological Resources

5.3.8 The ecology of Hong Kong is a finite resource and, with the pace of development over the past several decades, this resource has come under increasing pressure as natural and semi-natural habitats have been lost to competing land uses. In response, a series of legislative and procedural mechanisms have been introduced by the Administration to protect ecological resources and to ensure that in circumstances in which impacts to ecology are unavoidable, appropriate measures are implemented in order to mitigate predicted impacts or to compensate for the loss of key habitats on a "like-for-like" basis.

5.3.9 The scale of impact to a particular ecologically valued habitat is directly proportional to the extent of the habitat that is lost to a new development. As a consequence, the greater landtake associated with highways will tend to result in commensurate impacts to the ecological resource. Furthermore, the effects of a new highway on the severance to established ecological linkages, derived from both the greater landtake, and on increased mortality rates, as a result of collisions with vehicles, is such that significantly greater indirect ecological impacts can also be anticipated.

5.3.10 The Works Branch/PELB Technical Circular[8] on off-site compensatory measures requires the provision of land to compensate for ecological impacts on a "like-for-like" basis. Whilst a number of new developments are currently seeking to comply with this requirement through the identification of compensatory land on a ratio of 1:1, international experience suggests that when the success rate of recreating wetland habitats is taken into consideration a ratio of 2:1 may be a more appropriate assumption.

5.3.11 Clearly, the greater landtake of highways will require, on average, greater requirements for compensatory land. For example, if the indicative (at grade) road and rail alignments pass through wetland areas for some 2 km of their length the resultant wetland loss would require an additional 26,000 m^2 land to be provided to compensate for a railway and 68,000 m^2 for a highway[9]. If the ratio were set at 2:1 then the amount of additional compensatory land would double.

Impacts to Heritage Resources

5.3.12 Heritage resources are defined as including historic and cultural buildings, structures and locations, places of worship, *fung shui* features, historic landuse patterns and landscapes and upstanding and buried archaeological sites, features and deposits.

5.3.13 The number of such heritage features affected, and the scale of impact, is directly proportional to the extent of landtake required by a particular development. As a consequence, the greater landtake associated with highways will tend to result in commensurately greater impacts to the heritage resource.

5.3.14 For buried archaeological deposits the situation is somewhat more complex. Archaeological records cannot be considered as comprehensive. As a consequence, the lack of archaeological records for areas through which a new road or railway is to be constructed is likely to reflect a lack of previous investigation rather than an absence of sites and features. Unless the alignment is primarily through heavily disturbed areas, the precautionary principle requires an assumption that archaeological deposits are present until field investigations have established this not to be the case.

5.3.15 International standards on archaeological field evaluation are increasingly being adopted in Hong Kong; in advance of West Rail, field evaluation was applied to 5% of areas of archaeological potential. Such an approach would result in field evaluation, involving the excavation of evaluation trenches of 5m X 20m dimensions, of some 14,000 m^2 for the indicative railway and 22,200 m^2 for the indicative highway. The highway project would require over 80 additional 5m X 20m evaluation trenches to be excavated.

5.3.16 Such activity, whilst clearly demanding in terms of resources and programme, would establish the presence or otherwise of archaeological deposits and would enable the extent of archaeological impact to be fully assessed. In line with the greater physical landtake of highways, it can be assumed that the indicative highway would result in greater impacts to, as yet, unknown archaeological resources.

---

8 Planning, Environment & Lands Branch Technical Circular No. 1/97 / Works Branch Technical Circular No. 4/97 Guidelines for Implementing the Policy on Off-site Ecological Mitigation Measures.

9 The land areas quoted are calculated on the basis of the figures presented in Table 5.1 and 5.3.

5.4 Summary and Conclusions

5.4.1 This Section of the Paper has focused on the landuse efficiency of road and rail transport infrastructure. The comparison has demonstrated that rail infrastructure is less land consuming and that this inevitably reduces the potential destruction of environmental resources, which are located on the land surface.

5.4.2 The greater landtake requirements of highways have commensurately greater impacts upon ecological, landscape and heritage resources and on the ability of project proponents to effectively mitigate predicted impacts.

