Section 5

5 NOISE

5.1 INTRODUCTION

The purpose of this Section is to:

- assess the noise impacts of phased LAPH operations, associated traffic, and any concurrent construction at representative Noise Sensitive Receivers (NSRs);

- identify options for mitigating unacceptable noise impacts; and

- identify noise monitoring and audit requirements.

5.2 METHODOLOGY

5.2.1 Phasing of Assessment

The assessment has been performed with reference to the phasing of port facilities. Five major stages of operation/construction have been assessed:

- **Phase I Construction**: construction noise impacts from Phase I construction;

- **Phase I Operation**: noise from Phase I Container Port operations and traffic, and concurrent Phase II construction activities;

- **Phase II**: noise from Container Port operations at Phases I and II, concurrent Phase III construction activities, and Container Port traffic;

- **Phase III**: noise from Container Port operations at Phases I to III, concurrent Phase IV construction activities, and Container Port traffic; and

- **Phase IV**: noise from Container Port operations at Phases I to IV, with Container Port traffic.

5.2.2 Identification of Sensitive Receivers

For the assessment of Container Port noise, NSRs are primarily residences and schools in Discovery Bay, Peng Chau, and Hong Kong Island west of Mount Davis. The addiction treatment centre and residences on Hei Ling Chau have also been considered in this assessment. For the assessment of breakwater noise, receivers on Hei Ling Chau, Cheung Chau, and Lamma Island have been considered.

NSR areas are shown in Figure 5.1. Because of the source-receiver distances involved in this assessment (ranging from one to nine kilometres), individual receivers were not selected. The assessment has been performed for a representative facade. Receiver R1 represents existing village receivers in Sam Pak, and potential future receivers resulting from expansion of Discovery Bay. Receivers R2 and R3 represent existing Discovery Bay receivers in exposed positions. Receiver R5 represents existing retreat homes on northern Peng Chau, which will be exposed to future Container Port activities. More numerous and more protected receivers on central Peng Chau are represented by R4. Receiver R6 represents institutional and residential uses on Hei Ling Chau, and Receiver R7 represents sensitive uses on Hong Kong Island west of Mount Davis. Receivers R8, R9, and R10 (on Cheung Chau, Hei Ling Chau, and Lamma Island respectively) represent sensitive uses exposed to noise from breakwater construction.

TABLE 5.1

MEASURED L_{90} BACKGROUND NOISE LEVELS

Location	Daytime L_{90} Noise Level (dB(A))	Night-time L_{90} Noise Level (dB(A))
Discovery Bay (South)	47.5	35.2
Peng Chau (North)	48.2	42.8
Hei Ling Chau (North)	44.9	42.3
Cheung Chau (South)	46.5	44.3
Lamma Island (North)	54.7	53.3

Background noise surveys reported in Working Paper No. 12A *Environmental Baseline*, some of which are shown in Table 5.1, show that these areas currently enjoy quiet noise environments, particularly at night.

No NSRs are identified for assessing the impacts of North Shore river trade transhipment developments. Existing village receivers at Tsing Chau Wan, overlooking the North Shore development, are expected to be relocated and village land designated for landscape and recreational use. Receivers on Ma Wan are protected by existing topography from exposure to the proposed terminals. An additional source of noise will be the LFC Works Area in Penny's Bay which is projected to remain until 1997.

The small village settlement at Fa Peng will be subject to greatly increased noise directly from the container port, and its associated backup areas, industry, and traffic. For the small number of receivers who are not relocated after the commencement of development, measures to mitigate both construction and operation noise should be considered for individual receivers.

A small development is currently planned by Housing Department for the Peng Chau western waterfront between the ferry pier and the bridge. The development consists of 6 small blocks, varying in height from 3 to 8 storeys, on low-lying land. As of the time of this report, the site layout indicates that the three blocks on the western part of the site would be shielded from Port noise by the blocks on the eastern part of the site. These three blocks on the eastern part of the site are themselves shielded from much of the Port by the northern Peng Chau headland which rises about 16m above the rooftop of the 8-storey block. However, it is possible that the topmost storeys of the eastern blocks could be exposed to noise from a limited number of berths.

5.2.3 Noise Assessment Criteria

Operational Noise

Noise is assessed with reference to the Noise Control Ordinance (NCO) and the Hong Kong Planning Standards and Guidelines (HKPSG).

Acceptable Noise Levels (ANL) at NSRs are governed by the NCO, and are dependent on the character of the area within which the NSR is located. SRs in Discovery Bay, Peng Chau, Hei Ling Chau, and Cheung Chau, which are non-urban areas not affected by noise-producing industry or roads, are assumed to have an Area Sensitivity Rating (ASR) of "A". Receivers on Hong Kong Island west of Mt. Davis and Lamma Island (North), where housing is low-density and traffic noise is not significant, are also assumed to have ASR of "A". Corresponding Acceptable Noise Levels (ANLs) stated in the *Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places, or Construction Sites* are 60dB(A) during the day and evening (0700-2300 hrs) and 50dB(A) during the night-time period (2300-0700 hrs).

The HKPSG states that all fixed noise sources should be 5dB(A) below the appropriate *Technical Memorandum* ANL, or no higher than 10dB(A) above the prevailing background noise level, whichever is lower. Background noise levels in Table 5.1 above show the minimum daytime and night-time background (L_{90}) noise levels. Thus, using the HKPSG criteria, the appropriate noise levels against which Container Port-associated noise is assessed are as shown in Table 5.2

TABLE 5.2

HKPSG ASSESSMENT CRITERIA FOR OPERATIONAL NOISE

Location	Daytime Criterion (dB(A))	Night-time Criterion (dB(A))
Discovery Bay	55	45
Peng Chau	55	45
Hei Ling Chau	55	45
Cheung Chau	55	45
Lamma Island (North)	55	45
Hong Kong Island west of Mt. Davis[1]	55	45

Note : [1] In the absence of background noise levels at western Hong Kong Island receivers, (ANL-5) criteria have been used.

Construction Noise

ANLs at sensitive facades have been obtained from the *Technical Memorandum on Noise from Construction Work other than Percussive Piling.* The evening (1900-2300) and Public holiday ANL is 60dB(A); night-time (2300-0700) ANL is 45dB(A). Daytime works during non-restricted hours are not subject to NCO control, but exceedence of the prevailing background noise level by over about 10dB(A) is discouraged. Thus, effective assessment criteria for noise other than percussive piling are as shown in Table 5.3.

ANLs at sensitive facades for noise resulting from piling have been obtained from the *Technical Memorandum on Noise from Percussive Piling*, and are shown below in Table 5.4 The ANLs chosen have been based on the assumption that NSRs have no central air conditioning systems.

TABLE 5.3

ASSESSMENT CRITERIA FOR CONSTRUCTION NOISE OTHER THAN PERCUSSIVE PILING .

Location	Non-Restricted Hours Day-Time (dB(A))	Restricted Hours Day-time & Evening (dB(A)	Restricted Hours Night-time (dB(A))
Discovery Bay	60	60	45
Peng Chau	60	60	45
Hei Ling Chau	60	60	45
Cheung Chau	60	60	45
Lamma Island (North)	65	60	45
Hong Kong Island west of Mt. Davis	60	60	45

TABLE 5.4

ASSESSMENT CRITERIA FOR PERCUSSIVE PILING

Location of NSR	Daytime Criterion (dB(A))
Discovery Bay	75
Peng Chau	75
Hei Ling Chau	75
Hong Kong Island west of Mt. Davis	75

Note : Piling is not required for breakwater construction, so criteria for Cheung Chau and Lamma Island are not included.
NSR - includes schools, hospitals and medical clinics.

