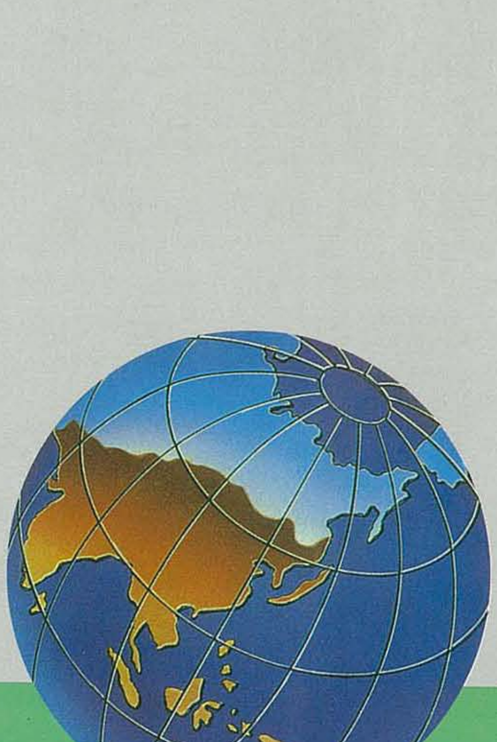
Lamma Quarry; Casting Basin & Moderate Quarry Extension, Environmental Impact Assessment

Final Report



AXIS Environmental

LAMMA ROCK PRODUCTS LIMITED

Lamma Quarry; Casting Basin & Moderate Quarry Extension, Environmental Impact Assessment

Final Report

May 1993

AXIS Environmental

SHUI ON QUARRIES LTD.

LAMMA ROCK PRODUCTS LTD.

AXIS Environmental Consultants Ltd.

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Section 1

1. INTRODUCTION

1.1 BACKGROUND

The quarry at Pok Tung Wan is operated by *Lamma Rock Products Ltd.*, a subsidiary of the Shui On Group, under a current Government Licence which expires at the end of 1993. A plan showing the location of the Pok Tung Wan quarry on Lamma Island, is given in Figure 1.1. The quarrying is being undertaken to an approved landform.

It is proposed that the existing Government Licence is extended for a further 2 years, which would give an expiry date at the end of 1995. If the application for the extension is approved it is proposed that the quarry limits be extended and that a casting basin/dry dock facility be constructed. The basin/drydock facility would be used for the construction of precast units which are required for the large number of existing, committed and proposed infrastructure projects within Hong Kong.

This Section briefly describes the existing facilities and activities at the Pok Tung Wan quarry and also outlines the scope and objectives of the environmental impact assessment (EIA).

1.2 SCOPE AND OBJECTIVES OF THE EIA

This EIA describes the existing and proposed development, identifies and assesses the potential impacts and recommends mitigation measures to reduce any impacts to acceptable levels in accordance with the study brief (in EPD letter (10) EP 2/N9/07 IV). It includes environmental monitoring and audit requirements that will be used to assess the effectiveness of mitigation measures.

1.3 SITE DESCRIPTION

The existing approved quarry land formation is shown in Figure 1.2. The Pok Tung Wan quarry site is approximately 1000m in length and the existing quarry boundary stretches some 400m northwards from the northern shoreline of Sok Kwu Wan.

1.4 EXISTING FACILITIES AND ACTIVITIES

1.4.1 Current Facilities

There are a number of facilities within the Pok Tung Wan quarry including those related to the quarrying operations being carried out by *Lamma Rock Products Ltd.*, and these are shown on Figure 1.3. The facilities and associated activities are briefly described below:

- ***rock crushing and screening plant***: this provides aggregates and other rock products to the local construction industry;

- ***cement silos (and associated equipment)***: this operation is carried out by the *Far East Cement Co. Ltd.*, of which the *Shui On Group* are a 50% share holder, and acts as a storage and redistribution centre for much of Hong Kong's imported cement. The cement is imported from Japan;

- ***facilities for handling aggregate and cement barges***: the import and redistribution of cement and the aggregate handling facilities are extensive and operationally flexible making them suitable for use by large ocean going vessels and small barges;

- ***tile factory***: now disused, this facility is located at the western end of the quarry and constitutes a large open plan style warehouse. It should be noted that this site has been recommended as the location of the Lamma Island Pumping Station for the Strategic Sewage Disposal Scheme;

- ***general storage area***: this is located around the disused tile factory and provides an area for the storage of construction plant/equipment and materials for the construction arm of the Shui On Group.

1.4.2 Current Activities

At present the quarry is being operated under the Government Contract No. 428 of 1977, entitled "Right to Quarry Stone at Pok Tung Wan, Lamma Island". The contract allows for the quarrying and processing of the stone and the precasting of concrete.

The present production rate of the quarry is approximately 230,000 tonnes per month. Part of the production of quarried stone is crushed and screened to create a consistently sized aggregate product suitable for many purposes.

Blasting at the quarry occurs approximately twice a week and on each occasion a government representative is required to be present. There are three drill rigs used at the quarry for the preparation of the blast holes, with the actual size of hole depending on the rig used. The larger rig, an *Ingersoll-Rand DM25*, is used for the majority of the normal production drilling and creates a blast hole 24m deep with a diameter of 140mm. The charge for these holes is 245kg of emulsion explosive. The two smaller hydraulic drill rigs create a blast hole of 70mm diameter, and are used for presplit drilling and any production drilling which is within 20m of a final slope. There rigs use a charge of 1kg for presplitting or a charge of 80kg for production blasting.

Following a blast the rock produced is of various sizes and is either transported, by a number of large dumptrucks, to the crushing unit to produce an aggregate or if large rock is required, eg. for rock armour, directly to the barge loading point. Following crushing the aggregate product is either taken to the various stockpiles located around the quarry or transported directly to the barge loading point.

The barges that are used to carry the large rock pieces are loaded by using the dumptrucks which, after dousing the load with water to reduce dust generation, reverse to a ramp located above the barges and deposit the load. The barges carrying aggregate are loaded by means of a covered conveyor belt system which is in turn fed by means of a reclaim tunnel beneath the stockpiles.

1.4.3 Health and Safety Aspects

A requirement of the EIA brief is to consider "the effects on the health and well being of workers on site" arising from the continued operation of the quarry for two years. It was agreed during discussions to confirm the scope of the brief that this was intended to be a short and qualitative assessment. It is considered that this continued operation will not significantly change any effects on the health and well being of employees. Information on the existing health and safety practices at the Lamma quarry is included as Appendix 1A.

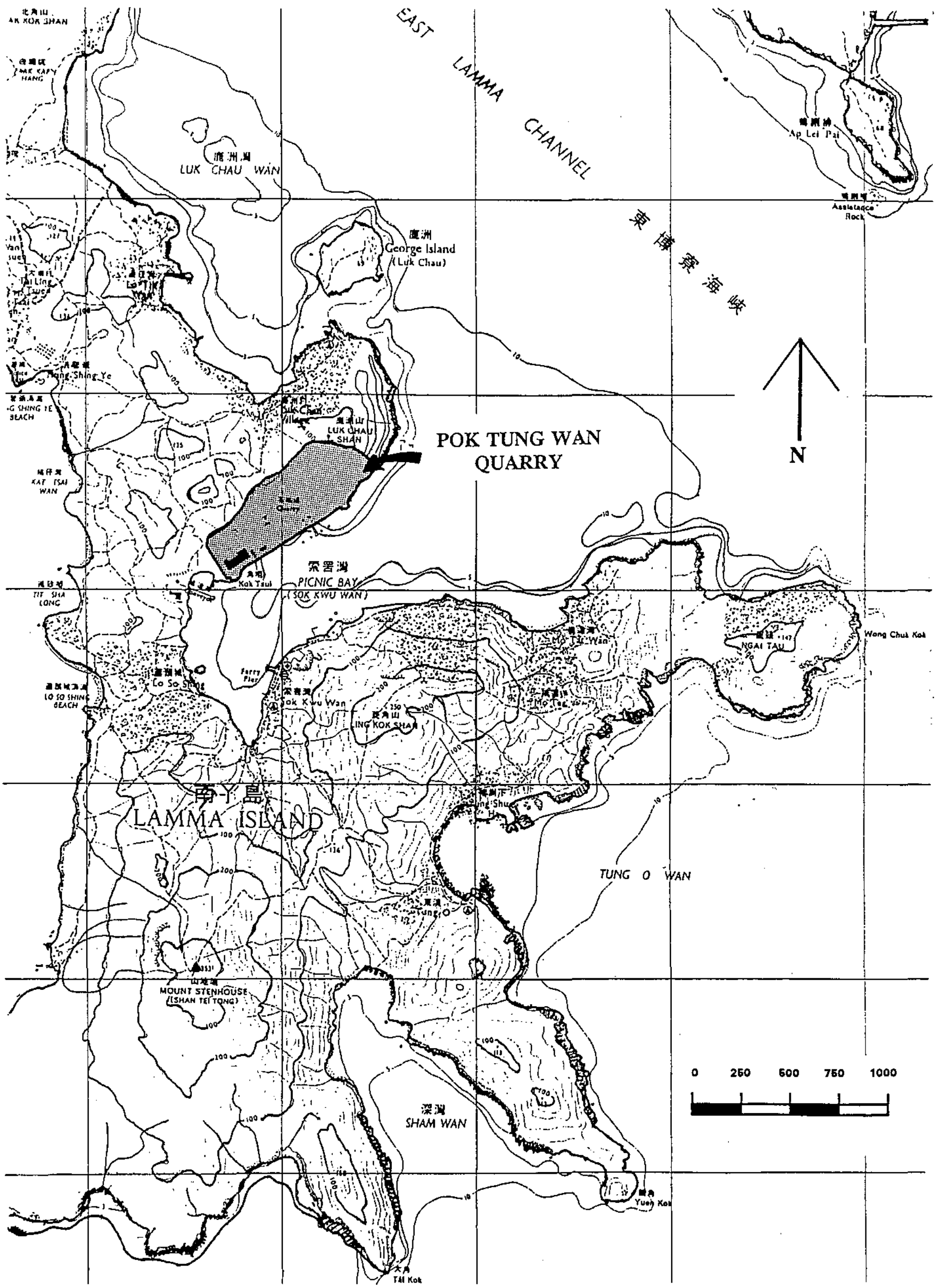
1.5 STUDY PROGRAMME

The study programme is shown in Figure 1.4. It should be noted that the terms of reference for the study did not call for an inception report. The assessment methodology was agreed through meetings with EPD and other government departments.

Overall the study programme called for a Study Management Group (SMG) meeting in the week ending 26th March, submission of the draft final Environmental Impact (EIS) in the week ending 30th April, and final approval of the EIS in the week ending 4th June.

1.6 CASTING BASIN DEVELOPMENT PROGRAMME

The detailed timing of the casting basin development is as yet unknown, Figure 1.5 shows a tentative development timing schedule. As can be seen from the figure the construction of the casting basin has a proposed start date of June 1993 and will take approximately 6 months to complete. During the last month of this period the site facilities would be completed; thus the operational phase of the casting basin could start December 1993.



AXIS Environmental	LAMMA ROCK PRODUCTS Ltd.	JOB TITLE LAMMA QUARRY, CASTING BASIN & EXTENSION	FIGURE TITLE LOCATION OF POK TUNG WAN QUARRY
		FIGURE No. 1.1	JOB NUMBER 054/000/93
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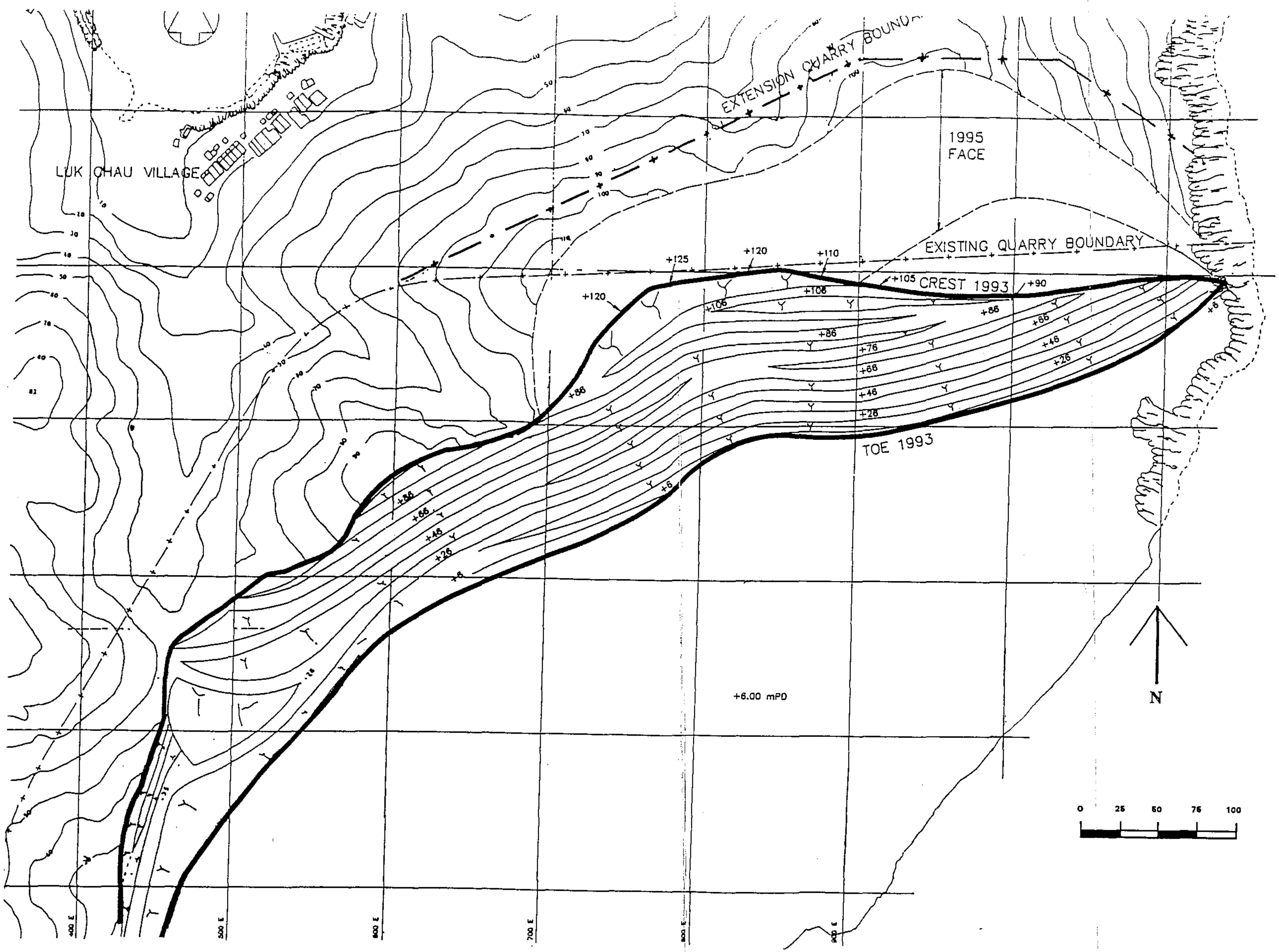
		DATE MAY 1993	



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JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	1.2
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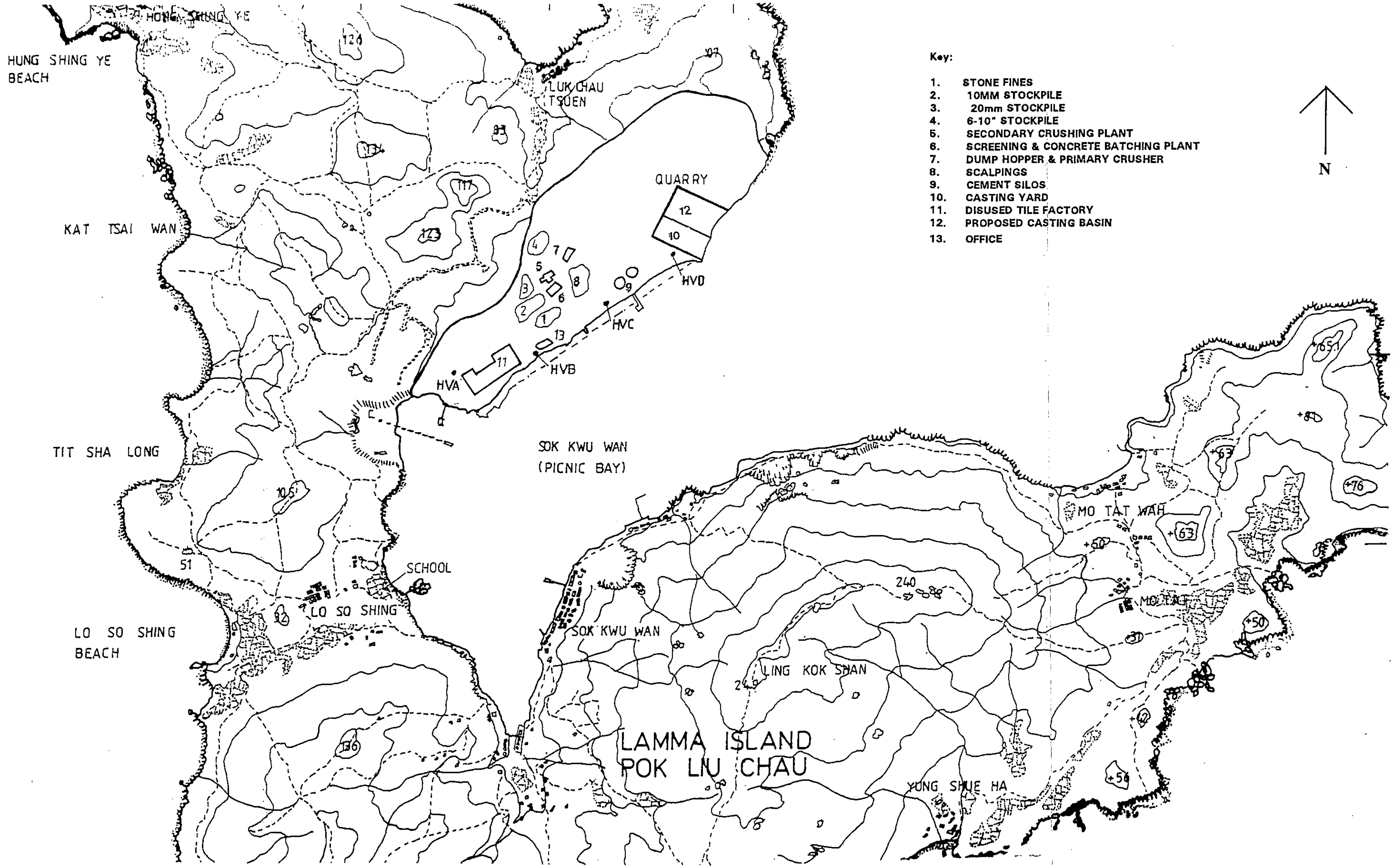
FIGURE TITLE	PROPOSED LANDFORM AT THE END OF 1993
JOB NUMBER	054\000\93



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JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	1.3
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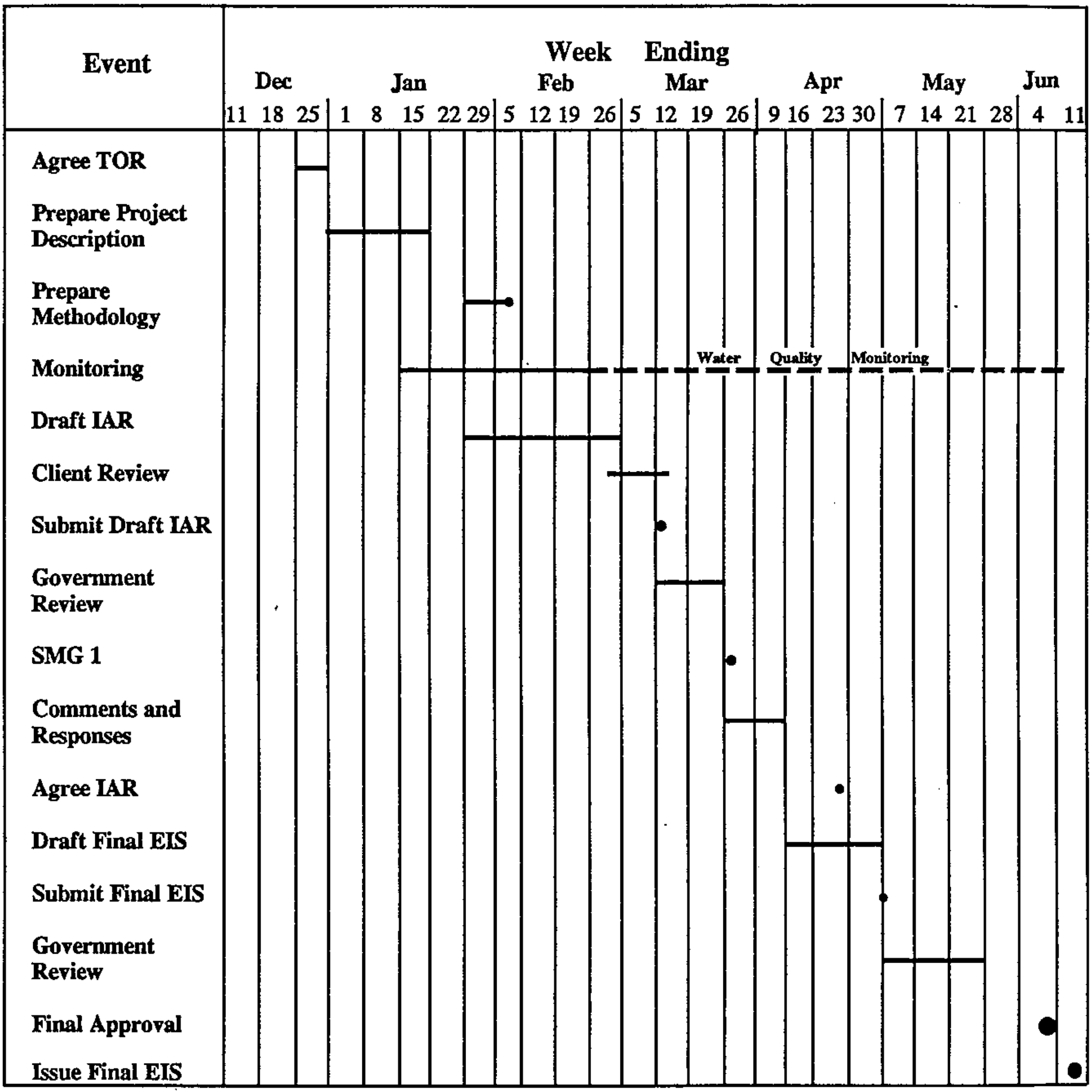
DATE:	MAY 1993
FIGURE TITLE	EXISTING FACILITIES
JOB NUMBER	054\000\93

Figure 1.4

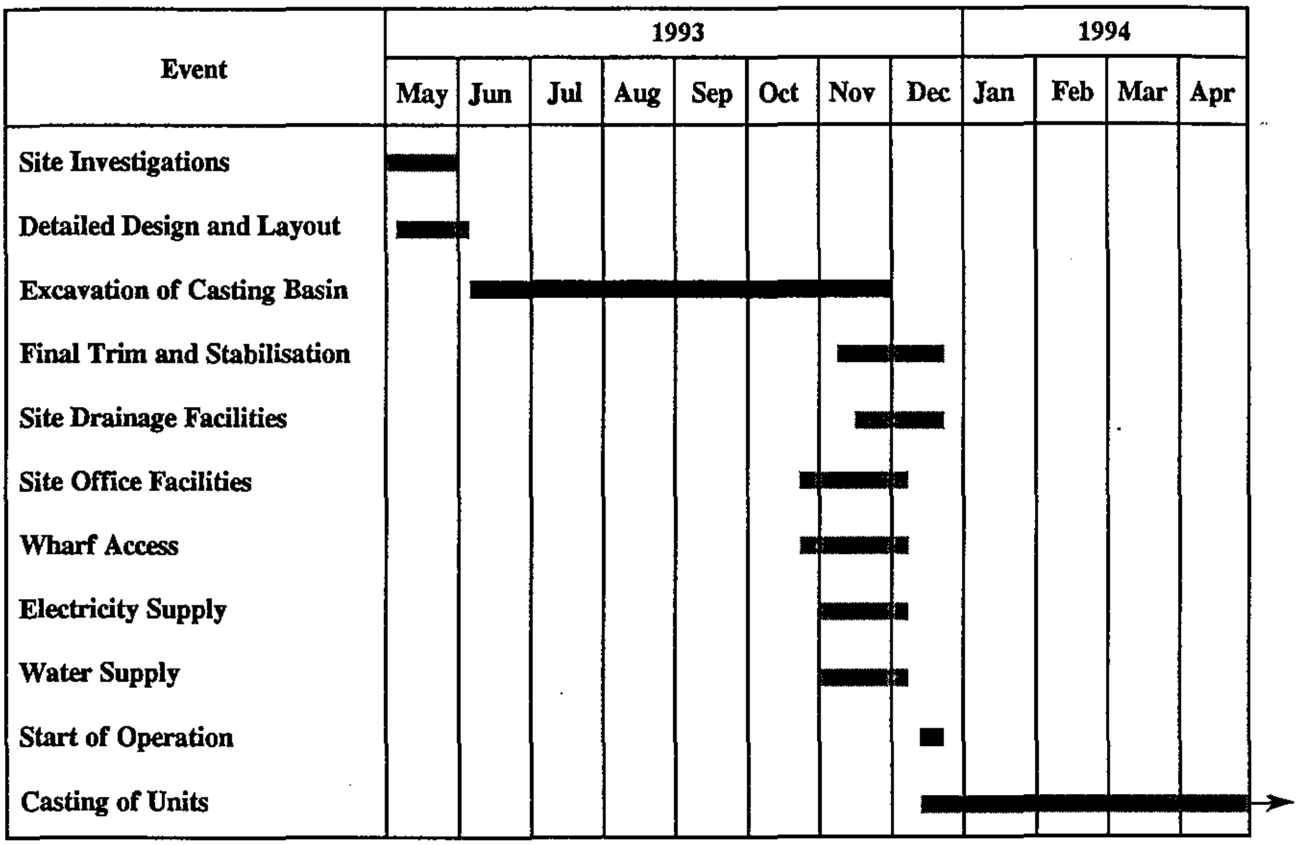
Lamma Quarry Environmental Impact Assessment
Study Programme



N.B. The Environmental Baseline Monitoring will continue for the whole length of the study

Figure 1.5

Casting Basin - Development Programme



Source : Lamma Rock Products Ltd.

Section 2

2. PROJECT DESCRIPTION

2.1 PROPOSED DEVELOPMENTS - CASTING BASIN CONSTRUCTION

2.1.1 Introduction

The Pok Tung Wan quarry has been identified as a potential site for the location of a casting basin in a number of Government feasibility studies including:

- the Lantau Airport Railway immersed tube crossing of Victoria Harbour;
- the Western Harbour Crossing Study, for construction of the dual 3-lane tunnel units;
- the Strategic Sewage Disposal Study, (Site Investigations and Engineering Studies) for the construction of the units for the Stonecutters Island interim outfall;
- the Route 3 connection to Tsing Yi Island;
- the Central and Wanchai reclamation;
- the Mass Transit Railway extension from Central to Tsim Sha Tsui;
- a Transmission Tunnel link for China Light and Power.

Additionally the casting basin could be used for the production of precast units necessary for the Central and Wanchai reclamations and other large scale infrastructure construction.

Plates 2.1 and 2.2 show the casting basins used for the construction of the immersed units for the MTR's Admiralty to Tsim Sha Tsui crossing and the Eastern Harbour Crossing. The units and basin used for the MTR crossing are of a similar size to that proposed for Pok Tung Wan Quarry.

2.1.2 Basin Construction

The size of the proposed basin would be in the order of 130m long by 120m wide at the quarry floor and have a depth of approximately 14m below the present ground level. At this level the invert of the basin would be approximately -9mPD, and be of size approximately 120m x 100m. This would enable four of the railway units to be cast in the basin at the same time. The proposed site for the basin is not currently large enough to accommodate the basin and so the existing benched slope at the back of the quarry will need to be pushed back to form a larger platform area.

The orientation of the casting basin will essentially be parallel to the adjacent existing casting yard. The reduced dimensions of the casting basin from previous plans will enable the basin to be located as close as practical to the casting yard. The distance between the quarry face and the crest of the casting basin will depend on the final positioning of the basin. Figure 2.1 shows the location of the proposed basin and the landform at end of 1995.

The basin itself will be formed as a drop cut (a normal quarry process) from the platform level at +5mPD to a basin floor level of -9mPD. Figure 2.2 shows a typical cross-section through the proposed basin. The operation will be carried out using drill/blast/muck-out equipment already being operated in the quarry, which is fitted with dust suppression measures.

Excavation will be achieved by producing progressive benches below the existing quarry floor, and mucking out by means of an inclined ramp/road from one corner of the dock. Access to the floor of the basin would be provided via a ramp excavated at a grade of 1:8 down the side of the casting basin. The width of the ramp is nominally 10m, with some additional excavation at the base of the ramp to provide turning access onto the casting basin floor.

Presplitting techniques will be employed to produce stable slopes.

The overall batter angles have not been specified as yet, but will depend on the specific method of excavation which is to be employed. The slope of the bench/benches has been nominally set at 15° from the vertical with the overall batter angle being a function of whether a single bench or double bench operation is used in excavation.

To minimise the extent of excavation, it will be necessary to consider slope stabilisation. A more detailed understanding of these requirements will be available once the geotechnical assessment has been undertaken. Also subject to the findings of the geotechnical investigations, it may be necessary to grout the rock between the casting basin and the sea. This requirement will in turn depend on the extent of water in-flow experienced, and will be assessed with pump-down tests when the basin is excavated below sea level.

There are several options available in terms of excavating the casting basin, the most cost effective method being a single bench excavation with blast holes drilled by the DM25 rig (140mm diameter). Depending on the available time for excavation of the basin, other methods may be employed to accelerate completion of the facility.

If fissures are encountered that appear to be potentially unstable, rock bolting/dowelling plus grouting techniques will be employed to ensure stability. (This is thought highly unlikely due to the known nature of the quarry rock quality and lack of faults). Any excessive inflow will be grouted.

As the drop cut reaches design level of approximately -9mPD, a perimeter drainage system will be developed leading to sumps that will also act as initial oil interceptors.

Ground vibration and dust emission will be controlled to the limiting criteria for the existing quarry practices. The proposed rate of excavation for the drop cut is lower than the average current quarry production rate. It is therefore expected to take approximately 4 months to excavate the 500,000 tonnes of rock in the drop cut.

2.1.3 Entrance Channel

To provide access between the casting basin and the sea, it will be necessary to excavate a channel to a depth of -9m below sea level. The width of the channel needs to be a minimum of 15m wide to allow for the passage of the railway tunnel units. Part of the channel may be excavated at the same time as the casting basin, however, the final break through to the sea is to occur after the casting basin is in use and when the construction of the first batch of tunnel units is completed.

To enable this to take place, it will be necessary excavate and dredge the full length of the channel, with drilling and blasting of any encountered rock. A small portion would be left adjacent to the sea, which is to be dredged just prior to floating out of the first batch of units.

Excavation of the entrance channel comprises two potential operations :

- dredging the approach profile in the existing soft marine deposits to rockhead level or down to -9mPD if no rock is encountered, to connect the basin invert to the existing navigational channel serving the cement berth;
- drill/blasting of any encountered rock, and subsequent dredging of shattered rock underlying the marine deposits and between the existing shoreline and the casting basin.

The first operation will be carried out inside a floating silt curtain designed to contain suspended solids. Suspended solids levels outside the screen will be carefully monitored as part of the operation control measures (Section 10.3.2 and Tables 10.3 and 10.7). The dredger will be fitted with a closed seabed grab and dredged material will be loaded into a split barge fitted with a water tight seal. No overflowing or use of automatic lean mixture overboard (ALMOB) systems will be permitted. When barges are moved in or out of the silt curtain enclosure, no dredging operations will take place and suspended solids levels will be allowed to reduce for the nominal time taken to reclose the screen.

In the second operation, overburden would be used as a blast 'cushion' and possible other measures, such as an air bubble curtain, would be used to minimise blast wave transmission to the fish culture zone. In addition, in the excavation of rock from the entrance channel, a floating silt curtain would be used to contain suspended solids.

It is proposed that the silt curtain will remain in place around the entrance channel throughout the operation. The silt curtain may be supplemented by a further parallel curtain in order to isolate a column of water as a further cushion against blast pressures.

Prior to drilling, decomposed granite overburden will be dozed into a layer over rockhead to a minimum thickness of 3m over any drill hole location. Drilling will use the overburden technique; holes will be formed using steel drill casings through the granular overburden and then drilled to required charge depth in rock. Plastic sleeves will be inserted down to bedrock and the casings extracted. Delay blasting techniques will be used employing preset delay detonators to reduce blast vibration to a specified level.

The purpose of the drill blast will be to shatter the rock in situ whilst minimising blast vibration and avoiding rock displacement or flyrock. On completion, the overburden and shattered rock will be removed, initially using face shovels and dumptrucks and later by grab dredger.

2.1.4 Entrance Gate

To enable repetitive use of the casting basin, it will be necessary for a dock gate to be constructed. The gate will be provided by using a large concrete caisson comprising a cellular reinforced concrete structure. The gate will be made inside the basin in parallel with the first batch of tunnel units. The approximate dimensions of the gate are 10m high by 15m wide with a thickness of approximately 10m.

The final design of the dock gate will be the subject of a separate engineering study to meet the specific requirements of the contractor utilising the casting basin. The general dimensions given above are for a dock gate suited to the Airport Railway tunnel units. The engineering study will also determine the most appropriate sequence of gate placement in relation to excavating the entrance channel.

On flooding the basin for the first time, the gate would be made to float, and when required would be subsequently towed into position. It would be then sunk and maintained in position by filling its cellular internal structure initially with seawater as ballast and subsequently with sand to achieve a more permanent stability. The gate structure can be sealed onto the entrance channel in a number of ways; these include rubber seals and concreting the gaps between the gate and the retaining structure.

To remove the gate in order to release the next batch of precast units, the gate would be deballasted, towed out clear of the entrance channel and moored to temporary moorings in Sok Kwu Wan. Electric submersible pumps and a small land-based grab crane unloading into a stockpile would be used to deballast the gate. It would be towed clear by two 2500 - 3000HP tugs and replaced by reversing the process.

2.2 PROPOSED DEVELOPMENTS - CASTING BASIN OPERATION

2.2.1 Site Facilities

To support the casting basin activities, it will be necessary to provide support facilities and a suitable works area. The activities that would be undertaken in this area would include:

- site offices
- workshop and laboratory
- stores
- steel bar cutting and bending area
- sand blasting and coating area
- form-work storage
- form-work fabrication.

The facilities and equipment required during the operation of the casting basin are briefly described below.

Batching Plant

The location of the batching plant for the casting yard will be dependent upon the most economical site. There are two potential alternatives, the first being to upgrade the existing batching plant, and the second to locate a batching plant closer to the casting yard between the current pre-cast yard and the cement works. The former of these alternatives is preferred at this time, and this has been assumed in the assessment.

The capacity of the concrete batching plant will be determined by the projects that occupy the casting basin.

To supply 40m^3 per hour from a batching plant adjacent to the existing concrete plant would require some 6-8 truckloads per hour. Should the batching plant be located adjacent to the casting basin, additional trucking of raw materials (or alternative methods of transportation) would be necessary.

To meet the specifications for concrete supplied to the casting basin, it will be necessary to produce a low temperature concrete. With some of the larger castings, a temperature delivered to site may be required of order of 20°C at placement.

There are two methods that can be used to reduce the temperature of concrete. The most commonly used method in Hong Kong is using crushed ice either added to the water or alternatively added directly to the concrete during mixing. The other alternative is to use liquid nitrogen.

Steel Bending

An area will need to be set aside to allow for bending and shaping of the reinforcing steel work. The requirements will be the basic standard requirements for any similar operation in Hong Kong.

Site Offices and Store

The current estimates are that approximately 200 people will be employed in the actual casting of the units. Offices to house project personnel have been estimated as twelve standard container size offices, plus two similar units to act as warehouse facilities. In addition to these facilities, a canteen will be provided, for use by employees.