5.4.3 It is concluded, therefore, that the landtake requirements of railway developments provide greater opportunities to manage the allocation of land in a sustainable manner, particularly in the context of Hong Kong's limited available land area.

6. TRANSPORT SAFETY - ROAD VS RAIL

6.1 Introduction

6.1.1 This section of the Paper addresses the perceived risk issues associated with the transportation of persons by rail and road.

6.1.2 Although the primary focus of this section is the safety of the travelling public using rail and road forms of transport, other issues discussed are the hazards involved with the transportation of Dangerous Goods (DG) by rail and alternative means and the comparative risks of rail and road developments in the vicinity of fixed sources of hazard such as Potentially Hazardous Installations (PHIs).

6.2 Safety of Rail and Road Transport

General Hazards Associated with Road and Rail Travel

6.2.1 Table 6.1 below summarises the major categories of hazards which could be expected to result from travel by either rail or road transport. The list of hazards has been derived from examination of past transport accidents in Hong Kong as well as risk assessment studies undertaken by the Consultants for new rail projects.

Table 6.1 Major Categories of Hazard

Hazards of travel by rail	Hazards of travel by road
Derailment	Collision
Collision	Rollover
Fire	Fire
Accidents associated with train doors	Boarding/alighting accidents
Falls inside train compartment	Accidents at bus stops/termini
Accidents on escalators/stairs/lifts	Accidents on-board buses
Slips/trips on platform/concourse	

6.2.2 From Table 6.1, it can be seen that the hazards associated with both rail and road travel are wide-ranging, from relatively minor, non-life threatening incidents involving falls on stairs or escalators within stations or PTIs to more serious incidents such as fires, vehicle collisions and derailments which may involve multiple injuries and even fatalities.

6.2.3 In order to provide a common basis for comparison between the two modes of transport, the following sections review historical accident records published by both rail corporations in Hong Kong. Data extracted from the 1998 Annual Digest of Statistics involving accidents from road vehicles is then used to develop a similar picture of hazards for road transport.

6.2.4 The risks associated with each form of transport are subsequently compared using the common indicators of Individual Risk and Societal Risk. Individual risk is the annual probability of a certain level of harm (e.g. serious injury or fatality) arising to a specified individual. Individual risk is usually calculated for the most exposed individual, e.g. a rail commuter or a road passenger. Societal risk is the risk to the travelling public as a whole, commonly expressed as the annual frequency of a given level of harm.

Risks of Transport by Rail in Hong Kong

6.2.5 Tables 6.2 and 6.3 below summarise the published safety records of the Kowloon-Canton Railway (East Rail) and Mass Transit Railway between 1990-1996 and 1991-1995 respectively.

Table 6.2 Safety Record of Kowloon-Canton Railway (East Rail), 1990-1996

Cause	Number of incidents	
	Serious injury	Fatality
Suicides	9	10
Accidents involving train doors	0	1
Falls between platform and train	19	1
Escalators	29	1
Trespassing	3	0
General sickness	5	2
Miscellaneous	2	0
Total (including categories unreported by KCRC*)	140	15
Total**(excluding suicides and general sickness)	126	3

* Falls inside train, 12 serious injury, 0 fatalities, Falls from platform onto track, 4 serious injury, 0 fatalities, Slips/trips on platform and concourse, 43 serious injury, 0 fatalities, Staircases, 13 serious injury, 0 fatalities, Lifts, 1 serious injury, 0 fatalities.

** Suicides and general sickness are commonly excluded from risk calculations because they are not attributable to any failure on the part of the rail operator.

Table 6.3 Safety Record of Mass Transit Railway, 1991-1995

Cause	Number of incidents	
	Serious injury	Fatality
Suicides/attempted suicides	28	36
Trespassing onto the track	6	4
Falling between the train and platform	4	0
Accidents associated with train doors	1	0
Accidents on escalators	8	0
Miscellaneous	10	13
Total (including categories not reported by MTRC)*	57	53
Total (excluding suicides and general sickness)**	29	17

* Fires and smouldering, 0 serious injury, 0 fatalities

** Suicides and general sickness are commonly excluded from risk calculations because they are not attributable to any failure on the part of the rail operator.