5.2.4 Road Traffic

Road traffic generated by the Container Port is potentially a significant source of noise. In this assessment, predicted peak hour traffic levels from the operation of Phase I and of Phases I-IV (including Green Island Link) were used. Peak hour traffic flows during the operation of Phases I-II and I-III were estimated from the predicted traffic for Phases I-IV by pro-rating according to number of container berths in use. Because the Green Island Link (GIL) will not be functioning during Phases II and III, this estimation procedure results in an over estimation of vehicle flows.

Noise from traffic has been assessed using the UK Department of Transport procedure provided in *Calculation of Road Traffic Noise* (UK DoT,1988), which provides a method for calculating the L_{10} noise from road traffic. The L_{eq} noise level has been estimated from the L_{10} noise level by a conversion equation:

$$L_{eq} = L_{10} - 3.45$$

This conversion equation is derived from a comparison of measured L_{10} and L_{eq} levels, reported in Cheung and Fan (Hong Kong Polytechnic, 1984).

Morning and evening peak hour flows are almost equal; the evening peak hour has been used in this assessment.

5.2.5 Construction Phase Impacts

At this stage of the LAPH Studies, the methods of construction for the Container Port and Lamma Breakwater have not been finalised. Thus, descriptions of construction activities provided below are tentative.

The expansion of the Container Port facilities has been phased over time. Container berths are to be provided over four phases, with four berths being provided in Phase I (see Section 2). Additional berths will be constructed at a rate of approximately one per year. Phase I construction is expected to extend over 27 months. The tentative works programme indicates that dredging and construction will continue simultaneously on only two berth sites. There is no current intention for night-time or extended working hours.

Construction will involve the use of dredgers, earth-moving equipment, and piling hammers, and other powered mechanical equipment, as listed in Tables 5.5 to 5.7. In addition, rock dredging may be necessary, which would require the use of pre-dredging drilling and blasting equipment. A works yard, where equipment and materials are stored and mobilised, and where fabricating activities are carried out, will be located near Penny's Bay.

Marine Dredging

Phases I to IV of the Container Port development, as well as the local breakwaters, will require dredging of marine mud (see Section 2.10). Foundation trenches for seawalls, breakwaters and the Hei Ling Chau Typhoon Shelter would require dredging using a combination of trailer suction and cutter suction dredgers.

Land Borrow Aspects

Phases I to IV of the Container Port development, as well as the Lamma Breakwater, will require the use of fill.

Marine sources of fill material (either within Hong Kong or from the Pearl River) would require transport within the Study Area entirely by sea barge. Alternatively, land-sourced borrow from the proposed Mega-Borrow Area at Tsing Chau Tsai (TCT) may be used. It is understood that Quarrying at TCT would involve explosive blasting and therefore elevated noise levels, vibration and the "startle effect" are of potential concern. Transport of the fill would involve the use of bulldozers, excavators/loaders, and large dump trucks. Due to the uncertainty over the use of this area as a source of fill for the LAPH development, there are no firm proposals or excavation plans, therefore it has not been possible to include these impacts in the current noise assessment.

Filling for Reclamation

Reclamation includes both the backfilling of foundation trenches for the breakwaters and seawalls, and the formation of land. Trenches will be backfilled by bottom-dumping from trailer dredgers or barges, or by direct pumping from a dredge site using a suction pipe.

Land formation is expected to require placement of a base layer of fill, either deposited by trailer dredgers, dumped from barges, or directly placed through dredger suction pipes. Bulk sand filling would use conventional methods such as hydraulic filling from a basin, pumping from a trailer dredger, and controlled bottom dumping.

Surface formation will involve tipping and spreading the fill, levelling, and compacting. Equipment requirements include bulldozers, dumptrucks, excavators/loaders, graders, scrapers, and vibratory rollers.

Container Port Quay Wall Construction

The quay wall is expected to be constructed using large diameter steel pipes with a reinforced concrete deck. Placement of the steel piles will require the use of a diesel or hydraulic piling hammer.

Works Area

The works yard is expected to be located east of Penny's Bay, south of the power station. Yard activities will include fabrication and maintenance, storage of equipment and materials, and concrete batching.

Road Construction

A surfaced roadway will provide access to the Container Port facilities from the land side.

Breakwater Construction

The preferred breakwater design is one that minimises the need for dredging of marine mud, has the least impact on water quality, and has a low capital cost. Rock mound breakwaters meet these criteria, and are recommended for the local breakwaters. Construction involves the dumping of fill and placement of rock or precast armour units. Fill will be dumped from barges, and armour units placed using a floating crane.

Hei Ling Chau Typhoon Shelter

The construction of the breakwater for the typhoon shelter will involve the dredging of a foundation trench, the dumping of fill and placement of rock or precast armour units.

The trench will probably be dredged by a trailing suction hopper or grab dredgers and the placement of fill and rock from barges and floating cranes respectively.

Estimations of construction noise at sensitive facades have been made using the procedure described in *BS 5228 (Part 1: 1984), Noise Control on Construction and Open Sites*. This procedure is applicable to sound travelling over water.

Because the distances between construction sites and receiver areas range from about 1 to 9km, a correction for air absorption has been applied. The correction has assumed a source frequency of 500Hz, relative humidity of 70%, and temperature of 20°C. These conditions result in attenuation of 0.27dB per 100m due to air absorption.

5.2.6 Operational Phase Impacts

Container Port operations have the potential to create significant noise. Tasks associated with the

TABLE 5.5

CONSTRUCTION EQUIPMENT FOR ONE BERTH (MARINE DREDGING AND FILL)

EQUIPMENT	SOUND POWER LEVEL (dB(A))	MAXIMUM NUMBER	DURATION OF USE (months)
CHANNEL AND TRENCH DREDGING			
Trailing suction hopper dredger	109	1	6.8
TRENCH FILLING AND SAND BLANKET			
Trailing suction hopper dredgers	109	2	2.7
Cutter suction dredger	104	1	2.5
GEOTEXTILE			
Pontoons with 4 winches	110	2	2.6
Tugboat	110	1	2.6
WICK DRAINS -- BERTH			
Derrick lighters	104	5	4.9
Tugboats	110	2	4.9
BERTH ROCK BUNDS AND ARMOUR			
Derrick lighter	104	1	4.8
Tugboat	110	1	4.8
FILL			
Trailing suction hopper dredger	109	1	9.5
Cutter suction dredger	104	1	9.5
Bulldozers	115	4	9.5
Dumptrucks	117	25	1.9
Excavator/loader	112	9	1.9
Grader	113	9	1.9
Scraper	119	9	1.9
Vibratory roller	108	9	1.9

TABLE 5.6

CONSTRUCTION EQUIPMENT FOR ONE BERTH (QUAY CONSTRUCTION)

EQUIPMENT	SOUND POWER LEVEL (dB(A))	MAXIMUM NUMBER	DURATION OF USE (months)
CONTAINER PORT QUAY WALL CONSTRUCTION			
Diesel hammer	132	1	5
Cranes	95	3	12
Electric saws	108	10	12
Rebar benders/cutters	90	10	12
Vibratory pokers	113	10	12
Derrick lighter	104	1	12
Tugboat	110	1	12
WORKS AREA			
Batching plant	108	1	
Hoist	104	1	
ROAD CONSTRUCTION			
Excavator	112	1	3
Dumper	106	1	3
Vibratory roller	108	2	3
Road planer	111	1	3
Vibratory poker	113	2	3
Paving train	109	1	3

Note : Works Area (Item 2 above) will be located in Penny's Bay.