These estimates of people do not include additional staff required for operation of the batching plant or any other ancillary activity not directly associated with casting of the units. These other activities may require up to twenty employees.

Wharf

For loading and unloading of materials, and for transport inwards and outwards personnel associated with the operation of the casting basin, a wharf will be required. A seawall wharf of approximately 50m long adjacent to a casting basin facility, is proposed.

Power Supply

The major components requiring additional electrical power are:

- the tower cranes
- the welding sets
- the dewatering pumps
- the concrete batching plant.

2.2.2 Sequence of Operations

When the basin interceptor drainage and site facilities are complete (but with the entrance channel unexcavated) the basin will be ready to be put into operation. This sub-section describes the sequence of activities to construct a batch of four precast immersed tube tunnel units such as would be required for the Lantau Airport Railway (LAR) immersed tube crossing of Victoria Harbour.

Since the tunnel units required for the LAR harbour crossing are as yet undesigned, typical quantities have been determined from the units used for the existing MTRC Admiralty to Tsim Sha Tsui tunnel which were constructed between 1976-79 using a basin on the recent reclamation at Chai Wan. Preliminary planning for the LAR indicates that 12 units each about 100m long are required, which could be built in 3 batches of four units. Using a casting basin of that proposed, the units would be completed with a frequency of approximately 5 months per batch.

The activities described here are given with as much detail in respect of quantities and plant as is possible to provide at this stage.

Preparation of Working Base

It will be necessary to smooth and blind the 'as shot' floor of the basin. The casting basin floor will consist of a prepared gravel bed of aggregates from quarry sources, the gravel being dumped and graded to fine tolerances to provide working surfaces for construction of the units. The aggregate base is necessary to allow the water to percolate beneath the cast units. This water develops a water pressure under the units making the flotation of the units easier.

Between the working platforms, aggregate will be maintained and selected areas may be concreted to form access ways. Perimeter drains will be designed to drain the base of the aggregate; these drains will also collect surface water runoff from the basin side slopes and discharge into catchpits/interceptors. Electric submersible pumps will discharge the catchpits to surface oil interceptor/grit traps and thence to the sea. Flows are expected to be low except in times of heavy rainfall. For normal, non rainfall flows, adequate discharge sump capacity will be provided in interceptors to enable long settling times. For rainfall discharge, contaminant concentrations would be comparable to runoff from the equivalent quarry floor area.

Unit Construction

The precast units will be constructed in short segments 10 to 15m long using a travelling formwork. During the operation of the basin it will be necessary to 'barge in' many of the materials needed for the construction of the units. This includes some 2,000t of steel reinforcing bar (enough for one batch of 4 units), 3600m^2 of formwork per batch (either resin plywood or steel plate), 84t of steel collar plates (per batch), approximately 16,000m^2 bitumen/epoxy/polyurethane waterproof membrane, small quantities of mould oil and some temporary fittings such as bulkheads and mooring attachment points.

The basic cyclic construction sequence is as follows:

- lay 6mm (typical) steel base plate (fabricated outside the basin, assembled on the casting bed and continuously welded using automatic shielded arc welding machines);
- fix to the base reinforcing bar matrix and wall kicker;
- concrete the base and wall kicker;
- cure the base and wall kicker;
- fix reinforcement to walls/roof;
- pull forward prefabricated formwork from previous segment;
- concrete walls and roof;
- strip formwork and cure walls and roof;
- clean down formwork and pull to next segment;

- for the end segments, erect and weld permanent steel collar plates (these plates carry the seals forming the joint between successive tunnel units);

- continue reinforcement, formwork concreting cycle to completion of each unit;

- apply waterproof membrane to outside of unit. Three types of membrane have been previously used for immersed tube units in Hong Kong, and it is expected one of these types may be used. Examples of these waterproof membranes are:

    - a steel shell for the Cross Harbour Tunnel;

    - a bitumen impregnated textile material in three layers for the MTRC Admiralty to Tsim Sha Tsui tunnel;

    - a spray-on bitumen/epoxy/polyurethane material for the Eastern Harbour Crossing;

- surface finish areas on permanent collar plates and apply protective paint;

- install temporary fitments to enable the unit to be floated, towed and sunk into position. These fitments include steel bulkheads, mooring/towing attachment points and internal tanks, piping and pumps. These will be prefabricated outside the basin, delivered and welded/bolted into position.

Flotation of Precast Units

When the fitments have been installed the units will be complete and ready for the basin to be flooded. A trial flotation of the units will occur at this time to commission and test the on-board ballasting system. Once the trial flotation is completed the units will be towed, using tugboats, out of the basin to the fit out/storage mooring. Approximately one unit per day will be towed out to the mooring. It will be necessary to agree the location of the mooring with Marine Department. Following discussions with a contractor it was decided that a mooring similar to the one provided for the Western Harbour Crossing would be suitable. This comprised a fixed point mooring and a drag and chain at the unanchored end of the floating units.

When all the units have been towed out of the basin the seagate will be replaced and the seawater trapped inside the basin drained, using submersible pumps, in preparation for the next batch of units. As noted previously preliminary planning for the LAR indicates that 12 units each about 100m long would be required and it is proposed that these would be built in three batches of 4 units each. It is estimated that the time taken for the completion of each batch, including construction and removal, would take approximately 5 months.

2.3 USE OF CASTING BASIN FOR THE SSDS

It in understood that the Strategic Sewage Disposal Scheme (SSDS) will require precast concrete units for use in the interim sewage outfall from Stonecutters Island and that the proposed casting basin at Lamma Quarry could be utilised. From communication with the SSDS consultants the following requirements have been identified:

- a casting basin facility will be required by end of 1995 at the latest;
- the SSDS Stage 1 sewage outfall (Interim Outfall) will be approximately 1.7km in length;
- each unit will be a twin 3m x 3m box culvert and approximatley 50m in length;
- some 34 precast units will be required in total.

Provided that the casting basin is operational by December 1993 the facility will be available to SSDS by the end of 1995.

2.4 PROPOSED DEVELOPMENTS - QUARRY EXTENSION

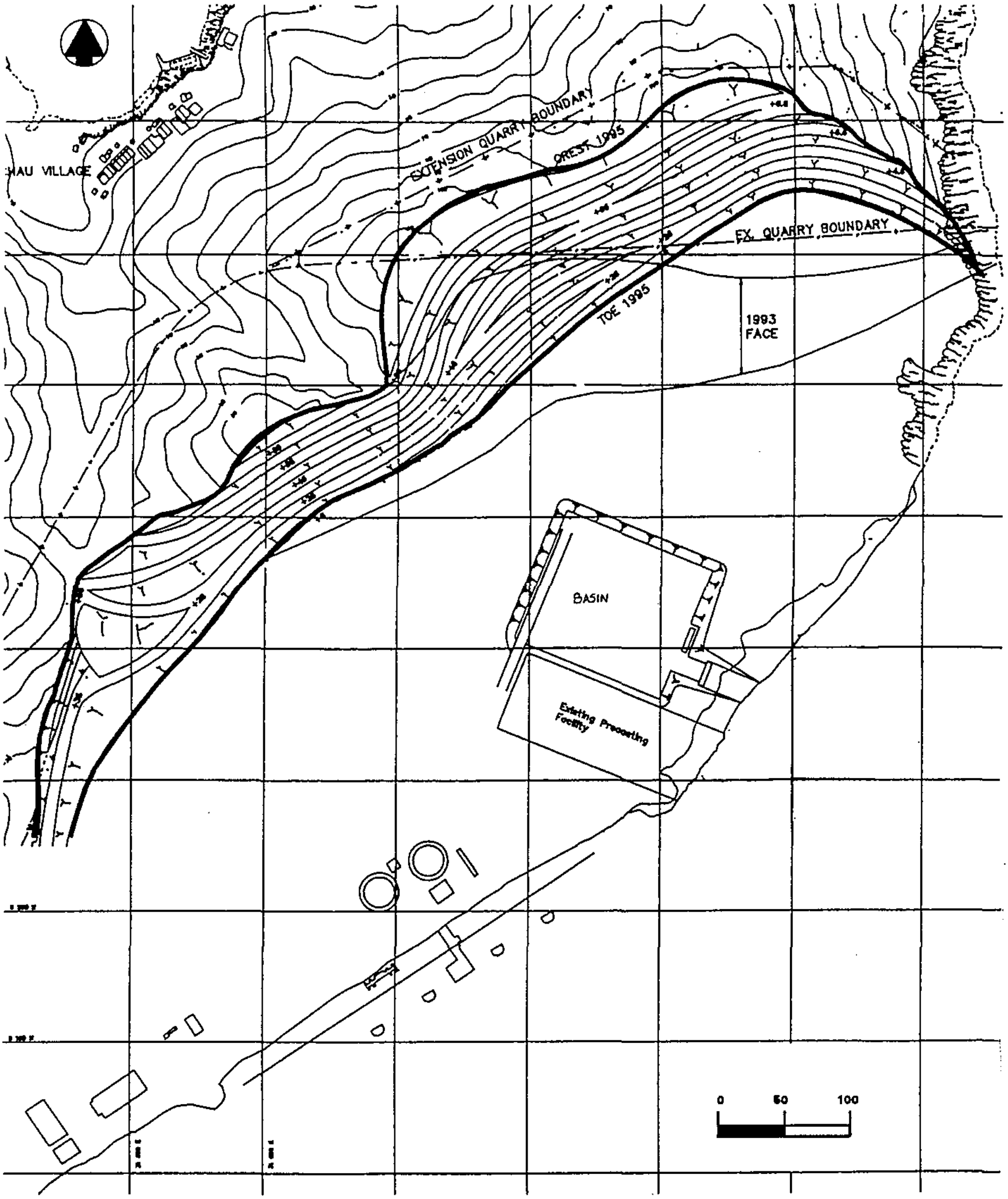
2.4.1 General

It is proposed that the existing lease permitting *Lamma Rock Products Ltd.* to operate at the Pok Tung Wan quarry be extended for a period of two years after the present lease expires at the end of 1993. The extension would allow the quarry to continue to produce rock and aggregates for the numerous infrastructure projects in Hong Kong.

The quarrying operations and activities during the extension period would be the same as those currently being employed at the quarry. Figure 2.1 shows the proposed landform at the end of 1995. As can be seen by comparing Figure 2.1 with Figure 1.2, the extension is limited to the north eastern half of the quarry.

Plate No 2.1 - Construction of the MTR Tsim Sha Tsui to Admiralty immersed tube units; Northpoint, Hong Kong Island 1977-1978. The size of the units and casting basin are similar to that proposed for Pok Tung Wan Quarry site.

Plate No 2.2 - Construction of the road/rail Eastern Harbour Crossing immersed tube units; Cha Kwu Ling, East Kowloon 1988. The photograph shows the flooded basin prior to the completed units being floated out.



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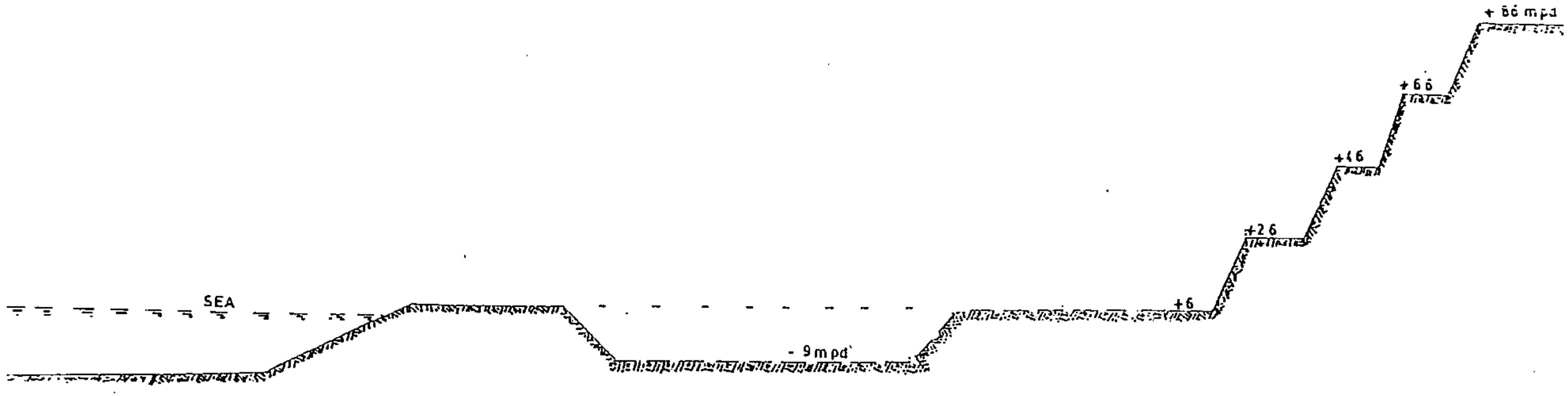
JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	2.1
SCALE:	NOT TO SCALE
DATE:	MAY 1993
FIGURE TITLE	PROPOSED CASTING BASIN AND QUARRY LANDFORM AT END 1995
JOB NUMBER	054\000\93



AXIS Environmental	LAMMA ROCK PRODUCTS Ltd.	JOB TITLE: LAMMA QUARRY, CASTING BASIN & EXTENSION EIA	FIGURE TITLE: SECTION THROUGH THE PROPOSED CASTING BASIN
		FIGURE No. 2.2	SCALE: N.A.
		DATE: MAY 1993	JOB NUMBER 054\000\93

Section 3

3. AIR QUALITY

3.1 INTRODUCTION

This section assesses the air quality impacts expected to result from the operation of the Lamma quarry and the proposed casting basin. The approach taken in assessing impacts has been to analyse operations taking place on the quarry site and to identify all significant dust producing activities.

The dust emissions from these activities has then been quantified and a dispersion model has been used with meteorological data provided by the Royal Observatory from Cheung Chau to predict the total suspended particulate (TSP) concentrations. The predicted dust concentrations and dust deposition rates have been compared with local Hong Kong and internationally recognised air quality objectives.

In the assessment three cases have been considered:

- existing operations, including the existing quarry, the existing casting operations and the cement handling operations;
- future operations, including operation of the extension to the quarry and the construction of the casting basin;
- future operation, including operation of the quarry extension and operation of the casting basin.

These three cases are almost identical as far as air quality impacts are concerned and the only one set of predicted TSP concentrations is presented to cover all three cases. However a table of the estimated dust emissions for all three cases is presented so that the minor differences that will apply in each case can be identified.

A detailed description of the project is provided in Chapter 2, which also provides a plan showing the location of the quarry and environs. The remainder of this section considers the following:

- air quality objectives
- existing air quality
- climatic and meteorological conditions
- emissions from the quarry
- approach to modelling
- predicted air quality impacts and assessment of impacts
- mitigating measures and monitoring/auditing requirements.

3.2 HONG KONG AIR QUALITY OBJECTIVES

Government policy sets air quality objectives (AQOs) for seven main urban air pollutants. Objectives relevant for the present study are those relating to particulate matter. The objectives are listed in Table 3.1.

Table 3.1: Relevant Hong Kong Air Quality Objectives

Pollutant	Measuring Period/Concentration	
	24-hour	1-year
Total Suspended Particles	260μg/m^3	80μg/m^3
Respirable Suspended Particles	180μg/m^3	55μg/m^3

In some air quality jurisdictions dust deposition has also been considered as an indicator of air quality. In Australia (New South Wales) dust deposition levels have been set to determine the potential for nuisance impacts from dust producing activities. The goals that have been set as a result of studies analysing community response to dust fallout are set out in Table 3.2.

It can be seen that projects are assessed on the basis of the increase dust deposition that is produced. The acceptable increase is determined by the existing dust fallout level. An effective maximum deposition level of 4g/m^2/month (annual average) applies for existing projects where dust deposition levels are already high.

Table 3.2: Australian Air Quality Objectives for Annual Average Dust Deposition

Existing dust fallout level (g/m^2/month)	Maximum acceptable increase over existing fallout levels - (g/m^2/month)	
	Residential	Other
2	2	2
3	1	2
4	0	1

3.3 EXISTING AIR QUALITY

Air quality (TSP) measurements have been taken at four monitoring sites in the vicinity of the quarry. These sites are marked HVA, HVB, HVC and HVD on Figure 3.1. The two main sites for which monitoring data are available are at Far East Cement (site HVC) and near the western boundary (site HVA). The available data for these sites is presented in Tables 3.3(a) and (b).

In December 1992, EPD undertook a short-term monitoring study taking TSP measurements at all four monitoring sites, and RSP at site HVB. These data were not available for inclusion in the Draft EIA, but have since been provided by EPD. These data are given in Table 3.3(c).

The TSP monitored at site HVC is derived primarily from the quarry and from the nearby cement handling facility. The original data are annotated to show which days cement handling took place. These days have been marked with a "C" after the wind direction information. For data after 31 May 1992 the records do not show if cement loading or unloading was taking place.

Table 3.3 (a): TSP 24-hour concentrations Lamma Island - site HVA ($\mu g/m^3$)

Date	TSP μm^3 24hr	Date	TSP μm^3 24hr
7/8 Oct-92	246	6/7 Dec-92	93
13/14 Oct-92	157	12/13 Dec-92	88
19/20 Oct-92	329	18/19 Dec-92	182
25/26 Oct-92	107	24/25 Dec-92	895
31 Oct/1 Nov-92	316	30/31 Dec-92	112
6/7 Nov-92	250	5/6 Jan-93	357
12/13 Nov-92	215		
18/19 Nov-92	137		
24/25 Nov-92	125		
30 Nov/1 Dec-92	212		

Table 3.3 (b): TSP 24-hour concentrations Lamma Island - site HVC ($\mu g/m^3$)

Date	$\mu g/m^3$	Wind	Date	$\mu g/m^3$	Wind
12-Aug-91	46	NE/SW	06/07-Apr-92	45	NE/SE C
19-Aug-91	142	SW/SE	02/03-Apr-92	70	N/NE
27-Aug-91	59	NE/NE	14-Apr-92	173	NE
			08/19-Apr-92	67	NE/SW
			25/25-Apr-92	-	
04-Sep-91	-	Typhoon	30 Apr/30 May-92	151	SW/SW
09-Sep-91	474	SE/SE	06/07-May-92	38	SE/NE
16-Sep-91	152	NE/NW	12/13-May-92	72	E/NE C
24-Sep-91	184	N/E	18/19-May-92	70	SE/NE
30-Sep-91	210	NE/NE C	24/25-May-92	27	E/E
			30/31-May-92	101	E/E C
02-Oct-91	32	E/E	05-Jun-92	41	SW/SW
14-Oct-91	38	E/SE	11-Jun-92	31	E/SE
21-Oct-91	96	E/E	17-Jun-92	95	S/S
28-Oct-91	568	SE/W C	23-Jun-92	114	S/S
			29-Jun-92	69	W/S
04-Nov-91	160	E/E	05-Jul-92	94	SW/SW
11-Nov-91	204	E/E	11-Jul-92	17	SE/E
18-Nov-91	100	NE/SE	17-Jul-92	-	E/
25-Nov-91	50	SE/NE C	23-Jul-92	57	W/E
			29-Jul-92	78	S/SW
02-Dec-91	112	NE/NE	04-Aug-92	117	SW/SW
09-Dec-91	93	NE/SE	10-Aug-92	56	NE
16-Dec-91	91	E/E	16-Aug-92	48	NE/NW
23-Dec-91	48	E/E	22-Aug-92	42	NE/NE
30-Dec-91	43	NE/W C	28-Aug-92	278	SW/NW
08-Jan-92	120	W/N	03-Sep-92	466	SW/SW
13-Jan-92	473	N/E	09-Sep-92	93	S/SW
20-Jan-92	297	NW/N C	15-Sep-92	180	S/S
27-Jan-92	75	E/E	21-Sep-92	143	S/S
			27-Sep-92	50	NW/NW
10-Feb-92	30	NE/NW	03-Oct-92	45	E/E
17-Feb-92	56	E/E	09-Oct-92	20	E/E
24-Feb-92	101	E/E C	15-Oct-92	134	NE/NE
			21-Oct-92	48	NE/NE
			27-Oct-92	61	E/E
02-Mar-92	37	E	02-Nov-92	48	E/E
09-Mar-92	113	calm	08-Nov-92	25	E/E
16-Mar-92	36	E	14-Nov-92	33	E
24-Mar-92	126	E/NE	20-Nov-92	117	SE/E
30-Mar-92	55	SE	26-Nov-92	94	NE/E

C = days for which cement handling has taken place (to end May 92)

Table 3.3(c) 24hr Particulate Concentrations at Pok Tung Wan Quarry as monitored by EPD

Date	Site (EPD Ref)	13	14	15		16
	Site (LRP Ref)	HVD	HVC	HVB		HVA
	Parameter	TSP	TSP	TSP	RSP	TSP
1/12/92	→ 2/12/92	211	111	928	874	305
2/12/92	→ 3/12/92	82	74	803	254	603
3/12/92	→ 4/12/92	79	59[4]	482	149	606
4/12/92	→ 5/12/92	55	62[5]	582	195	471
5/12/92	→ 6/12/92	44	55	386	113	173
6/12/92	→ 7/12/92	57	97	180	59	VOID[6]
7/12/92	→ 8/12/92	146	180	451	150	476
8/12/92	→ 9/12/92	73	69	853	177	334

Particulate Level µg/m3

4 - The flow controller failed and was bypassed
5 - The Power supply was found to be unsteady, and the sampler stopped for approximately 5hrs as observed on the chart recorder
6 - The sampler stopped due to failure of the motor brushes
Source : *Environmental Protection Department*

3.4 REVIEW OF CLIMATIC ELEMENTS

3.4.1 Introduction

This section reviews those aspects of the climate and meteorology of the area that are important as far as determining the generation and dispersion of dust.

3.4.2 Wind speed and direction

Wind speed and wind direction data are available from a meteorological station operated by the Hong Kong Royal Observatory located on Cheung Chau Island, approximately 10km west of Lamma Island. The station is sited 92m above sea level. Data for 1991 have been provided for the assessment by the Royal Observatory. The data comprises ten minute averages of wind speed on the hour for each hour in the year. Wind direction data were provided on the hour as a wind direction values in degrees within ten degree intervals.

The dispersion model used to assess the dispersion of dust requires valid data in 24-hour blocks. Thus the Royal Observatory data set was edited to discard days where three or more invalid or missing data occurred consecutively. Where two or less hours were missing the invalid or missing data were replaced with interpolated values.

Wind direction data were randomised by adding a random number between -5 and +5 to the Royal Observatory data so that the adjusted data consisted of values to one degree instead of the original values which were logged in ten degree intervals.

After processing the wind data as described above a total of 8592 valid hours of data (98 per cent data recovery) were available for the study. The data are summarised by the annual wind rose diagram in Figure 3.2. Monthly wind roses are presented in Appendix 3A.

The most common wind direction is ESE, followed by E and SE. Winds from the N through to the ENE are also common, but the quarry site is sheltered from the N and NNE by the ridge which currently forms the material being quarried. Thus the wind rose and the modelling study based on the use of the Cheung Chau data will overstate the amount of dust transported to the S and ESE. This is a conservative feature of the assessment.

The monthly wind roses in Appendix 3A show the variation in the pattern of winds over the year. The period September through to March is affected by winds mainly from the N or E, while the period April through to August is affected mainly by winds from the E to the SSW.

Tables presented in Appendix 3A show the frequency of occurrence of various wind speed classes and stability conditions as a function of wind direction. The data show the frequency of occurrence of different stability class (see Section 3.4.5 below). The annual average wind speed for Cheung Chau in 1991 was 4.4 m/s^{-1}.

3.4.3 Rainfall

Table 3.4 summarises the monthly and annual average rainfall and evaporation amounts for Hong Kong. Mean annual rainfall is 2214mm which exceeds the mean annual evaporation of 1762mm by 452mm. However the winter months are comparatively dry and evaporation exceeds rainfall by a significant margin average for six months of the year (see Table 3.4).

3.4.4 Temperature and humidity

Temperature and humidity data are also presented in Table 3.4. Temperatures are highest in July when the mean maximum is 31.5°C and lowest in January when the mean minimum is 13.6°C. The highest recorded maximum was 36.1°C (18^{th} and 19^{th} August 1990) and the lowest minimum was recorded on 18^{th} January 1893.

The relative humidity is highest during the month of April/May and lowest during November.

Table 3.4: Summary of Monthly Meteorological Data For Hong Kong (1884-1939 and 1947-1992)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year (total)
Rain (mm)	23.4	48.0	66.9	161.5	316.7	376.0	323.6	391.4	299.7	144.8	35.1	27.3	2214
Number of rain days (>0.1mm) (dimensionless)	5.63	8.93	10.07	11.13	14.93	19.23	17.47	17.30	14.37	8.60	5.87	3.87	137.4
Evaporation (mm)	120.2	93.2	114.8	124.5	169.7	159.4	182.2	170.1	171.6	179.6	150.0	126.9	1762
Temperature (°C)													
Mean max	18.6	18.6	21.3	24.9	28.7	30.3	31.5	31.3	30.3	27.9	24.2	20.5	25.7
Mean	15.8	15.9	18.6	22.2	25.9	27.8	28.8	28.4	27.6	25.2	21.4	17.6	23.0
Mean min	13.6	13.9	16.5	20.2	23.9	26.9	26.6	26.3	25.5	23.1	19.2	15.4	20.9
Relative Humidity (%)	75	79	83	85	85	84	83	84	79	72	69	70	79

Source: Hong Kong Royal Observatory

3.4.5 Atmospheric stability

Atmospheric stability is a parameter that describes the turbulent state of the atmosphere and is a measure of the capacity of the atmosphere to disperse pollution. In the assessment procedure used in this study, atmospheric stability was assigned by the Royal Observatory who provided the meteorological data file. Pasquill-Gifford stability classes were used. In the Pasquill-Gifford classification six stability categories, A through to F, are used.

Stability class A corresponds to light winds occurring with strong insolation. Mixing of plumes is rapid in these circumstances. Class B stability occurs under either cloudy or windy conditions or both cloudy and windy conditions. Again dispersion is generally rapid. Class F occurs under light wind conditions at night with clear skies. It is associated with inversions and poor dispersion. The other classes represent intermediate conditions.

Analysis of the data set for Cheung Chau shows the following distribution of stability classes over the year:

- Stability A 0.6%
- Stability B 9.3%
- Stability C 10.9%
- Stability D 54.2%
- Stability E 10.6%
- Stability F 14.3%.

For sources close to the ground such as the dust sources in the quarry it is the stable conditions (E and F) that give rise to high ground-level concentrations for a given emission rate. However, some fugitive dust sources, such as wind erosion, are wind speed dependent and conditions with high winds speed and generally neutral stability conditions will also give rise to high ground-level concentrations.

3.4.6 Mixing-height

Mixing-height is the height through which the ground-level emissions from the quarry would ultimately be mixed if particle deposition was not taking place. The mixed-layer is usually capped by an inversion which limits the height through which the emission is mixed.

In practice ground-level concentrations resulting from dust sources such as quarries are insensitive to the value for mixing-height. This is because by the time the dust plume has been mixed to a height at which the capping inversion would limit dispersion the ground-level concentrations is well below the level of concern. In view of this the mixing-height has been arbitrarily set in the model to 999m for all hours.

3.5 ESTIMATED DUST EMISSIONS

Details of dust emission estimates are presented in Appendix 3B. Table 3.5 summarises the estimated emission from each operation in the quarry for three cases:

- existing operations
- during construction of the casting basin
- during routine operation of the casting basin.

The data in Table 3.5 indicate that emissions during routine operation of the casting basin are identical to the existing operation. This is because the production rate and activities at the quarry will be unchanged, and dust emissions from the casting basin itself (during construction of the tunnel units) are negligible.

During construction of the casting basin the annualised emissions are less than the existing emissions. This is because the production of stone from the casting basin will be sold "as blasted", and not crushed. Apart from reduced emissions for crushing, screening, loading to stockpiles and reclaim from stockpiles, there is also less movement of trucks.

Table 3.5: Summary of Dust Emissions (After Controls) - (kg/yr)

Activity	Existing	During construction	During operation
Drilling	2,196	2,196	As for existing
Blasting	18,100	18,100	
Loading trucks	39,600	16,830	
Transport of material to crusher	180,000	51,516	
Dumping at crusher	27,000	12,021	
Other dumping	8,280	-	
Primary crushing	7,290	2,430	
Secondary crushing	20,988	6,996	
Screening	97,200	32,400	
Loading to stockpiles			
- fines	37,692	12,564	
- scalping	24,499	8,166	
- 10mm	351	117	
- 20mm	702	234	
- 6 to 10"	422	140	
Reclaim from stockpiles			
- fines	14,400	4,800	
- scalping	8,640	2,880	
- 10 mm	108	36	
- 20 mm	160	53	
- 6 to 10"	25,600	8,533	
Dump to barges			
- fines	21,600	7,200	
- scalping	12,960	4,320	
- 10mm	162	54	
- 20mm	240	80	
- 6 to 10"	38,912	12,970	
Wind erosion from stockpiles			
- fines	1,268	1,268	
- scalping	1,268	1,268	
- 10mm	8	8	
- 20mm	6	6	
- 6 to 10"	6	6	
General wind erosion	141,255	141,255	
Cement unloading (ship to silo)	4,000	4,000	
Cement outloading (silo to ship)	54	54	
Total	734,967	352,501	734,967

Note: Construction emissions apply over a four month period. In Table 3.5 the emissions have been annualised by assuming that the construction phase continue for 12 months. In this way the existing emissions and construction phase emissions can be compared.

3.6 APPROACH TO MODELLING AND PREDICTED DUST DISPERSION

3.6.1 Modelling approach

The approach taken in the study is to use a dispersion model to predict the 24-hour maximum and annual average concentrations of dust due to the quarry operations for three different cases:

- existing operations, including the existing quarry, the existing casting operations and the cement handling operations;
- future operations, including operation of the extension to the quarry and the construction of the casting basin;
- future operation, including operation of the quarry extension and operation of the casting basin.

The model used in the assessment is the AUSPLUME model. AUSPLUME was developed on behalf of the Victorian Environment Protection Authority (VEPA) from the US EPA's Industrial Source Complex Model (ISC-ST). It incorporates a number improvements to dispersion modelling practice as recommended by the American Meteorological Society's expert panel on dispersion modelling practice (Hanna et al. 1979). The model is fully described in a user manual (VEPA 1986). However it is useful to elaborate on the way in which the model has been used to simulate the dispersion of dust in the present study.

The model allows a number of options concerning the selection of various methods of simulating dispersion, for example what dispersion curves are used and how these are adjusted for surface roughness and so on. The options selected are summarised in Appendix 3C.

3.6.2 Predicted dust dispersion

To simulate the removal of material from the plume each emission was specified in three particle size categories 0 to 2.5, 2.5 to 15 and 15 to 30μm. These are referred to as the fine, inhalable and coarse particle categories. Work undertaken on Australian open cut mines (NERDCC 1986) was used to determine the mass fraction in each size range. The NERDCC studies indicate that the distribution of particles sizes depends on the material being handled, and the method of handling and the distance from the source.

In the absence of site specific measurements it is reasonable to assume that the initial size distribution in dust emissions close to (within a few tens of metres) earth-moving operations will be such that approximately 6% of the mass will be in the fine particle category, 50% in the inhalable particle category and 44% in the coarse particle category. This distribution was assumed to apply for all sources except wind erosion where the assumed distribution was 67% inhalable particles and 33% coarse particles.

Wind erosion dust is a significant source of dust in the inventory. The use of an annual average figure as provided by the US EPA (1985) emission factor can give misleading results for short-term averages. To overcome this it was assumed that wind erosion dust varies as the cube of the wind speed. AUSPLUME has the facility to vary emissions depending on stability class and wind speed in six wind speed classes and six stability categories.

Emission rates were determined for each wind speed class (emissions were assumed to depend only on wind speed and not on stability class). The emission rates were selected so that the annual average emission was the same as that estimated from the US EPA emission factors, but hour-by-hour emissions varied as the cube of the wind speed. The wind speed categories selected were 0 to 3, 3 to 4.5, 4.5 to 6, 6 to 7.5, 7.5 to 9 and 10.5 m/s. The relative dust emission rates, taking the lowest category as 1 were, as follows 1, 29, 74, 320, 806, 5,011.

3.7 ASSESSMENT OF IMPACTS

Predicted dust concentrations for 1-year and 24-hour maximum periods are presented in Figures 3.3 and 3.4 respectively.

These figures have been created from the output of the AUSPLUME model runs using the monitoring data from High-Volume sampler at HVC (31674m E and 8176m N) for calibration. HVC is the only sampling site for which there is a significant number of measurements and so is the only data set on which a calibration factor can be determined. The adjustment to the predictions has been made by first running AUSPLUME to calculate the maximum 24-hour average TSP concentration and the annual average concentration with HVC set as a special receptor, using the raw emssions data in Table 3.5.

In response to discussions with EPD, an added level of conservatism has been included by adding 30 $\mu g/m^3$ to the calibrated figures annual averages to account for TSP from non-quarry sources. This is considered to be a conservative estimate of TSP concentrations that would apply on Lamma if the quarry were not present. It should be noted that the calibration data sets would have to include data from areas remote from the specific dust sources to take account of background levels properly. These TSP data from areas remote from dust sources are not available at this stage.

The maximum predicted 24-hour average concentration was 1520$\mu g/m^3$ and the maximum measured 24-hour average over the most recent 12 months of data was 568$\mu g/m^3$. This indicates that the model overestimates the maximum 24-hour concentration by a factor of 2.68 [1520/568]. For the annual average concentration the predicted value was 168$\mu g/m^3$ and the measured value was 97$\mu g/m^3$, which indicates an overestimation by a factor of 1.73 [168/97].

To compensate for the overestimation the model predictions were divided by 2.68 in the case of the maximum predicted 24-hour concentrations and by 1.73 for the annual average concentrations. In both instances a background of 30μg/m^3 was then added to the calibrated figures. The contour plots given in Figures 3.3 and 3.4 have been prepared using these adjusted predictions.

There are many reasons why the model predictions may require different calibration factors for different averaging times. One possible explanation is that the US EPA emission factor equations relate to seasonal or annual average conditions and the modifications made to provide short-term estimates may overestimate the actual emission rates. However the approach adopted in this assessment is a practical one made necessary by the imperfect state-of-the-art concerning the estimating of short-term fugitive dust emissions.

Overall the results indicate 24-hour TSP concentrations of 120μg/m^3 at Lo So Shing and 185μg/m^3 at Sok Kwu Wan, which is within the 24-hour AQO of 260μg/m^3. The annual average results of 48 and 55μg/m^3 at Lo So Shing and So Kwu Wan respectively are within the annual average AQO of 80μg/m^3. These figures include a nominal background level of 30μg/m^3.

It would be expected that the model might overestimate concentrations because of the shielding afforded by the topography of the island which would affect winds from most directions except from E and NE.

The isopleths indicate that no residential or commercial properties are expected to experience either annual average or 24-hour average TSP concentrations due to emissions from the quarry above the annual AQO of 80μg/m^3 or 24-hour AQO of 260μg/m^3. The industrial land which forms the quarry, the cement handling facilities, wharf area and the disused tile factory is expected to experience levels above the goals. However, given the land use this would be unlikely to be considered an impact on this land.

The pattern of TSP pollution in the area as indicated by the modelling study is one of acceptable air quality degraded on occasions for short periods.

Since the Draft EIA was completed, further air quality data (with meteorological data) collected on behalf of EPD over eight days at four sites, have been made available to the project. These data (in Table 3.3(a)) have been used to develop a modified pediction of dust dispersion. The details of the new data and the results of the revised analysis are presented in Appendix 3D.

The revised analysis, which is not necessarily superior to that presented above, indicates that the Sok Kwu Wan area could experience maximum 24-hour average TSP concentrations above the AQO on five days per year. The differences between the first and second modelling analysis are not unexpected and are simply a result of the limitations of modelling. The issue as to whether these impacts will in fact be realised can only be resolved by implementing a TSP monitoring program in Sok Kwu Wan.

3.8 MITIGATION AND MONITORING

Modelling results are subject to uncertainties for many reasons, including uncertainties in the emission estimates, the applicability of the meteorological data and the model itself.