6.2.6 Table 6.4 below calculates the individual and societal risks for railway travel (i.e. MTRC and KCRC combined).

Table 6.4 Risk due to Transport by Rail

Parameter	Value
Average Passenger Journeys per year #	9.9164 x 108
Individual risk of fatality*	7.1111 x 10-7 per year
Individual risk of serious injury*	1.42 x 10-5 per year
Societal risk (fatal accidents)**	1.23 per year
Societal risk (serious injury)**	23.4 per year

\# Data from 1998 Annual Digest of Statistics

* Individual Risk = number of journeys by a hypothetical individual (taken as 6 per day or 2190 per year)/total number of passenger journeys over reference period x number of fatal or serious injury accidents over reference period

** Societal Risk = number of fatalities or serious injuries/reference period

Risks of Transport by Road in Hong Kong

6.2.7 For road transport, information on accidents has been obtained from the Hong Kong Police Annual Reports for 1996 and 1997 and the 1998 Annual Digest of Statistics, which are summarised in Table 6.5 below.

Table 6.5 Road Accidents in 1996 and 1997

Classification	1996	1997	Total
Number of fatal accidents	252	229	481
Number of fatalities	263	241	504
Number of serious injury accidents	3084	3154	6238
Number of serious injuries	3432	3599	7031

6.2.8 Table 6.6 calculates the individual and societal risks for road travel in 1996 and 1997.

Table 6.6 Risk due to Transport by Road

Passenger journeys (buses and taxis)	5.04×10^9
Passengers journeys (private car, goods vehicle etc.)*	3.72×10^9
Total	8.76×10^9
Individual risk of fatality**	2.0×10^{-4} per year
Individual risk of serious injury**	2.6×10^{-3} per year
Societal risk (fatal accidents)***	252 per year
Societal risk (serious injury)***	3516 per year

* estimated from number of registered vehicles (Annual Digest of Statistics, 1997) assuming an average of 10 journeys per vehicle per day

** Individual Risk = number of journeys by a hypothetical individual (taken as 10 per day or 3650 per year)/total number of passenger journeys over reference period x number of fatal or serious injury accidents over reference period [This is the risk for an individual who might otherwise travel by rail, i.e.. excluding taxi drivers, goods vehicle drivers etc.]

*** Societal Risk = number of fatalities or serious injuries/reference period (years).

Comparison of Risks

6.2.9 Comparing the risk results in Tables 6.4 and 6.6, it can be seen that the individual and societal risk for rail travel are significantly lower than that for road travel, in terms of both fatalities and serious injury (i.e. typically two orders of magnitude lower).

6.2.10 It is noted that the development of railways would not eliminate the need for road travel altogether. However, by reducing the number of road journeys required and/or the distances travelled by road, it would be expected that a lower overall risk to the travelling public would result.

6.2.11 In terms of the nature of the risks posed by rail and road travel, it is noted that rail accidents have the potential to result in larger numbers of fatalities for certain remote, but catastrophic, events such as a train derailment at high speed or a major fire. However, even taking this into account, rail travel is still significantly safer.

6.2.12 These findings for Hong Kong road and rail transport are in line with recent studies undertaken by ERM in the United Kingdom. These studies presented the following comparative figures:

Mode	Individual Risk per year
Car	1.5×10^{-4}
Bus or coach	1.9×10^{-5}
Rail	3.7×10^{-5}

6.2.13 It should be noted that the values from this UK study were derived from fatality rates per journey and number of journeys per year, as assumed for derivation of risk values for Hong Kong.

6.3 Dangerous Goods Transport by Rail and Road

6.3.1 Dangerous Goods (DGs) are not currently transported by rail in Hong Kong, although elsewhere, rail is a common means of transporting a wide variety of DGs. Whether rail or road transport offers a safer means of transport depends on a range of factors, including:

- the routes, i.e. length and proximity to populated areas;
- the route 'environment', i.e. other traffic, presence (or otherwise) of tunnels, busy road junctions, etc.;
- the types of DG being carried (i.e. whether possessing 'short range' or 'long range' effects);
- associated risks such as those from railway marshalling yards or lorry waiting areas;
- risks associated with any additional handling operations, e.g. cargo transfer.