TABLE 5.7

CONSTRUCTION EQUIPMENT FOR LAMMA BREAKWATER

EQUIPMENT	SOUND POWER LEVEL (dB(A))	MAXIMUM NUMBER	DURATION OF USE (months)
TRENCH DREDGING AND FILLING			
Trailing suction hopper dredgers	109	2	1.8
Cutter suction dredger	104	1	2.5
GEOTEXTILE			
Pontoons with 4 winches	110	2	2.5
Tugboat	110	1	2.5
WICK DRAINS			
Derrick lighters	104	5	0.5
Tugboats	110	2	0.5
ROCK BUNDS AND ARMOUR			
Floating crane	112	1	19.9
Tugboat	110	1	19.9
FILL			
Trailing suction hopper dredger	109	1	2.6
Cutter suction dredger	104	1	2.6
Bulldozers	115	5	2.6

operation of the Container Port are outlined below, with activities and equipment likely to produce significant noise. Port operations are expected to continue 24 hours a day.

- Unloading containers from berthed ships onto container trucks (and vice versa) results in noise from the operation of cranes, from spreaders engaging and disengaging containers, use of gantry gongs and crane sirens, the hoist motor, placement and tightening of supporting cables, and the movement of container lorries. During unloading, impulsive noise results from the impact of the container on the truck chassis.

- Transtainers operating between stacks of containers produce noise from the use of their engines, hoists, spreaders, sirens, and the movement of container lorries. Impulsive noise results from the impact of the container on truck chassis or other containers. In addition to the transtainers, 40-tonne forklifts can be used to manoeuvre containers in the stacks.

- Moving trucks produce engine, transmission, and brake noise, in addition to impulsive noise from the movement of their containers as they travel over uneven pavement or bumps. Monitoring of container trucks shows that the increase over normal operational noise due to use of horns or air brakes is about 5dB(A), and that produced by the chassis and container when passing over uneven surfaces is up to 15dB(A).

- Container Back-up Areas (CBA) are planned for the Container Port. Phase I CBA is assumed to be located along the existing Lantau Island coastline, behind Berths 3 and 4. CBAs for Phase II have been assumed to be located adjacent to individual berths, and no CBAs have been assumed for Phases III and IV because of the presence of the access road. Straddle carriers and lorries operating in the CBAs are the main source of operational noise.

- A Container Freight Station (CFS), where containers may be stripped and stuffed, may be operated on the Container Port, and has been assumed to be in phased operation for this Study. The facility has been assumed to be a multi-storey concrete building with direct vehicular access. Existing CFS structures in Kwai Chung have half-height walls on each storey, similar to car park walls, which provide little shielding for the noise from freight handling activities. For the purpose of this assessment, a CFS facility has been assumed to operate immediately north of Berths 3 and 4.

- Approaching and departing ships produce little engine noise, but produce occasional impulsive noise from horns during berthing and notifying intended course changes, particularly during periods of low visibility such as misty or foggy weather.

- Engineering workshops produce noise during the daytime from workshop activities such as drilling, hammering, and engine testing. However, these noise sources have been omitted from the assessment, since they are generally shielded from NSRs by the walls of the workshop building. Outdoor container maintenance activities, such as hammering metal plates and other noisy activities should be banned during night-time (2300-0700 hrs).

- No noise generation has been assumed from areas designated for Port Related Industries, since the nature of these industries is uncertain. Additionally, Discovery Bay and central Peng Chau are shielded by topography. For receivers at northern Peng Chau, relocation or insulation of receivers should be provided. There are no planned activities on the Lamma Breakwater, though noise generating activities could be located there in the future.

Total assumed requirements for significant noise-producing equipment are provided below. The listed sound power level for yard tractors has been obtained from the *Technical Memorandum on Noise from Construction Work other than Percussive Piling*. Sound power levels for container cranes and transtainers are typical of noise levels generated by the use of these pieces of equipment, and include noise associated with their operation, such as noise from use of spreaders, placement of cables, impact of containers, and the movement of trucks.

In the preliminary noise assessment no adjustment was made for impulsiveness or intermittency of these noise sources. The barrier effect of stacked containers on the quay and in CBAs was also neglected.

Estimates of the levels (in dB(A)) of Port and Breakwater noise at sensitive facades were made using the following equation :

$$L_p = L_w - 20 \log(R) - 5$$

where L_p = A-weighted sound level at Rm from source, and

L_w = A-weighted sound power level.

As with construction phase impacts, because the distances between berths and receiver areas range from approximately 1 to 9km, a correction for air absorption was applied in the preliminary assessment. The correction was based on sample frequency spectra of representative port equipment. For a single berth, the combined sound power level of Container Terminal equipment shown in Table 5.8 was 132dB(A), assuming simultaneous operation of all berth equipment.

TABLE 5.8

PORT OPERATIONS: ASSUMED EQUIPMENT REQUIREMENTS

EQUIPMENT AND ASSUMED UNMITIGATED SOUND POWER LEVEL (dB(A))		PORT EQUIPMENT REQUIREMENTS			
		4 berths (Phase I)	8 berths (Phase II)	12 berths (Phase III)	17 berths (Phase IV)
CONTAINER TERMINAL					
Container cranes (electric)	115	10	20	30	43
Transtainers (diesel)	116	35	70	105	149
Yard tractors (diesel)	118	60	120	180	255
40t forklifts (diesel)	122	4	8	12	17
CONTAINER FREIGHT STATION					
Forklifts (electric)	95	70	140	210	298
Yard tractors (diesel)	118	20	40	60	85
Miscellaneous vehicles (diesel and gasoline)	112	25	50	75	106
CONTAINER BACKUP AREAS					
Straddle Carriers	112	12	12	--	--
Lorries	118	48	48	--	--

In practice, the noise emitted by an operating berth would be moderated by the self-screening effect of stacked containers or docked ships, as well as the effect of varying levels of equipment utilisation. To determine the actual effects of these factors, the noise from actual port operations was monitored in November 1992. Evening measurements were taken from the water opposite the occupied and vacated berths as well as an elevated position (approximately 26mPD) on Stonecutters Island overlooking Container Terminals 6 and 7 (equivalent to one Lantau Container Terminal) of these the measurements taken at Stonecutters Island were considered to be most representative. A moderate level of activity on the berths was observed at the time of monitoring, and a mix of quietened and standard port equipment was assumed to have been in operation. At a distance of 900m from the southern edge of CT7, the monitored L_{eq}(30 min) noise level was 53.6dB(A). Adjusting for distance and air attenuation effects, and approximating the port noise as a point source, this provides an equivalent operation sound power level (SWL) of 127dB(A). An additional 3dB(A) may be added to indicate the increase in noise levels expected during greater activity levels, resulting in an approximate equivalent SWL for four berths of 130dB(A) based on monitored conditions. This value may be compared to the SWL value calculated from the equipment list in Table 5.8, which is 132dB(A) for a single berth, or 138dB(A) for four berths. The lower monitored value reflects the effects of realistic levels of equipment utilisation and noise generation. However, the greater value of 132dB(A) per berth is used in the preliminary calculations shown in Tables 5.10, 5.12, 5.14, and 5.16. SWLs associated with the CBAs and CFS are derived from the assumed equipment and individual SWLs shown in Table 5.8.