For this reason it would be useful to monitor dust concentrations in the close sensitive receivers. In this regard *Lamma Rock Products Ltd* have been endeavouring to establish a TSP monitor at Sok Kwu Wan for some time, and are hoping to commence monitoring in the near future.

Most of the accepted mitigating measures for quarries are already in place. These include:

- maintenance of haul roads and trafficked areas in a damp condition by use of sprinklers and water trucks;
- enclosure or partial enclosure of crushers, conveyors and conveyor transfer points and use of water suppression sprays at these points;
- application of water generally to ensure that moisture levels are maintained for all material in storage or being processed;
- use of fabric filters on cement silos.

Lamma Rock Products Ltd is reviewing other potential practical measures that may be able to be introduced to further reduce dust emissions from the quarry. This will be done by undertaking a site inspection audit to determine an action list prioritizing the mitigation measures. The potential measures include:

- ensuring that vehicle exhausts are upwardly directed;
- installation of a bag filter on the primary crusher;
- minimising the drop heights for all transfer points in particular stockpile loading and barge loading;
- improved skirting on the conveyor loadout;
- minimising exposed areas;
- increased enclosure of conveyor hopper;
- revegetating areas not likely to be subject to future disturbance.

3.9 CONCLUSIONS

The operation of the casting basin will not result in any significant change in levels of TSP in the area. In particular the estimates indicate that dust emissions during operation of the casting basin are identical to those at present.

During construction the estimates indicate a reduction in dust emissions. This is due to a reduction in material being crushed, and less movement of trucks. This should result in lower long-term average concentrations of dust, however the construction period of four months will be too short for this to be reflected in an significant change in air quality. Short-term impacts under windy conditions are expected to be unchanged because this is determined to a large extent by wind erosion dust.

Overall the modelling results using the TSP data collected from August 1991 to November 1992, and Royal Observatory data for Cheung Chau for 1991, indicate 24-hour TSP concentrations of 120$\mu g/m^3$ at Lo So Shing and 185$\mu g/m^3$ at Sok Kwu Wan, which is within the 24-hour AQO of 260$\mu g/m^3$. The annual average results of 48 and 55$\mu g/m^3$ at Lo So Shing and So Kwu Wan respectively are within annual average AQO of 80$\mu g/m^3$.

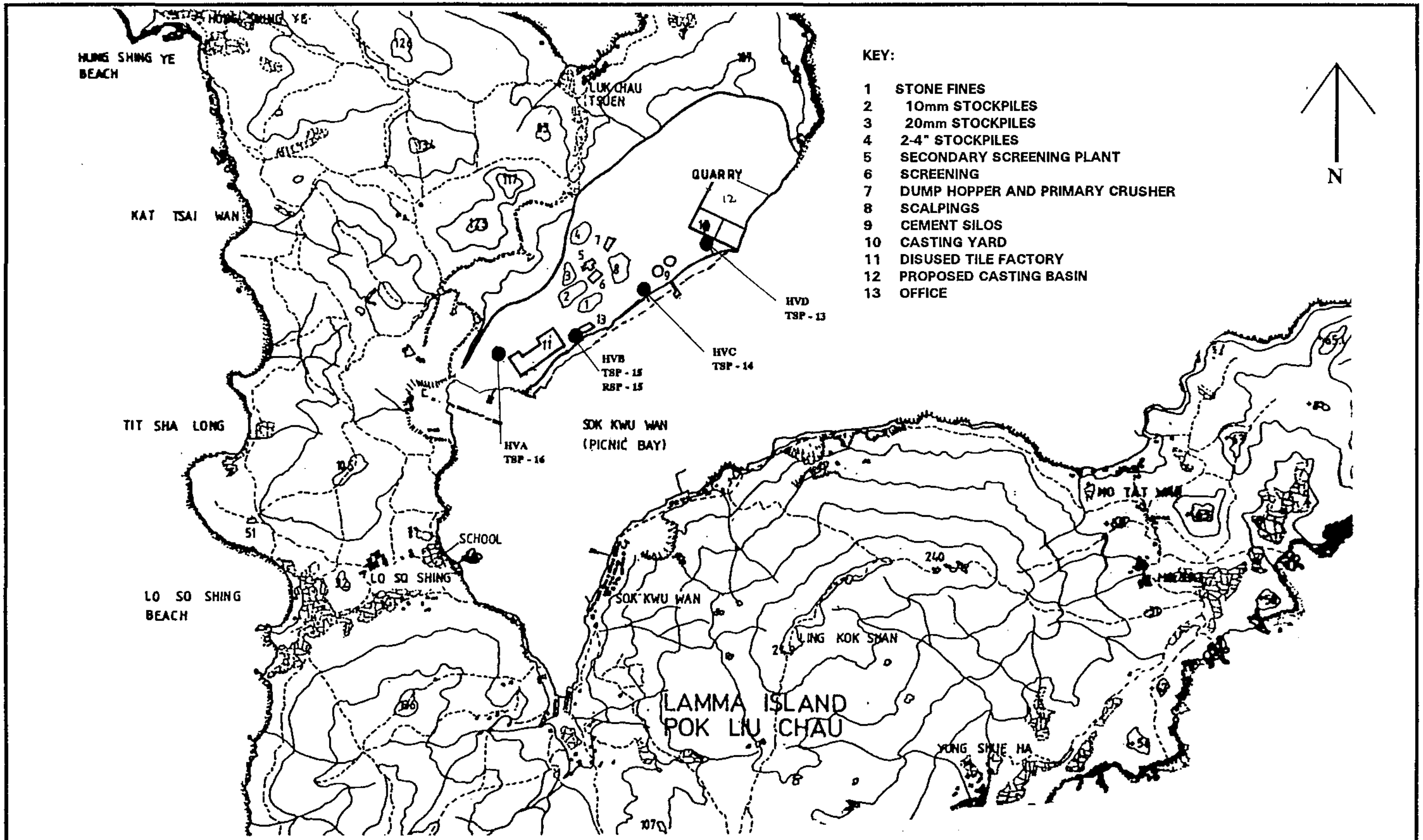
A second calibration study using data collected over an eight day period in December 1992 indicated 24-hour TSP concentrations of approximately 255$\mu g/m^3$ at Lo So Shing and 290-320$\mu g/m^3$ at Sok Kwu Wan. This second study was limited by its short duration, incomplete meteorological data, and influence of the ridge behind the quarry on the wind data obtained.

The first calibration study used TSP data collected over a 15 month period, and used a complete meteorological set less affected by local terrain, and was therefore considered to be a more appropriate basis for assessment.

The modelling studies overall were constrained by the lack of environmental monitoring data. The only way that dust levels can be reliably quantified is via an air quality monitoring programme at Sok Kau Wan. In this respect *Lamma Rock Products* have been endeavouring to establish a high volume sampler at Sok Kwu Wan, and are hopeful to be able to commence monitoring in the near future.

The pattern of TSP pollution in the area as indicated by the modelling study using the long-term monitoring data from site HVC is one of acceptable air quality degraded on occasions for short periods.

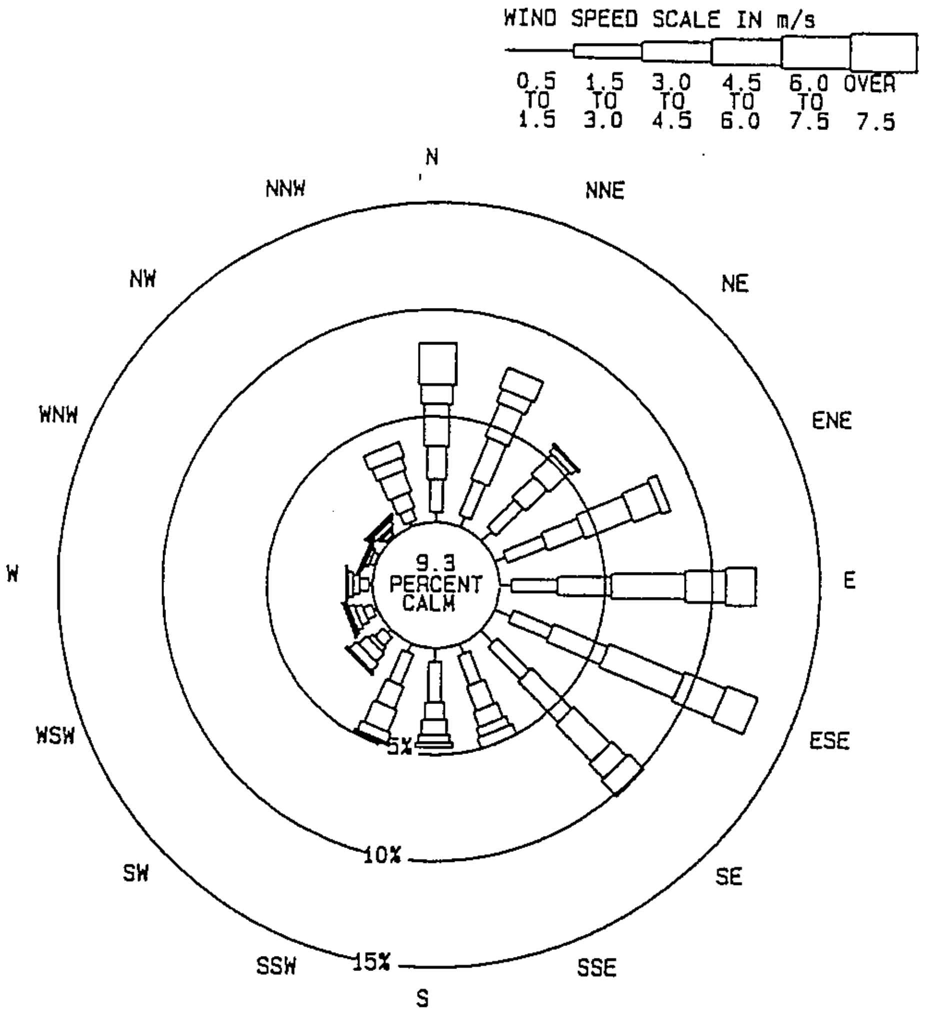
As part of the specified process licensing procedure a site inspection audit would be carried out to determine an action list prioritizing the measures for control of fugitive dust from the quarry. Details of the monitoring and audit programme should be agreed with EPD.



AXIS Environmental

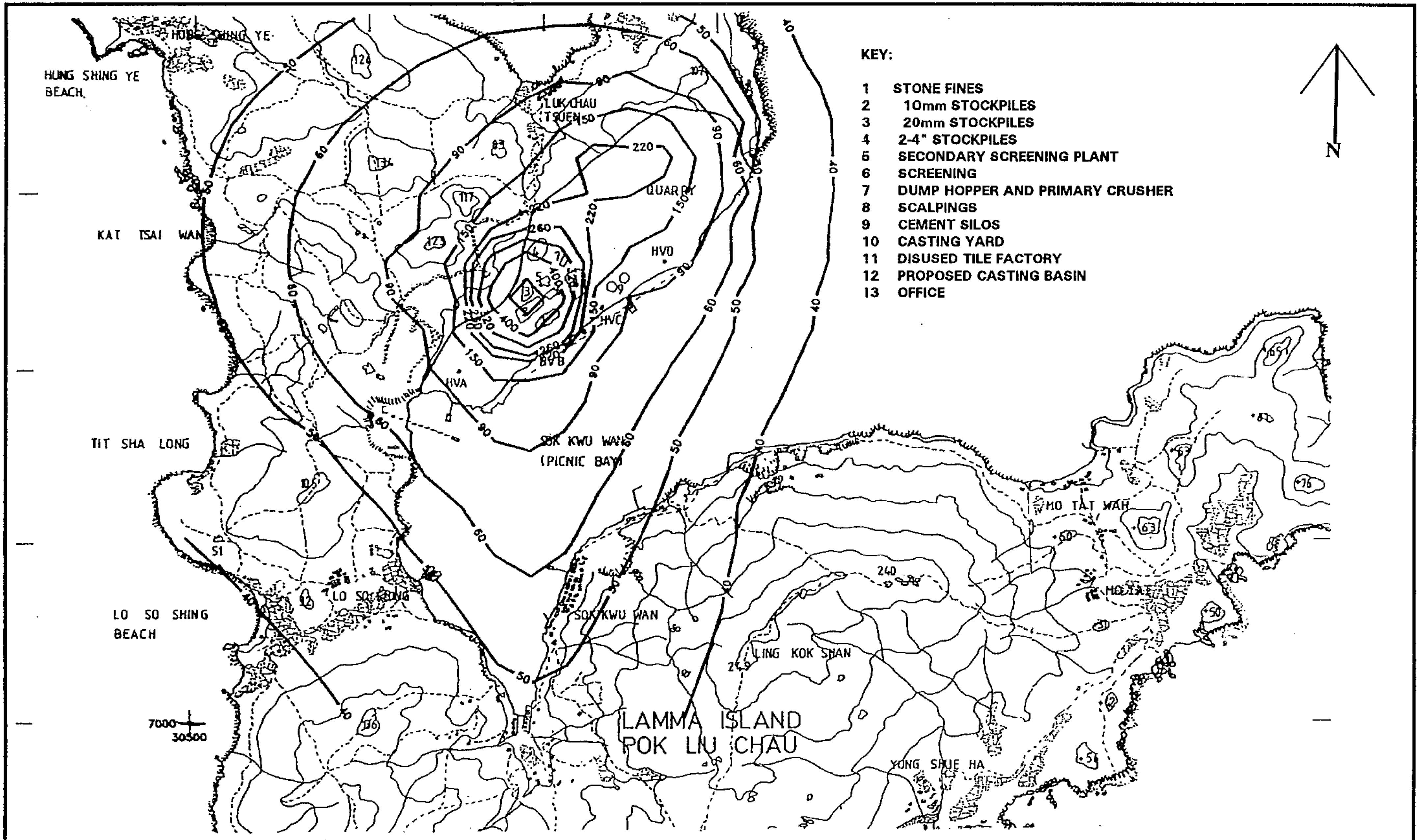
LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA	FIGURE TITLE	TSP MONITORING SITES
FIGURE No.	3.1	SCALE:	N.A.
DATE:	MAY 1993	JOB NUMBER	054\000\93



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau 1991 (all hours)

AXIS Environmental	LAMMA ROCK PRODUCTS Ltd.	JOB TITLE: LAMMA QUARRY, CASTING BASIN & EXTENSION EIA	FIGURE TITLE: WIND DATA FOR CHEUNG CHAU, 1991
		FIGURE No. 3.2	
		SCALE: NOT TO SCALE	JOB NUMBER: 054\000\93
		DATE: MAY 1993	



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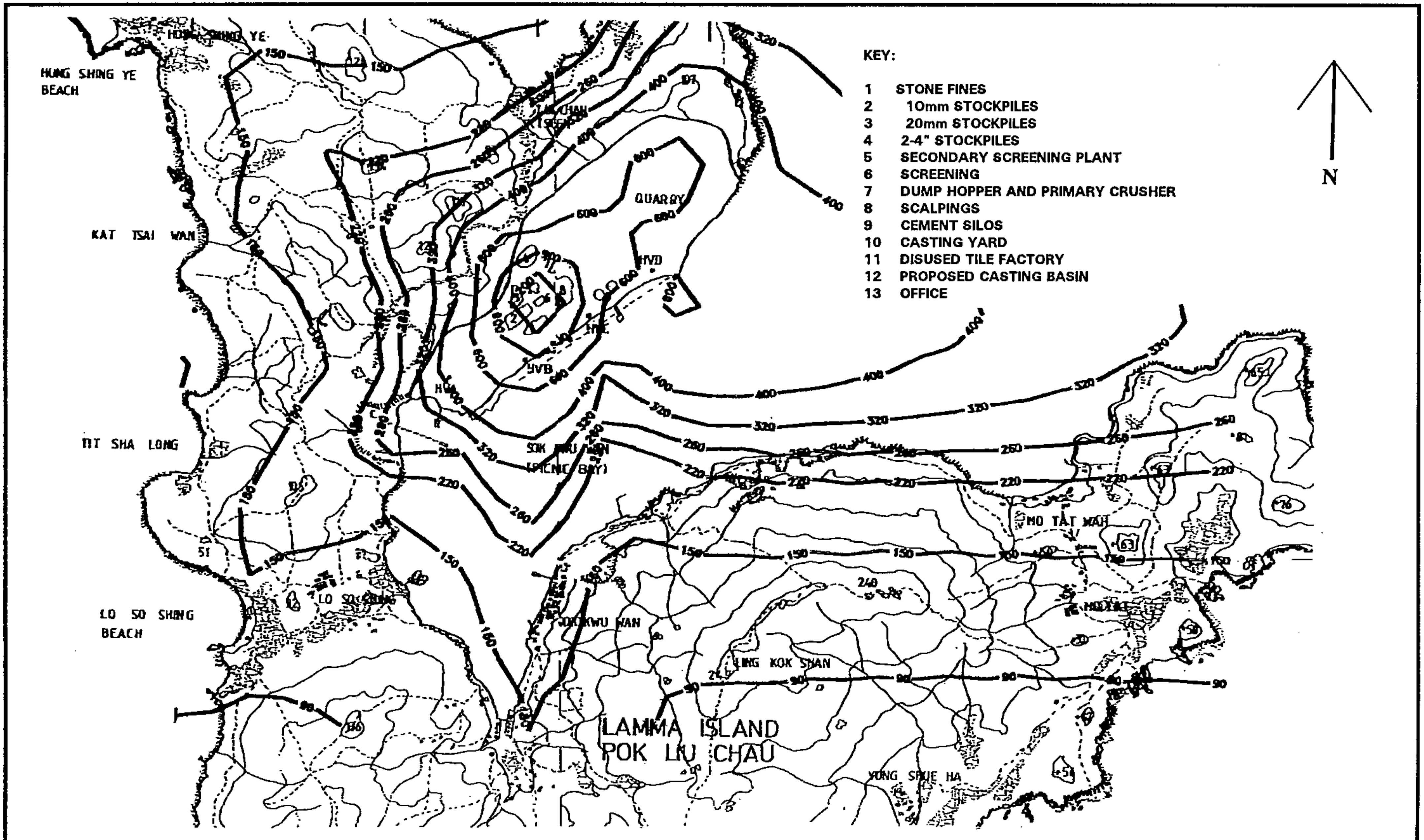
LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	3.3
DATE:	MAY 1993
FIGURE TITLE	TSP - PREDICTED ANNUAL AVERAGE DUE TO QUARRY $\mu g/m3$
SCALE:	N.A.
JOB NUMBER	054\000\93



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	3.4
DATE:	MAY 1993
FIGURE TITLE	TSP - PREDICTED 24hr AVERAGE DUE TO QUARRY μg/m3
SCALE:	N.A.
JOB NUMBER	054\000\93

Section 4

4 NOISE

4.1 INTRODUCTION

This Chapter identifies possible Noise Sensitive Receivers (NSRs) and determines the noise level at NSRs from the existing operations of the quarry. It also discusses the effect of noise from the proposed quarry extension and the construction and operation of the proposed casting basin. The expected noise levels are then compared to the existing levels and to the relevant environmental standards.

4.2 METHODOLOGY

The approach taken was as follows:

- potential NSRs were identified;
- noise levels were measured at the closest NSR, the restaurants at Sok Kwu Wan and near the school located at Lo So Shing;
- the types of equipment used on the site were identified and the noise levels of the most prominent machines were measured;
- noise from existing operations was measured at the NSRs;
- using the Environmental Noise Model (ENM) model, noise from operations was predicted and the future noise levels estimated; and
- the noise levels associated with the proposed development were compared to existing background noise levels, to the existing quarry noise levels and to the Acceptable Noise Levels (ANL) contained in the *Technical Memorandum for the Assessment of Noise from Places Other than Domestic Premises, Public Places or Construction Sites* and the *Technical Memorandum on Noise from Construction Work other than Percussive Piling*. The noise levels were also compared to the recommended criteria contained in the *Environmental Guidelines in Hong Kong (HKPSG)*.

The approach taken was developed after consultation with EPD.

4.3 IDENTIFICATION OF NOISE SENSITIVE RECEIVERS

4.3.1 Location of Noise Sensitive Receivers

The closest settlement to the quarry is Luk Chau Tseun (Figure 4.1), which is shielded by the high ridgeline behind the quarry. An assessment of the noise at that location showed that no noise from the Quarry operation would be audible other than noise from very occasional drilling on the highest bench and occasional blasting. The location of Luk Chau Tsuen is therefore not considered to be significantly affected by either the existing noise from the quarry operations or from the proposed development of the casting basin. The noise at Luk Chau Tseun due to the expansion of the quarry is also not considered to be significant given the infrequent nature of drilling above the top quarry face.

Other NSRs are located to the south and south-west of the proposed casting basin. These include several small groups of buildings, and further south the village of Sok Kwu Wan. Many buildings, particularly those in Sok Kwu Wan, are restaurants with accommodation for local inhabitants above. The closest buildings in this direction are due south of the proposed casting basin and are approximately 700m from the closest point of the proposed basin. The buildings at Sok Kwu Wan are located approximately 850m from the closest point of the proposed basin.

To the south west of the quarry is the small settlement of Lo So Shing and a school. The school is approximately 1km from the casting basin.

4.3.2 Background Noise at the Nearest NSR

The background noise in the areas around many NSRs will be dependant on the noise that arises from the constant motion of waves. Therefore when the sea is choppy, for example when there is a significant wind, the background noise would be expected to be high. Even on still days the motion of the waves would prevent the background noise falling as low as would be expected in a quiet inland area. In the areas of the restaurants and near the Fish Culture Zone the background noise during the day and evening would also be determined by the number of people and activities in those areas.

A 24hr sample of the noise was taken at Sok Kwu Wan (Position 1) on 12th January 1993. The results are tabulated in Table 4.1(a). These data were obtained from a site on the roof of a building located approximately in the middle of the Sok Kwu Wan. The roof of a building was chosen to reduce the direct influence of noise in the restaurants. During the measurement the weather was fine with a slight breeze and was considered to be typical for the area.

The data showed that the lowest L_{90} noise level was approximately 50dBA and this occurred during the very early morning when the sea was calm. It thus provides an indication of the lowest background noise level in the area. During the period that the quarry presently operates, and in which the casting basin would operate in the future, the background noise was between 52 and 60dBA.

Samples of the background noise were also taken at other NSRs on 16th February 1993. The weather during these measurements was fine with a moderate variable breeze. These data are contained in Table 4.1(b). During these assessments, other than at Position 3 (near Lo So Shing) the noise from the quarry would have influenced the L_{90} noise level. At Lo So Shing the quarry was audible but was not the predominant noise source.

Position 2 (located above the residences to the north-east side of Sok Kwu Wan) was some distance from the shore and therefore the local effect of the motion of waves as they reach the shore would have been reduced. At Lo So Shing (Position 3) the area was sheltered from the effects of wind on the sea and it was expected that the background noise would be lower than at other locations around Picnic Bay. Position 4 (located on the shore to the north of Sok Kwu Wan) was selected for comparative purposes only, as it was located close to the Fish Culture Zone but away from the direct influence of activities in the restaurants at Sok Kwu Wan.

During the measurements the quarry was operating continuously and, except at Lo So Sing, would have influenced the L_{90} noise level.

Background Noise Monitoring

Table 4.1 (a): 24-Hour Noise Monitoring at Sok Kwu Wan - 12th January, 1993

Hour	L_{eq}	L_{90}
0	53.6	50.9
1	53.2	50.3
2	52.7	50.1
3	53.3	51.0
4	52.2	49.8
5	59.1	49.5
6	59.9	50.4
7	56.1	52.1
8	61.9	54.8
9	63.5	58.1
10	67.9	58.6
11	66.1	58.2
12	62.1	58.7
13	67.5	60.0
14	66.4	57.1
15	65.7	57.9
16	65.4	58.2
17	66.3	56.1
18	62.3	55.0
19	60.9	55.7
20	59.4	56.2
21	59.9	54.4
22	58.5	51.7
23	55.9	50.7

Position 1 - Roof of restaurant located approximately in the centre of Sok Kwu Wan

Table 4.1(b): Other Background NSR Noise Monitoring - 16th February, 1993

Position 2	(above closest residences in Sok Kwu Wan)	
	2.45pm	L_{90} 55dBA
	2.55pm	L_{90} 54.5dBA
	3.30pm	L_{90} 55.5dBA
Note:	the quarry would have influenced the L_{90} noise level at Positions 2 and 4.	
Position 3	(near Lo So Shing, between the school and the Pavilion)	
	4.00pm	L_{90} 48dBA
Position 4	(near shore, north-east of the main area of Sok Kwu Wan)	
	3.35pm	L_{90} 54dBA

4.4 IDENTIFICATION OF IMPACT SOURCES

4.4.1 Site Description

The site of the proposed development is an existing quarry that has been operating under Government Contract No. 428 of 1977 and has been in operation for in excess of 10 years. It currently operates a number of machines and processes that generate noise. A list of this equipment is contained in Appendix 4.A.

It is proposed that the extension of the quarry and the construction of the casting basin will not require the introduction of any new equipment. Current numbers of drills, graders and crushers are considered adequate as it is proposed that the output from the quarry, including that obtained by the digging of the casting basin, will not be increased.

Once the casting basin has been constructed it is expected that there may be some new equipment required. This may include expanding or replacing the existing concrete batching plant, increasing the number of concrete mixing trucks, and if necessary installing an electricity generating set.

4.4.2 Baseline Data

At the nearest NSRs

A series of L_{eq} noise measurements were taken at the principal NSRs to determine the existing noise level from operations. Table 4.2 lists the results of the assessment of the noise at those locations.

During the assessment the quarry was operating at its full capacity with the primary and secondary crusher operating and vehicles moving about the site. The principal noise source was clearly the operation of the crushing plant. Individual sources such as trucks and front end loaders could not be heard over the noise of the crushers.

Table 4.2 : L_{eq} Noise Level at NSRs - 16th February, 1993

Position 2	(above closest residences in Sok Kwu Wan)	
2.45pm	L_{eq} 57.1dBA	
2.55pm	L_{eq} 56.0dBA	
3.30pm	L_{eq} 57.1dBA	
Position 3	(near Lo So Shing, between the school and the Pavilion)	
4.00pm	L_{eq}	50.1dBA
Position 4	(north-east of the main area of Sok Kwu Wan)	
3.35pm	L_{eq}	56.4dBA

At the Existing Machines

The quarry has a number of potentially noisy machines. However, it is the operation of the crushers that are the predominant noise source. Vehicle movements are generally not audible on the opposite side of Picnic Bay while the crushers are operating, although the reversing alarms fitted to the vehicles were audible. These alarms did not add measurably to the overall sound pressure level.

The quarry has three hydraulic drilling rigs which are used to drill holes to lay the explosives used at the quarry to shear away the rock face. These drills are operated frequently and are moved around the site. They would be the second most noisy machines used at the site.

To determine the noise caused by the quarry measurements were taken at the three NSRs. Also octave measurements were taken at 130 metres from the crushers in a position in the direction of the nearest NSR. The primary crusher varies in noise level between periods of relative quiet when it is operating but not actually crushing and periods of maximum noise when it is crushing and unloading rock via conveyor to stock piles. The secondary crushers generally operate at a relatively steady noise level. Measurements of the noise from the crushers were performed only during periods that the primary crusher was crushing rock and with the conveyor unloading material onto low stock piles. This is the maximum noise condition of the quarry. These figures are given in Table 4.3(a).

Octave measurements were also taken at 10m from the two types of rock drill to enable prediction of the noise from those machines. These figures are given in Table 4.3(b).

The octave levels for the crushers and the drills were used to calculate the noise at the nearest NSR from the current operations at the quarry, using the ENM model for single section calculations. This model has been approved as an acceptable noise prediction model by EPD. The results of the prediction were then compared to the measured values at the three major NSRs.

Although the movement of trucks and loaders was not audible at the nearest NSR it was considered desirable to determine the noise levels of these machines.

The trucks and loaders used are six Caterpillar 769C Trucks fitted with 8 cylinder diesel engines rated at 336kW and three Caterpillar 988B Loaders fitted with 8 cylinder diesel engines rated at 280kW. All vehicles are modern and kept in good repair. In particular the trucks are only about 6 months old.

A noise spectrum for a laden quarry truck travelling up a grade was obtained from field measurements of similar vehicles and is given in Table 4.3(c). This represents a worst case scenario. A spectrum could not be obtained for the loaders but Caterpillar have advised that the sound pressure level of the loaders is approximately 4dB lower.

Table 4.3(a): Sound Power Levels of Principal Noise Sources Located on the Quarry:- Crushers

Frequency hz	31.5	63	125	250	500	1K	2K	4K	8K	16K
Sample 1 SPL(dBA)	39.6	46.8	54.8	60.4	62.2	65.8	64.5	58.1	45.7	-
SWL(dB)	129.3	123.3	121.2	119.3	115.7	116.1	113.6	107.4	107.1	-
Sample 2 SPL(dBA)	39.5	47.2	54.9	60.7	59.8	64.9	65.2	59.7	45.5	-
SWL(dB)	129.2	123.7	121.3	119.6	113.3	115.2	114.3	109.0	96.9	-

Sound Power Level of the Crushers

Sample 1	131.4 dB (120.2 dBA)
Sample 2	131.4 dB (120.2 dBA)

Note: Sound Power Levels of the crushers were calculated from measured A weighted octave sound pressure levels at a point 130 metres from the midpoint between the crushers. Appendix 4.B shows the method used to calculate Sound Power Levels from measured Sound Pressure. Two samples were taken approximately 30 minutes apart.

Table 4.3(b): Sound Power Levels of Principal Noise Sources Located on the Quarry:- Drills

Frequency hz	31.5	63	125	250	500	1K	2K	4K	8K	16K
Model 742 SPL(dBA)	-	51.7	65.3	68.4	76.4	81.7	82.4	82.2	82.1	61.3
Linear (dB)	-	105.9	109.4	105.0	107.6	109.7	109.2	109.2	111.2	95.9
Model 712 SPL(dBA)	39.8	56.5	66.7	65.7	76.1	84.1	86.8	86.6	81.8	70.9
Linear (dB)	107.2	110.7	110.8	102.3	107.3	112.1	113.6	113.6	110.9	105.5

Note: Sound Power Level of the Drills

Atlas Copco Model 742 117.9dB (116.5dBA)
Atlas Copco Model 712 120.1dB (118.5dBA)

Sound Power Levels of the drills were calculated from measured A weighted octave sound pressure levels at a point 10 metres from each drill on the side of the exhaust and adjacent to the drill stem. Appendix 4.B shows the method used to calculate Sound Power Levels from measured Sound Pressure.

Table 4.3(c): Sound Power Levels of a Laden Truck Moving Up an Incline

Frequency hz	31.5	63	125	250	500	1K	2K	4K	8K
SWL(dB)	-	110	112	110	108	108	106	100	-

Note: Sound Power Level 112 dBA

4.4.3 Predicted Noise at the NSRs

Predictions were calculated using the baseline data of the crushers and the drills to determine the noise level at the NSRs. The ENM was used for all predictions.

Crushers

Modelling of the noise from the crushers was undertaken assuming no wind. This was done as the prevailing wind is towards the quarry and therefore the no-wind situation will represent a higher noise situation than if wind was included. Also the quarry itself is likely to provide a barrier to any wind in the direction of the NSR. Temperature has been selected to be 20^{0}C and humidity 70%. Temperature gradient has been selected to be 1^{o}C/100m. These are considered to be representative of normal conditions and particularly conditions on the day of the monitoring of the noise.

The model does not take into account reflection from surfaces behind the noise source. Therefore 3dBA has been added to the predicted noise level to take into account the reflections from the quarry face.

The ENM model does not take into account the existing background noise level. Therefore, to compare the predicted noise levels to the measured noise levels, a correction for the background noise must be made.

Background noise could not be accurately measured without the quarry at Positions 2 and 4 as the quarry was operating continuously at the time of measurement. Therefore for the purposes of comparing the measured level to the predicted level the background noise at those positions was assumed to be 50dBA. At Lo So Shing the measured L_{90} level of 48dBA was considered to be the prevailing background noise level and this may be used at that Position.

Table 4.4 : Noise Predictions at NSRs - Crushers Operating

Position Number		Measured Noise Level dBA L_{eq}	Predicted Noise Level dBA L_{eq} *
1	(Sok Kwu Wan)	Measurements of noise from the quarry could not be made due to noise associated with the village and restaurants	48.6 + 3 = 51.6
2	(north of Sok Kwu Wan - behind residences)	56 - 57.1	51.1 + 3 = 54.1
3	(Lo So Shing)	50.1	47.1 + 3 = 50.1

* Note: The predicted noise level is the level predicted by the ENM model plus 3dB due to reflection from the quarry face. The effect of the prevailing background noise is not included.

Rock Drills

Modelling of the noise from the rock drills was undertaken for the same weather conditions as the crushers, and also corrections for reflections were similarly applied. The model used the data measured from the Atlas Copco 714 as this was the noisier of the two types of drill used on the quarry.

Unlike the crushers the rock drills are mobile. Therefore for the purpose of modelling the operations of the quarry a drill was assumed to be located in the approximate centre of the current quarry face. To evaluate the noise during the construction of the casting basin a further set of predictions were obtained for a drill operating in the centre of the proposed casting basin. In the latter case the drill was assumed to be operating on the surface which would be the worst case situation.

Table 4.5 : Drills operating on the Existing Quarry Face

Position Number and Location		Predicted Noise Level dBA L_{eq} *
1	(Sok Kwu Wan)	36.0 + 3 = 39.0
2	(north of Sok Kwu Wan - behind residences)	35.4 + 3 = 38.4
3	(Lo So Shing)	33.7 + 3 = 36.7

* Note: The predicted noise level is the level predicted by the ENM model plus 3dB due to reflection from the quarry face. The effect of the prevailing background noise is not included.

Table 4.6 : Drills operating in the centre of the Proposed Casting Basin

Position Number and Location		Predicted Noise Level dBA L_{eq} *
1	(Sok Kwu Wan)	39.7 + 3 = 42.7
2	(north of Sok Kwu Wan - behind residences)	40.8 + 3 = 43.8
3	(Lo So Shing)	36.2 + 3 = 39.2

* Note: The predicted noise level is the level predicted by the ENM model plus 3dB due to reflection from the quarry face. The effect of the prevailing background noise is not included.

Mobile Plant

Modelling of the large earth moving equipment on the site was also carried out for the same weather conditions. To allow an assessment to be made of the noise from the quarry vehicles one truck was modelled at a central point in the quarry. This was selected to be the location of the crushers.

The total noise from the vehicles using the site will depend on a number of factors such as whether the trucks and loaders are operating at the same time. It would normally be correct to assume the trucks are stationary while they are being loaded or waiting to be loaded. The location of the vehicles will also be significant as the loaders are usually operating in the stockpiles and are therefore usually screened from the NSRs. A worst case scenario would therefore be half of the trucks (3) travelling up a grade to be loaded and two of the loaders operating at the top of the stockpiles with a direct line of site to the NSR.

Table 4.7 describes the predicted noise levels of one truck and the predicted noise levels assuming the worst case scenario.

Table 4.7: Trucks and Loaders Operating at the Quarry

Position Number and Location		Predicted Noise Level (dB(A)L_{eq})	
1	(Sok Kwu Wan)	1 Truck	41.1 + 3 = 44.3
		Worst Case	3 x 44.3 +2 x 40.3 = 50.3
2	(north of Sok Kwu Wan - behind residences)	1 Truck	43.4 + 3 = 46.4
		Worst Case	3 x 46.4 + 2 x 42.4 = 52.3
3	(Lo So Shing)	1 Truck	38.9 + 3 = 41.9
		Worst Case	3 x 41.9 + 2 x 37.9 = 47.3

4.4.4 New and Modified Plant and Equipment

The proposal to extend the life of the quarry and to construct a casting basin is being considered as new development. However, both activities will use the existing equipment located on the site and therefore the baseline data for the existing operations applies to the proposed new development.

There will be no new equipment associated with the continuation of the quarry operations. Further the construction of the casting basin will be achieved with the existing equipment.

Once the casting basin has been constructed new equipment will be limited to an upgraded concrete batching plant located at its current site, some cranes within the casting basin and possibly some extra concrete mixing trucks and an electricity generation plant.