6.3.2 The UK Transport Risk Study (*Major Hazard Aspects of the Transport of Dangerous Goods by Road, UK Health and Safety Commission, 1991*), contains a detailed comparison of transport of DG by rail and road. This study concluded that there was no discernible difference between rail and road transport of DG from a risk perspective. This arises due to a number of competing factors, e.g. accident frequencies tend to be lower for rail transport, but the consequences may be more severe due to the increased speed of movement. Also road accidents may involve exposure of a large number of people within vehicles which build-up behind the accident scene, but equally, rail transport may involve movement through heavily-populated areas (in contrast to 'out of town' highways).

6.3.3 Therefore, whilst the assessment of specific rail/road alternatives may reveal a preference for one form of transport over the other, there is no broad preference for DG transport by rail as opposed to road.

6.3.4 However, a number of key factors must be borne in mind. The affected population in the case of road transport is both the road-side public as well as those travelling by road traffic. In the case of rail transport, the affected population is mostly the public on the side of the railway although the potential for collision incident with a passenger train cannot be ruled out.

6.3.5 Rail transport involves the movement of a larger quantity of DGs (multiple rail cars) as compared to road transport (single tanker or truck) and therefore an escalation or domino event is a common occurrence in the case of rail accidents involving Dangerous Goods.

6.3.6 Whilst much of the transport in the Hong Kong context is through densely populated areas, it is important to recognise that rail transport cannot be a substitute for much of the road DG transport in Hong Kong. For example, the delivery of petrol to filling stations, which constitutes the bulk of DG road transport in Hong Kong, can only be served by road.

6.3.7 Any comparison between road and rail should therefore be between transport through expressways and by rail where the two modes of transport can be considered as alternatives. The Consultant's recent study on transport of dangerous goods by road has shown that accident rates for road transport vary with respect to roads, it is lower in the case of expressways as compared to interior roads. The risks are also lower for transport through expressways and there is significant transport of DG through the expressways in Hong Kong serving cross-border/transit trade.

6.3.8 Whether the risks associated with transportation by rail is lower than transport along expressways will therefore need to be evaluated on a case to case basis, considering the population on either side of the road/rail development and the passenger traffic on the road/ rail link and type of dangerous goods.

6.3.9 The type of dangerous good involved is another factor. The difference between road and rail is not significant in the case of toxic materials, which impact a larger area, compared with the risks from flammables that have a lower impact distance.

6.3.10 It is concluded, therefore, that further comparative risk assessments between road and rail transportation of dangerous goods will need to be based upon specific alternative routes and will need to assess the implications of a range of different dangerous goods.

6.4 Comparative Risks of Rail and Road Developments in the Vicinity of PHIs

6.4.1 Hong Kong currently has 37 PHIs, comprising 20 water treatment works (WTWs), five LPG/oil terminals, six LPG storage installations, three Towngas facilities and three explosive storage and manufacturing facilities. There are also numerous other, smaller hazardous facilities, such as DG godowns, small bulk LPG installations, petrol stations etc., as well as other external sources of hazard such as gas pipelines and DG transport arteries.

6.4.2 The most significant external hazards, however, are those posed by the PHIs. These have designated Consultation Zones, which range from 150 m (LPG storage installations) to 1 km in radius (LPG/oil terminals and water treatment works using chlorine in 1 tonne drums). Within the Consultation Zone, development may need to be restricted to ensure compliance with Government Risk Guidelines. Water treatment works, in particular, are of concern due to their number, size of Consultation Zone and location (some within the Strategic Growth Areas identified in the ongoing NENT and NWNT Planning studies).

6.4.3 The question arises therefore whether railway or road development is preferable in terms of the risk posed by PHIs. This is an important question as, given Hong Kong's limited space, there is a need to accommodate both major infrastructure (roads and railways) as well as essential public utilities.