5.3 IDENTIFICATION AND ASSESSMENT OF IMPACTS

5.3.1 Background

An assessment of potential noise impacts is given below for the five stages of construction/operation. This preliminary assessment is based on the worst-case situation, with 24-hour simultaneous operation of all construction equipment and plant for each phase and with no mitigation.

5.3.2 Phase I Construction

Construction of Berths 1 to 4 is expected to result in the following facade noise levels at NSRs:The non-piling construction noise levels shown in Table 5.9 below are within the daytime and evening criteria, with the exception of noise levels at exposed facades on northern Peng Chau. If full scale construction proceeds between 2300 and 0700, night-time ANLs could be exceeded at all locations except and Hong Kong Island. Given the low existing night-time background noise levels in these areas, noise from night-time construction could be intrusive to exposed residents.

Noise from piling is not expected to exceed the assessment criteria at any NSR.

TABLE 5.9

FACADE NOISE LEVELS DUE TO CONSTRUCTION OF BERTHS 1-4 (PHASE I)

RECEIVER		FACADE NOISE LEVEL DUE TO PORT CONSTRUCTION (dB(A))
R1	Discovery Bay	45
R2	Discovery Bay	53
R3	Discovery Bay	55
R4	Peng Chau	46
R5	Peng Chau	61
R6	Hei Ling Chau	56
R7	Hong Kong Island	18

Note : Shows facade noise levels due to use of construction equipment listed in Tables 5.5 and 5.6, exclusive of piling hammer and equipment in Works Yard.

Noise at R6, Hei Ling Chau, is due to construction of the Hei Ling Chau Typhoon Shelter.

5.3.3 Phase I Operation (including Phase II Construction)

Unmitigated operation of Berths 1 to 4 could result in the noise impacts as shown in Table 5.10, below.

For Discovery Bay receivers, all predicted noise levels are well in excess of HKPSG day-time and night-time maxima. Most receivers on Peng Chau are protected by topography from excessive daytime noise, but would be exposed to night-time noise levels greater than the HKPSG maximum. Receivers in Peng Chau who are not shielded by topography would be exposed to daytime and night-time noise levels significantly over the HKPSG

TABLE 5.10

FACADE NOISE LEVELS DUE TO OPERATION OF BERTHS 1-4 (PHASE I)

RECEIVER		FACADE NOISE LEVEL DUE TO PORT PENINSULA TRAFFIC (dB(A))	FACADE [1] NOISE LEVEL DUE TO PORT OPERATION (dB(A))
R1	Discovery Bay	14	57
R2	Discovery Bay	43	57
R3	Discovery Bay	43	59
R4	Peng Chau	28	49
R5	Peng Chau	46	54
R6	Hei Ling Chau	17	35
R7	Hong Kong Island	14	33

Note : [1] Shows facade noise levels due to use of all Phase I port equipment listed in Table 5.8. Contribution from road traffic is also included, but is negligible.

maxima. Receivers on Hei Ling Chau and Hong Kong Island are not expected to be exposed to significant levels of Port noise.

Concurrent construction of Berths 5 to 8 is expected to result in the noise impacts as given in Table 5.11.

TABLE 5.11

FACADE NOISE LEVELS DUE TO CONSTRUCTION OF BERTHS 5-8 (PHASE II)

RECEIVER		FACADE NOISE LEVEL DUE TO PORT CONSTRUCTION (dB(A))
R1	Discovery Bay	40
R2	Discovery Bay	47
R3	Discovery Bay	47
R4	Peng Chau	38
R5	Peng Chau	52
R6	Hei Ling Chau	24
R7	Hong Kong Island	32

Note : Shows facade noise levels due to construction equipment listed in Tables 5.5 and 5.6, exclusive of piling hammer and equipment in Works Yard.

Construction noise levels shown in Table 5.11 are expected to fall within daytime and evening criteria at all receivers. Construction noise at Hei Ling Chau and Hong Kong Island is predicted to be well within the appropriate ANLs.

If full scale construction proceeds between 2300 and 0700 hrs, night-time ANLs could be exceeded at Discovery Bay and parts of Peng Chau. Given the low existing night-time background noise levels in these areas, noise from night construction could be intrusive to exposed residents.

Noise from piling is not expected to exceed assessment criteria at any NSR.

5.3.4 Phase II

Unmitigated operation of Berths 1 to 8 could result in the noise impacts as shown in Table 5.12.

TABLE 5.12

FACADE NOISE LEVELS DUE TO OPERATION OF BERTHS 1-8 (PHASES I AND II)

	RECEIVER	FACADE NOISE LEVEL DUE TO PORT PENINSULA TRAFFIC (dB(A))	FACADE NOISE LEVEL DUE TO PORT OPERATION (dB(A))
R1	Discovery Bay	44	60
R2	Discovery Bay	47	60
R3	Discovery Bay	47	62
R4	Peng Chau	33	54
R5	Peng Chau	50	66
R6	Hei Ling Chau	10	37
R7	Hong Kong Island	20	37

Note : Shows facade noise levels due to use of all Phase I and Phase II port equipment listed in Table 5.8. Contribution from road traffic is also included, but is negligible.

For Discovery Bay receivers, all predicted noise levels are well outside HKPSG day-time and night-time standards. Most receivers on Peng Chau would be exposed to day-time noise levels approaching the HKPSG maximum and night-time noise levels exceeding the HKPSG maximum; those receivers on the exposed Peng Chau headland would be subject to noise levels significantly exceeding both daytime and night-time HKPSG standards. Receivers on Hei Ling Chau and Hong Kong Island are not expected to be exposed to significant levels of Container Port noise.

Concurrent construction of Berths 9 to 12 is expected to result in the noise impacts as given in Table 5.13.

TABLE 5.13

FACADE NOISE LEVELS DUE TO CONSTRUCTION OF BERTHS 9-12 (PHASE III)

	RECEIVER	FACADE NOISE LEVEL DUE TO PORT CONSTRUCTION (dB(A))
R1	Discovery Bay	48
R2	Discovery Bay	48
R3	Discovery Bay	52
R4	Peng Chau	59
R5	Peng Chau	65
R6	Hei Ling Chau	35
R7	Hong Kong Island	38

Note : Shows facade noise levels due to use of construction equipment listed in Tables 5.5 and 5.6, exclusive of piling hammer and equipment in Works Yard.

Due to the proximity of construction activity at Phase III, the non-piling construction noise levels (Table 5.13) approach or exceed both the daytime and evening criteria at both northern and central Peng Chau. SRs in Discovery Bay should be exposed to construction noise below the daytime and evening criteria. Construction noise at Hei Ling Chau and Hong Kong Island is expected to be below the desired daytime level and evening and night-time ANLs.

If full scale construction proceeds between 2300 and 0700 hrs, night-time ANLs could be exceeded at Discovery Bay and Peng Chau. Given the low existing night-time background noise levels in these areas, noise from night-time construction could be intrusive to exposed residents.

Noise from piling is not expected to exceed criteria levels at any NSR.

5.3.5 Phase III

Unmitigated operation of Berths 1 to 12 could result in the noise impacts as given in Table 5.14. For Discovery Bay and Peng Chau receivers, all predicted noise levels are well in excess of the HKPSG maximum daytime and night-time noise levels. Receivers on Hei Ling Chau and Hong Kong Island are not expected to be exposed to levels of port noise exceeding current background noise levels or HKPSG maxima.