In order to confirm that the noise of any new equipment would not exceed the maximum criteria or the design level of 45dBA (50dBA for industrial plant) examples of similar equipment have been evaluated, and this information is provided below.

Generators

The noise of a generator varies considerably according to the location, any natural screening and the construction of attenuation equipment such as mufflers and enclosures. As an indication of the maximum noise level from a generator the results of an unattenuated 135kW Cummins powered ONAN 75 ENT generator was tested. These showed that the noise level 7m from the machine ranged between 74dBA and 79dBA with the highest noise level at the front. If it assumed that the noise is 79dBA in all directions the sound power level can be calculated to be 104dBA.

However, Cummins Diesel quote that a reduction of 20dB can be readily achieved by enclosing the unit. Acoustic louvres can be fitted to the enclosure to allow air flow to the units. Commercially available units can provide attenuation in the 250 to 500Hz range of between 15 and 30dB. As a future generator would be a stationary unit the noise level can be readily controlled to a sound power level of less than 90dBA and would therefore be less than 45dBA at the nearest NSR.

Cranes in the Casting Basin

The principal noise sources associated with a crane is the noise of the power unit. At this stage it has not been finally determined whether the power units would be electric or diesel. However it is likely that electric cranes would be used.

The Technical Memorandum on Noise from Construction Equipment other than Percussive Piling advises that an electric crane has the sound power level of 95dBA. The noise level of an electric crane is therefore considerably less than other equipment being used on the site and would not exceed 45dBA at the nearest NSR.

If a diesel crane were to be used the noise level produced would be a major consideration in selecting the units to be used. As with generators the actual noise of a unit will depend on the model and the mufflers/enclosures used. The resulting noise level is likely to be between that predicted for the earth moving trucks and the fixed generator as they would be expected to have similar power plants.

Concrete Batching Plant

Noise from a concrete batching plant is associated with several discrete sources. These are the truck and mobile plant movements, the silo hopper vibrators, the compressor house and the high speed bowl rotation of the concrete trucks.

The existing concrete batching plant would be upgraded to meet the requirements of the casting basin. It should be noted that the concrete batching plant is categorised as industrial plant.

Measurements at a typical concrete batching plant has found that the noise at approximately 150m was:

truck and mobile plant movements	62dBA
silo hopper vibrators	47dBA
compressor house	32dBA
high speed bowl rotation	61dBA

At 700m (approximately the distance to the nearest NSR) the noise from the batching plant was found to be between 44-48dBA. This is within the night-time requirement for industrial plant of 50dBA at the nearest NSR.

Conclusion

The actual noise level produced from any new equipment in the quarry and casting basin operations will depend on the specifications of the equipment selected. However, the information given above shows that construction equipment would be able to comply with a cumulative night-time level of 45dBA, and the industrial operation would be able to comply with a night-time level of 50dBA at the nearest NSR.

4.5 ASSESSMENT OF IMPACTS

4.5.1 Comparison to Existing Background Noise

The purpose of environmental noise standards is to protect the quality of life of those people who are unwillingly required to listen to noise. Most international standards, including British Standard 4142 recommend that to minimise disturbance a noise should not significantly intrude above the background noise. BS 4142 advises that a difference of around 10dB or higher between a noise (L_{eq}) and the background (L_{90}) indicates that complaints are likely, but differences of around 5dB are of marginal significance.

In the current situation the background noise has been found to be influenced by the sea and is usually above 50dBA L_{90}. During the day the background noise would be higher due to the activities associated with the restaurants and the Fish Culture Zone.

The 24 hour sample of the noise at Sok Kwu Wan shows that the background noise there during the period that the quarry operates is generally above 55dBA L_{90}, and at night the background is about 50dBA. Further, as the background noise was measured on the roof of a building it can be assumed that the local background noise within the restaurants would be higher due to the constant activities in those areas.

The noise level at the nearest NSR in the day time and during operation of the quarry has been measured and found to be 56-57dBA (Table 4.2). The night-time background has also been measured to be approximately 50dBA (Table 4.1(a)). The expected daytime background would be expected to be at least 2dB higher than this figure. Therefore the noise from the quarry is not likely to be more than 5dB above the background noise level.

At Sok Kwu Wan, above the restaurants, the background noise level has been found to be above the noise from the quarry, particularly during the times that the quarry operates. Within the restaurants the background noise would be even higher. On a number of occasions attempts to measure the noise from the quarry in Sok Kwu Wan have found that the noise is not measurable and is mostly not audible due to the noise within Sok Kwu Wan itself.

At Lo So Shing the background noise is lower than at Sok Kwu Wan due to it being more sheltered. However, at this site the measured and predicted noise from the quarry operations is also less. At this location the noise from the quarry is also not more than 5dB above the background.

It is therefore concluded that noise from the quarry, while it is audible at Position 2 and at Position 3, it is not considered by international standards to be significant.

Another important issue in relation to background noise is that most people will be concerned if they perceive a significant worsening in their environment. A new noise source is therefore more likely to cause concern than an existing noise. In the case of the current application the noise from the quarry will not change. It is therefore unlikely to lead to any complaints or disturbance.

4.5.2 Compliance with Acceptable Noise Levels (ANL)

Industrial Noise

The Environmental Protection Department has determined that some of the operations of the quarry and the casting basin should be considered as 'industrial' noise and should be assessed under the criteria described in the *Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites.*

The existing operations that may be described as 'industrial' include rock crushing and screening, concrete batching, and cement bulk handling.

In accordance with the Technical Memorandum the Acceptable Noise Level (ANL) for a particular NSR shall be determined by:

- identifying the NSR;
- determining the Area Sensitivity Rating (ASR) of the area within which the NSR is located;
- determining the ANL from the appropriate table in the Technical Memorandum.

In accordance with that procedure the ANL was determined for all the NSR as being as follows:

day-time (0700 to 1900hr)	60dBA L_{eq};
evening (1900 to 2300hr)	60dBA L_{eq}; and
night (2300 to 0700hr)	50dBA L_{eq}.

Predictions and direct measurements of the existing operations reveal that the noise from the operation of the quarry is approximately 54dBA at the nearest NSR (Table 4.4). As the EPD usually assess the noise at a building facade, with a 3dB allowance for reflection from a facade at an NSR, this would indicate a total noise level of up to about 57dBA.

Other equipment which may be described as being 'industrial' would include the concrete batching plant. As noted in Section 4.4.4, the concrete batching would meet the night time ANL of 50dBA.

Construction Noise

The EPD has determined that some of the operations associated with the quarry and the casting basin shall be considered as being 'construction' and should be assessed under the criteria described in the *Technical Memorandum on Noise from Construction Work other than Percussive Piling*.

Activities that may be described as construction include drilling and the transport of materials to the crushers.

The Technical Memorandum for construction noise specifies ANLs for evening and night time (1900 to 2300hrs), general holidays and Sundays.

The usual operating time for the quarry is 0700 to 2100hrs weekdays, with work on Sundays limited to maintenance. The working hours for the casting basin will be similar. However, on occasions there may be some need to operate outside those hours.

In accordance with the Technical Memorandum the ANL shall be calculated by:

- determining the Area Sensitivity Rating (ASR);
- determining the Base Noise Level (BNL); and
- applying corrections to the BNL in accordance with the Technical Memorandum

To determine the ASR, account must be taken of the existing nature of the surrounding area by determining an Influencing Factor. This recognises that the effect of construction noise will be influenced by the existing nature of the area. For example if the surrounding area was predominantly industrial, nearby residents would expect and accept a higher noise level than if it was a quiet residential or rural area.

In the case of the quarry the area is an unusual mixture of rural land, small villages and the large and significant quarry. Because of the size of the quarry it must influence the nature of the area. However, because of the small scale of the villages it is appropriate to design for the most stringent construction noise level. An Influencing Factor of "Not Affected" has therefore been accepted by the operators and the most stringent construction noise standards have been applied.

The ANL for the construction activities are therefore:

- All days during the evening (1900 to 2300hrs), and general holidays (including Sundays) during the day-time and evening (0700 to 2300hrs) - 60dBA;

- All days during the night-time (2300 to 0700hrs) - 45dBA.

The total noise from activities considered to be Construction will depend on the number of machines operating and their locations. The worst case scenario would be for all drills to be operating on the surface of the casting basin and the large earth moving equipment also to be operating as described in Table 4.7. It should be noted that this scenario would only occur during the initial stages of the casting basin construction.

During this period the noise at the most sensitive NSR from a drill was predicted to be 43.8dBA. If all three drills were operating at that location the resulting noise level would be 48.5dBA. The total noise level at the nearest NSR (north of Sok Kwu Wan) would be 54.1dBA (52.3dBA + 48.5dBA) in this worst case situation.

In accordance with the Technical Memorandum noise shall be assessed at the facade of a premises and therefore a further 3dB should be added to the predicted noise level to allow for reflection from the facade. Thus a total noise level measured in accordance with the TM would be approximately 57.1dBA. This level is below the maximum ANL of 60dBA for evening use (all days) and for general holidays (day time and evening).

The night-time ANL for construction activity is 45dBA, and as noted in Section 4.4.4, equipment is available to comply with this requirement. In addition, night-time operation of the casting basin would require application for a Construction Noise Permit (CNP) from EPD. Prior to any operations at night, baseline monitoring of all equipment which may be used would be undertaken to confirm that the ANL, and any conditions of the CNP, would be complied with.

Combined Industrial and Construction Noise

If both construction noise and industrial noise were considered together the worst case situation would occur when the crushers were operating and all three drills were located on the top level of the casting basin. In this situation the total noise, including a 3dB allowance for reflection from a facade at an NSR, would be:

(54.1 + 54.1)dBA + 3dB = 60.1dBA.

The maximum noise level due to the crushers, drills and trucks is therefore approximately 60dBA. This level conforms with the daytime and evening level permitted for industrial activities. It also conforms with the level permitted for evening construction activities.

The maximum permissible noise level at night-time (2300 to 0700hrs), measured at the nearest NSR, reduces to 45dBA for construction activities and 50dBA for industrial activities.

There are no night time operations at the quarry. However, there may be times that the casting basin is operated outside of normal hours. In this case the cranes and concrete batching plant may be used. Other equipment associated with the casting basin would be operating within the basin and would therefore be effectively screened.

As noted above, a CNP would be required for use of the casting basin within restricted hours. Prior to any operations at night, baseline monitoring of all equipment which may be used would be undertaken to confirm that the ANL, and any conditions of the CNP, would be complied with.

4.5.3 Environmental Guidelines

The HKPSG advise that the noise from new development should not exceed a standard that is 5dB less than the relevant ANL. In the current case the ANL for the industrial activities in daytime/evening and night-time are 60dB(A) and 50dB(A) respectively. Therefore the relevant planning level would be 55dB(A) and 45dB(A).

The quarry is not operated at night-time. Should the casting basin be operated at night baseline monitoring would be undertaken to confirm that it complies with the relevant criteria. The assessment indicates that noise levels of 45dBA and 50dBA at the nearest NSR would be achievable from the construction and industrial activities respectively in the casting basin.

The measured and predicted noise from the industrial activities associated with the quarry at the closest NSR is approximately 54dBA (57dBA at a building facade). The noise level therefore exceeds the recommended Environmental Guideline by approximately 2dBA.

Environmental guidelines are intended to ensure that noise from any new development does not have an adverse impact upon NSRs. An adverse impact occurs when people living in a NSR are exposed to noise above the relevant ANL or when the level of noise is significantly increased. In the current situation the proposed development is, in terms of noise, a continuation of an existing situation, a situation that has continued over ten years.

Those residing at the NSR will perceive no change in the level or character of noise. It is therefore considered unnecessary that the quarry noise level be reduced by the 2dB(A) that the Planning Guidelines recommend. Instead the quarry noise should be assessed against the existing background noise and the ANL. Both of these indicate that the noise from the industrial and construction activities are acceptable.

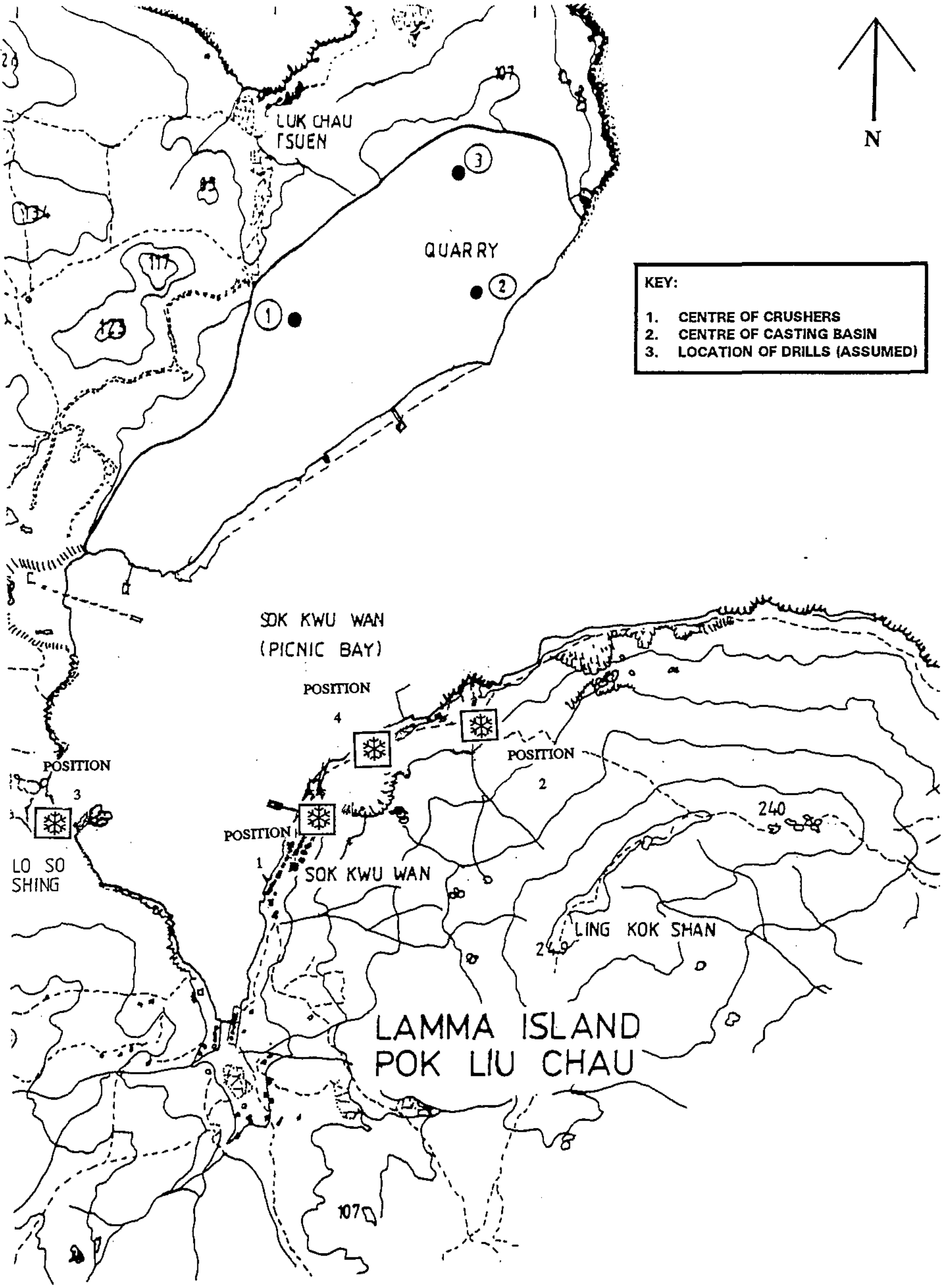
4.6 CONCLUSIONS

From the discussion it is concluded that the existing operations comply with the criteria appropriate for industrial and construction activities. Further the extension of the quarry will not introduce any new noise sources and will not alter the current level of noise. The proposed casting basin will require some new sources of noise but these will also not increase the current level of noise from the quarry site.

The standard for new construction equipment to be operated on site, such as new cranes and possibly a generating set, will be 45dBA cumulative at the nearest NSR (north of the village of Sok Kwu Wan).

Some of the current operations do exceed the recommended Environmental Guidelines for new development by 2dB. However, this is not considered significant as the noise will be a continuation of the existing noise and will not have a significant impact upon those residents in any NSR. The study leading to this report has also identified that the principal noise sources are the crushers, and these will be addressed during regular maintenance programs in a continuing effort to reduce noise. In addition industrial operations , such as crushing, should not be conducted during night-time.

A Construction Noise Permit would be required for construction activities associated with the casting basin at night.



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	4.1
SCALE:	NOT TO SCALE
DATE:	MAY 1993
FIGURE TITLE	LOCATION OF NOISE SENSITIVE RECIEVERS
JOB NUMBER	054\000\93

Section 5

5. LANDSCAPE AND VISUAL IMPACT ASSESSMENT

5.1 INTRODUCTION

The construction of the casting basin will take approximately 6 months and will be operational until the end of 1995. It is possible, however, that the working life of the basin could be extended to provide pre-cast units for other future infrastructure projects. The extension to the quarry itself would result in excavation continuing up to the end of 1995.

This Chapter assesses the landscape and visual impacts of both the quarry extension and construction and operation of the casting basin during these periods.

5.2 OBJECTIVES

It is the purpose of the assessment to identify the significance of the impacts, on both the landscape and visual resource, that may arise from either the introduction of a new element or modification to the existing environment. This Chapter sets out to:

- assess the visual and landscape impact of the proposed casting basin during both the construction and operational periods;
- assess the visual and landscape impact of the proposed extension to the quarry; and
- provide guidelines for the mitigation of any impact.

5.3 EXISTING ASSESSMENT LEGISLATION AND GUIDELINES

There is currently no legislation which specifically relates to the visual impacts that arise from development. However, the need to address visual impact has been identified as part of the environmental review process and is recognised as an issue in the Environmental Protection Department's Advice Note (2/92) on the "Application of the Environmental Impact Assessment Process to Major Private Sector Projects". Landscape impact, however, is not specifically identified.

5.4 METHODOLOGY

For the purposes of the assessment process it is important to distinguish between landscape and visual impacts:

- landscape impact relates to the effect upon the physical characteristics or components which together form the landscape, e.g. landform, vegetation etc;

- visual impact is a measure of the change to views of that landscape experience by individual receptor groups, e.g. local residents at Sok Kwu Wan.

The approach to the landscape and visual assessment has been divided into four stages:

- appraisal of baseline conditions
- appraisal of the sources of impact
- assessment of the landscape and visual impacts
- development of mitigation measures.

5.4.1 Appraisal of Baseline conditions

Detailed baseline information is essential to predict and evaluate impacts. The baseline landscape and visual conditions will be assessed through the appraisal of:

- the landscape context; the physical features of the natural landscape, settlements and land use, as well as the quarry itself;

- the visual context; the views in and out of the area and their existing quality.

5.4.2 Appraisal of the Sources of Impact

While the quarrying operations involved in the extension of the quarry and construction of the casting basin would be in line with current practice, the operational stage of the basin could result in somewhat different impacts depending upon the scale and nature of the pre-cast units to be developed.

5.4.3 Assessment of Landscape and Visual Impacts

The basis for the appraisal is a qualitative evaluation of the visual intrusion of the proposals and their impact upon key receptor groups and the baseline landscape. In order to determine the extent and level of impact on receptors, the immediate area as well as more distant viewpoints on Hong Kong Island were examined. This allows a Zone of Visual Influence (ZVI) to be determined and the establishment of key viewpoints and receptors within this area (Figure 5.1). The sensitivity of receptors, identified within the ZVI, to change is categorised as high, moderate or low:

- highly sensitive receptors include residential areas, and institutions such as schools and hospitals;

- moderately sensitive receptors include public open space and commercial development;

- low sensitivity receptors include transport corridors, and industrial and manufacturing areas.

Impacts are defined within three categories, severe, moderate and slight, according to the significance of the impact upon the following criteria:

- visibility of the quarry extension and casting basin
- value of the existing views
- degree of change to existing views
- sensitivity of receptors
- proximity of receptors.

More variable factors, such as weather conditions, also need to be considered; for example, hazy conditions frequently prevail at specific times of the year, which can substantially reduce the significance of the visual impact of intrusive features and their contrast with the adjacent area. Seasonal variations in vegetation and colour will also reduce the level of contrast with the surrounding landscape.

Landscape impacts are determined principally in terms of their physical change to component elements of the landscape. This is assessed utilising the following criteria:

- character and quality of the existing landscape
- degree of change to key features of the existing landscape
- nature of predicted impacts
- ability of the landscape to accommodate change, (i.e. sensitivity).

Both landscape and visual impacts are predicted primarily on the basis of the order of change to the existing baseline conditions. However, it is also necessary to consider the indirect impacts that may arise from the current proposals, for example, the effect on timing of possible rehabilitation proposals.

5.4.4 Development of Mitigation Measures

Mitigation measures, including earth mounding and planting, are considered. Temporary measures are also considered where appropriate.

5.5 BASELINE CONDITIONS

5.5.1 Existing Environmental and Character

The quarry is located on the north side of Picnic Bay on the eastern side of the island. The landscape in this area is a complex relationship between landform, vegetation and land use.

The bay is enclosed by strongly defined, undulating ridgelines, (150m - 200m) reaching a maximum elevation of 353m at Mt. Stenhouse (Figure 1.1). Woodland areas on the lower slopes give way to more scrubby vegetation and rocky outcrops towards the ridgeline and peaks.

There are a number of small settlements scattered along the southern edge of the bay, of which Sok Kwu Wan is the largest. In recent years Sok Kwu Wan has developed a thriving restaurant trade popular with tourists and Hong

Kong residents alike. The small villages of Mo Tat Wan and Lo So Shing are located at the east and west end of the bay respectively (Figure 1.1). The local school is also located at Lo So Shing. The western half of the bay is dominated by a Fish Culture Zone which contributes significantly to the varied visual character of the area.

A well developed footpath network extends around the bay providing links with the villages further to the north. These are heavily used by residents commuting between the villages and by visitors, the latter particularly at weekends.

The typical relationship between settlement, land use and the natural environment within Picnic Bay is dominated by the quarrying activity. Quarry faces extend from sea level to 125m in 5 benches, breaking through the former ridgeline at 128m The base of the quarry and the waterfront are dominated by the crushing plant, stockpiles, loading facilities and barge traffic. The active quarry merges with the site of the obsolete *Opiocolour* tile to factory area to the south-west of the site (Figure 1.3), which is primarily used as a storage area for a wide range of industrial materials.

5.5.2 Existing Visual and Landscape Impact of the Quarry

The scale of the quarry and extraction operation result in a severe visual impact upon many of the settlements and areas within the bay. Of particular significance is the impact upon Sok Kwu Wan and the restaurants northeast of the ferry pier along the waterfront where views are dominated by the quarry operation. South of the ferry pier the view towards the quarry is at an oblique angle and is obscured by the ferry pier.

From Mo Tat Wan, and from the local footpath network, the quarry is again highly visible and the impact remains severe. However, south and west of Sok Kwu Wan the angle of view is oblique and much of the quarry area is screened by landform and vegetation, including for many viewpoints at Lo So Shing and the school.

The ridgelines are strong enclosing elements, restricting views of the quarry from other areas of the island including the villages at Lo Tik Wan and Luk Chau Tsuen to the north. The landform also delays views of the quarry from the Hong Kong ferry, until the entrance to the bay is reached.

On clear days, when there is little haze, the quarry is visible and quite distinct from a number of distant viewpoints between Aberdeen and the Stanley Peninsula on Hong Kong Island. The distance between the quarry and these viewpoints, and the backdrop of the surrounding landscape, moderates the impact according to the angle of the view.

The past quarrying activity has resulted in a dramatic physical change and substantial loss of landform for the northern area of Picnic Bay. Furthermore, the current permission has broken through the existing ridgeline at its highest point, resulting in a severe and significant scar upon the landscape.

Overall, the quarry and associated features represents a significant visual intrusion that dominates many of the views within the bay. The scale and nature of the operation creates a fundamental imbalance between it and the surrounding landscape.

5.6 CASTING BASIN: IMPACTS AND MITIGATION

5.6.1 Source of Impact

The casting basin will take approximately 6 months to construct and will utilise equipment and machinery currently operating on site. While excavation of the basin takes place, quarrying activity will be reduced across the remainder of the active quarry. The depth of the basin will extend from + 5mPD to - 9mPD and will be achieved by excavating progressive benches that culminate in a basin approximately 120m x 100m in size.

Once operational the majority of activity will take place below ground level. No increase in the number and size of stockpiles is anticipated, while equipment will be limited to a single crane that will extend some 10 - 15m above existing ground level. Additional site offices will be required. Once the pre-cast units have been constructed, individual units will be floated out of the basin and transported to their ultimate destination.

5.6.2 Landscape and Visual Impacts

As there is no anticipated change in the mode or type of operations involved in the construction of the basin, the visual impact will not exceed current levels. During the operational period, the majority of activity will be screened by the casting basin itself, which, coupled with the minimal impact of additional equipment, will not increase the existing level of visual impact on receptors at either Sok Kwu Wan or Mo Tat Wan. However, from footpaths located at higher elevations the activity within the basin will be more visible, although the impact will be no greater than levels arising from the present operations on the quarry floor.

From more distant viewpoints, such as those on Hong Kong Island, no additional visual impact is anticipated.

Transportation of the pre-cast units from the casting basin to their destination will periodically increase the visual impact on receptors within the bay.

The construction of the basin will increase the landscape impact by creating a further incongruous element within the landscape. However, given that the excavation will be within the existing operational area, and that the impact of the quarry is already severe, the landscape impact from development of the casting basin is regarded as no more than moderate.

5.6.3 Mitigation Proposals

The visual clutter at the base of the quarry, and in particular the storage of equipment and materials in the *Opiocolour* factory area of Phase I, contribute significantly to the visual intrusion of the quarry. The visual appearance of this area could be greatly improved by removing the disused factory, clearing up the waste ground and implementing restoration proposals. It is expected that these aspects will be considered in the forthcoming Civil Engineering Department (CED) quarry rehabilitation study.

Visually, the operation of the casting basin is seen as an integral part of the quarry floor activity, and while no specific proposals are suggested for the basin itself, screening of the quarry floor activity, wherever possible, through a combination of earth mounding and planting along the waterfront would be beneficial. Such mitigation measures will be considered in the detailed design planning of the casting basin. Receptors at Sok Kwu Wan and Mo Tat Wan would benefit significantly from such proposals.

5.7 QUARRY EXTENSION: IMPACTS AND MITIGATION

The crest of the existing quarry face is currently at the limit of excavation and has broken through the ridgeline at its highest point, reducing the maximum height from 128m to 125m. Figure 5.2 indicates how the proposed extension would further modify the ridgeline at the west end of the quarry, reducing it from approximately 125m to 110m at its highest point.

The quarry operation, so far, has been visually contained by retaining the ridgeline, as far as possible, which has restricted the most significant impacts to receptors within Picnic Bay. Modifications to the ridgeline will not increase the ZVI of the working area and will ultimately reduce the visual impact of the quarry face. However, changes to the ridgeline will result in a more significant and broader visual impact on areas to the north and north-west.

Figure 5.1 indicates the limit of the ZVI, which follows the immediate ridgelines around Luk Chau and Picnic Bay before extending across the East Lamma Channel to Hong Kong and Aberdeen Islands. It also differentiates between areas where modifications to the ridgeline only, and those where a reduced height of quarry face will be visible.

The visual appraisal that follows assesses:

- visual impact on receptors on Lamma Island;
- visual impact on receptors on Hong Kong Island.

5.7.1 Visual Impact on Receptors on Lamma Island

When viewed from Sok Kwu Wan, the Pavilion to the west of Lo So Shing, the Fish Culture Zone, and the local footpath network within Picnic Bay, the proposed extension would effectively reduce the height of the final quarry face at the western end (Figure 5.3). In the long term this would marginally reduce the visual intrusion of the quarry, although the residual impact would still be severe.

The reduced quarry face would also be visible from Mo Tat Wan, although this would be offset by a further loss of landform at lower levels at the extreme eastern end of the quarry. A marginal increase in impact would therefore result. Lo So Shing remains outside the ZVI.

From viewpoints immediately to the north, the proposals would be seen as a gradual reduction in height of the ridgeline, as indicated in Figures 5.4 and 5.5, although no active quarrying would be visible. Sensitive receptors in this area include Lo Tik Wan, on the northern edge of Luk Chau Bay, and Luk Chau (Figure 1.1).

The change in ridgeline would be screened by existing vegetation and landform from Luk Chau village, but would become increasingly visible from the marine-culture area and from Lo Tik Wan to the north. However, the reduction in ridgeline would be seen against a backdrop of higher ground, rather than open sky, which would effectively reduce the level of impact. The impact on Lo Tik Wan is therefore regarded as moderate.

5.7.2 Visual Impact on Distant Receptors

Figure 5.1 indicates a number of key viewpoints from where the impact of the proposed extension was assessed. Weather conditions would play an important part in determining the visibility of the proposed extension from such distant viewpoints; in hazy conditions, the level of contrast would be reduced and consequently the impact significantly less.

Viewpoint A: Pok Po Wan, near Wah Fu Estate (4km), *B*: Kai Lung Wan (3.6km), *C*: West end of Aberdeen Island (3.4km). From these residential areas the change in ridgeline would be visible, becoming more apparent the closer the viewpoint. However, the distance involved and the general backdrop of the higher landform to the south would result in only a slight visual impact on these receptors.

Viewpoint D (3.25km): Ap Lei Chau. Receptors include residential areas and the local school from where the edge of the active quarry is just visible. Changes to the ridgeline would again be visible from this area, particularly from Mt. Johnston to the south-east. While this is the closest of the viewpoints considered the angle of view is such that the impact of the extension would be no more than slight.

Viewpoint E (4.75km): Ocean Park. From the upper levels of Ocean Park more of the active quarry is visible, and is relatively intrusive in the panoramic views from the headland. Modifications to the ridgeline would be relatively minor in the context of the impact of the existing quarry and therefore no increase in impact is anticipated.

Viewpoint F (6.5km): Deepwater Bay. From receptors on Island Road the quarry is screened by the headland at Ocean Park. It is possible that the quarry extension would be visible from higher elevations but the impact would not be significant.

Viewpoint G: Middle Bay (7km); *H*: South Bay (6.75km), *I*: Chung Hom Wan (7km); *J*: Chung Hom Kok (6.75km); and *K*: Stanley Peninsula (8.25km). The angle of viewpoint in relation to the active quarry is such that the working faces become more visible further to the south. The quarry is approximately 6 to 8km away from these viewpoints, and although reasonably distinct on clear days, is sufficiently distant to ensure that the proposed extension would have no significant impact.

5.7.3 Landscape Impact

The landscape impact of the proposed extension may be considered in the context of the severe local impact already created by the existing quarry. In these terms, a further reduction in landform is not very significant. However, the enclosed character of the existing landscape is largely determined by the undulating ridgelines, and any modifications to these needs to be carefully considered.

The proposals to reduce the crest of the ridgeline from 125m to 110m would create a shallow saddle between the two high points at 110m and 106m. This would result in a relatively flat top to the east end of the quarry compared to the existing rounded form. This would be less significant from the quarry side where the landscape impact is already severe. From the north, this would appear more as a break in the natural flow of the ridgeline, which, combined with the loss of vegetation, is regarded as a moderate impact.

5.7.4 Mitigation Proposals

Possible mitigation during the working phase of the quarry is restricted by the on-going operations. Nevertheless, planting measures will be considered in areas where active quarrying has ceased. Planting in close proximity to the active faces would need to be avoided as plant survival would be severely hampered by dust from blasting and general quarry operations.

To avoid abortive planting, such measures would need to consider the final land use and rehabilitation proposals developed by CED.

The long term rehabilitation measures will also need to consider the relationship between the final landform and the surrounding landscape. To achieve a satisfactory and sympathetic relationship, substantial regrading of slopes will be required that may involve the removal of the upper benches. The aim should be to provide a natural landform as possible, with slopes that can be readily planted and as such lie in with the existing vegetation pattern.

5.8 INDIRECT IMPACTS

Granting approval for an extension to the current limit of excavation and development of the casting basin would effectively extend the life of the quarry until 1995, and consequently delay any rehabilitation programme. The villages and other receptors in Picnic Bay, as well as more distant viewpoints, would therefore be subject to the continuing visual impact of an active quarry rather than a rehabilitated landscape.

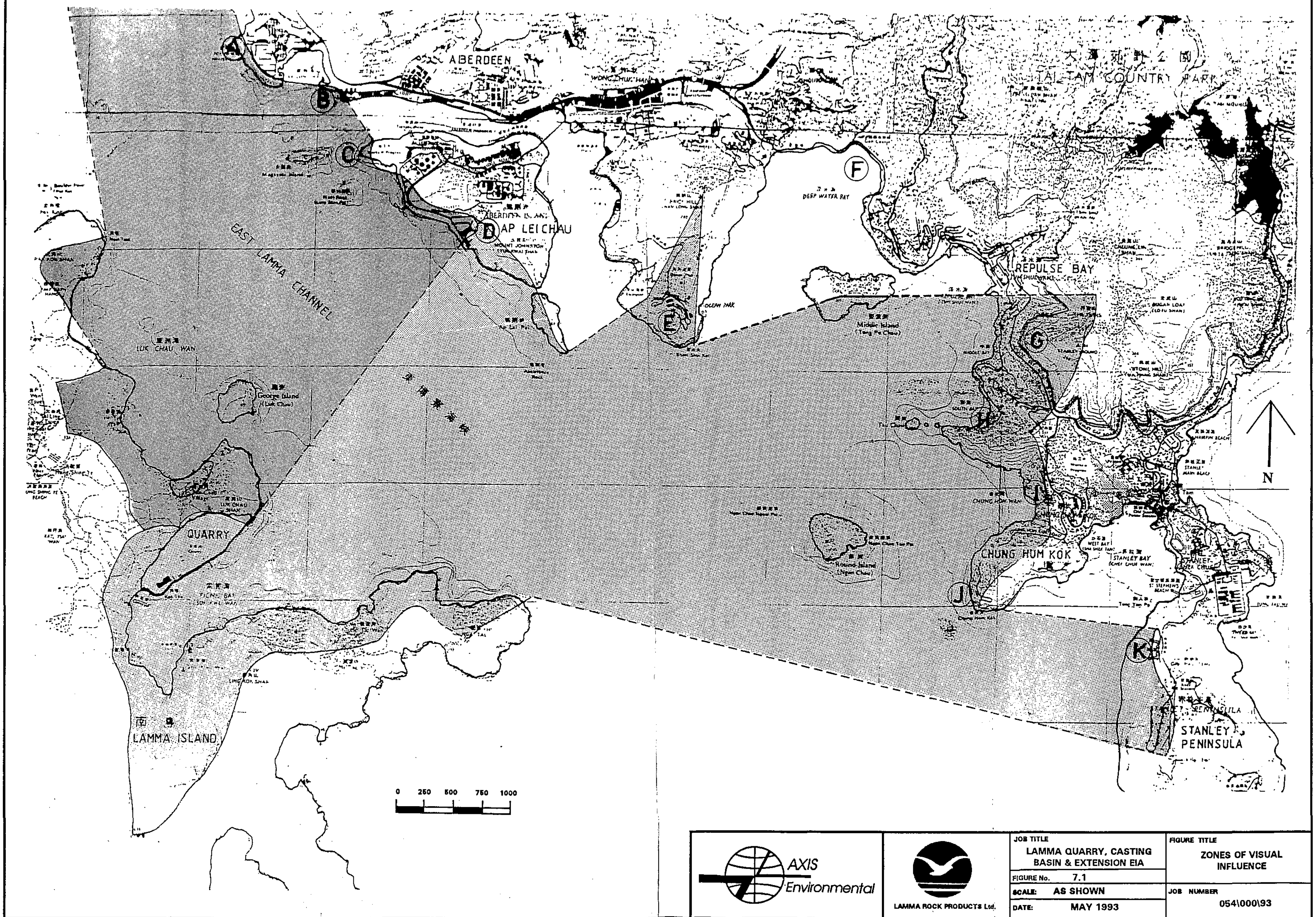
However, the continued operation of the quarry, in conjunction with recommendations arising from the CED rehabilitation study, presents an opportunity to derive a final landform more natural in character.

Development of the casting basin would also create a landform, which to some degree, could affect the final rehabilitation and land use in that area.