6.4.4 There are a number of aspects of railway development that are of concern: the alignment itself, the stations and any station-related development (i.e. commercial and/or residential development). In each case, it is the above ground developments which are of primary concern.

6.4.5 The first aspect to consider is the comparative risks to passing trains as opposed to passing road vehicles. For toxic gas hazards (such as may potentially arise from WTWs), it is generally recognised that the toxic hazard is more severe for roads than railways. This is because of the generally faster speed of rail travel and lower vehicle air exchange rate, which means that any toxic gas would potentially build up much more slowly within trains compared to road vehicles.

6.4.6 For trains that are stationary however, the degree of hazard would be expected to be comparable. Given the widespread use of Automatic Train Operation (ATO) systems for new railways which aim to minimise the headways between trains and maximise their frequency, the probability of encountering a stationary train in Hong Kong would be much lower than the probability of stationary road traffic.

6.4.7 For fire/explosion hazards, such as may arise from LPG installations, gas pipelines etc., no clear distinction can be made between the risks to railways or roads. This is because on the one hand, a fire or explosion incident potentially affecting a train would be expected to result in larger numbers of injuries and/or fatalities while the probability of presence of a train on a particular section of track could be expected to be much lower than for a road equivalent case.

6.4.8 The paragraphs above address the risk to trains compared with road vehicles on a section of alignment or carriageway without consideration of related facilities. However, associated with railway developments are stations and typically, station-related development (shops, offices, apartment etc.). PHIs may pose significant risks to these developments if they lie within the designated Consultation Zone. The level of risk will depend on such factors as the proximity of the development to the PHI, the nature of the development and patronage of the various facilities.

6.5 Summary

6.5.1 The risk evaluation conducted confirms the widely-held perception that rail travel offers significantly reduced levels of risk for the travelling public compared with road transport. This is based on historical accident data for Hong Kong. For new railway developments, rail operators are demanding even lower levels of risk to be achieved and quantitative risk assessments have shown that it is possible to achieve a lower level of risk than for the existing railways. The provision of platform screen doors (PSD) for new railways and the desire for retrospective fitment to busier stations along the current operating railway network is also expected to further reduce risks in respect of falls onto the track.

6.5.2 In respect of risks due to transportation of Dangerous Goods, it has been discussed that in general, no clear distinction on a risk basis can be made between transport by rail and road. However, given the current situation in Hong Kong whereby dangerous goods are transported by road, there are clear gains in safety to be achieved if a reduction in traffic congestion could be achieved. As discussed in the *Network Options Evaluation* conducted by the RDS-2 SEA, this could be achieved through provision of greater rail infrastructure so long as policy measures to curb road use and/or enhance the attractiveness of railway travel are also introduced.

6.5.3 In respect of the risks posed by external sources of hazards, for the majority of PHIs of interest (i.e. water treatment works), rail development is generally preferred to road development on the basis that stations, and any station-related development, are located outside the Consultation Zone of the PHIs. This preference for rail arises because the travelling public is generally better protected from external hazards when within a rail car than within a road vehicle.

7. SUMMARY AND CONCLUSIONS

7.1 General

7.1.1 This Paper identifies and outlines the environmental benefits accruing from railway developments as part of an overall environmental justification for the development of additional railway infrastructure in Hong Kong. One of the factors in this demonstration and justification was the investigation of the comparative treatment of railways as compared to road infrastructure within the statutory planning and assessment processes and within wider Government appraisal procedures.

7.1.2 The Paper has considered:

- the comparative treatment of railways and roadways within existing financial appraisal procedures;
- air quality and greenhouse gas considerations for alternative forms of transport;
- noise generation by different transport means;
- landtake and landuse issues associated with the implementation of alternative transport means; and
- safety associated with alternative modes of transport.

7.1.3 In this concluding section, the Consultants provide a summary of the key findings of the comparisons undertaken and provide a number of "pointers" to improving the strategic planning of transportation to encompass environmentally sustainable objectives.