TABLE 5.14

FACADE NOISE LEVELS DUE TO OPERATION OF BERTHS 1-12 (PHASES I TO III)

RECEIVER		FACADE NOISE LEVEL DUE TO PORT PENINSULA TRAFFIC (dB(A))	FACADE NOISE LEVEL DUE TO PORT OPERATION[1] (dB(A))
R1	Discovery Bay	46	60
R2	Discovery Bay	50	60
R3	Discovery Bay	49	62
R4	Peng Chau	46	61
R5	Peng Chau	54	69
R6	Hei Ling Chau	25	40
R7	Hong Kong Island	25	41

Note : [1] Shows facade noise levels due to use of all Phase I, II and III port equipment listed in Table 5.8. Contribution from road traffic is also included, but is negligible.

Concurrent construction of Berths 13 to 17 is expected to result in the noise impacts as shown in Table 5.15.

TABLE 5.15

FACADE NOISE LEVELS DUE TO CONSTRUCTION OF BERTHS 13-17 (PHASE IV)

RECEIVER		FACADE NOISE LEVEL DUE TO PORT CONSTRUCTION dB(A)
R1	Discovery Bay	48
R2	Discovery Bay	47
R3	Discovery Bay	51
R4	Peng Chau	59
R5	Peng Chau	63
R6	Hei Ling Chau	35
R7	Hong Kong Island	41

Note : Shows facade noise levels due to use of construction equipment listed in Tables 5.5 and 5.6, exclusive of piling hammer and equipment in Works Yard.

Noise from piling is not expected to exceed assessment criteria at any NSR.

Due to the proximity of construction activity at Phase IV, the non-piling construction noise levels shown in Table 5.15 above approach or exceed the desired daytime maximum and the evening ANL at Peng Chau. Receivers in Discovery Bay should be exposed to construction noise below these criteria. Receivers on Hei Ling Chau and Hong Kong Island should experience noise levels below the desired daytime maximum and evening and night-time ANLs.

If full scale construction proceeds between 2300 and 0700 hrs, night-time ANLs could be exceeded at Discovery Bay and Peng Chau. Given the low existing night-time background noise levels in these areas, noise from night-time construction could be intrusive to exposed residents.

5.3.6 Phase IV Operation of Berths 1 - 17

The noise impacts from the full, unmitigated operation of the Container Port are shown in Table 5.16.

TABLE 5.16

FACADE NOISE LEVELS DUE TO OPERATION OF BERTHS 1-17 (PHASES I TO IV)

RECEIVER		FACADE NOISE LEVEL DUE TO PORT PENINSULA TRAFFIC (dB(A))	FACADE NOISE LEVEL DUE TO PORT OPERATION[1] (dB(A))
R1	Discovery Bay	49	61
R2	Discovery Bay	55	61
R3	Discovery Bay	55	63
R4	Peng Chau	55	64
R5	Peng Chau	60	70
R6	Hei Ling Chau	34	46
R7	Hong Kong Island	31	44

Note : [1] Shows facade noise levels due to use of all port equipment listed in Table 5.8. Contribution from traffic is also included, but is negligible.

For Discovery Bay and Peng Chau receivers, predicted noise levels are in excess of the daytime and night-time assessment criteria. Receivers on Hei Ling Chau can expect to be exposed to Container Port noise that exceeds the night-time criteria by about 1dB(A). The isolated Hong Kong

Island receivers represented by R7 could experience noise levels approaching the night-time criterion.

5.3.7 Lamma Breakwater

Construction of the Breakwater between Lamma Island and Cheung Chau can be expected to produce noise impacts on nearby NSRs. As shown in Table 5.17, most tasks associated with construction of the Breakwater are not expected to cause significant noise impacts at nearby NSRs. A possible exception occurs with the use of several bulldozers during finishing of the fill. This task would generate the greatest impact on exposed receivers on Cheung Chau and Lamma Island. Noise from this operation would be expected to meet the *Technical Memorandum* ANL criterion for daytime noise, but could exceed the night-time ANL criterion for receivers unprotected by topographical features.

TABLE 5.17

FACADE NOISE LEVELS DUE TO CONSTRUCTION OF LAMMA BREAKWATER

RECEIVER	PREDICTED FACADE NOISE LEVEL (DB(A))				
	DREDGING AND FILLING	GEO-TEXTILE	WICK DRAINS	ROCK BUNDS AND ARMOUR	FILL
R8 (Cheung Chau)	40	42	43	42	50
R9 (Hei Ling Chau)	33	35	35	34	42
R10 (Lamma Island)	42	44	44	43	51

Note : Barrier effects of topography have been excluded.

Noise-generating activities could be located on the Breakwater reclamation in the future. Such activities could affect NSRs on Cheung Chau and Lamma Island (South), which are equidistant from the Breakwater. To meet HKPSG guidelines for noise from fixed sources, future activities on the Breakwater should be limited to the approximate levels of noise generation shown in Table 5.18.

5.3.8 Discussion

Construction of port facilities is expected to generate noise that could exceed the desirable limit for daytime non-piling construction noise at Peng

TABLE 5.18

MAXIMUM SOUND POWER LIMIT OF FUTURE BREAKWATER ACTIVITY

RECEIVER LOCATION	Day (0700-2300)	Night (2300-0700)
Cheung Chau	132	122
Lamma Island (South)	128	122

Note :
- Assumes Area Sensitivity Rating "A" for receivers on Cheung Chau and Lamma Island;
- Relevant maxima for facade noise levels at receivers are:
  55dB(A) [HKPSG daytime: Cheung Chau];
  45dB(A) [HKPSG night-time: Cheung Chau];
  51dB(A) [HKPSG daytime: Lamma Island South];
  45dB(A) [HKPSG night-time: Lamma Island South].
- Assumes noise-generating activity is located at the centre of the breakwater reclamation.

Chau. If full scale construction works extend into the night-time hours, the *Technical Memorandum* night-time ANL criterion is likely to be exceeded at both Discovery Bay and Peng Chau. Hei Ling Chau and Hong Kong Island are generally expected to be protected by distance from excessive port construction noise.

In addition, noise from the construction of the Lamma Breakwater is expected to have a very slight impact on sensitive receivers in Hei Ling Chau, Cheung Chau, and Lamma Island, and should generally meet desirable and statutory criteria. Full scale night-time construction works could result in exceedence of the night-time ANL criterion during finishing of the fill.

Of greatest concern, however, is the level of port operational noise. Results in Tables 5.10, 5.12, 5.14, and 5.16 show that noise associated with a high level of port operations, if left unmitigated, could be expected to cause significant impacts on receivers in Discovery Bay and Peng Chau. Assessed against the standard of 5dB(A) below the Acceptable Noise Level (ANL) for fixed noise sources shown in Table 5.2, predicted unmitigated operational noise exceeds acceptable levels by upto 19dB(A) in the final phase of port operation (except at the few exposed NSRs on northern Peng Chau, where the maximum exceedence could reach 25dB(A)). A discussion of possible mitigation measures, and an assessment of their effects, are examined below.

5.4 MITIGATION MEASURES

5.4.1 Operational Noise Mitigation:Quietened Port Equipment

Container Cranes

Efforts to quieten ship-to-shore cranes have resulted in noise reductions for container crane operation. In the U.K., Morris Cranes have reduced noise from the crane's hoist motor and gearbox using various measures, including enclosing the hoist drive with an acoustic shield. The acoustic shield alone resulted in a reduction of 10dB(A) in hoist drive noise. In addition, air inlets and outlets have been orientated to reduce noise transmission toward sensitive receivers, while maintaining the volume of air required to effectively cool the engine.