5.9 SUMMARY OF KEY ISSUES

The assessment has identified the following impacts:

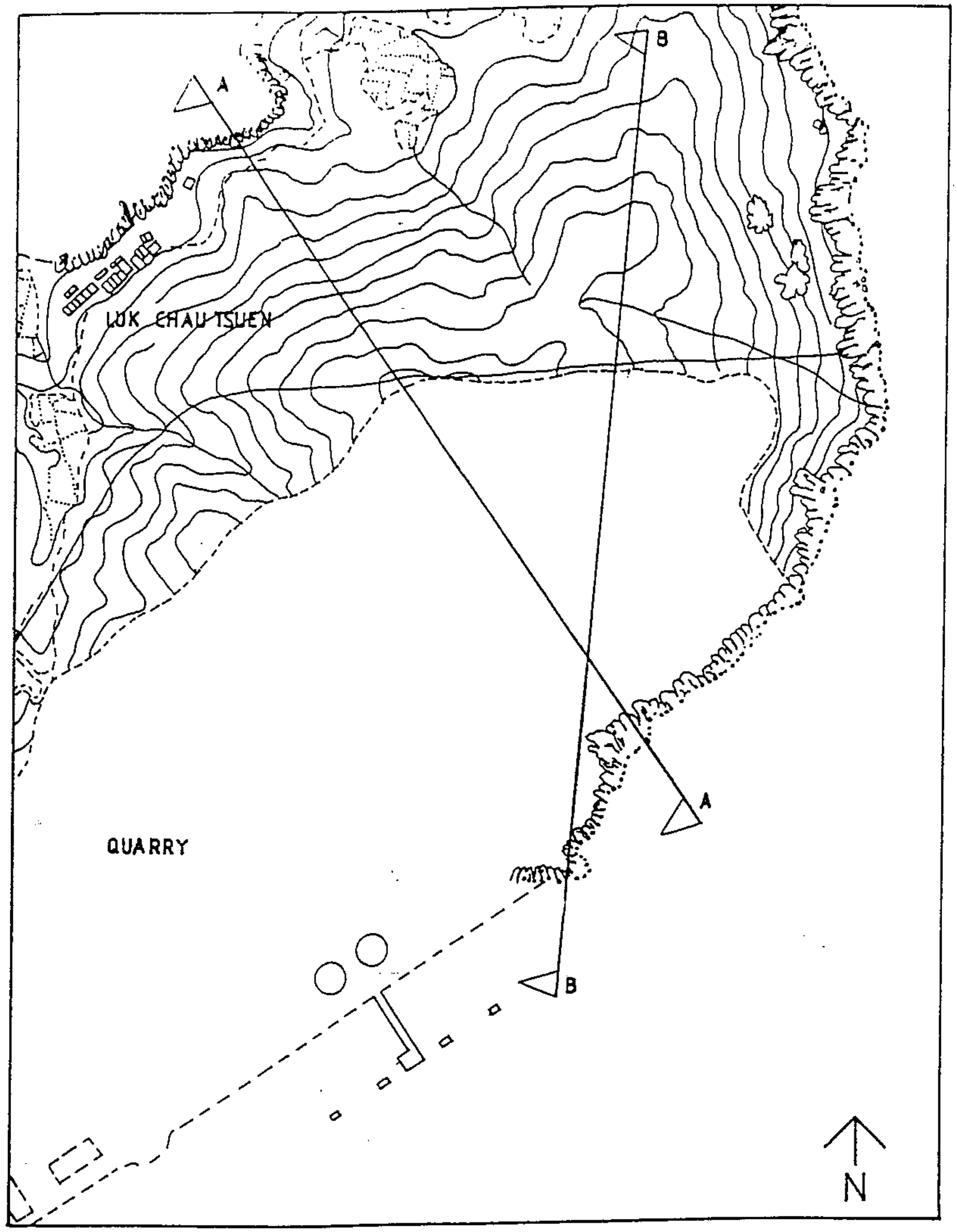
- no significant increase in the visual impact from the construction or operation of the casting basin on key receptors in Picnic Bay;
- no significant increase in the visual impact from the proposed quarry extension on key receptors in Picnic Bay, or on more distant viewpoints on Hong Kong Island;
- moderate visual impact, due to modification of the ridgeline, on sensitive receptors at Lo Tik Wan;
- landscape impacts of the proposed casting basin and quarry extension are seen as moderate only, in view of the severe impact already created by the existing quarry;
- delay in implementing the rehabilitation programme, however the continued operation of the quarry presents the opportunity to derive a more natural final landform.



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	7.1
SCALE:	AS SHOWN
DATE:	MAY 1993
FIGURE TITLE	ZONES OF VISUAL INFLUENCE
JOB NUMBER	054\000\93



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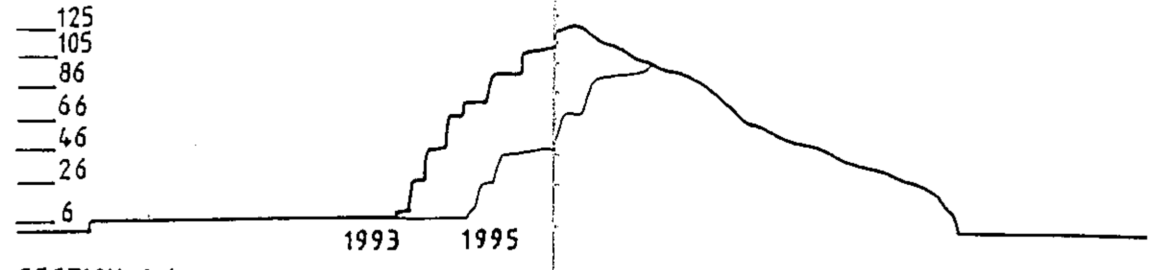
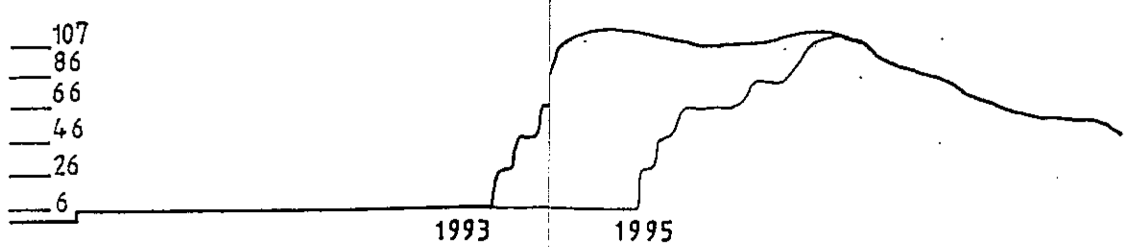


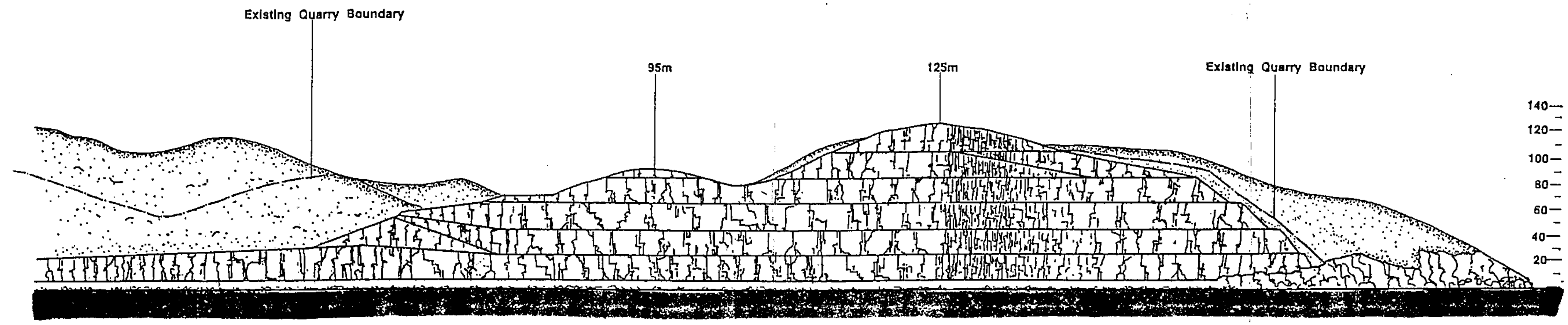
SECTION A-A



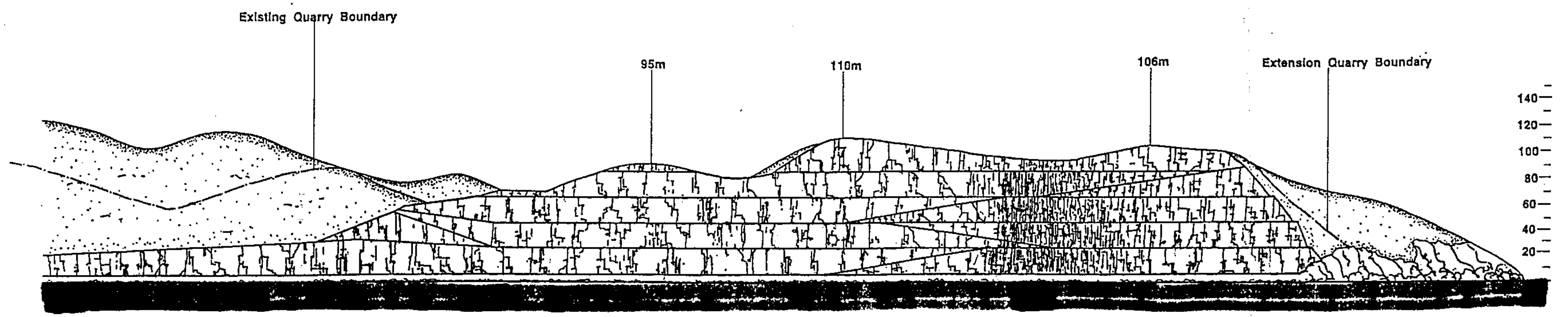
SECTION B-B

EXISTING AND PROPOSED LAND FORMS

AXIS Environmental	LAMMA ROCK PRODUCTS
JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	5.2
SCALE:	AS SHOWN
DATE:	MAY 1993
FIGURE TITLE	MODIFICATIONS TO THE RIDGELINE
JOB NUMBER	054\000\93



ELEVATION A : FROM PICNIC BAY LOOKING NORTH NORTH WEST - 1993

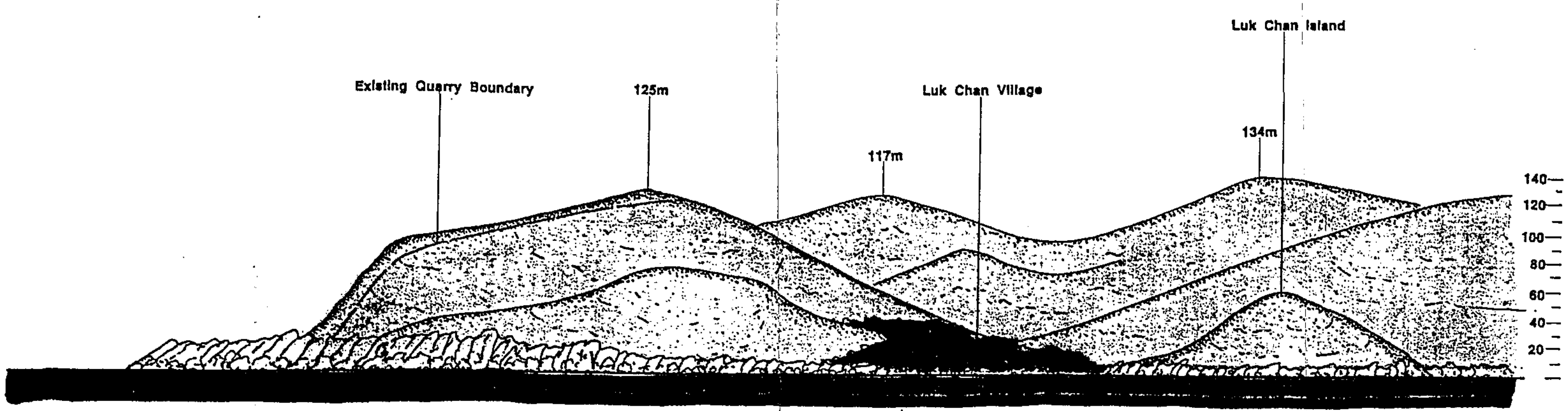


ELEVATION A : FROM PICNIC BAY LOOKING NORTH NORTH WEST - 1995

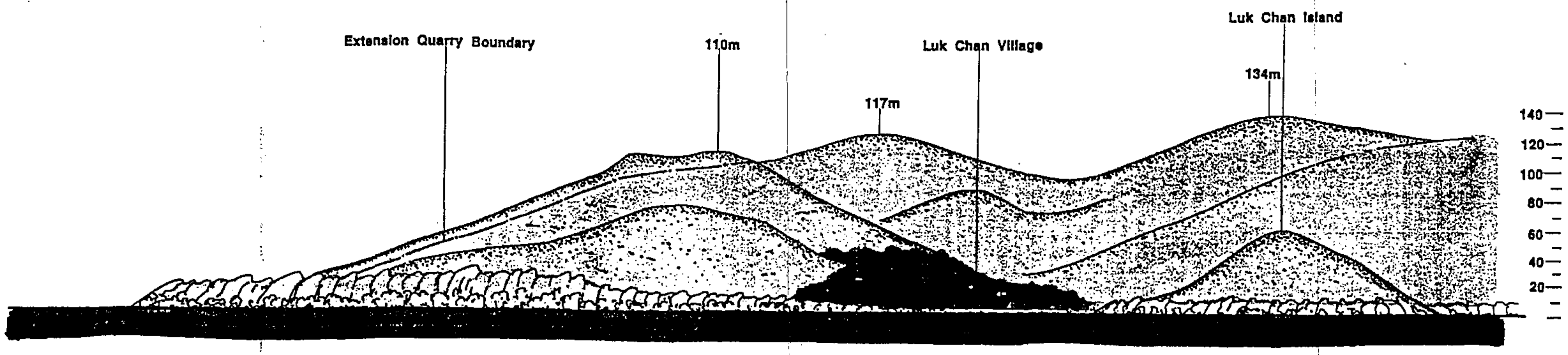
AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

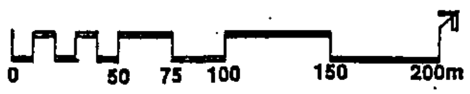
JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	5.3
SCALE	AS SHOWN
DATE:	MAY 1993
FIGURE TITLE	PROPOSED MODIFICATIONS TO QUARRY FACE: ELEVATION A
JOB NUMBER	054\000\93



ELEVATION B : FROM EAST LAMMA CHANNEL LOOKING SOUTH WEST - 1993



ELEVATION B : FROM EAST LAMMA CHANNEL LOOKING SOUTH WEST - 1995



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE: LAMMA QUARRY, CASTING BASIN & EXTENSION EIA

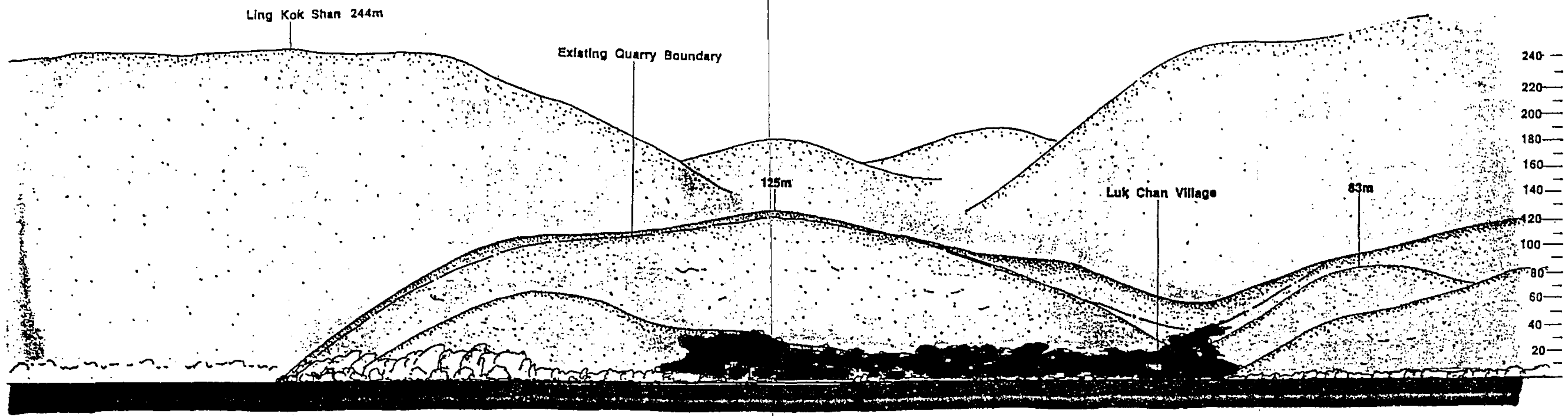
FIGURE TITLE: PROPOSED MODIFICATIONS TO QUARRY FACE: ELEVATION B

FIGURE No. 5.4

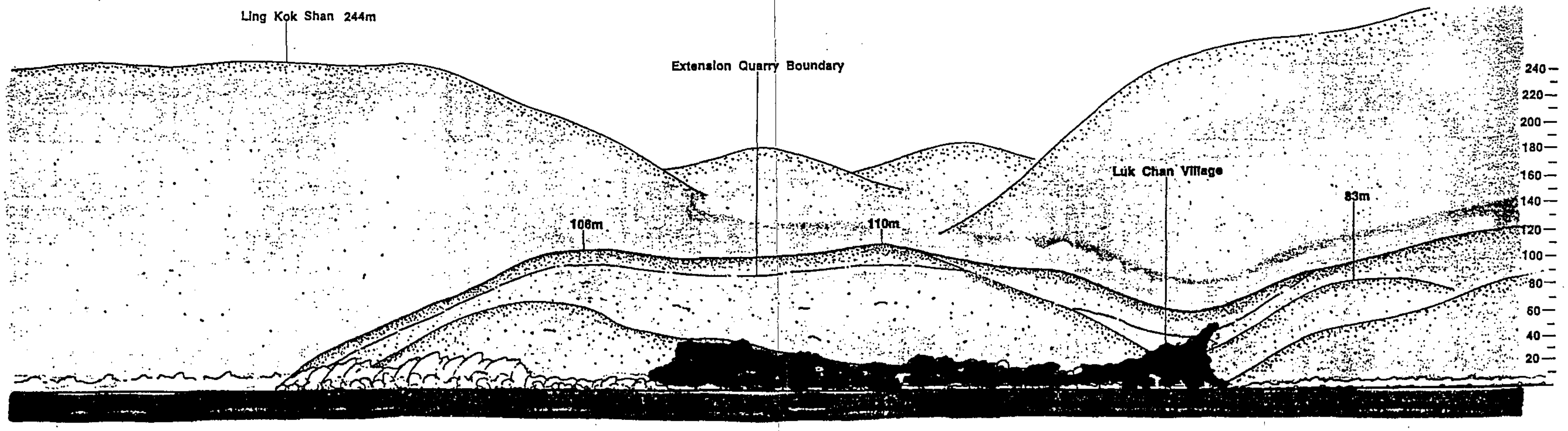
SCALE: AS SHOWN

DATE: MAY 1993

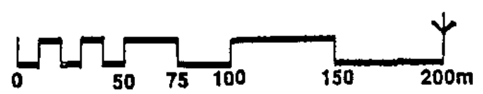
JOB NUMBER: 054\000\93



ELEVATION C : FROM LUK CHAU ISLAND LOOKING SOUTH - 1993



ELEVATION C : FROM LUK CHAU ISLAND LOOKING SOUTH - 1995



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE LAMMA QUARRY, CASTING BASIN & EXTENSION EIA		FIGURE TITLE PROPOSED MODIFICATIONS TO QUARRY FACE: ELEVATION C
FIGURE No.	5.5	
SCALE	AS SHOWN	JOB NUMBER 054\000\93
DATE:	MAY 1993	

Section 6

6. MARINE WATER QUALITY AND MARINE ECOLOGY

6.1 BACKGROUND

6.1.1 General

The existing water quality in the Study Area is well-documented having been the subject of regular monitoring by EPD and AFD over recent years. Sok Kwu Wan lies within the Southern Waters Control Zone (SWCZ) which was gazetted in 1988. Water quality in the Study Area is also controlled through the Water Pollution Control Ordinance (WPCO) section 21, - the Technical Memorandum on Effluent Standards. There is however, evidence of significant failure in compliance with the Southern Waters Water Quality Objectives (WQOs) at present. This is mainly due to the extensive caged fish culture zone (FCZ) which produces a significant amount of solid waste matter. As a result exceedances of the WQOs are consistently recorded for ammonia and inorganic nitrogen.

Fish farming first started in Sok Kwu Wan during the 1960s. Following the implementation of the Marine Fish Culture Ordinance during 1982, gazetted fish culture zones (FCZs) were introduced throughout the territory, including those at Sok Kwu Wan. The gazetted FCZ in Sok Kwu Wan initially covered two areas located in the inner portion of the bay, and during late 1992 a third area, located at the mouth of the bay, was gazetted. The purpose of the third area was to allow a redistribution of the existing rafts to reduce the overcrowding and associated water quality problems.

Due to the presence of the gazetted FCZ at Sok Kwu Wan, EPD and AFD closely monitor water quality in the area. The location of the FCZ is shown in Figure 6.1. The concentration of dissolved oxygen is a key parameter for which commercial fisheries and shell fisheries require protection. In addition, tighter controls on bacterial concentrations, pH, ammonia and inorganic nitrogen levels are exercised both to ensure a suitable environment for the FCZ and to monitor the polluting effects of the FCZ.

The FCZ at Sok Kwu Wan has a total area of cage nets in the order of 24,000m^2, and some additional minor areas are devoted to fish holdings. The FCZ is operated privately producing a variety of finfish species, most of which are sold locally to the restaurant trade.

6.1.2 Existing Water Quality

Comprehensive background water quality data is available from EPD and AFD. This has been supplemented by additional monitoring undertaken by Lamma Rock Products Ltd. The locations of all the respective monitoring positions are shown in Figure 6.1 .

Data obtained from AFD's two monitoring points, one inside the FCZ and one outside shows, that the water quality generally meets the requirements of the Southern Waters WQO with the exception of ammonia and inorganic nitrogen. However, there are notable fluctuations in turbidity, dissolved oxygen, *E. Coli*, ammonia and BOD_5. This would suggest that the water quality is effected by waste water discharges arising from the FCZ, and possibly human sources including the restaurants situated in Sok Kwu Wan.

The temperature data indicates a well mixed water column, although there is some evidence of an inversion in dissolved oxygen levels. It is anticipated that the high dissolved oxygen levels detected at mid-depths are a result of planktonic growth in water which is nutrient enriched mainly by the waste arising from the FCZ.

The critical parameter for protection of the FCZ is dissolved oxygen. Fish kills have been recorded in the past due to oxygen depletion, as shown in Table 6.1.

Table 6.1: Fish Mortalities at Sok Kwu Wan 1986 - 1992

Date	Loss (tonnes)	Value, HK$ 000's	Cause
10.11.87	5.4	323.2	Oxygen depletion
22.08.88	0.2	10	Fish disease
27.09.88	1.8	133.6	Oxygen depletion
16.09.89	0.9	49	Oxygen depletion
20.11.89	0.06	7.5	Oxygen depletion
27.11.89	0.31	24	Oxygen depletion
01.04.90	3.0	300	Fish disease

Source: Agriculture and Fisheries Department

EPD's water quality data covering 1991 and 1992 is consistent with that collected by AFD, with exceedances of the WQO for ammonia levels (The analytical results from the background water quality monitoring for NH_3-N is calculated as the unionised form and reported as mgN/l). The relevant background water quality data is presented at Appendix 6A .

Water quality monitoring has also been undertaken by Lamma Rock Products Ltd, supervised by AXIS Environmental, to provide further background data. The monitoring locations are indicated in Figure 6.1 and are described below:

1 North eastern point, located by a Lamma Rock Products Buoy;

2 North Central point, located by a Lamma Rock Products Buoy;

3 South Central point, located by a FCZ (newly gazetted sub-area of Sok Kwu Wan FCZ) demarkation buoy laid out by the marine department;

4 South Western point, located by a FCZ demarkation buoy laid out by the Marine Department;

5 South Eastern point, located by a FCZ (newly gazetted sub-area of Sok Kwu Wan FCZ) demarkation buoy laid out by the Marine Department, (this point was added at the request of EPD and AFD to the monitoring programme, the first sample being taken on 23rd February 1993).

Results obtained from the sampling on the 12th January, 23rd February, 30th March and the 27th April 1993 are shown in Appendix 6B. It should be noted that the background water quality monitoring programme will continue for a further 2 months.

As already noted ammonia (as NH_3) and inorganic nitrogen both exceed the Southern Waters WQOs. Ammonia levels for the last 3 months monitoring averaged at 0.134mg/l and for Inorganic nitrogen the average is 0.277mgN/l. It is likely that these high levels arise from the FCZ which releases large quantities of organic waste in the form of surplus food and faecal matter.

The soluble waste arising from the fish cages causes nutrient enrichment of the water, with the potential to cause algal blooms (red tides). With the introduction of the third gazetted area the density of the rafts will be reduced and water quality should be improved. It is anticipated that the cause of the fluctuations in dissolved oxygen at various depths could also be affected by the high oxygen demand the FCZ exerts on the water column. Sudden changes in dissolved oxygen levels in the water surrounding fish culture areas are common.

6.1.3 Existing Ecology

The benthic fauna of Sok Kwu Wan is likely to be impoverished as a result of the FCZ activities and to a lesser extent the effects of propeller wash of the ferries, junks and tug boats. These craft frequently traverse the bay, keeping the bottom sediments moving and creating an unstable and unattractive environment for the benthic organisms/communities. Solid wastes from the FCZ comprises excess food and faecal material, and this is deposited on the sea bed smothering the sediments. Research (Smith and Haig) has indicated that the macrobenthic fauna is depleted within approximately 30m of fish culture cages.

6.2 POTENTIAL IMPACTS

6.2.1 General

Sensitive receivers in the study area which would be potentially affected by a deterioration in water quality are mainly the mariculture activities in Sok Kwu Wan, however restaurant customers could also be deterred by poor water quality or blooms. The FCZs support a thriving economy based on the sale and local consumption of seafood. No impacts from the quarry extension or casting basin activities are anticipated on the gazetted beaches on Lamma owing to the distance between source and receiver.

The activities associated with construction activities at the casting basin that potentially have an impact on the FCZs are discussed below. The potential impacts of marine blasting are discussed separately in Section 7.

6.2.2 Construction - Surface Works

Construction phase impacts from operations outside the casting basin will relate to wastewater discharge or surface runoff carrying suspended solids, oils and grease. Site activities will be similar to those presently being carried out at the quarry, and impacts are anticipated to be minor.

6.2.3 Sewage Treatment

At present the wastewater produced by the 100 or so people being employed at Lamma Quarry is directed to a septic tank for treatment. This septic tank system has recently been upgraded. The effluent from the septic tank is discharged by using a soakaway located towards the rear of the quarry. The continued use of this method after the construction of the casting basin is not expected to alter the impact on the water quality of Sok Kwu Wan.

It is expected that the casting basin will have a workforce of some 220 people, and the discharge of an untreated waste water from a work force of this size would have a potentially significant impact on water quality within Sok Kwu Wan, most importantly on the nearby FCZ. It will be necessary to provide treatment of some sort to the wastewater from the casting basin prior to discharge, to minimize any impacts on water quality. The effluent will have to comply with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* and it may be necessary for the casting basin operator to apply for a discharge licence.

6.2.4 Marine Traffic

There would be few shipments associated with operations of the casting basin:

- one steel reinforcing rod delivery per set of four tunnel units (1 every 6 months);
- fuel consumption will be minimal, and will most likely be obtained from the Quarry Operator;
- there will be no additional cement/sand aggregate shipping requirements;
- formwork is steel and reusable-expect 1 or 2 movements total;
- other miscellaneous shipments are expected to be infrequent, and may be timed to co-ordinate with supply movements to the quarry.

In terms of ferrying staff the marine movements present and future are:

- there are presently 8 scheduled launch trips per day for the quarry operations;
- a similar additional number will be required for the casting basin.

These additional launch movements are not considered significant compared with junk and sampan movements in the Bay.

The present units will be removed from the casting basin on three occasions at approximately six monthly intervals. Each removal operation will take 2-3 days and will require close cooperation with the local fishing community and Marine Department. There will be an increase in marine traffic in the area on those occasions when the units are removed, as a result of tug movements, which may lead to temporary navigational problems. Marine Department will be consulted regarding the logistics and timing of operations.

Some limited water pollution impacts from the leakage of engine oils and discharge of bilge waters could occur, but only at the same order of frequency for other marine activities in Hong Kong.

6.2.5 Dredging

To cater for the removal of the units and to provide access to the casting basin, some dredging will be necessary to create an access channel. The channel will lead from the existing dredged channel serving the cement berths to the casting basin's sea gate. The channel will be dredged to approximately -9mPD. Dredging results typically in an increase in suspended solids in the water column. The consequent reduction in light penetration reduces the oxygen generated by photosynthetic plant life, reducing dissolved oxygen levels in the water.

The degree to which dredging effects water turbidity is dependent on a number of factors including the methods and equipment employed, physio-chemical characteristics of the dredged material, water currents and the location of the dredged site.

The removal of benthic organisms which are entrained within the dredged muds will lead inevitably to some fatalities of these organisms. However, the area involved is only small and the type of organisms found in the sediment are opportunistic species and the disturbed area could be recolonised within a short period of time.

Impacts will also arise from the increase in suspended solids in the water column, in particular the smothering of local benthic organisms and the clogging of gills. Pelagic fish species will generally avoid a cloud of high turbidity, although some species do not exhibit such a response.

It expected that the dredging will be carried out by using grab dredgers, with tightly fitting jaws. All the dredging will be carried out inside silt curtains and at certain tide times to minimise the impacts, these aspects are discussed further in Section 6.3.2.

A survey of the sediment quality within the area of the proposed entrance channel has been carried out and is discussed in Section 7.4.

6.2.6 Operation - Opening of the Dock Gate/Dewatering

This activity has the potential to impact on the FCZ mariculture activities. The casting basin area used for the preparation of 100m long tunnel units will be potentially contaminated to some extent with oils and grease, and high in suspended solids and pH from cement mixing and the concrete curing waters. Filters and surface booms would be employed to treat contaminated water prior to dewatering and eventual effluent discharge.

The potential contaminants of main concern are fuel and oil from mechanical plant, mould oils/release agents, and high pH and suspended solids from concrete curing waters. These matters are discussed below.

Fuels/oils from mechanical plant

To reduce this impact mechanical plant (e.g. tower crane, concrete vibration pokers, hoists, etc.) will, where possible, be electric and any refuelling and maintenance of the plant would be carried out outside the basin. This aspect is covered in more detail in Section 8, Waste Management.

Any oils in the basin will be removed prior to flooding the basin during a pre-flood cleanup and washdown. Oil mops and other cleanup aids will be available to remove any residual before the seagates are opened (Section 6.3.3).

Application/use of mould oils/release agents

Before use, the moulds would be coated with a mould oil/release agent which eases the separation of the formwork from the cast concrete unit. The mould oil/release agent is usually a hydrocarbon-based compound and can be applied to the moulds using sprays or by hand. During the coating process it is inevitable that some of the mould oil is lost owing to spillages and to removal of mould oil from places of excess coverage. This lost mould oil could contaminate the casting basin floor with subsequent impacts on water quality.

Once the formwork moulds have been separated from the cast units, it is necessary to clean them in preparation for the next phase of casting. The cleaning of the formwork will result in the production of cement grout particles contaminated with mould oils and contaminated wash waters. Because of the potential impacts associated with the formwork preparation, the preparation would be carried out outside the basin in a suitable area. This area would be provided with a solid concrete base and sides, and be connected to the casting basin water treatment tank to allow treatment of the wash waters and settlement of the contaminated grouts prior to discharge to the sea. This aspect is covered in further detail in Section 8.3.1.

Many types of mould oils/release agents are available on the market. It is proposed that non-phenolic agents, such as *Febstrike®* manufactured by *FEB*, would be used. This will significantly reduce the polluting potential of the release agents.

The timing of the gate opening would be carefully controlled. The inside of the basin, even after a washdown, would contain a small but still potential pollutant load which could become significant on flooding the dock. If the basin were flooded on a flood tide any remaining pollutant load in the basin would be carried further into Sok Kwu Wan towards the FCZ. However if the basin were flooded on an ebb-tide any remaining pollutants would be carried out of Sok Kwu Wan, away from the FCZ, on the tide. It is therefore proposed that the basin only be opened at high tide so that any pollutant load is removed from sensitive receivers in Sok Kwu Wan on the receding ebb-tide.

Concrete Curing Waters

Once the formwork has been stripped from the cast units the fresh concrete needs to be cured so that the concrete reaches its optimal strength. The curing process can be carried out in a number of ways. These include use of curing water covering with wet hessian; or use of curing membranes, or polyethylene sheets.

The details of the actual operational procedures to be used by the casting basin operator are as yet unknown, and consequently the curing method to be used is also unknown. Below a brief discussion is given of the more commonly used methods, and the environmental issues of each method.

Curing Water/Hessian Cover

The curing water method is a more traditional method of curing and entails the fresh concrete having a constant flow of clean water passed over the surfaces for up to 14 days. The curing water will, once it has flowed over the concrete, become contaminated with lime leached from the immature concrete surface, assuming a high pH, and possibly become also contaminated with mould oils from the formwork.

A variation of using curing waters is to apply a dampened hessian cloth to the concrete during the curing process; this has the advantage of not producing large quantities of curing water effluent as in the continuous flowing water method as discussed above.

Curing Membranes/Polyethylene Sheets

This method of curing is carried out by spraying the fresh concrete surface with a liquid compound which rapidly forms an impermeable skin of resin over the concrete surface. The impermeable skin prevents the rapid evaporation of surface moisture and allows the concrete to cure to its optimum strength. The resin film disintegrates over time leaving a clean stain-free surface suitable for applying the waterproof membrane on the tunnel units.

If this method is used it will be ensured that the curing membranes used do not contain potential pollutants such as phenols. As with the release agents mentioned above there are a large number of proprietary brands readily available on the market and many of these are phenol free.

Covering the immature concrete with polyethylene also prevents the rapid evaporation of surface moisture, enabling the concrete to cure.

Of the above methods the use of membranes is preferred on environmental grounds, because it produces minimal quantities of water requiring treatment prior to disposal to the sea.

6.3 MITIGATION

6.3.1 Construction (Surface Works)

Typical mitigation measures required for surface works include sediment traps and oil interceptors at appropriate locations. These measures are currently adopted at the site by *Lamma Rock Products Ltd.* An extension of these existing pollution control measures would be implemented to control any surface works associated with the casting basin.

6.3.2 Dredging

Dredging of the existing marine sediments is required to a depth of - 9mPD if no rock is encountered. As described in Section 2.1.3, it is intended to use a floating silt curtain designed to contain suspended solids. As part of the operation control measures, suspended solids would be monitored outside the screen; dredging would be halted if levels approach 90% of the upper control limits. Owing to the small area to be dredged, mechanical grab dredgers would be used.

The dredger would be fitted with a closed seabed grab, and the dredged material loaded onto a split barge with a water tight seal. As also noted in Section 2.1.3, no barge overflowing would be permitted, and dredging would be curtailed when barges move in and out of the silt curtain enclosure.

In addition, further mitigation measures would be employed, including:

- dredging at times of the tide when current flow is at its lowest;
- using slow hoist speeds, and grabs that offer a tight seal, to minimise the release of sediments into the water column.

6.3.3 Opening of the Dock Gate/Dewatering

Prior to flooding the basin a washdown will be carried out. This operation will remove a significant amount of the pollution load inside the basin. This includes suspended solids, oils/grease, mould oil/release agents, waterproofing materials and any contaminated water produced during the concrete curing.

The washdown, including any curing water, will be drained through the gravel base of the casting basin to the perimeter interceptor drainage network and pumped up to the treatment tank on the quarry platform. Settlement of construction wastes and oil removal will occur and if necessary the pH adjusted prior to effluent discharge to sea.