7.2 Summary of Findings

7.2.1 A summary of the findings has been presented at the conclusion of each individual section in the Paper; it is considered that the purpose of this concluding section of the report is to provide an overall conclusion for the document taking into consideration recurring themes and those issues which may be reinforced by the findings of other sections and providing a strategic and forward-looking interpretation to the issues identified.

7.2.2 *Section 2* of the Paper addresses the Administration's existing project appraisal procedures and identifies discrepancies between the treatment of road and rail infrastructure. The outcome of these discussions is that it is harder for rail infrastructure projects to demonstrate the required level of justification because, in addition to the economic appraisal applied to road and rail projects, they are also subject to a financial appraisal, which road projects are not. Additionally, the present economic appraisal systems militate against rail investment because environmental factors are omitted from the quantifiable economic framework that is currently being used. Annex A identified the manner in which overseas countries, predominantly Europe, employ the concept of "environmental economics" to describe and monetorise the environmental benefits of transport projects which can then be considered along with other factors in the project appraisal/evaluation process; particularly pertinent where choices are to be made between different transport schemes or alternatives and where different forms of transport compete for use of public monies. This is suggested as one possible avenue worthy of further investigation if the identified imbalance in the existing process is to be redressed.

7.2.3 In *Sections 3* and *4* of the Paper, legislative reviews and technical assessments of air quality and operational noise criteria for road and rail transport are undertaken which highlight the level of resourcing required to effectively manage pollution arising from each type of source and provides a means of comparing the pollution efficiency of each form of transport. The results of the legislative review for operational noise also conclude that in Hong Kong, railways are more stringently regulated than roads and, that Hong Kong's railway operational noise criteria are among the strictest in the world when compared with 13 overseas countries. The technical assessments conducted support existing beliefs that railway developments generate less pollution than roadways and that in terms of control over the resulting noise and air emissions, railways are more easily managed and offer advantages through more strict and enforceable regulations.

7.2.4 *Section 5* of the Paper focuses on the issue of landuse efficiency of road and rail transport infrastructure and demonstrates that rail infrastructure is a less consuming project and that this inevitably reduces the potential destruction of environmental resources which are located on the land surface. The conclusion is made, that within such constraints as Hong Kong's limited available land area, railway developments are considered a more environmentally sustainable form of transport in the long term.

7.2.5 Finally, *Section 6* reviews the potential risks of serious injury and fatality when travelling by road as opposed to rail and concludes that the risks associated with rail travel are significantly lower than that posed by road based on the published safety records of the two railway corporations and accident statistics from the Annual Traffic Census. Regarding the planning of new railways, a constraint is posed to surface rail-lines by the existing potentially hazardous installations (in particular water treatment works which make up half of all PHIs in Hong Kong) and the additional residential development following completion of a rail link as a result of the perceived attractiveness of rail transport. However, if the railway infrastructure itself is located underground it be a relatively non-contentious hazard issue.

7.3 Strategic Interpretation of Results

7.3.1 Hong Kong is approaching a critical stage in its social, economic and environmental development. *Hong Kong 1997* states that close to 1,000,000 people are exposed to a road traffic noise level higher than the minimum acceptable standard outlined in the Hong Kong Planning Standards and Guidelines and that this makes traffic noise one of the most pervasive forms of pollution in the Territory. Similarly, Hong Kong's deteriorating air quality conditions have recently been highlighted in the international media and have caused public health concerns for local residents as well as for international visitors and foreign investors. Clearly, air quality and noise are two fundamental environmental concerns that must be tackled to bring about relief to the public and provide an environmental quality which will support the growth and development of Hong Kong into the new millennium.

7.3.2 A series of technical reviews and institutional and legislative assessments were undertaken as part of the SEA of RDS-2. The technical assessments have demonstrated that the environmental benefits attributable to rail transport (safety to the travelling public, air quality and noise emissions) clearly outweigh those of road transport. In theory, therefore, the development of railway infrastructure, as the main thrust of future transportation initiatives, would form a robust basis for best meeting Hong Kong's transport needs whilst providing long-term sustainable solutions to the Territory's environmental challenges. However in practice, to receive these benefits in full, the Administration needs to both ensure a balanced and equitable approach to the appraisal and approval of new rail infrastructure, and actively promote alternatives to road-based forms of transportation.