Mitsui Engineering and Shipbuilding Co. in Japan have produced a quietened container crane presently in use in Hong Kong. The quietened crane requires no diesel generator for electrical supply, and has no induction motor. Recent monitoring of the quietened crane indicates a reduced sound power level (SWL) of 109dB(A), about 3dB(A) below the unquietened noise levels of cranes operating at the newer existing container terminals at Kwai Chung.

Rail-mounted Gantries

In order to reduce the noise associated with diesel-powered transtainers, the use of electrically-powered rail-mounted gantries (RMG) has been considered. The noise level of a typical unquietened RMG, monitored in November 1992 at Thamesport (U.K.), is about 110dB(A). The use of a low-noise motor on this piece of equipment could achieve a further reduction of 5 to 10dB(A) at frequencies of 250Hz and above.

Yard Tractors

In Table 5.8 above, the sound power level of 118dB(A) was based on EPD's Technical Memorandum on Noise from Construction Work other than Percussive Piling.

Information from UK tractor manufacturers indicates that this sound power level can be considered high. Data obtained from three manufacturers shows that the sound power levels of unquietened tractors varies between about 94 and 114dB(A), depending upon engine speed, vehicle make and other factors.

Information from one manufacturer also indicates that a reduction of 4dB(A) in engine noise was achieved by modifying the exhaust system, engine fan and engine speed of a tractor.

Taking a Douglas Tugmaster NS8-220 RoRo/Terminal Tractor, with an approximate sound power level of 111dB(A), as representative of currently-achieved SWLs for unquietened operating tractors, and extending the 4dB(A) engine noise reduction to it, a sound power level of 106.5dB(A) is proposed for quietened yard tractors.

40-tonne Forklift

Possible reductions in the sound power level of a forklift are discussed by Baker *"Reducing Noise at the Operator's Ear of a Large Army Forklift Truck", Internoise '74*; who describes the measures taken to reduce by 11dB(A) the noise generated by a Rough Terrain Forklift Truck:

- installation of a conventional, increased-volume muffler,
- quietening of intake system by damping the air cleaner canister and installing extra silencing elements,
- reduction of panel vibration through damping, isolation mounting of the engine and transmission, and treatment of hydraulic system components,
- replacement of standard engine fan with shrouded or larger fan, and
- reduction of noise transmission by blocking openings and adding absorptive material to interior surfaces.

5.4.2 Construction Noise Mitigation

The most significant noise-generating pieces of equipment are those associated with finishing the reclamation fill (Task 6 in Table 5.5 above) and constructing the quay wall (Task 1 in Table 5.6 above). The most effective mitigation measure is to control this noise at its source. In the case of powered mechanical equipment, this involves either selecting silenced equipment, or reducing the transmission of noise using mufflers, silencers, or acoustic enclosures.

Serious consideration of alternative piling methods/techniques is important, this should include the possible use of bored and or vibratory piles.

It is feasible to recommend certain methods of construction to be employed by the contractor, noise control requirements should be incorporated in the tender/contract documents, specifying the noise standards to be met and requirements for noise monitoring on the site.

Use of Silenced Construction Equipment

The power units of non-electric stationary plant and earth-moving plant can be quietened by vibration isolation and partial or full acoustic enclosures for individual noise-generating components, such as acoustic shrouds for piling activities.

Construction plant should be properly maintained and operated. Construction equipment often has silencing measures built in or added on, e.g., bulldozer silencers, compressor panels, and mufflers. These silencing measures should be properly maintained and utilised.

Hours of Operation

Limited hours of use for powered mechanical equipment may be necessary. Loud pieces of equipment, such as bulldozers or dumptrucks, may be restricted to daytime operating hours.

Noise Barriers

Temporary noise barriers or earth embankment may be used to screen receivers in certain areas.

Fill deposited on the site may be formed into an embankment to shield receivers in Discovery Bay and Peng Chau as much as possible. Embankments may be levelled at the end of fill operations when they are no longer required as noise barriers.

A purpose-built mobile noise barrier can be fabricated to shield sensitive receivers. Effective barriers are typically lined on the noise-generating side with a noise-absorbing material, and have a surface mass of at least 7 kg/m^2. Assuming that the barrier has no gaps, and that it blocks the line of sight between noise generator and noise receiver, reductions of 5 to 10dB(A) can be achieved.

Establishment of Effective Communication

Though not effective in reducing noise levels, the establishment of good communications can assist both the contractors and NSRs. Residents of Discovery Bay, Peng Chau, Hei Ling Chau and other nearby settlements should be notified in advance of planned operations, and informed of progress. Notification of blasting operations at TCT is particularly important. If necessary, a liaison body can be established to bring together representatives of the affected communities, the government, and the contractors. In addition, residents may be provided with a telephone number for the Resident Engineer's office, where they may register complaints concerning excessive noise. If justified, the Resident Engineer may authorise noisy operations to cease or to be conducted at more restricted hours.

The exact sound reduction possible with the use of silenced equipment is estimated to be of the order of 5 to 10dB(A). Further reductions of 5 to 10dB(A) could be effected with noise barriers, though these would generally be effective only for lower level receivers. With a night-time construction noise criterion of 45dB(A), these reductions could prove inadequate for a limited number of receivers during some phases of construction. Restrictions on night-time construction could then be considered, or measures taken at the receiver to block the transmission of construction noise (particularly at those receivers who may be eligible for individual protective measures due to operational noise levels). It should be noted that the construction noise estimates presented in Tables 5.9, 5.11, 5.13 and 5.15 represent a worst-case scenario of simultaneous use of almost all equipment. In the absence of greater detail concerning construction methods and schedules at this stage, a more detailed noise assessment cannot be made.

5.4.3 Operational Noise Mitigation

Noise Impact Assessment

Using the measured and published noise reduction data cited above, a reassessment of port operational noise has been conducted.

The reassessment is based on the following assumptions:

Quietened Port Equipment:

Container Cranes (3 per berth) :
109dB(A) SWL

Rail Mounted Gantries (9 per berth) :
110dB(A) SWL

Yard Tractors (15 per berth) :
106.5 B(A) SWL

40-tonne Forklift (1 per berth):
111dB(A) SWL

Where this equipment operates in the Container Backup Areas and Container Freight Station, it is assumed to be quietened.

Activity Noise Levels:

$L_{A(eq)}$ noise levels associated with port equipment have been assessed with reference to the actual time that port equipment would be expected to operate over a 30-minute interval. Based on experience with port operations and typical cycle times for port equipment, percentages of "on-time" have been assumed as follows:

0.75 rail mounted gantries
0.22 yard tractors
0.10 40-tonne forklifts

No adjustment for cycle time has been considered for container cranes because their monitored sound power level already incorporates cyclical changes.

Utilisation Factors :

For the purpose of the noise assessment, all of the Phase 1 and Phase II berths were assumed to be operational for the 30-minute evaluation period. However, this 100% utilisation is considered unrealistic as discussions with existing operators in Hong Kong has clearly indicated that a 65% berth occupancy is the norm. For Phases 3 (maximum 12 berths) and 4 (maximum 17 berths) two possible scenarios, utilising 11 and 14 berths respectively, have been assessed. The 11 or 14 occupied berths have been selected to give a worst-case scenario for the receiver area under consideration and is considered to be well beyond realistic operational occupancies. In summary the maximum berth occupancies which have been assessed are :

Phase I	-	100%
Phase II	-	100%
Phase III	-	92%
Phase IV	-	80%

This allows for any possible increases in berth occupancy during future years.