It will be necessary to ensure that the treatment tank is of sufficient size, and that any discharges from the treatment tank comply with the *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters* (TM). In particular, contaminants which may be present in the mould oils and waterproofing membranes would be treated and monitored prior to discharge.

It is intended that sophisticated filtration booms would be deployed during the opening of the dock gate. During filling of the casting basin no escape of water from the basin to the marine environment is anticipated. As an additional safeguard oil interceptors would be employed at the exit from the casting basin.

The gate would be opened only after final site inspection and approval by the Site Manager.

6.3.4 Sewage Treatment

When the construction is at its peak a workforce of up to about 220 would be employed at the casting basin site. The proposed sewage treatment plant type for the casting basin site is a Rotary Biological Contactor, RBC. This is a self contained, fully enclosed, sewage treatment system ideal for small populations, and would ensure compliance with the TM. The advantages of such a system include comparative economy of land-take, ease of operation and low operating costs.

Flows into the RBC would have to kept at a fairly constant rate so that the level of treatment is maintained. In order to maintain a constant rate inflow a buffer tank will have to be incorporated into the design of the RBC. Discharges from the RBC would have to be licensed by EPD and regular water quality monitoring carried out to ensure the discharge complies with the discharge license and does not adversely affect the water quality of the area.

The proposed discharge point from the RBC is shown of Figure 6.1 and is several hundred metres from the existing quarry septic tank and soakaway. It is considered to be neither desirable nor feasible that these discharge points be combined.

6.3.5 Marine Traffic

Overall marine traffic in the study area is not expected to significantly alter as a result of the change in works at the Lamma Quarry. However, critical navigational impacts may potentially arise during transportation of the precast units. Detailed planning, involving consultation with all potentially affected bodies and the Marine Department, is proposed to ensure a successful operation of minimum inconvenience to other marine traffic.

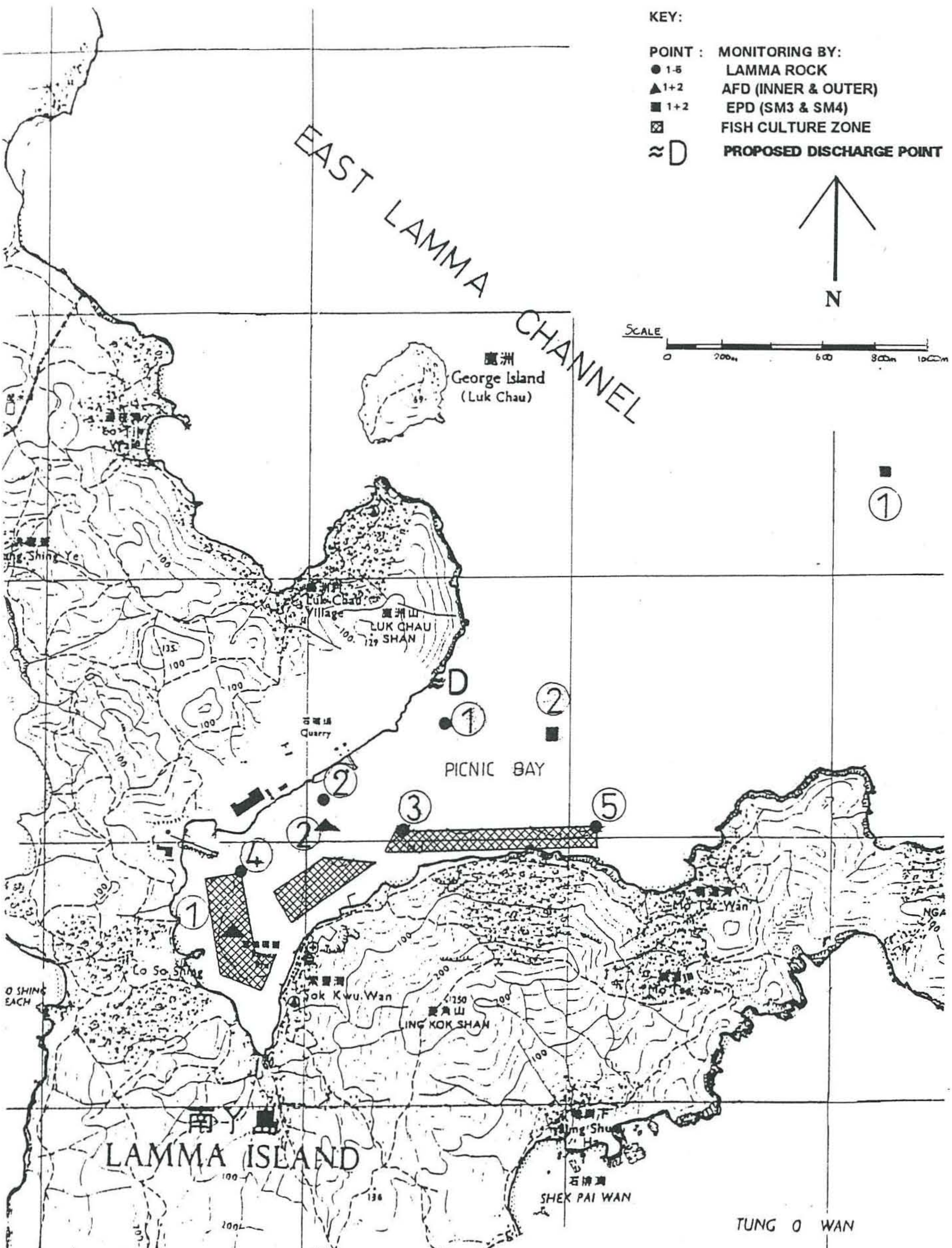
6.4 CONCLUSIONS

The key areas of potential water quality impact identified in the assessment relate to dredging to provide adequate clearance at the dock gate, treatment and discharge of water following the flooding of the basin, and sewage treatment for construction workers on-site. Blasting may also potentially affect marine ecology and water quality, and this issue is discussed further in Section 7.

Environmental monitoring will be undertaken to ensure that no deterioration in marine water quality occurs in the vicinity of the FCZs. The key parameters to be tested will be the aesthetic appearance of the water (particularly noting the presence of oils and grease), the concentration of dissolved oxygen and the level of suspended solids.

In addition, effluents arising from the settlement tank and from the sewage treatment plant would be monitored to check compliance with the TM. Depending on the type of mould oils utilised, effluents discharged may be tested for phenolic and other substances, however it is proposed that the mould oils/release agents used would not contain phenolic substances. Environmental monitoring schedules and audit procedures are discussed in detail in Section 10.

To ensure that the mitigation measures discussed in this Section to control/minimise water quality impacts are adopted effectively, it is proposed that specific environmental clauses would be incorporated into the contract documents for operating the casting basin.



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	6.1
SCALE:	AS SHOWN
DATE:	MAY 1993
FIGURE TITLE	WATER QUALITY MONITORING STATIONS AT SOK KWU WAN
JOB NUMBER	054\000\93

Section 7

7. MARINE BLASTING AND DREDGING

7.1 INTRODUCTION

To excavate the casting basin facility it will be necessary to blast the bedrock below the existing quarry floor. The area to be drilled and blasted comprises the basin that will accommodate the tunnel units and the channel that will connect the basin to the sea.

Blasting for the basin and the majority of the channel will be completed with conventional techniques already used in the quarry. Beyond the existing shoreline it will be necessary to blast any bedrock within the channel that is above -9.0mPD, and to dredge any overlying sediments.

7.2 EXTENT OF MARINE BLASTING

To determine the extent of marine blasting Lamma Rock Products Ltd is undertaking a site investigation. Preliminary results indicate bedrock at -7mPD in drillholes set back 10m from the existing shoreline. Further investigation will confirm if the bedrock is below -9.0mPD at the shoreline.

Historical topographical plans shows that the original shoreline is approximately 20m inside of the existing shoreline. The plans also show that the original bedrock dipped steeply at approximately 45° into the sea. If it is assumed that this rock face continued at the same angle beneath the sea, then at the current shoreline bedrock should be at -15mPD. If this is confirmed by the site investigation then minimal, if any, marine blasting will be required.

Seabed soundings in the area of the casting basin channel show a loose rubble shoreline, sloping at approximately 40°. A few metres below the water the seabed flattens to between 5° and 10°. The seabed continues at that angle away from the shoreline some 50m, and then flattens off, at approximately -14mPD.

The flattening of the seabed indicates the edge of the sea channel dredged in the early 1980's to provide access for the 23,000t cement ships servicing the Far East Cement cement facility. During dredging of the sea channel no blasting was required and no rock was encountered.

In the absence of the results of the site investigation being finalised it has been assumed that some marine blasting will be required and potential impacts have been assessed.

7.3 POTENTIAL IMPACTS

The potential impacts of dredging have been addressed previously in Section 6.2.5. This section describes the potential impacts during blasting.

7.3.1 Effects of blasting

Of major concern during the marine blasting, which may be required for the construction of the basin entrance channel, is the potential impact of the blast pressure wave on the nearby Sok Kwu Wan FCZ and also on the general environment.

Explosions in the marine environment can cause the death of marine fauna which are in close proximity to the blast area (referred to as the "lethal zone"). The lethal zone varies according to the species of organism, its biology and the orientation of the blast wave. The organisms which are killed or damaged over the longest range are those which possess an air bladder. When the explosion occurs a pressure wave is generated, which is reflected when it reaches the water surface and then descends as a negative pressure wave. It is thought that the negative pressure wave causes the air bladder to rupture which is fatal to fish. The mortality levels for marine fauna are therefore expressed in terms of pressure levels.

The nearby Sok Kwu Wan FCZ is outside the 'lethal zone', where immediate and acute fish kills occur. However, there is the potential for the blast shock waves to frighten the fish causing them to dash around the cages, and crashing against the cage netting. This could lead to the fish getting wounds and bruises on the body, and if these wounds become infected the fish could die.

The potential effect of shock waves from blasting may also be fatal to humans, marine mammals and amphibians. It is therefore essential to ensure that at the time of the blast no people, and as far as possible no marine mammals, are in the water close to the blast area. Should marine blasting be required the proponent will notify the District Office of the local community in advance of any blasting.

7.3.2 Blast Pressure Waves

Research has shown that the lethal pressure level for fish with an air bladder is between about 2.0 and 5.0 bar (approximately 200 to 500kN/m^2), whereas a crab can withstand a pressure of about 15 bar (1,500kN/m^2) and a lobster up to 45 bar (4,500kN/m^2) (Standards Association of Australia, 1983). Experiments on the use of explosives and their effect on shrimps have been carried out using charges of up to 360kg. The results showed that shrimps at a distance of 15m were not harmed by the explosions (Sjøblom, 1949). Laboratory experiments have indicated that susceptibility depends on age, species, and whether the air bladder is open or closed. It is also understood that fish fry are particularly susceptible to blasting.

The use of surface or suspended charges for underwater blasting is not considered to be an acceptable practice as the blast is not as effective as when the charge is buried, and also the effects of the blast on the marine environment are significantly more damaging. Therefore drilling methods will be employed for the placement of the explosive charges.

It is generally accepted that the water shock from the detonation of explosive buried in shotholes underwater is some 10 to 20% of that of a freely suspended charge of the same weight. However, Australian Standard (AS) 2187 Part 2 *Use of Explosives* 1983 recommends use of an adjustment figure of 40% for a confined charge in calculation of the pressure level.

7.4 ENTRANCE CHANNEL

It will be necessary to create an entrance channel to connect the existing deepwater channel, which was formed for the cement berth, to the casting basin entrance. The channel will have a depth of -9mPD which is the same as that of the casting basin.

A survey of the marine sediments in the area of the proposed entrance channel was carried out on the 7th May, 1993. Samples were taken at 4 locations (Figure 7.2) using a 0.05m^2 Van Veen Grab and subsequently analysed for contamination of heavy metals. The results of the analysis are given in Table 7.1.

From the results it can be seen that the sediments in the area of the entrance channel are clean Class A sediments. In light of the sediment contamination results it is considered that the dredging, transport and disposal of the sediments would not require any special precautions and requirements other than those already proposed to minimize the impacts normally associated with the dredging of clean material.

Table 7.1 Marine Sediment Analysis: Date of Sampling 7th May 1993

SAMPLE	METAL mg/kg dry weight						
POINT	Zn	Cu	Ni	Cr	Pb	Cd	Hg
1	120	44	16	25	28	<0.3	0.2
2	80	35	13	21	13	<0.3	0.2
3	100	41	17	27	14	<0.3	0.2
4	80	31	11	20	17	<0.3	0.2

KEY :

WITHIN CLASS A LIMITS	EXCEEDS CLASS B LIMITS	EXCEEDS CLASS C LIMITS

The channel will measure approximately 20m wide and run out into Sok Kwu Wan for 50m from the entrance of the casting basin. The construction of the channel will entail the removal of the soft marine deposits from the area down to a depth of -9mPD. This will create some 6,000m^3 of mud for disposal.

If rock is encountered before a depth of -9mPD is reached then it will be necessary to carry out underwater blasting to allow removal of the rock. As noted in Section 7.2, Lamma Rock Products Ltd has commissioned a site investigation to quantify the amount of mud and rock to be removed during the formation of the entrance channel. The survey will investigate the sea bed profile in the area and the depth of the mud-rock interface.

7.5 DETERMINATION OF CHARGE SIZE

Owing to the unknown extent and details of the blasting which will be carried out for the construction of the casting basin entrance, the assessment of the potential impact of blasting is based on the effect of nominal charge sizes.

In order to assess the environmental impact of blasting it is necessary to know the amount of explosive charge to be used in each blast, along with several other variables related to the site, e.g. bathymetry, water depths, etc. With this information it is possible to calculate the peak overpressure and ground vibrations which will result from any particular blasting event. This will enable prediction of the lethal zone for fish and other marine fauna surrounding the blast.

It has been assumed that a 10kg charge will be used in each blast hole in the construction of the entrance channel, and that a total of ten shotholes will be required. The charges would be fired in a delay sequence that would ensure the maximum overpressure would not be significantly greater than that for a single 10kg charge.

The lethal zone resulting from an underwater explosion using a depth charge or rocket weighing 100kg is thought to be equal to a radius of 77m for most marine fauna, and 309m for most fish (Westing, 1978). By comparison it is expected that the maximum total explosive charge to be used for the development will be 100kg, and this charge will be buried in shotholes rather than freely suspended in the water, which will reduce the water shock considerably (Section 7.3.2). The proposed blasting is unlikely to cause any impact on the local FCZs in terms of fish kills, the nearest FCZ being approximately 500m from the blasting area. The potential impact on local fish populations (outside the FCZs) is therefore considered to be limited.

An alternative assessment of the blast pressure impact can be made using the charge weight/pressure pulse relationship from Australian Standard (AS) 2187 Part 2, *Use of Explosives*, 1983:

$$P = 50.94 \times 10^3 \times \left[\frac{(W^{0.333})}{D}\right]^{1.15}$$

where

P	=	pressure due to an unconfined source (kN/m^2);
W	=	charge weight (kg); and
D	=	distance from blast point to subject (m);

and $P_c = 0.4 \times P$

where P_c = pressure due to a confined charge (kN/m^2)

Therefore for a single charge of 10kg which is confined in the blast hole the peak pressure produced is:

$$P_c = 0.4 \times 50.94 \times 10^3 \times \left[\frac{(W^{0.333})}{D} \right]^{1.15}$$

and for $D = 30m$, $P_c = 985kN/m^2$

$D = 500m$, $P_c = 39kN/m^2$

From this it can be seen that the pressure attenuates rapidly with distance and the pulse pressure at the mariculture zone should be considerably less than the fish injury threshold (200 to 500kN/m^2) if a 10kg charge per shothole is used.

7.6 MITIGATION MEASURES

Blasting

The impact of blasting is dependant on the size of the charge, placement techniques adopted, type of explosive used, detonation sequence and distance to SRs, i.e. to the FCZ. In the event that marine blasting is required, overburden material will be placed over the area to be blasted until a working platform for the drill rig is established. This activity will at the same time isolate the rock to be blasted from the marine environment.

Allowing for the natural slope of the overburden covering the blast area, any explosive charge will be isolated from the sea by at least 10m (Figure 7.1). With dissipation of explosive energy through the soft overburden, pressure levels will be minimised.

The size of the charge can be controlled by the size of blasthole. *Lamma Rock Products Ltd* have drillrigs capable of drilling different diameter holes. Hole diameters of 140mm or 76mm may be used depending on the requirements for controlling the blast pressure waves. In addition, the use of decked charges could be employed if it is considered that further reduction of the pressure wave is required, however this is considered unlikely.

There is a wide variety of explosives available to meet specific blasting requirements. An explosive which fulfils the technical needs for fracturing the rock, but at the same time minimising the blast pressure wave, will be selected in consultation with explosive suppliers.

Any marine blasting that involves the initiation of multiples holes will separate the initiation of those holes with delay detonators. The ability to increase the delay between detonations can be further extended by using a sequential timer.

The blast will be designed to minimise the pressure wave. This can be carried out through a number of different ways including:

- altering the explosive sequence delay
- type of explosive used
- increasing the depth of cover of the charge
- altering the charge size.

A further mitigation measure that can be used to reduce the transmission of the pressure wave through the water is the use of air curtains situated between the blast and the FCZ (Graves 1968, Jacobson 1954). The curtain is formed by pumping air into a perforated tube which is placed on the seabed. The air bubbles rising form a curtain between the blast point and the FCZ. The shock wave reduction obtainable using this method depends to a great extent on the amount of air used. Further attenuation of the pressure wave can be achieved by the use of two parallel air curtains between the blast and potentially affected areas of the bay.

The use of air bubble curtains as a means of reducing the energy and transmission of an underwater blastwave has been extensively used in North America and Australia. The curtains were initially used as a means of protecting underwater structures, but is now also used to minimise impacts on marine organisms. The first recorded use of an air bubble curtain was at Niagara falls in 1954 by Canadian Industries Ltd. where blasting was carried out within 100ft of a hydroelectric power station. In this case over 6 tonnes of explosive were used to remove some 90,000 cubic yards of rock. Two air curtains were employed and these enabled the blasting to occur without disrupting the operation of the power station or damaging any of the underwater structures. It was reported that the pressure wave received at the power station was 1.4% of that which would have been received if no air bubble curtains were employed. Since this time the use of air bubble curtains as an effective measure in reducing the water borne shockwaves has become an accepted practice.

If the blast charge is considered to present too high a risk, then using a series of smaller blasts would be preferential. The technical requirement for blasting is not determined at this stage. An assessment of the technical requirements for any marine blasting would be undertaken by an independent technical specialist, and the assessment submitted to the Mines and Quarries Division of Civil Engineering Department and the Marine Department.

7.7 CONCLUSIONS

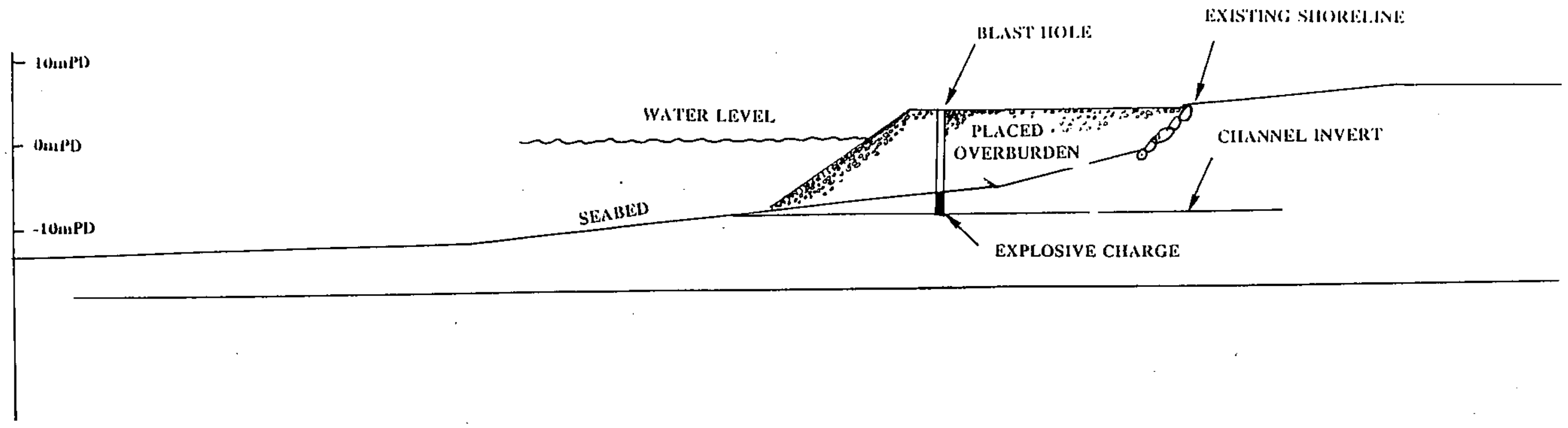
At present it is not known if marine blasting will be necessary, because information on the depth to bedrock in the area of the proposed channel is not known.

Should marine blasting be required the design of the blasting sequence, charge size etc. will be carried out by an independent technical specialist, and submitted to the Mines and Quarries Division of Civil Engineering Department for their approval, and the Marine Department and other departments if necessary.

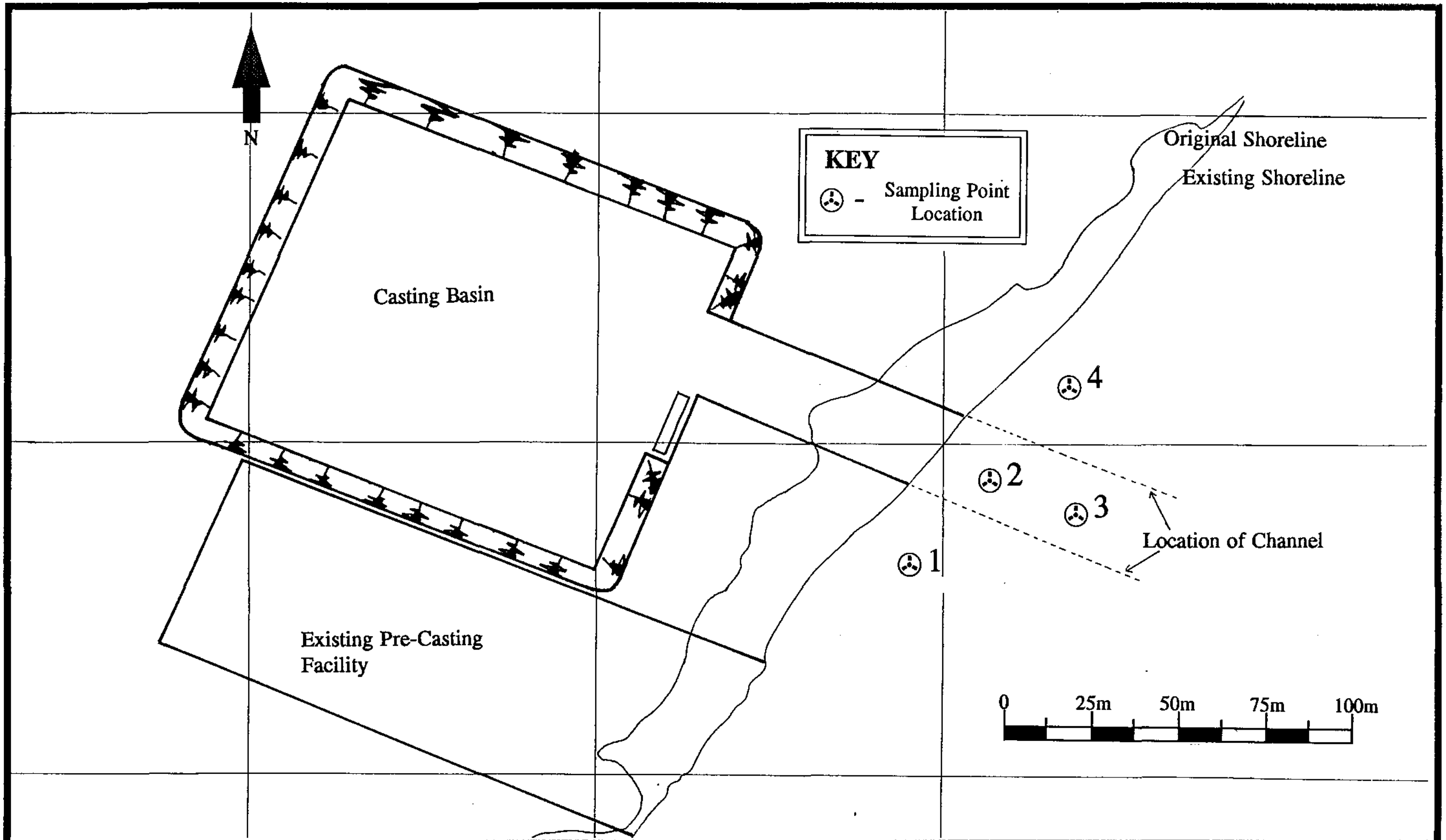
The assessment has indicated that, should marine blasting be required, the FCZ would not be affected. The predicted peak pressures at the nearest FCZ (some 500m away) have indicated levels well below known fish injury thresholds.

Should the site investigation indicate the need for marine blasting, a marine ecology survey would be undertaken immediately prior to and after blasting. The survey would note and record the presence and abundance of marine species in the vicinity of the area to be blasted. The survey programme would be discussed and agreed with AFD prior to any blasting, and the results of the survey would be submitted to AFD and EPD.

A survey of the marine sediments in the area of the proposed channel has indicated that the sediments are categorised as clean Class A sediments. It is therefore considered that the dredging, transport and disposal of the sediments do not require any special precautions or requirements other than those normally applied for the dredging of clean material.



AXIS Environmental	LAMMA ROCK PRODUCTS Ltd.	JOB TITLE: LAMMA QUARRY, CASTING BASIN & EXTENSION EIA	FIGURE TITLE: SCHEMATIC DRAWING SHOWING EXPOLSIVE CHARGE PLACEMENT
		FIGURE No. 7.1	SCALE: N.A.
		DATE: MAY 1993	JOB NUMBER 054\000\93



AXIS Environmental

LAMMA ROCK PRODUCTS

JOB TITLE: LAMMA QUARRY, CASTING BASIN & EXTENSION EIA

FIGURE No: 7.2

DATE: May 1993

FIGURE TITLE: LOCATION OF MARINE SEDIMENT SAMPLING POINTS

Scale : AS SHOWN

Job No: 054\000\93

Section 8

8. WASTE MANAGEMENT

8.1 INTRODUCTION

Owing to its direct marine frontage and location adjacent to a small bay with a nearby FCZ the Lamma Quarry is situated in a sensitive location. It will therefore be essential that good waste management practises are employed during the construction and operation of the proposed casting basin and the extension to the quarry.

8.2 WASTE ARISINGS

8.2.1 Extension to Quarry

The quarry is currently licensed to operate and the existing waste management practises are considered acceptable. From a waste production viewpoint the proposed quarry extension will involve a continuation of the existing procedures and practices and will not involve any significant changes. The existing waste practices are briefly described below:

- oils/greases are stored on site awaiting collection by a waste oil reprocessing agent. In future these wastes will be disposed of at the chemical waste treatment facility (CWTF) located on Tsing Yi;

- scrap steel is sold to an agent who collects and recycles the steel;

- food wastes from the Canteen are directed to the septic tank, via grease traps and screening pits

- general office wastes in very small amounts, is burnt on-site;

All the sewage generated at the quarry is directed to a septic tank fitted with a soakaway (Section 6.3.2).

8.2.2 Casting Basin: Construction

During the construction of the casting basin it is anticipated that some additional waste materials will arise from various sources/activities including:

- residues from construction materials/processes
- plant and vehicle maintenance and servicing
- workforce generated waste
- sediment from construction of the entrance channel.

8.2.3 Casting Basin: Operation

The operation of the casting basin will be likely to lead to generation of wastes from the following main sources/activities:

- residues from unit construction materials/processes
- plant and vehicle maintenance and servicing

- workforce generated waste.

Some of these sources and activities and the associated waste types are similar for both construction and operational phases. They are therefore discussed together below.

It should be noted that re-usable steel form work would be used.

8.3 POTENTIAL IMPACTS AND MITIGATION

8.3.1 Residues from Construction and Operational Materials and Processes

During the casting basin construction phase residues would be anticipated to be of limited type and quantity and consist principally of grout, cement, curing waters, curing membrane wastes, release agents and packaging. A most important aspect would be to ensure good site practise whereby materials are quickly and thoroughly collected and disposed of by acceptable methods and not permitted to be flushed or leached by rainwater into the marine environment.

During the operational phase of the casting basin, which will extend for a much longer period than the construction phase, there is potential for waste related impacts particularly to the local marine environment. Particular sources of waste will include waste concrete (including concrete chippings), metal fines from the finishing process (which may involve some grinding of parts of units to smooth and remove rough edges etc.), welding slag, release agents (mould oils), water proofing chemicals and others.

As for the construction phase, good site practise would be employed to prevent routine and chronic pollution. The most effective mitigation is to control and reduce spillages as far as possible, and this policy would be adopted.

A main activity of concern will be the flooding of the casting basin to remove the unit. This activity will occur infrequently, about once every 6 months, but is potentially very significant. A thorough collection of materials and cleaning of the area would be adopted as part of a routine procedure, and in particular as a specific cleaning exercise prior to every flooding of the basin.

A condition of the monitoring and audit procedures would require this pre-flooding clean-up to be formalised and a written confirmation being obtained from the site manager and a member of an independent monitoring team.

As discussed in Section 6.3.3, all surface water and waste water will be required to pass through sediment traps and oil/grease interceptors. Any discharge water would be regularly monitored for basic parameters such as turbidity, suspended solids, and pH, and any necessary treatment applied. The water discharged should comply with the *Technical Memorandum on Standards for Effluent Discharge*.

8.3.2 Plant and Vehicle Maintenance and Servicing

The main items of construction and operational plant and equipment will require regular maintenance and servicing for efficiency reasons, as well as to minimise noise and air pollutant emissions. This will generate dirty lubricants, spent air and oil filters, and other sundry materials such as tyres. As the number of extra plant/vehicles required is limited, consisting of a small number of additional concrete lorries, only limited quantities of these wastes will be produced. The relatively inert, solid materials such as air filters are suitable for disposal to landfill and could be disposed of via the normal waste stream.

Appropriate collection and disposal measures would be used to prevent oil, grease, gear box fluids, brake fluids etc., from contaminating the groundwater or land. The existing collection, storage and disposal method of collecting spent oils etc. to a central storage facility, and then collection by the original supplier via a barge transfer, will be continued and will be capable of accommodating the small increase in quantities.

8.3.3 Workforce Generated Waste

It is estimated that the numbers of workers on the site will increase from 90 at present to a maximum of about 310. Of this increase some 200 of these will be employed in the casting basin operations, and twenty for associated activities including operation of the concrete batching plant and driving concrete trucks.

Wastes from the workforce engaged in construction and longer term operation would include general refuse such as food scraps and residues, paper and containers etc. This type of waste is already arising and being dealt with at the site offices and site buildings. The existing facilities for collection and disposal of these wastes would be extended to cater for the additional waste volumes.

The projected three fold increase in the numbers of workers on the site will lead to a proportional increase in the quantity of sewage and grey water produced. As discussed in Section 6.3.4, it is proposed that a Rotary Biological Contactor would be installed to cater for the increased volume of sewage.

8.3.4 Dredged Sediment from Construction of the Entrance Channel

In order to deepen the entrance channel it will be necessary to dredge the marine mud and sediments down to the rock. This material will require disposal, most likely to a gazetted marine disposal site. As noted in Section 7.4, the total amount of material to be disposed of is about 6,000m^3. Compared with many current projects, the quantities are small and should not present a major problem with disposal site capacity.

Discussions on disposal of this material would be held with the Fill Management Committee (FMC). It is possible that this sediment could be contaminated, and a limited sampling and analysis exercise will be undertaken to enable decisions to be made regarding appropriate methods for dredging and disposal, and for a suitable disposal site to be identified.

8.3.5 General

The site has various waste materials lying around, such as scrap metal, disused construction equipment, plant etc. It is proposed that a general clean up of the site and removal of some of these materials will be undertaken, and that improved housekeeping measures will be introduced.

8.4 CONCLUSIONS

The extension of the existing quarry in particular and the construction of the casting basin are not anticipated to generate any significant waste management related impacts provided good site practice is adhered to. For the proposed casting basin operations, waste would be collected and surface water is passed through settlement and pretreatment tanks prior to discharge.

The marine mud which will need dredging for formation of the entrance channel will be assessed for contamination and the dredging and disposal will be carried out according to agreed procedures.

The operation of the casting basin has significant potential to create impacts during the basin flooding and pre-cast unit flotation and removal processes. General good site practice and ongoing careful collection of waste materials and wastewater will be required as well as a special clean up exercise during each flooding/flotation event in order to minimise waste related impacts.

The installation of a sewage treatment facility will keep sewage related discharges to within acceptable limits.

A general site clean up and removal of existing scrap and waste materials will be undertaken prior to every flooding of the basin.

Section 9

9. ECOLOGICAL ASPECTS

9.1 TERRESTRIAL ECOLOGY

9.1.1 Introduction

Lamma Island falls into two main areas of landscape character which, whilst similar in form, are differentiated by scale of relief. On the one hand, on south Lamma Mt. Stenhouse rises to a height of 350m, whereas the highest point on north Lamma, Luk Chau Shan, is about 130m.

By reference to the on-site survey and photographs it is possible to identify four major landscape character and vegetation types on the Luk Chau Shan headland:

- grassland
- scrubland
- mature broadleaf woodland
- shoreline and associated marine vegetation.

The diversity and density of vegetation covering the area is affected by degree of exposure to the elements, availability of topsoil, steepness of slope and the characteristics of the watersheds. The principal watersheds are also superimposed on the plan.

The zone of each of the above classification is shown in Figure 9.1.

These vegetation classifications have been studied previously by Maunsell Consultants Asia Ltd. 1990 in a previous report for *Lamma Rock Products Ltd.* and a summary of the results of this study are given in Sections 9.1.2 to 9.1.5.

9.1.2 Shoreline

The shoreline along the northern and eastern coasts of the Luk Chau Shan headland is generally rocky with only a few areas of sandy beach, the longest being at Luk Chau Village. There is a pier and breakwater on the north tip, together with several jetties situated along the more sheltered shoreline running north-west from Luk Chau Village. The western coastline running south from the northern tip to the quarry site is more exposed, being generally rocky and steep with no beaches or sheltered inlets.

Pollution from the adjacent FCZ and the east Lamma Channel is evident along the shoreline and continues to be a limiting factor on the potential of the area for water based recreational activities. The bathing beaches most popular with day trippers continue to be on the western side of the island facing Cheung Chau and the cleaner waters of the West Lamma Channel. Prior to the increase in water pollution levels in East Lamma Channel, Georges Island (Luk Chau), Luk Chau Village and Lo Tik Wan (Figure 1.1) were all popular destinations for junk trips and weekend trippers.

9.1.3 Broad Leaf Woodland

The broadleaf woodland zone is confined to the more gentle lower slopes of the western watershed behind Luk Chau Village and the individual houses located along the coastal strip running north-west to the tip of the headland. The woodland surrounds several areas of terraced vegetable fields, most of which are overgrown and no longer under cultivation.

The range of mature tree species include *Acacia confusa, Ficus microcarpa, Macaranga tenarius, Mellotuus paniculatus* and the fruit trees *Euphoria longan* and *Lichi chinensis*. Although the species found in this zone are common to many parts of the island, the woodland is of relative significance as it has been able to reach a state of maturity and diversity now scarce on Lamma.

The recent increase in construction activity associated with the power plant and cable routes, together with the boom in residential property development around Yung Shue Wan in the north, has resulted in the loss of a substantial amount of tree cover and destruction of wild life habitats.

In addition to the ecological benefit, the woodland zone provides all important shelter and shade to dwellings and footpaths, acts as a filter to quarry dust and supplies a range of tree crops to the villagers. In visual terms, the woodland also provides a scenic backdrop to village and the associated development along the shore.