7.3.3 In particular, whilst respecting the "prudent commercial principle" set for railway operation, the SEA Study Team has investigated the disparity in the financial and economic criteria by which railway and highway infrastructure are judged and has noted that for railways, the criteria should be reviewed.

7.3.4 The introduction of competition between modes of transport is generally desirable because of benefits it is perceived to provide in terms of lower fares. However, due to the fundamental differences in the infrastructure financing criteria applied to roads and to railways, inter-modal competition is not currently undertaken on a "level playing field". Furthermore, evidence from the RDS-2 patronage forecasting studies indicate that the proliferation of Hong Kong's road-based public transport services is eroding the potential benefits of the existing rail services, as the lower fares that road-based services charge draw potential passengers from the rail network.

7.3.5 Whilst the operation of low-cost road-based public transport services may be desirable from the consumers' point of view, a farsighted strategic approach to Hong Kong's current environmental challenges would involve harnessing the benefits that both modes can offer with services which are structured to complement rather than compete (unfairly) with each other.

7.3.6 A related point is the detrimental effect that the "true-cost" fare structure, imposed on rail services only, has on the achievement of modal shifts from road to rail. The advantages to Hong Kong of achieving such a modal shift are considerable and range from the improvement of environmental conditions to the increase in the life span of existing road infrastructure that would be achieved through a reduction in road traffic.

7.3.7 In Hong Kong, rail links are retrospectively introduced into urban areas where a roadway network has been established, often for long periods of time. As mentioned above, the "prudent commercial return" required by the Administration provides railway operators with little flexibility to lower their fares in order to attract greater patronage and thereby encourage and enhance potential modal shifts. Another aspect of this situation is how rail transport can better meet community needs. Current levels of service by both railway operators are superior to the reliability and frequency of road transport alternatives, although the higher levels of comfort and direct "door-to-door" service provided by bus and minibus services (and by private cars and taxis) will ensure that these forms of transport are an essential complement to an expanded rail network.

7.3.8 The logical extension of the Administration's stated aim of giving preference to rail transportation will be changes to the objectives and guidelines applied to new residential and commercial developments, so as to ensure that the future development of Hong

Kong is not structured towards a reliance upon road transport. There are already a number of existing, and planned, residential and commercial centres that have maximised the efficient and convenient service provided by railways. Examples of residential estates include those at Kowloon Bay, Tai Koo Shing and Laguna City at Lam Tin, whilst Hong Kong's premium shopping centres, such as Pacific Place, Festival Walk, Times Square and the Princes Building, have each been developed with rail service provision as an integral component. These examples of rail-led or rail-integrated developments provide a range of proven development concepts that could provide the basis for the next generation of new town developments including the proposed new residential areas within South-East Kowloon and the north east and north west of the New Territories. The setting of rail accessibility criteria for new residential developments within the New Territories would provide the twin benefits of guiding such development to areas served by the existing and committed rail services (East Rail and its planned extensions and West Rail) whilst generating proposals for additional development-led rail services (or as a minimum rail-feeder services) as a means of achieving the accessibility criteria. This would make easier the task of tightening restraint on car usage and thereby reducing the need to expand road infrastructure for future major developments.

7.3.9 The incorporation of a preference for rail would also ensure that priority is given to improving the level of convenience that rail offers through the development of systems and mechanisms for moving passengers to and from station ingress and egress points (e.g. by dedicated trolley buses and people-mover systems). In such a manner, while road infrastructure would still need to be provided in and around new developments, the magnitude of the infrastructure required could be considerably lessened. At a more detailed level, the improvement in accessibility to rail services could be complemented by the provision of active incentives to encourage residents and visitors to use the rail system.

7.3.10 In summary, therefore, it can be seen that the traditional approaches to the planning of transport and land use development, the setting of strategic economic objectives and the general framework for the provision of social and community needs, could be significantly enhanced in the development of sustainable transportation strategies.