Use of Barriers :

In order to block the transmission of noise from the quietened port equipment, purpose-built noise barriers are considered. As these barriers are assumed only west of Berths 4, 9 and 15, they have a dual function in helping to alleviate not only noise, but also visual impacts, from the container ports. In the interests of reducing their obtrusiveness and increasing their stability in the event of strong winds, their height has been limited to 13.7 m, corresponding to the maximum stacking height of containers. These barriers would be solid, and extend approximately from the quayside to the rear of the berth.

Unfortunately, container cranes are positioned at the quayside, so that noise barriers are of negligible effect in blocking the transmission of noise from these sources. Thus, the barrier effect has been ignored for container cranes.

It has also been assumed that the Container Backup Areas and Container Freight Station will incorporate barriers capable of reducing noise transmission by 10dB(A).

As in the preliminary assessment, reductions due to distance attenuation and air absorption are included in the calculations. As facade noise levels are being examined, 3dB(A) are added to account for the facade effect.

The effects of the above mitigation measures are examined with reference to receivers in Discovery Bay and central Peng Chau, since these are the receivers exposed to noise levels greatly exceeding HKPSG and NCO standards.

In order to examine the impact of mitigated port operation in Discovery Bay, the expected facade noise levels at the top and bottom storeys of receivers represented by R2 and R3 were assessed. Differences between top-storey and ground-level facade noise levels are generally attributable to the effect of barriers, topographical and/or those proposed for the western ends of Berths 4 and 9. Receivers R1 and R4 (central Peng Chau) have also been assessed. The expected noise levels are given in Table 5.19.

Sensitive receivers on northern Peng Chau Island (Receiver R5) and in Fa Peng are few in number but are in positions that are very exposed to the noise of port operations. These receivers do not benefit from any topographical or purpose-built barriers. It is anticipated that mitigation measures at the receiver may have to be implemented for these scattered dwellings. The most effective method to reduce port noise will be use of good quality glazing, with air conditioning for ventilation. A preliminary estimate of noise reduction has been carried out for a typical receiver. The use of 6mm glass panes in sealable frames provides a noise reduction of about 18dB(A) for port noise. This reduction brings internal noise levels due to the port operations well below the background level produced by an operating air conditioner (about 55dB(A)). However, the effectiveness of glazing as a mitigation measures is heavily dependent on the quality of its installation. An adequate window seal must be provided to effectively block gaps around the window edges. The seal should be airtight (such as a rubber gasket) and should extend around the entire perimeter of the frame. Fasteners should be wedge formed so that, when closed, the window frame compresses the seal.

The cost of this measure is estimated at $3,000 to $5,000 per sealable window. Air conditioning units vary in price, but are approximately $4,000 for a 1-hp unit. These estimated figures include the cost of labour, and refer to current prices and rates.

Site visits have indicated that the Peng Chau headland (R5) only contains one residential building which will be exposed to direct, line of sight noise and the small settlement of Fa Peng is limited to only a few buildings. Consequently the potential cost of noise mitigation measures (or even relocation in the case of Fa Peng) would not be significant in terms of the container port development.

Flats in Housing Department's planned development on the Peng Chau western waterfront are not expected to require mitigation at the receiver. North-facing top-storey facades in the 8-storey north west block may be exposed to noise from Berths 1 to 8 which is anticipated to reach 48dB(A) with the use of quietened equipment. East- or south-facing top-storey facades in the eastern blocks may be exposed to noise from Berths 1-14 (greatly reduced by the intervening Peng Chau headland) and Berths 15-17; facade noise levels are expected to reach 46dB(A) with the use of quietened equipment. Lower-storey receivers would benefit from the proposed noise/visual barriers by Berths 9 and 15, and should be exposed to even lower noise levels.

The noise levels obtained in Table 5.19 must be considered in relation to the noise level anticipated from road traffic. In Phases I and II, port-related L_{eq} traffic noise is less than or equal to the port operational noise; however, in Phases III and IV (particularly the latter, after the Green Island Link connects the port peninsula to Hong Kong Island), unmitigated traffic noise could dominate the noise environment.

TABLE 5.19

FACADE NOISE LEVELS FROM QUIETENED PORT OPERATIONS

		Facade Noise Level dB(A) (by Phase and Number of Operating Berths)						
		I	II	III		IV		
ID	Receiver Elevation	4	8	11	12	11	14	17
R1	Ground	43	43	46	46	48	48	48
R2	Ground	41	44	45	45	45	45	45
	Top-Storey	42	45	45	45	45	46	46
R3	Ground	43	46	47	47	47	48	48
	Top-Storey	47	49	49	49	49	50	50
R4	Ground	36	38	43	43	45	46	46
R5		52	53	56	56	57	57	57

These results show that with the use of quiet equipment and purpose-built barriers west of Berths 4, 9 and 15, anticipated noise levels are not expected to exceed NCO standards during all four phases of operation. However, exceedences of the HKPSG would be expected, leading to the desirability of investigating the performance of "ultra-quietened" equipment - port equipment quietened from the levels indicated as presently achievable.

Use of 'Ultra' Quietened Equipment

The reduced noise levels indicated in the previous section for quietened port equipment are those that are currently achieved in practice. (The exception to this is the reduced noise level for the 40-tonne forklift, which is derived from the SWL and reductions achieved with other large diesel forklifts. This is considered to be relevant because the equipment finally selected by the operators may not necessarily be as powerful or generate as much noise as that specified (which is considered to be a worst-case situation) and may be merely a large forklift. Also, because it is expected to be used infrequently, the contribution of the 40-tonne forklift to the overall noise level is significantly lower than that of any other equipment.) Equipment manufacturers world-wide are currently examining ways to further quieten their equipment in response to requirements to reduce the noise generated by ports and distribution depots.

The following noise reductions are proposed as reasonable and practical reductions that can be expected by the time Phase 1 berths commence operation:

- Container Cranes : The noise from quietened cranes recently monitored at Kwai Chung may be further reduced by acoustic treatment of the gear box and motor, and possibly by an alternative warning system to replace the siren. A further reduction of 4dB(A) is proposed, bringing the ultra-quietened container crane SWL to 105dB(A).

- Rail Mounted Gantry : An unquietened Davy Morris electric RMG produced a monitored SWL of 110. The consultant who measured the SWL suggested that the use of low-noise motors could result in further reductions of 5 to 10dB at frequencies of 150Hz and above. Adopting the lower bound of this range, a reduction of 5dB(A) is proposed, bringing the ultra-quietened sound power level of a RMG to 105dB(A).

- Yard Tractors : In addition to the 4dB(A) reduction for a static tractor obtained by modification of the exhaust system, engine fan, and engine speed, it is proposed that a further 2dB(A) may be achievable with such measures as partial engine enclosure and use of resilient engine mounts. This would bring the SWL of 107dB(A) for a quietened yard tractor to 105dB(A) for a ultra-quietened yard tractor.

No further reductions are proposed for the 40-tonne forklift although it is considered that significant reductions could be achieved if required.