9.1.4 Scrubland

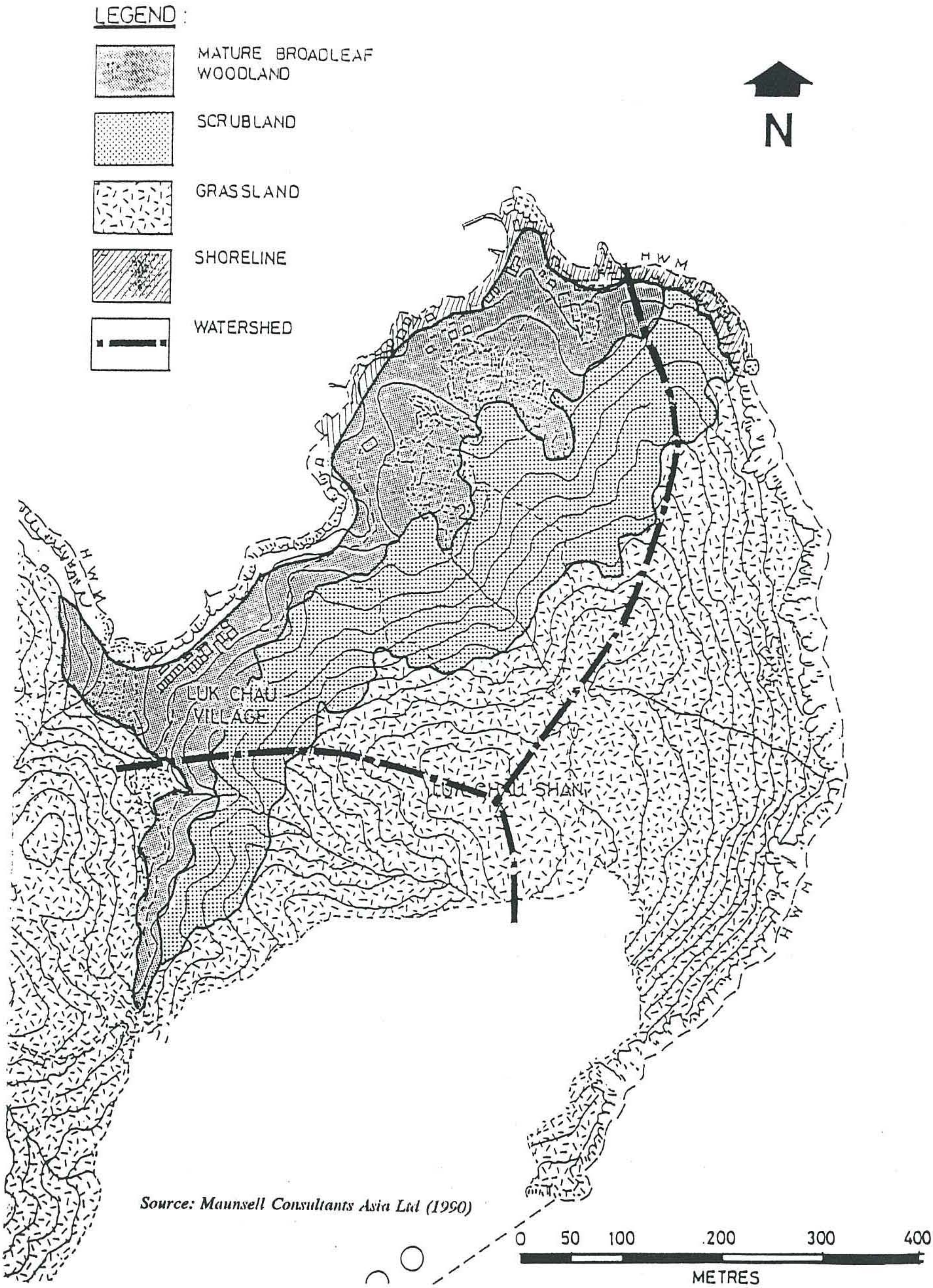
The scrubland occupies the intermediate steeper slopes and forms the transitional zone between the lowland woodland and the grassland zone on the higher more exposed hillsides. Species identified include *Litsea spp., Melastoma spp., Rhodomytrus spp. and Dicranopteris spp.* The thin soil and frequent exposure to hill fires are the main reasons for the absence of tree cover and the development of more mature vegetation.

9.1.5 Grassland

The grassland zone occupies the higher, more rugged slopes around the summit together with the exposed east facing slopes of Luk Chau Shan and includes scattered areas of scrub, rock outcrops and a number of areas of eroded hillside. In the places where quarrying activities have reached beyond the ridge the grassland has been disturbed exposing areas of unprotected decomposed granite susceptible to erosion.

9.2 POTENTIAL IMPACTS

Apart from the area of mature broadleaf woodland located in the vicinity of Luk Chau Village there is little vegetation of importance in the north of Lamma Island. The vegetation which would be impacted on by the quarry extension is grassland, which is not of any particular significance in either territorial terms or in terms of the existing vegetation on Lamma Island. There will be no additional impacts on the terrestrial ecology of the area due to the proposed casting basin development.



Source: Maunsell Consultants Asia Ltd (1990)

AXIS Environmental	LAMMA ROCK PRODUCTS Ltd.	JOB TITLE LAMMA QUARRY, CASTING BASIN & EXTENSION EIA	FIGURE TITLE VEGETATION MAP
		FIGURE No. 9.1	
		SCALE: AS SHOWN	JOB NUMBER 054\000\93
		DATE: MAY 1993	

Section 10

10. ENVIRONMENTAL MONITORING AND AUDIT SCHEDULES

10.1 INTRODUCTION

Environmental monitoring schedules and audit procedures are essential in order to:

- ensure that any environmental impacts resulting from the construction and operation of the Casting Basin are minimised or kept to 'acceptable' levels at all times;
- establish procedures for checking that mitigation measures have been applied and are effective, and that the appropriate corrective action is undertaken if and when required;
- provide a means of checking compliance with environmental objectives, recording anomalies and documenting corrective action.

This Chapter outlines monitoring and audit requirements in relation to air quality, noise, water quality and waste management, the details of which may be referred to in the appropriate Section.

Monitoring schedules have been provided for the necessary environmental parameters in Tables 10.1 to 10.4. Monitoring schedules and audit requirements would be incorporated into the construction contract(s) and lease conditions in the form of environmental clauses.

10.2 TECHNICAL/PERSONNEL REQUIREMENTS

10.2.1 Responsibilities

Ensuring that the environmental monitoring and audit requirements are met is the overall responsibility of the Site Manager, who in this project is the Manager - Operations for *Lamma Rock Products Ltd*. However the actual breakdown of responsibilities will be determined by contract condition or agreement between the contractor and site operator.

In this Section "the contractor" refers to the operator of the casting basin, and "the site operator" refers to the operator of the quarry and associated facilities (*Lamma Rock Products Ltd*).

10.2.2 Staffing

The monitoring and audit work will be carried out by suitably qualified and experienced personnel. The qualifications and experience of the monitoring and audit personnel will be sent to EPD for information/comment.

10.2.3 Monitoring and Audit Manual

The contractor/operator would prepare an environmental monitoring and audit (EM & A) manual in conjunction with the proponent and EM&A personnel, the content of which would be agreed with EPD. The contents would include the following:

- the programme for construction of the tunnel units and the required EM & A programmes;
- the location, frequency and type of environmental monitoring and audit requirements to assess the environmental impacts of the construction;
- the form/content of event/action plans (including any emergency plans) for air, water and noise impacts;
- review of pollution sources and working practices/procedures required in the event of environmental pollution levels being exceeded;
- the content/presentation of monitoring data, their audit and the actions taken with respect to non-compliance with environmental pollution levels;
- appropriate report formats/frequency of submission/special event reports, etc.;
- complaints/consultation procedures ;
- equipment service records and calibration requirements;
- the locations of sensitive receivers.

10.2.5 Reporting

A periodic monitoring and audit report would be prepared and submitted to the senior management representative and simultaneously sent to EPD.

The frequency of reporting would be agreed with EPD. However, given the general low potential for additional environmental impact of the proposed operations, it is suggested that a quarterly report would be appropriate. However, during the construction phase, a twice quarterly report may be appropriate.

The report should be a relatively brief and concise account of the environmental monitoring during the previous period and should include a summary of:

- ***Project Data*** - A synopsis of the project organisation; project programme; management liaison structure;

- ***Monitoring/Audit Requirements*** - Summary of monitoring parameters; Trigger/Action/Target Levels; Action Plans; environmental protection requirements in contract documents; and engineering conditions;

- ***Monitoring Methodology*** - Monitoring equipment used; locations; duration/frequency;

- ***Monitoring Results*** - Parameter; date; time; environmental conditions; location; etc.;

- ***Audit Results*** - Review of pollution sources, working procedures in the event of non-compliance with environmental monitoring levels; action taken in the event of non-compliance; follow-up procedures related to earlier non-compliance actions;

- ***Complaints*** - Liaison and consultation undertaken; subsequent action; database of telephone /written complaints, location of complaints; action plan and follow-up procedures etc.;

- ***Appendices*** - Appropriate drawings/tables of monitoring locations, sensitive receiver locations, environmental monitoring and audit requirements etc..

The quarterly monitoring and audit reports would be supported by submission of a summary report at the completion of the tunnel unit construction contract.

10.3 ENVIRONMENTAL MONITORING SCHEDULES

10.3.1 General

Environmental monitoring falls broadly into two categories: firstly baseline monitoring which has been or is being undertaken to establish the existing conditions in the Study Area (this makes it possible to set limits for the construction and operational phases); and secondly compliance monitoring, which should be carried out during both the construction and operational phases to achieve the following 'general' objectives:

- to assess the performance of construction/operation activities in environmental terms;

- to obtain early warning of potential problem areas, permit timely remedial action and identify any environmental impacts;

- to comply with appropriate standards and environmental objectives; and

- to provide reassurance to local communities.

As part of the monitoring schedules three levels have been devised to monitor compliance with environmental objectives and to provide early warning of potential problem areas, thus stimulating the implementation of mitigation before the regulatory standards are reached (Figure 10.1). The three levels are described below:

- the **Trigger Level** is a reference value to be used as an 'early warning' of a deterioration in environmental quality. Achievement of this level may stimulate increasing the frequency of monitoring and undertaking preliminary investigation (for example to identify any obvious causes) and possibly remedial action if appropriate;

- the **Action level** indicates that deterioration is significant and that urgent corrective action is required;

- the **Target Level** is the maximum permissible level which will achieve compliance with the appropriate regulatory standards, or other standards such as construction noise criteria outside restricted hours, and is therefore the upper boundary/limit which is acceptable in terms of environmental quality. Consequently, achievement of this level is undesirable. Compliance monitoring schedules are therefore devised such that remedial action is taken to prevent this level being attained. The Target Level should not therefore be considered as the desired level.

As identified in the relevant sections of this Report, monitoring will be required to measure noise levels, particulate levels (for air quality), water quality parameters and waste management practices. In addition, monitoring will involve checking on general working practices and compliance with the various control and mitigation measures also identified in this Report. Monitoring results should be reported to the contractor/site operator and EPD, and reviewed on a regular basis.

The requirements for each of the environmental parameters are different, and therefore it is not possible to propose a single monitoring programme for all aspects. Requirements for individual parameters are summarized below, and where appropriate outline schedules are presented in Tables 10.1 to 10.4.

10.3.2 Environmental Monitoring Plan

A check list would be prepared relating to each of the environmental issues. Together with environmental clauses in the contract documents, this check list will form the basis of a proforma for the environmental monitoring programme.

Air Quality Monitoring

A programme of particulate monitoring would be developed to ensure both the effectiveness of dust control measures and to highlight any associated deterioration of air quality.

An outline air quality monitoring schedule is presented in Table 10.1. The

Target Level comprises the accepted TSP limits of at the SR monitoring location, 260$\mu g/m^3$ (24hr average) and 80$\mu g/m^3$ (annual average). On breaching the warning levels, action should be taken as described in the Outline Action Plan (Table 10.5).

It is proposed that monitoring be carried out at or within the site boundary, and at an appropriate SR location. In this respect Lamma Rock Products Ltd have been endeavouring to establish a TSP monitor at Sok Kwu Wan for some time, and are hopeful of commencing monitoring in the near future.

In addition, it will also be necessary to monitor and check the effectiveness of mitigation measures. This will involve assessing the efficiency, maintenance and use of:

- water trucks
- fixed water sprays in open areas
- dust covers
- cement silo fabric filters
- water suppression sprays
- barriers and enclosures.

Regular checks would be made to ensure:

- enforcement of speed limits
- regular servicing of plant and site vehicles
- site cleanliness and the implementation of good site practice.

Noise Monitoring

Noise monitoring will be required to verify compliance with the Noise Control Ordinance ANL levels and with requirements of any construction noise permits (CNP) and criteria contained in the contract documents. An outline noise monitoring schedule is presented in Table 10.2.

As noted in Section 4.5.2, some of the activities are classed as industrial and some as construction. In summary the limits are 60dBA L_{eq} during the day and evening (0700 to 2300hrs) for industrial activities, 60dBA L_{eq} during the evening (1900 to 2300hrs) and general holidays during daytime and evening (0700 to 2300hrs) for construction activities, and at night (2300 to 0700hrs) 50dBA L_{eq} for industrial noise and 45dBA L_{eq} for construction noise.

The quarry is an existing operation and contributes significantly to the existing noise background in the area, and operates in the day time only. Noise levels are not expected to change in any significant way as a result of the casting basin activities. Taking account of the existing background noise levels, the Target level is based on the ANL value of 60dBA (day time), with the Trigger and Action levels to meet this figure and also to meet an L_{eq} - L_{90} value of 5dBA and 10dBA respectively.

Should any construction at the casting basin be undertaken during restricted hours i.e. night-time (2300-0700hrs), public holidays and Sundays, noise levels will be controlled under the provisions of a CNP. The Target is therefore the relevant ANL in the Noise Control Ordinance. Where a CNP is in force, monitoring results would be submitted to EPD immediately they are available. On breaching the permit, action should be taken as described in an outline action plan (Table 10.4).

Monitoring would be undertaken when new equipment is installed and when significant modifications are made to existing plant.

Day-time compliance monitoring would be also undertaken in response to complaints. Restricted hour monitoring would be undertaken at least twice during the restricted hours, (per 24hr period, once in the evening and once in the night-time), for a 5 minute time period, in accordance with the *Technical Memorandum on Noise From Construction Work, Other Than Percussive Piling*. Measurements would be taken (1m from the external facade) at the worst affected NSRs.

Checks will also be required to establish the implementation and effectiveness of mitigation measures. This will require checking and monitoring of:

- the use, maintenance and efficiency of construction equipment;
- the appropriate location of noisy plant/equipment;
- the hours of operation;
- the implementation of good site practice.

Marine Water Quality Monitoring

The objective of water quality monitoring is to minimise adverse impacts on water quality which may result from the construction and operational activities. Monitoring is required to check the impacts resulting from dredging and will involve measurement of dissolved oxygen, suspended solids and turbidity. An outline marine water quality monitoring schedule is given in Table 10.3.

In addition to EPD's water quality monitoring programme, ambient levels will be determined by baseline monitoring at five locations close to the areas to be dredged.

Compliance monitoring will be undertaken to establish compliance with the water quality objectives (WQOs). Target, Trigger and Action Levels have been defined according to the WQOs for Southern Waters such that for the parameters the Target is the appropriate WQO. On breading the warning levels, action should be taken as described in the outline Action Plan (Table 10.7).

In order to account for the significant seasonal variations in water quality, Trigger and Action Levels have been defined according to background levels as monitored at a representative control station. The Trigger Level is 20% above the running background for suspended solids and 20% below the running background for dissolved oxygen.

The running background is derived from the mean of monitored data taken in the previous 2 weeks at the control station. The Action Level is the average of the Trigger and Target values. This definition of Trigger level for DO applies only when ambient DO is lower than the WQO. When ambient DO is higher than the WQO the trigger level is defined as:

ambient DO - $^{2}/_{3}$(ambient DO - WQO).

If a suitable control can be found then the ambient level can be taken as the value measured at the control station, and the running mean would not be necessary.

Designated monitoring stations have been established and a control monitoring station will be established at an appropriate location which will not be influenced by the project or any other development activities. (It is proposed that the EPD monitoring location SM4 be used as the location for the control station). Samples will be taken at both the control and designated monitoring stations at appropriate intervals during the project.

In order to check the effectiveness of mitigation measures it will be necessary to ensure:

- drainage channels, settlement tanks and other construction phase water pollution control measures are being used and maintained;
- the effectiveness and maintenance of oil/grease interceptors;
- the use of equipment for removing floatables;
- the use and adequacy of any waste reception/storage facilities.

Waste Management

Monitoring of waste arisings will occur during the construction and operational phases. Records should be maintained by the site operator with respect to quantities of arisings, handling, storage, movement and disposal of these wastes. An outline waste management monitoring schedule is given in Table 10.4.

10.3.3 Action Plans

Action Plans would be devised to facilitate the appropriate and immediate response by relevant personnel, in the event that the Target, Action and Trigger Levels are either attained or exceeded. The appropriate action is determined by the frequency of complaints and/or exceedence of the compliance monitoring levels.

The requirement for Action Plans for the casting basin operations would be contained in the contract/lease conditions and suitable plans for both the casting basin and the quarry operations would subsequently be submitted by the site manager to EPD. Examples of appropriate Action Plans are outlined in Tables 10.5 to 10.7.

10.4 ENVIRONMENTAL AUDITING

10.4.1 General

The purpose of environmental auditing is to review the effectiveness of the overall environmental protection programme (both construction and operation) in terms of monitoring, mitigation and corrective action. The audit process should not be divorced from general management activities, and should promote a pro-active approach to environmental protection.

10.4.2 Construction Phase Auditing

Records of environmental monitoring would be maintained by the environmental personnel for both the site operator and the contractor, and the environmental audit would seek to check:

- records of exceedance of any trigger and action levels;
- records of environmental monitoring procedures and results;
- records of exceedence of any regulatory requirements/target levels;
- details of control and mitigation action taken in response to unacceptable environmental impacts;
- records of any complaints from residents/SRs in the Study Area and the actions taken once the complaints have been received.

Assessment of monitoring records will ensure that any unanticipated impacts are being addressed and that any improvements required for future monitoring programmes are identified.

10.4.3 Operational Auditing

The audit will be designed to assess the environmental performance of each operational phase, which for this project relates to when the tunnel sections are removed from the casting basin.

Auditing should verify the findings of the EIA and provide a mechanism for:

- reviewing the effectiveness of, and requirement for on-going monitoring programmes;
- reviewing environmental management practices in terms of achieving environmental objectives;
- reviewing the effectiveness of environmental mitigation;

- recommending improvements in environmental controls and operations in the event that environmental objectives are not achieved and environmental impacts are unacceptable.

An Audit Report and executive summary would be submitted to EPD within 4 weeks of completing the audit.

10.5 Lease Recommendations

A number of environmental clauses for inclusion in the lease conditions of the casting basin and quarry extension have been recommended and are given in Appendix 10. The list identifies whether a recommendation pertains to the casting basin operations or the quarry, or both.

Table 10.1: Air Quality Monitoring Schedule

PARAMETER	OBJECTIVE	TRIGGER LEVEL	ACTION LEVEL	TARGET LEVEL	LOCATION	FREQUENCY/TIMING
Particulates	Baseline assessment	N/A	N/A	N/A	Boundary or within site	One year prior to commencing construction activities. **24hr samples every 6 days.
Particulates	Compliance monitoring	24hr TSP of 150$\mu g/m^3$ at SR	24hr TSP of 200$\mu g/m^3$ at SR	24hr TSP of 260$\mu g/m^3$ at SR	Boundary or within site and at an appropriate SR location	** 24hr samples every 6 days.

Note :

** USEPA Ambient Air Quality Surveillance Regulations
SR Sensitive Receiver
N/A Not Applicable

Table 10.2: Noise Monitoring Schedule

PARAMETER	OBJECTIVE	TRIGGER LEVEL	ACTION LEVEL	TARGET LEVEL	LOCATION	FREQUENCY/TIMING
L_{90}, L_{Aeq}	Baseline Assessment	N/A	N/A	N/A	NSRs	24hr monitoring period at main SR site. L_{90}, $L_{Aeq\ (5\ min)}$ monitoring at other nominal SR sites.
L_{90}, $L_{Aeq\ (5\ min)}$, L_{90}, $L_{Aeq\ (30\ min)}$*	Assessment for non-restricted hours	L_{eq} - L_{90} = 5dBA; $L_{eq} \leq$ 60dBA	L_{eq} - L_{90} = 10dBA; $L_{eq} \leq$ 60dBA	$L_{eq} \leq$ 60dBA	Complainant	In response to complaints
L_{90}, $L_{Aeq\ (5\ min)}$, L_{90}, $L_{Aeq\ (30\ min)}$*	** Assessment for restricted hours (casting basin operations)	L_{eq} - L_{90} = 5dBA;	L_{eq} - L_{90} = 10dBA;		Complainant	In response to complaints
	Construction activities	$L_{eq} \leq$ 45dBA	$L_{eq} \leq$ 45dBA	$L_{eq} \leq$ 45dBA		
	Industrial activities	$L_{eq} \leq$ 50dBA	$L_{eq} \leq$ 50dBA	$L_{eq} \leq$ 50dBA		
L_{90}, $L_{Aeq\ (5\ min)}$, L_{90}, $L_{Aeq\ (30\ min)}$*	Confirm Baseline Assessment for installation of new equipment, or mitigation measures, or change in operations	N/A	N/A	N/A	NSRs	L_{90}, $L_{Aeq\ (5\ min)}$ monitoring at nominal SR sites.

Note :
- NSRs - Noise Sensitive Receivers
- N/A - Not Applicable
- * - L_{90}, $L_{Aeq\ (30\ min)}$ measurements to be undertaken if L_{90}, $L_{Aeq\ (5\ min)}$ measurements exceed the appropriate limits.
- ** - The quarry will not usually operate occur during restricted hours. The casting basin operations are considered to be a construction activity other than for operation of the concrete batching plant.

Table 10.3: Marine Water Quality Monitoring Schedule

PARAMETER	OBJECTIVE	TRIGGER LEVEL	ACTION LEVEL	TARGET LEVEL	LOCATION	FREQUENCY/TIMING
Aesthetic Appearance pH, SS, DO Salinity Ammoniacal Nitrogen Inorganic Nitrogen Phenols E.Coli Turbidity	Baseline assessment	N/A	N/A	N/A	5 Designated monitoring stations - 1m below surface - mid level - 1m above sea bed **	Prior to commencing construction.
Aesthetic Appearance pH, SS, DO Salinity Ammoniacal Nitrogen Inorganic Nitrogen Phenols E.Coli Turbidity	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	5 Designated monitoring stations - 1m below surface - mid level - 1m above sea bed **	Monthly during the construction of the casting basin, 3 samples per monitoring station
Appropriate Discharge Parameters	Compliance monitoring	N/A	N/A	TM	At settlement/treatment tank	During basin dewatering
Suspended Solids Dissolved Oxygen	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	5 Designated monitoring stations 2 Selected extra stations - 1m below surface - mid level - 1m above sea bed	Immediately prior to and during the course of dredging, 3 samples per monitoring station
Aesthetic Appearance pH, SS, DO Salinity Ammoniacal Nitrogen Inorganic Nitrogen Phenols E.Coli Turbidity	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	3 Designated monitoring stations - 1m below surface - mid level - 1m above sea bed **	Monthly during the casting of units, 3 samples per monitoring station.
Dissolved Oxygen	Compliance monitoring	20% deterioration from running background levels	Average of Trigger and Target Levels	*WQO	5 Designated monitoring stations 2 selected extra stations - 1m below surface - mid level - 1m above sea bed	1 day prior to basin flooding and during basin flooding.
Appropriate Discharge Parameters	Compliance monitoring	N/A	N/A	TM	At settlement/treatment tank	During basin dewatering

Note :
- N/A — Not applicable
- * — In the event that the running background level is in excess of the WQO, the Target Level = a deterioration from the running background level of 30%
- ** — Turbidity is measured to extinction depth to give an instantaneous indication of the water quality.

TM = Technical Memorandum
SS = Suspended Solids
DO = Dissolved Oxygen

Table 10.4: Waste Management Monitoring Schedule

PARAMETER	OBJECTIVE	STANDARD	LOCATION	FREQUENCY/TIMING
Casting Basin Construction Waste	Record the quantities arising and confirm that handling, storage, transfer and disposal of wastes are in accordance with GWMP and government requirements.	'Duty of Care' requirements with respect to quantities of waste arisings, handling , storage and disposal of wastes; and appropriate licensing requirements	Lamma Quarry Site	After initial set up, monthly checks
Casting Basin Operational Waste	Record the quantities arising and confirm that handling, storage, transfer and disposal of wastes are in accordance with GWMP and government requirements.	'Duty of Care' requirements with respect to quantities of waste arisings, handling , storage and disposal of wastes; and appropriate licensing requirements	Casting Basin	After initial set up, monthly checks
Waste	Comprehensive cleaning of basin area and waste removal	Approval of Site Manager	Casting Basin and immediate surrounds	Prior to basin flooding

Note :

GWMP - Good Waste Management Practice.
N/A - Not appropriate

Table 10.5: Air Quality Action Plan - Suspended Particulates

EVENT	FREQUENCY	ACTION	
		Monitoring Personnel	*Contractor/Site Manager*
Breach of Trigger Value	**One sample**	Inform contractor and site manager	
	Two consecutive samples	Inform EPD, contractor and site manager	Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary
Breach of Action Level	**One sample**	Inform EPD, contractor and site manager	Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary
	Two consecutive samples	Inform EPD, contractor and site manager	Undertake detailed check of working methods and practices
		Propose remedial action	Carry out appropriate remedial action and inform EPD of remedial action
		Record events in monitoring report for submission to the contractor and EPD	Amend method statement, if appropriate
Breach of Target Level	**One sample**	Inform EPD, contractor and site manager	Undertake immediate check of activities and employ any appropriate mitigation.
		Propose remedial action	Ensure corrective action has been undertaken and is effective, and inform EPD of remedial action
		Record events in monitoring report for submission to and EPD	Amend method statement, if appropriate

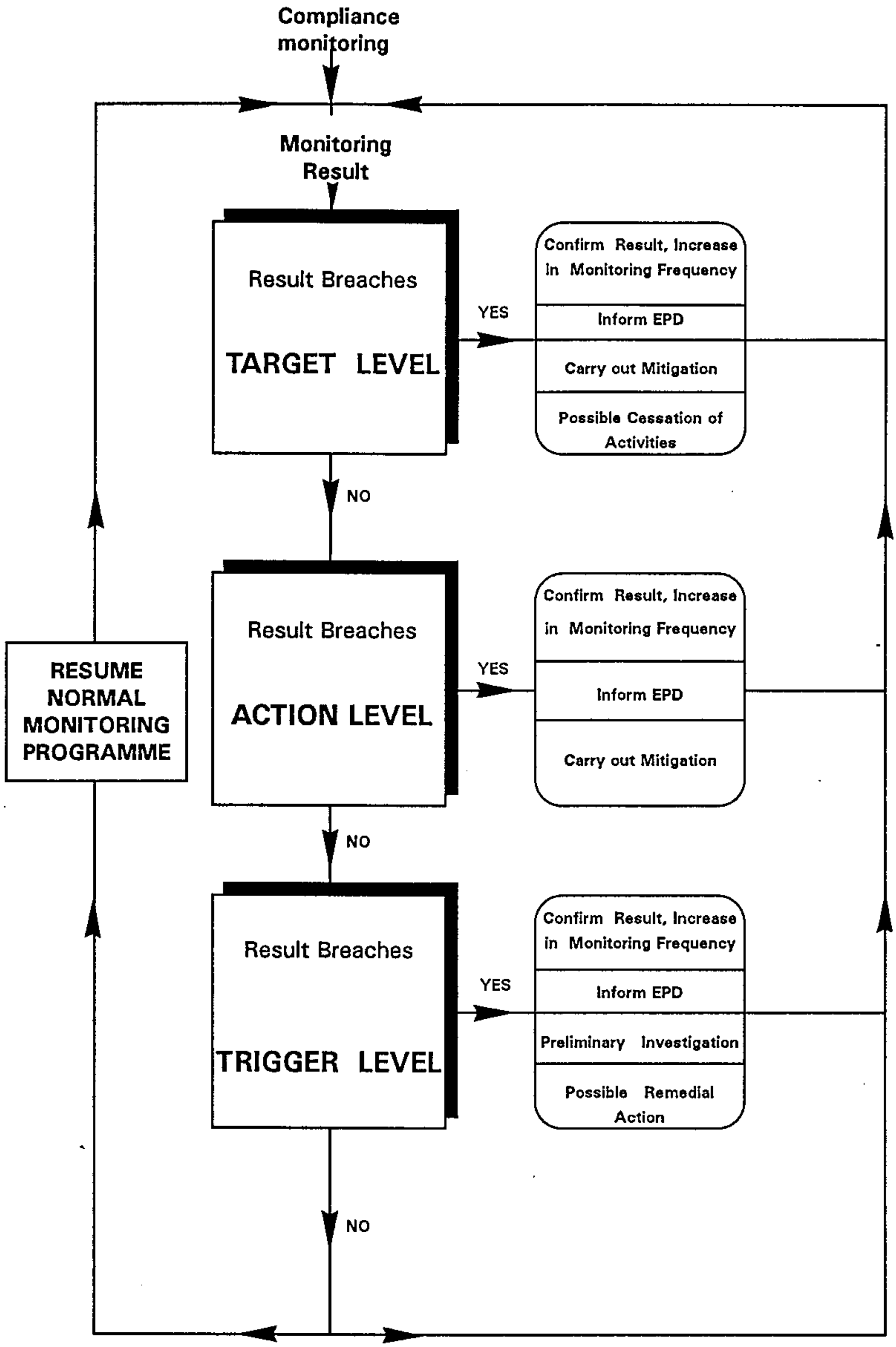
Table 10.6: Noise Action Plan

EVENT	ACTION	
	Monitoring Personnel	*Contractor/site manager*
Breach of: daytime (unrestricted hours) **Trigger value**	Inform contractor and site manager Investigate complaint Submit a report to EPD within 2 weeks of reciept of a complaint	
Breach of: restricted hours **Trigger value;** daytime (unrestricted hours) **Action Value;** **1 complaint**	Inform contractor, site manager and EPD **Submit report to EPD within two weeks of receipt of complaint. Should the measured noise level exceed the Target, proposals to reduce noise should be recommended in the report	Check working methods, practices, to identify causes, take appropriate remedial action if necessary Inform EPD of remedial action taken
Breach of: restricted hours **Action value;** **More than 2 complaints**	Inform contractor, site manager and EPD; resample to confirm monitoring result Propose remedial action **Submit report to EPD within two weeks of receipt of complaint. Should the measured noise level exceed the target, proposals to reduce noise should be recommended in report. Confirm corrective action has been undertaken and is effective in monitoring and audit report	Undertake detailed check of working methods and practices. Ensure corrective action has been undertaken and is effective Amend method statement if appropriate Inform EPD of remedial action taken
Breach of: daytime (unrestricted hours)/ restricted hours **Target Value**	Inform contractor/site manager, EPD Confirm monitoring result and repeat measurement Undertake immediate check of activities Propose remedial action Submit report to EPD within two weeks Confirm corrective action has been undertaken and is effective in monitoring and audit report	Review noise sources and working procedures and methods For breach of restricted hours Target Value, cease restricted hours operation Ensure implementation of prompt remedial action Inform EPD of remedial action

note: ** Action associated with response to complaints

Table 10.7: Water Quality Action Plan

EVENT	FREQUENCY	ACTION – *Monitoring Personnel*	ACTION – *Contractor/operator*
Breach of Trigger Value	**One sample**	Inform contractor/operator	Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary
	Two consecutive samples	Inform EPD, AFD, contractor/operator; resample to confirm result	
Breach of Action Level	**One sample**	Inform EPD, AFD, contractor/operator; resample to confirm result	Check working methods/practices to identify any immediate causes; take appropriate remedial action if necessary
	Two consecutive samples	Inform EPD, contractor/operator; resample to confirm result Increase frequency of monitoring Propose remedial action Continue monitoring after completion of remedial action to confirm action is effective Record event in monitoring report for submission to contractor/operator and EPD	Undertake detailed check of working methods and practices Carry out appropriate remedial action and inform EPD of remedial action Ensure corrective action has been undertaken and is effective Amend method statement, if appropriate
Breach of Target Level	**One sample**	Inform EPD, AFD, contractor/operator; Confirm result & increase monitoring frequency Propose remedial action Undertake monitoring at nearest water quality SR Continue monitoring after completion of remedial action to confirm action is effective Complete Monitoring Report and submit to contractor/developer and EPD	Undertake immediate check of activities and employ any appropriate mitigation. Ensure immediate implementation of remedial action and in extreme cases cease activities Ensure corrective action has been undertaken and is effective and inform EPD of remedial action Amend method statement, if appropriate



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITLE	LAMMA QUARRY, CASTING BASIN & EXTENSION
FIGURE No.	10 .1
SCALE	AS SHOWN
DATE	MAY 1993
FIGURE TITLE	GENERAL GUIDE TO COMPLIANCE MONITORING
JOB NUMBER	054/000/93

Appendices

APPENDICES

Appendix 1

APPENDIX 1

HEALTH AND SAFETY

HEALTH AND SAFETY PRACTICES

General

Lamma Rock Products have managed the existing operations at the site for a number of years and have considerable experience with the nature of the risks associated with such operations. The design, construction and operation of all phases of the extension to works would meet standards recognised by the Hong Kong Government.

Safety procedures within the project can be divided into three main areas: site safety, personnel safety and emergency equipment. All these areas are subject to certain Hong Kong Government legislations and regulations according to requirements. Various procedures are observed in order to satisfy stipulated standards, and additional measures are also undertaken in certain areas.

Site Safety

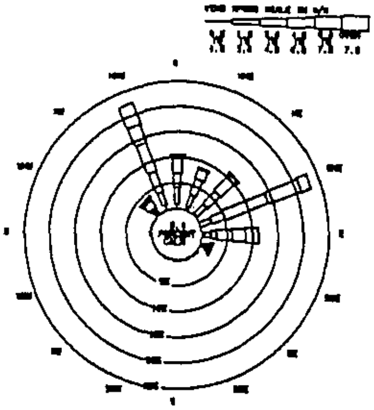
Site Safety procedures are set out to satisfy the Hong Kong Government Factories and Industrial Undertakings Ordinance (Cap. 59), especially the subsidiary Quarries (Safety) Regulations (Cap. 59, Section 7). Satisfaction of these regulations requires operations to be adequately supervised in the areas of site operations and personnel safety. Any blasting is carried out under supervision by the Government Mines Inspectors, who supervise the presence of explosives on site. No explosive is permitted to be stored on-site. There is a warning given 15 minutes before blasting takes place and the area is cleared. General observance of accident prevention measures is carried out; for example the wearing of helmets and other relevant protective equipment.

There is a fully equipped emergency first aid room on site with rescue equipment including breathing apparatus. There are special procedures in place for particular emergencies requiring removal of personnel off the site. For an additional personnel safety measure all personnel have annual X-ray tests.