Substituting these ultra-quietened SWL values for the quietened SWL values used to obtain Table 5.19, the following values are obtained :

TABLE 5.20

FACADE NOISE LEVELS FROM ULTRA-QUIETENED PORT OPERATIONS

		Facade Noise level dB(A) (by Phase and Number of Operating Berths)						
		I	II	III		IV		
ID	Receiver Elevation	4	8	11	12	11	14	17
R1	Ground	39	39	43	43	42	45	45
R2	Ground	39	42	42	43	42	43	43
	Top-Storey	40	42	43	43	43	43	43
R3	Ground	40	43	44	44	44	45	45
	Top-Storey	44	46	47	47	47	46	47
R4	Ground	33	34	39	39	41	41	42
R5		49	50	54	54	54	54	54

These results indicate that with the use of "ultra-quietened" equipment and purpose-built barriers west of Berths 4, 9 and 15, anticipated noise levels are expected to remain well within NCO standards during all four phases of operation. Facade noise levels at the receivers evaluated in Tables 5.19 and 5.20 are anticipated to remain within HKPSG standards except at upper storey facades in southern Discovery Bay, where 2dB(A) exceedence of HKPSG standards is expected.

5.5 MONITORING AND AUDIT REQUIREMENTS

5.5.1 Operational Noise Monitoring

The purpose of operational noise monitoring is to ensure that the Port Operator complies with relevant NCO requirements for daytime and night-time operation.

L_{90}, L_{eq}, L_{10} and noise levels should be monitored over a 24-hour period at the nearest or worst-affected sensitive receivers, probably in Discovery Bay and Peng Chau. The monitoring programme should be the responsibility of the Port Operator, and should commence with the start of Phase I operations. It is suggested that monitoring be conducted every two months initially and decreasing in frequency if NCO standards are consistently met, or increasing in frequency if NCO maxima are being exceeded, or if justified by the level of complaints.

5.5.2 Construction Noise Monitoring

The primary purpose of construction phase monitoring and auditing is to establish compliance with the terms and conditions set out in the Construction Noise Permits and with any daytime noise criteria contained in the contract documents.

The monitoring schedule should be determined by the resident site engineer (RSE), and should depend on the Contractor's method of working. The procedure for noise monitoring should follow that contained in the *Technical Memorandum on Noise from Construction Works other than Percussive Piling*. Measurements should be carried out at least twice per day, once in the evening (1900-2300 hrs) and once in the night-time (2300-0700 hrs). Daytime measurements should also be carried out three times per week.

If complaints are received, more frequent measurements will be needed. It may be necessary to introduce Trigger and Action Levels which are defined according to the frequency of complaints. Such a scheme is given in Section 14, Table 14.2.

The Contractor should be instructed to take action to reduce noise levels whenever noise measurements exceed the appropriate ANL.

It is recommended that Trigger and Action levels for construction noise be incorporated into the contract document. The setting of Trigger and Action levels and recommendations for corrective action to be taken when they are exceeded are given in Section 14.

5.6 CONCLUSIONS

Noise from Container Port construction has the potential to cause significant noise impacts on receivers in Peng Chau and Discovery Bay, particularly at night.

Port operational noise similarly has the potential to cause significant noise impacts. Adoption of quietened equipment currently available on the market can reduce noise levels significantly, particularly in combination with end-of-berth barriers. With quietened equipment and barriers, noise levels are not expected to exceed NCO standards except at scattered, highly exposed dwellings. "Ultra-quietened" port equipment and end-of-berth barriers would be expected to result in even lower noise levels that lie within HKPSG standards at all but very exposed receivers.

In summary, with the use of appropriate and reasonable mitigation measures, NCO standards at all evaluated NSRs (except those on Peng Chau headland and the tiny settlement at Fa Peng) are expected to be achieved in all phases of the Port operation. HKPSG standards can similarly be met at all but a limited number of receivers.

The Breakwater construction is not expected to have significant impacts on nearby NSRs if finishing of the fill is restricted to daytime hours.

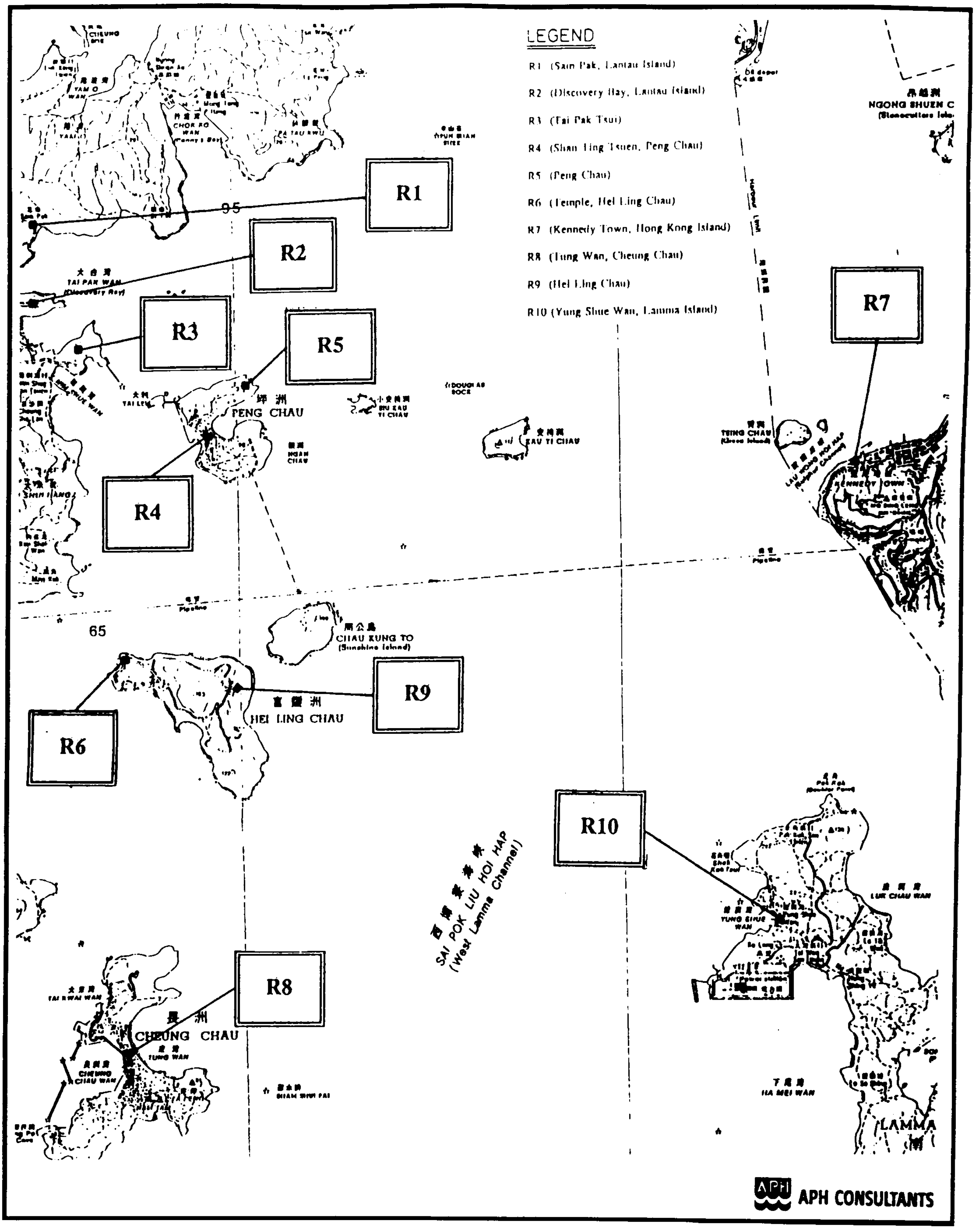

FIGURE 5.1

IDENTIFICATION OF NOISE SENSITIVE RECEIVERS