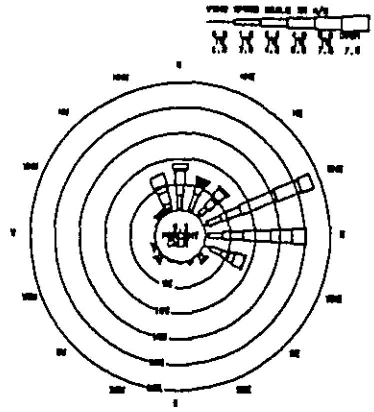
Appendix 3A

APPENDIX 3A

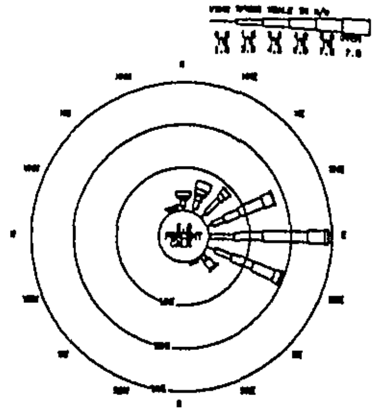
MONTHLY WIND DATA FOR CHEUNG CHAU



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Jan 1981 (all hours)



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Feb 1981 (all hours)



DISTRIBUTION OF WINDS
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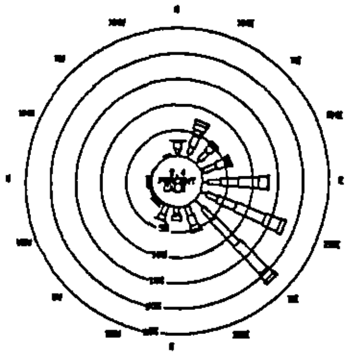
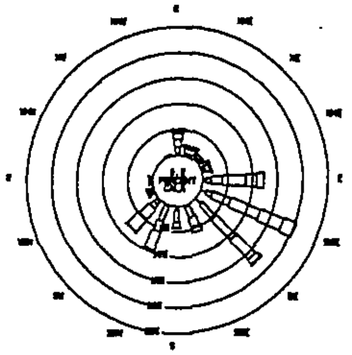
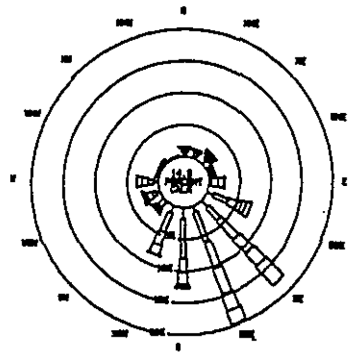
Cheung Chau Mar 1981 (all hours)



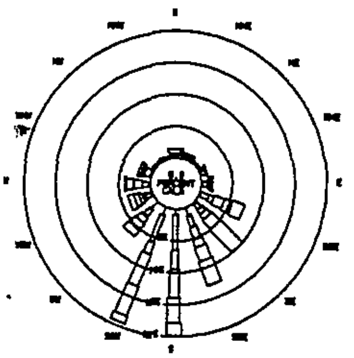
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Apr 1981 (all hours)



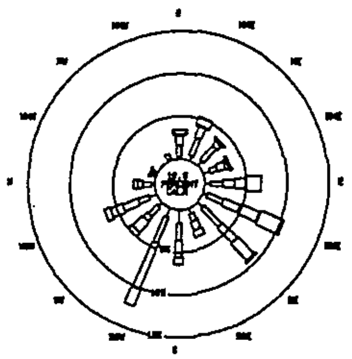
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau May 1981 (all hours)



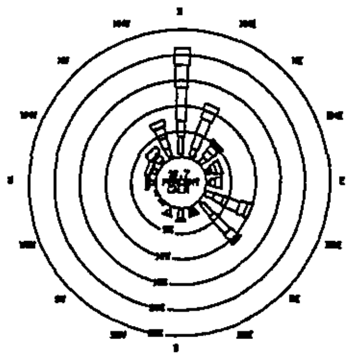
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Jun 1981 (all hours)



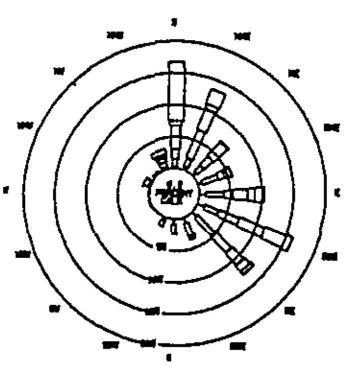
DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Jul 1981 (all hours)



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Aug 1981 (all hours)



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Sep 1981 (all hours)



DISTRIBUTION OF WINDS
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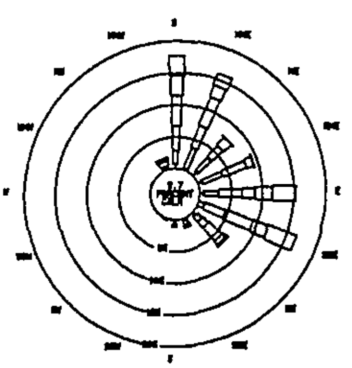
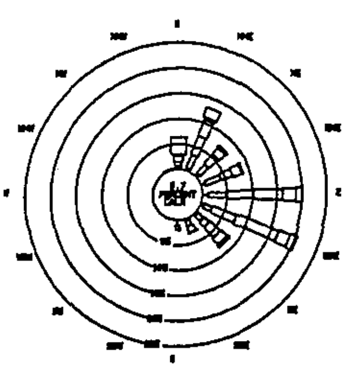
Cheung Chau Oct 1981 (all hours)



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Nov 1981 (all hours)



DISTRIBUTION OF WINDS
FREQUENCY OF OCCURRENCE IN PERCENT
Cheung Chau Dec 1981 (all hours)

Cheung Chau 1991 (all hours)
FROM 91. 1. 1 TO 91.12.31

PASQUILL STABILITY CLASS "A"
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.000116	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000116	1.50
NE	.000233	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000233	1.25
ENE	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.00
E	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.00
ESE	.000698	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000698	1.17
SE	.000931	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000931	1.25
SSE	.000931	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000931	1.31
S	.000931	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000931	1.31
SSW	.000582	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000582	1.30
SW	.000466	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000466	1.37
WSW	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.00
W	.000116	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000116	1.50
WNW	.000116	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000116	1.50
NW	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.00
NNW	.000116	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000116	1.50
N	.000116	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000116	1.00
CALM									.001513	
TOTAL	.005354	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.006868	1.06

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 8592

PASQUILL STABILITY CLASS "B"
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.001280	.002095	.001397	.000000	.000000	.000000	.000000	.000000	.004772	2.51
NE	.001164	.002444	.000582	.000000	.000000	.000000	.000000	.000000	.004190	2.26
ENE	.000466	.001048	.000233	.000000	.000000	.000000	.000000	.000000	.001746	2.23
E	.001397	.001630	.000116	.000000	.000000	.000000	.000000	.000000	.003143	1.91
ESE	.002910	.003608	.002212	.000000	.000000	.000000	.000000	.000000	.008730	2.46
SE	.002561	.005587	.005471	.000000	.000000	.000000	.000000	.000000	.013619	2.85
SSE	.001630	.004889	.001397	.000000	.000000	.000000	.000000	.000000	.007915	2.43
S	.001862	.006286	.000466	.000000	.000000	.000000	.000000	.000000	.008614	2.15
SSW	.001746	.005354	.001164	.000000	.000000	.000000	.000000	.000000	.008264	2.39
SW	.000698	.001513	.000931	.000000	.000000	.000000	.000000	.000000	.003143	2.37
WSW	.000466	.000931	.000582	.000000	.000000	.000000	.000000	.000000	.001979	2.56
W	.000233	.000466	.000349	.000000	.000000	.000000	.000000	.000000	.001048	2.56
WNW	.000000	.000233	.000116	.000000	.000000	.000000	.000000	.000000	.000349	3.00
NW	.000349	.000349	.000116	.000000	.000000	.000000	.000000	.000000	.000815	1.93
NNW	.000931	.001280	.000931	.000000	.000000	.000000	.000000	.000000	.003143	2.57
N	.000931	.001280	.001397	.000000	.000000	.000000	.000000	.000000	.003608	2.69
CALM									.018042	
TOTAL	.018624	.038994	.017460	.000000	.000000	.000000	.000000	.000000	.093121	2.03

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 8592

PASQUILL STABILITY CLASS "C"
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.000000	.002212	.004307	.000466	.000000	.000116	.000000	.000116	.007217	3.95
NE	.000000	.003259	.002328	.000349	.000000	.000000	.000000	.000000	.005936	3.25
ENE	.000000	.002212	.002561	.000233	.000233	.000116	.000000	.000000	.005354	3.79
E	.000000	.001862	.003492	.001397	.000582	.000582	.000116	.000116	.008148	4.75
ESE	.000000	.003608	.007217	.004540	.003725	.001397	.000116	.000000	.020603	4.96
SE	.000000	.003143	.008381	.005354	.001862	.000582	.000582	.000233	.020137	4.80
SSE	.000000	.002444	.003376	.000698	.000233	.000233	.000000	.000000	.006984	3.90
S	.000000	.002328	.001862	.000466	.000000	.000116	.000000	.000000	.004772	3.55
SSW	.000000	.002444	.003376	.000931	.000698	.000116	.000000	.000000	.007566	3.99
SW	.000000	.000815	.000349	.000931	.000815	.000000	.000000	.000000	.002910	4.90
WSW	.000000	.000698	.000815	.000698	.000000	.000116	.000000	.000000	.002328	4.17
W	.000000	.000466	.001048	.000582	.000000	.000000	.000000	.000000	.002095	4.19
WNW	.000000	.000582	.000349	.000000	.000000	.000000	.000000	.000000	.000931	3.00
NW	.000000	.000233	.000349	.000000	.000000	.000000	.000000	.000000	.000582	3.70
NNW	.000000	.000698	.001746	.001164	.000233	.000116	.000000	.000116	.004074	4.73
N	.000000	.002910	.003143	.001397	.000698	.000349	.000233	.000233	.008963	4.51
CALM									.000000	
TOTAL	.000000	.029915	.044698	.019206	.009079	.003841	.001048	.000815	.108602	4.40

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 8592

PASQUILL STABILITY CLASS "D"
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.000815	.005587	.011756	.016529	.006751	.004540	.002212	.003376	.051566	5.91
NE	.001397	.005354	.008614	.013153	.002910	.000931	.000116	.000349	.032825	4.77
ENE	.000349	.006984	.009661	.023629	.013503	.003259	.000698	.000349	.058433	5.48
E	.000349	.006984	.014550	.033058	.017577	.009661	.002095	.001397	.085671	5.94
ESE	.000698	.003725	.010592	.033174	.016529	.008264	.002910	.002794	.078687	6.19
SE	.001164	.004074	.006402	.018973	.007799	.003608	.002212	.002910	.047142	6.12
SSE	.000815	.001862	.003026	.006984	.004190	.002561	.000582	.001979	.022000	6.38
S	.000233	.002561	.001746	.006402	.003841	.001164	.000116	.000698	.016762	5.71
SSW	.000815	.001979	.002444	.010127	.003958	.000582	.000233	.000349	.020487	5.37
SW	.000000	.000931	.000349	.004423	.003725	.000815	.000233	.000349	.010825	6.22
WSW	.000116	.000698	.001164	.001979	.001513	.000698	.000233	.000000	.006402	5.63
W	.000233	.000582	.000815	.001862	.000698	.000466	.000000	.000000	.004656	5.04
WNW	.000233	.000116	.000233	.000466	.000466	.000466	.000349	.000466	.002794	7.56
NW	.000116	.000582	.000582	.002212	.000815	.000233	.000116	.001048	.005704	6.70
NNW	.000233	.001630	.003958	.009312	.005936	.003492	.001513	.001862	.027936	6.37
N	.000815	.003725	.006751	.018391	.008497	.007682	.003492	.007217	.056571	6.91
CALM									.013619	
TOTAL	.008381	.047375	.082645	.200675	.098708	.048423	.017111	.025143	.542079	5.85

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 8592

PASQUILL STABILITY CLASS "E"
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.000000	.005005	.003492	.000000	.000000	.000000	.000000	.000000	.008497	3.07
NE	.000000	.004889	.002561	.000000	.000000	.000000	.000000	.000000	.007450	2.87
ENE	.000000	.006169	.006053	.000000	.000000	.000000	.000000	.000000	.012222	3.21
E	.000000	.006169	.007566	.000000	.000000	.000000	.000000	.000000	.013735	3.28
ESE	.000000	.004772	.007799	.000000	.000000	.000000	.000000	.000000	.012571	3.45
SE	.000000	.005354	.006635	.000000	.000000	.000000	.000000	.000000	.011989	3.33
SSE	.000000	.002095	.004423	.000000	.000000	.000000	.000000	.000000	.006518	3.63
S	.000000	.003492	.003841	.000000	.000000	.000000	.000000	.000000	.007333	3.48
SSW	.000000	.002444	.004307	.000000	.000000	.000000	.000000	.000000	.006751	3.51
SW	.000000	.000466	.000815	.000000	.000000	.000000	.000000	.000000	.001280	3.27
WSW	.000000	.000815	.000815	.000000	.000000	.000000	.000000	.000000	.001630	3.50
W	.000000	.001280	.000815	.000000	.000000	.000000	.000000	.000000	.002095	3.17
WNW	.000000	.000349	.000931	.000000	.000000	.000000	.000000	.000000	.001280	3.32
NW	.000000	.000233	.000466	.000000	.000000	.000000	.000000	.000000	.000698	3.50
NNW	.000000	.001280	.001164	.000000	.000000	.000000	.000000	.000000	.002444	3.19
N	.000000	.005122	.004074	.000000	.000000	.000000	.000000	.000000	.009196	3.22
CALM									.000116	
TOTAL	.000000	.049936	.055756	.000000	.000000	.000000	.000000	.000000	.105808	3.30

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 8592

PASQUILL STABILITY CLASS "F"
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.002910	.002910	.000000	.000000	.000000	.000000	.000000	.000000	.005820	1.72
NE	.003841	.002212	.000000	.000000	.000000	.000000	.000000	.000000	.006053	1.60
ENE	.004423	.003492	.000000	.000000	.000000	.000000	.000000	.000000	.007915	1.71
E	.003958	.004772	.000000	.000000	.000000	.000000	.000000	.000000	.008730	1.80
ESE	.004190	.004190	.000000	.000000	.000000	.000000	.000000	.000000	.008381	1.76
SE	.003608	.003259	.000000	.000000	.000000	.000000	.000000	.000000	.006868	1.70
SSE	.001630	.003608	.000000	.000000	.000000	.000000	.000000	.000000	.005238	1.94
S	.003376	.004540	.000000	.000000	.000000	.000000	.000000	.000000	.007915	1.87
SSW	.001397	.003376	.000000	.000000	.000000	.000000	.000000	.000000	.004772	2.00
SW	.001164	.001746	.000000	.000000	.000000	.000000	.000000	.000000	.002910	1.76
WSW	.001397	.000931	.000000	.000000	.000000	.000000	.000000	.000000	.002328	1.57
W	.001164	.001513	.000000	.000000	.000000	.000000	.000000	.000000	.002677	1.83
WNW	.000349	.001048	.000000	.000000	.000000	.000000	.000000	.000000	.001397	2.00
NW	.000931	.000466	.000000	.000000	.000000	.000000	.000000	.000000	.001397	1.50
NNW	.001048	.000698	.000000	.000000	.000000	.000000	.000000	.000000	.001746	1.47
N	.002910	.002561	.000000	.000000	.000000	.000000	.000000	.000000	.005471	1.66
CALM									.063904	
TOTAL	.038296	.041322	.000000	.000000	.000000	.000000	.000000	.000000	.143522	1.09

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID STABILITY DEPENDENT OBSERVATIONS = 8592

Cheung Chau 1991 (all hours)

FROM 91. 1. 1   TO 91.12.31

ALL PASQUILL STABILITY CLASSES
WIND SPEED CLASS (MPS)

WIND SECTOR	.51 TO 1.50	1.51 TO 3.00	3.01 TO 4.50	4.51 TO 6.00	6.01 TO 7.50	7.51 TO 9.00	9.01 TO 10.50	GREATER THAN 10.50	TOTAL	MEAN SPEED
NNE	.005122	.017809	.020952	.016995	.006751	.004656	.002212	.003492	.077989	4.89
NE	.006635	.018159	.014085	.013503	.002910	.000931	.000116	.000349	.056687	3.82
ENE	.005238	.019905	.018508	.023862	.013735	.003376	.000698	.000349	.085671	4.64
E	.005704	.021418	.025725	.034455	.018159	.010243	.002212	.001513	.119427	5.14
ESE	.008497	.019905	.027820	.037714	.020254	.009661	.003026	.002794	.129671	5.16
SE	.008264	.021418	.026889	.024328	.009661	.004190	.002794	.003143	.100687	4.74
SSE	.005005	.014899	.012222	.007682	.004423	.002794	.000582	.001979	.049587	4.47
S	.006402	.019206	.007915	.006868	.003841	.001280	.000116	.000698	.046328	3.73
SSW	.004540	.015598	.011291	.011058	.004656	.000698	.000233	.000349	.048423	4.01
SW	.002328	.005471	.002444	.005354	.004540	.000815	.000233	.000349	.021534	4.60
WSW	.001979	.004074	.003376	.002677	.001513	.000815	.000233	.000000	.014667	4.10
W	.001746	.004307	.003026	.002444	.000698	.000466	.000000	.000000	.012688	3.67
WNW	.000698	.002328	.001630	.000466	.000466	.000466	.000349	.000466	.006868	4.69
NW	.001397	.001862	.001513	.002212	.000815	.000233	.000116	.001048	.009196	-5.06
NNW	.002328	.005587	.007799	.010476	.006169	.003608	.001513	.001979	.039460	5.47
N	.004772	.015598	.015365	.019788	.009196	.008032	.003725	.007450	.083925	5.72
CALM									.097195	
TOTAL	.070655	.207543	.200559	.219881	.107787	.052264	.018159	.025957	1.000000	4.35

NUMBERS BELOW BASED ON ALL OBSERVATIONS
NUMBER OF INVALID OBSERVATIONS = 0
NUMBER OF VALID OBSERVATIONS = 8592

Appendix 3B

APPENDIX 3B

DETAILS OF DUST EMISSIONS- ESTIMATES

LAMMA QUARRY CASTING BASIN DUST EMISSIONS INVENTORY

The following text sets out the methods used to estimate dust emissions for the dispersion modelling study described in Section 3.

Dust emissions from the quarry and casting basin construction work have been estimated using US EPA (1985) emission factors. Where possible the site specific information on the properties of the material being handled and the equipment used has been incorporated into the US EPA equations. Appendix 3C, Table 1 summarises the operational details (production rates etc) and details of the physical properties (density, silt and moisture contents) of the materials processed. The text below sets out the equations used and the assumptions made in estimating the dust emission amounts from each operations. Even with the guidance of the US EPA emission factor equations, assumptions have to be made and engineering judgements taken. The discussion below sets out the details of how the estimates were made.

Appendix 3B, Table 1: Lamma Quarry Operational and Materials Property Details

	Mt/yr	Density (t/m^3)	Moisture (%)	Silt (<75 μm)
IN-SITU				
Overburden	0.2880	1.80		
Used as blasted	0.540	2.00		
Armour rock	0.072	1.30		
To crusher	2.700	2.00		
Total in-situ	3.600	2.65		
PRIMARY CRUSHER				
Crusher output	2.232	1.30		
6-9 inch scalpings	0.468	1.61		
Total through primary crusher (feed)	2.700	2.00		
SECONDARY CRUSHER				
20mm aggregate	0.720	1.43	0.40	0.04
10mm aggregate	0.360	1.45	0.50	0.06
fines	0.720	1.61	0.80	8.50
other	0.432	1.40		
Total through secondary crusher (feed)	2.232	1.30		

DRILLING

Drilling is undertaken using a Atlas Copco drill equipped with a dry dust collection system. Holes are approximately 22m deep and have a diameter of 140mm for normal blasts and 76mm for pre-split blasts. Pre-split blasts involve much closer hole spacing and smaller charges. Hole spacing for normal blasts is 6.5m and for pre-split blasts is 1.5m. Pre-split blasting is a small fraction of the total blasting and the dust emission estimates assume that ten % of the volume of rock blasted is done with pre-split blasts and 90% with normal blasts.

Approximately 3.6Mt of product is produced annually. Assuming an in-situ density of $2.65t/m^3$, the volume of rock blasted per year is, 1,358,490bcm [3.6 x $10^6 t/2.65t/m^3$]. The volume of rock per blast hole is $1{,}014m^3$ [6.5m x 6.5m x 24m] for normal blasts and $54m^3$ [1.5m x 1.5m x 24m] for pre-split blasts. The number of holes drilled per year will be 3,721 [(0.9 x 1,358,490/1,014) + (0.1 x 1,358,490/54)]. Using the US EPA (1985) emission factor for blast holes of 0.59kg/hole the total emission from drilling is therefore 2,196 kg/yr. Note: this emission factor does not specify the depth of the hole.

BLASTING

Assume that blasting takes place twice per week a typical blast will have an area of $544m^2$ [$1{,}358{,}490m^3$/(24m x 104 blasts)]. The emission factor equation used to estimate the dust generation from blasting shows that the dust generated is approximately propotional to the area blasted, varying as the area (A) to the power 0.8. Thus the assumption concerning the number of blasts is not critical for estimating the total annual dust emission. For example 52 shots/yr blasting twice the area per shot would generate only 13% less dust than 104 smaller shots. The US EPA (1985) emission factor equation is:

$$E = \frac{344\ A^{0.8}}{D^{1.8}\ M^{1.9}} \quad \ldots\ (kg/blast) \qquad (1)$$

where A = area of blast (m^2)
D = depth of drill holes (m)
M = moisture content (%).

The hole depth is 24m and moisture content is 1.0% therefore the dust generation will be 174kg/shot. The total number of shots per year will be approximately 104. Therefore the total dust from blasting will be 18,100kg.

Note: The assumed moisture content of 1.0% is a conservative use of the US EPA (1985) recommendation of using a value between 1 and 2% (see Table 8.19.2-1 US EPA (1985)).

FRONT-END LOADER LOADING TRUCKS

Blasted rock is loaded to 30t Cat 769C trucks using Cat 988B front-end loaders (with a bucket capacity of $5.4m^3$). The **US EPA (1985)** emission factor equation is:

$$E = \frac{0.73 \times 0.0009\ (\frac{s}{5})(\frac{u}{2.2})(\frac{H}{1.5})}{(\frac{Y}{4.6})^{0.33}(\frac{M}{2})^2} \quad \ldots\ (kg/t) \qquad (2)$$

where s = silt content (%)
u = wind speed (m/s)
H = drop height (m)
Y = capacity of dumping device
M = moisture content (%).

The formula requires information on the average wind speed. Cheung Chau data indicates a wind speed of 4.4m/s at 92mPD. The approximate average wind speed at the mean height at which loading will take place (approximately 30m) will be approximately 76% (namely 3.3m/s) of the wind speed at 92m.

Notes: Wind speed varies with height in accordance with a power law. The exponent for neutral conditins, the most prevalent for the area, is 0.25 so the wind speed at 30 should be $(30/92)^{0.25}$, which is 0.76.

Assuming a material with a free-moisture content of 1.0%, silt content of 7% mean wind speed of 3.3m/s and material drop height of 3m the emission factor is 0.011kg/t. If 3,600,000t of material is removed each year the total dust emission will be 39,600kg.

Notes: (1) The assumed moisture content of 1.0% follows the assumption for blasting see above and (2) the value for silt content of 7% has been taken as the geometric mean of data (range 3.8 to 15.1%) provided by the US EPA (1985) (Table 8.2.24-3) for overburden from western coal mines.

TRANSPORT OF MATERIAL TO DUMP HOPPER

The emission factor for dust from haulage of material from the loading point in the quarry to the dump hopper is 4kg/vkt (NERDDC 1988). This can be reduced to 2kg/vkt by the application of water to the trafficked areas. The number of truck trips required to move 3,600,000t of material annually will be 128,571 [3,600,000t/28t/trip]. This assumes a 28t payload in the 30t trucks. Assuming the average return trip is 0.7km the total amount of dust generated annually will be 180,000kg [2 kg/vkt x 128,571 trips x 0.7km/trip].

DUMPING MATERIAL TO PRIMARY CRUSHER DUMP HOPPER

Use Equation (2) to estimate the dust emissions from truck dumping of raw rock from the quarry. First we need to know the size of the dump device. The payload is 28t and the bulk density of the fractured rock feed to the primary crusher is $2.0t/m^3$. The volume of each truck load will be $14.0m^3$ [$28t/2.0t/m^3$]. With a drop height of 4m the emission factor will be 0.01kg/t. Therefore the total annual dust emission will be 27,000 [0.01kg/t x 2,700,000t] kg.

DUMPING OF OTHER MATERIAL

Again use Equation (2) to estimate the dust emissions from truck dumping of overburden and "as blasted material" from the quarry. First we need to know the size of the dump device. The payload is 28t and the bulk density of material is as a weighted average $1.93t/m^3$ [(288,000t x $1.80t/m^3$ + 540,000t x $2.00t/m^3$)/(288,000t + 540,000t)]. The volume of each truck load will be $14.5m^3$ [$28t/1.93t/m^3$]. The emission factor will be 0.01kg/t. Therefore the total annual dust emission will be 8,280 [0.01kg/t x 828,000t]kg.

Note: this calculation assumes that dust emission from the handling of armour rock is negligible.

PRIMARY CRUSHING

Use the US EPA (1985) emission factor for wet material of 0.009kg/t. In this context wet refers to material that is either naturally wet or has been wet to a moisture level of 1.5 to 4% by weight (see Table 8.19.2-1 US EPA (1985)). Assume that 70% control is achieved by enclosure of the crusher. The total annual dust will be 7,290kg [0.3 x 0.009kg/t x 2,700,000t].

SECONDARY CRUSHING

A total of 2,232,000t/yr of material passes through the secondary crusher and the emission factor is the same so the total annual emission is 20,988 kg [0.009 kg/t x 2,232,000 t].

SCREENING

Assume that on average material passes through five stages of screening. The emission factor for dry unenclosed screening is 0.08kg/t (see US EPA (1985) - Table 8.19.1-1). Assuming 70% control for added moisture, and 70% for enclosure the total annual dust emission will be 97,200kg [5 levels of screening x 0.08kg/t/level of screening x 0.3 x 0.3 x 2,700,000t].

LOADING TO STOCKPILES

Use the US EPA (1985) equation:

$$E = \frac{0.73 \times 0.0009 \left(\frac{s}{5}\right)\left(\frac{u}{2.2}\right)\left(\frac{H}{3.0}\right)}{\left(\frac{M}{2}\right)^2} \quad \ldots \; (kg/t) \qquad (3)$$

where s = silt content (%)
u = wind speed (m/s)
H = drop height (m)
M = moisture content (%).

Measured moisture contents of the products are 0.80, 0.50 and 0.40% for fines, 10mm and 20mm products respectively. Assume that the moisture content of the 6 to 9 inch product is 0.4% (the same as for 20mm product). Assume an average drop height of 15m and use the measured silt contents of 8.5% for fines, 0.06% for 10mm product and 0.04% for 20mm product. For the six to nine inch product the silt content has been taken to be the same as for 20mm product, namely 0.04% and for the scalpings the silt content has been taken to the same as for fines namely 8.5%. The emission factors will be 0.052kg/t, 0.001, 0.001 and 0.001kg/t for fines (and scalpings), 10mm, 20mm (and 6 to 9 inch product) respectively. The total annual emissions are calculated to be:

- fines - 37,692kg/yr
- scalpings - 24,499kg/yr
- 10mm - 351kg/yr
- 20mm - 702kg/yr

- 6 to 9 inch - 422kg/yr.

RECLAIM FROM STOCKPILES

This is undertaken by front-end loader ($5.4m^3$) and the emission will depend on the material handled. Equation (2) is used to estimate the emission using the silt and moisture contents listed in Appendix 3C, Table 1. The emission factors are, 0.02, 0.02, 0.00030 and 0.00018kg/t for fines, scalpings, 10mm, 20mm material respectively.

The annual emissions are:

- fines - 14,400kg/yr
- scalpings - 8,640kg/yr
- 10mm - 108kg/yr
- 20mm - 160kg/yr
- other - 25,600kg/yr.

LOADING TO BARGES

The exported material then dumped into barges. Some is dumped directly and other material is dumped to a hopper feeding a conveyor which then loads the barges. The second method will generate more dust since it involves two dust generating steps. For the purposes of assessment it is assumed that all the materail goes through the two stage loading process.

Using Equations (2) and (3) for the two stages the dust emission will be:

- fines - 21,600kg/yr
- scalpings - 12,960kg/yr
- 10mm - 162kg/yr
- 20mm - 240kg/yr
- other - 38,912kg/yr.

WIND EROSION FROM STOCKPILES

Several types of stockpiles and erodable surfaces are present on the site. The US EPA (1985) emission factor equation for wind erosion of active storage piles is:

$$E = 1.9\left(\frac{s}{1.5}\right)\left(\frac{365-p}{235}\right)\left(\frac{f}{15}\right) \quad ... \ (kg/day/ha) \qquad (4)$$

where s = silt content (%)
p = number of days with precipitation >25mm
f = %age of time that the unobstructed wind speed exceeds 5.4m/s at the mean stockpile height.

The silt contents have been assumed to be as specified in the discussion on stockpile loading above. The number of raindays per year is 137. The percentage of time the wind speed is above 5.4m/s is 20% see Cheung Chau data in Appendix A adjusted for height difference (see footnote 1)). The estimated emission factors are therefore 13.9kg/Ha/day for fines and scalpings, 0.09kg/Ha/day for 10mm product and 0.07kg/Ha/hr for 20mm and 6 to 9 inch product. The stockpiles are typically 0.25Ha so the estimated annual emissions are:

- fines - 1,268kg/yr
- scalpings - 1,268kg/yr
- 10mm - 8kg/yr
- 20mm - 6kg/yr
- 6 to 9 inch - 6kg/yr.

WIND EROSION FROM OTHER EXPOSED AREAS

For the exposed quarry floor and trafficked areas the silt content is 7.9% (US EPA 1985 - Table 11.2.6-1 the maximum value listed for sand and gravel processing). The emission factor is 12.9kg/Ha/day. The area of exposed quarry floor is 30Ha, therefore total annual emissions of dust are 141,255kg [30Ha x 365 days x 12.9kg/Ha/day].

UNLOADING OF CEMENT TO SILOS

Cement and fly-ash are unloaded from barge to silos on the wharf. The throughput of cement is 400,000t/yr and the operation is undertaken approximately twice per month. Unloading is done using a screw conveyor to remove the cement from the ship's hold and transfer it to a covered conveyor. Very little dust is generated by this process. However, some dust is generated by wind erosion when the hold is open and some dust is generated at the end of the process when a small front-end loader is lowered into the ship's hold to move the cement to achieve sufficient depth so that the screw conveyor can work. The emission is variable and depends on weather conditions. An emission factor of 0.01kg/t has been assumed in the absence of any reliable method of estimating it. Total annual emission is therefore 4,000kg.

BARGE LOADING OF CEMENT

Cement is reloaded from the silos to barges. Assuming that all cement leaves the site (that is the usage on-site is assumed negligible compared with the total throughput). The load out operation is undertaken with a completely enclosed system. Three transfer points on the conveyor and the transfer to the barge are fully enclosed and and fitted with dedusting bag filters. The density of cement is approximately 1,478kg/m^3. The volume of displaced air will be approximately 270,636m^3/yr. If this volume of air is handled at each of the four transfer points and with a residual dust loading in the de-dusted air of 50mg/m^3 the dust emission would be 54kg/yr.

DUST EMISSIONS DURING DEVELOPMENT AND OPERATION OF THE CASTING BASIN

Excavation of the casting basin will take approximately four months. The dust emissions from the operation are estimated below. During construction of the basin equipment will be diverted from the routine quarrying operation and used to excavate the basin. Thus emissions from the quarry will include increased emissions from the casting basin and reduced emissions from other parts of the quarry.

LOADING CASTING BASIN EXCAVATION ROCK TO TRUCKS

The volume of rock to be removed is 151,200m^3 [120 x 90 x 14m^3]. Assuming a density of 2.65kg/bcm the total rock to be removed will be 400,680t. Using the emission factor of 0.014kg/t the total amount of dust produced over four months will be 5,610kg [0.014kg/t x 400,680t]. The annualised emission will be 16,830kg/yr.

TRANSPORT OF CASTING BASIN ROCK TO CRUSHER

The total number of trips required to remove 400,680t of rock in 28t truck loads will be 14,310 [400,680/28]. Assuming an average return trip of 0.6km and an emission rate of 2kg/vkt the total dust emission will be 17,172kg [14,310 trips x 0.6km/trip x 2kg/vkt]. The annualised emission will be 51,516kg/yr.

DUMPING OF CASTING BASIN EXCAVATED MATERIAL TO CRUSHER HOPPER

Assume an emission factor of 0.01kg/t (see above) the dust generated by dumping excavated rock will be 4,007kg [0.01kg/t x 400,680t]. The annualised emission is 12,021 kg/yr.

LOADING PRE-MIX CEMENT TO CONCRETE TRUCKS

Mixed concrete is loaded wet to trucks so will be a negligible source of dust.

TRANSPORT OF CONCRETE TO CASTING BASIN

A total of 40,000m^3 of concrete will be taken to the casting basin per year. This will involve a total of 0.7km round trip.

Appendix 3C

APPENDIX 3C

AUSPLUME MODEL RUN SETTINGS

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+----------+
|          |
|  Lamma   |
|          |
+----------+
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Concentration or deposition................................ Concentration
Emission rate units........................................ grams/second
Concentration units........................................ micrograms/cubic metre
Units conversion factor.................................... 1.00E+06
Background concentration................................... 0.00E+00
Terrain effects............................................ None
Smooth stability class changes?............................ No
Other stability class adjustments ("urban modes").......... None
Ignore building wake effects?.............................. No
Decay coefficient (unless overridden by met. file)......... .000
Anemometer height.......................................... 10 m
Averaging time for sigma-theta values...................... 60 min.
Roughness height at the wind vane site..................... .300 m

DISPERSION CURVES
Horizontal dispersion curves for sources <100m high........ Sigma-theta
Vertical   dispersion  curves for sources <100m high........ Pasquill-Gifford
Horizontal dispersion curves for sources >100m high........ Briggs Rural
Vertical   dispersion  curves for sources >100m high........ Briggs Rural
Enhance horizontal plume spreads for buoyancy?............. Yes
Enhance   vertical  plume spreads for buoyancy?............. Yes
Adjust horizontal P-G formulae for roughness height?....... Yes
Adjust   vertical  P-G formulae for roughness height?....... Yes
Roughness height........................................... 1.000m
Adjustment for wind directional shear...................... None

PLUME RISE OPTIONS
Gradual plume rise?........................................ Yes
Stack-tip downwash included?............................... Yes
Entrainment coefficients for adiabatic & stable lapse rates. .60, .60
Partial penetration of elevated inversions?................ No
Disregard temperature gradients in the hourly met. file?.... No
```

and in the absence of boundary-layer potential temperature gradients given by the hourly met. file, a value from the following table (in K/m) is used:

Wind Speed Category	Stability Class A	B	C	D	E	F
1	.000	.000	.000	.000	.020	.035
2	.000	.000	.000	.000	.020	.035
3	.000	.000	.000	.000	.020	.035
4	.000	.000	.000	.000	.020	.035
5	.000	.000	.000	.000	.020	.035
6	.000	.000	.000	.000	.020	.035

```
WIND SPEED CATEGORIES
  Boundaries between categories (in m/s) are:  1.50,  3.75,  5.25,  6.75,  8.25

WIND PROFILE EXPONENTS: "Irwin Urban" values (unless overridden by met. file)

AVERAGING TIMES
 24 hours
  average over all hours
```

Appendix 3D

APPENDIX 3D DEVELOPMENT OF SECOND CALIBRATION FACTOR FROM NEW DATA

Following submission of the Draft EIA a second set of TSP monitoring data was made available to the study. These data have been used to develop a second estimate of a calibration factor for use with the model. This appendix describes the data and the way they have been used to develop a new calibration factor.

Originally it was proposed that the new TSP information would be added to the existing monitoring date set at HVC (see Section 3 of the EIA). However the new data set contains meteorological data not available with the original data set. It therefore invites a more comprehensive comparison between predicted TSP concentrations and measured concentrations. It should be noted that had the new data set been simply added to the existing data set and the meteorological data ignored then the revised calibration factors would be little changed from the originals.

The monitoring data provided were measurements of 24-hour average TSP concentrations and summary wind rose tables for four sites. The data were available for eight consecutive days in December 1992, and are given in Table 3.3(a) of the main text.

In the wind rose tables wind direction was specified to 16 sectors 22.5 degrees wide and wind speed was specified in wind speed classes as follows 0 - 0.8 (calm - no direction specified), 0.8 - 1.54, 1.55 - 2.50, 2.51 - 4.30, 4.31 - 6.80, 6.81 - 9.50 and > 9.51 m/s. To determine wind speed and wind direction information for the calibration tests the daily summaries of wind data were modified by redistributing the calm into directions according to the frequency of occurrence of lowest non-calm wind speed class (that is the 0.8 - 1.5 m/s class). Using this approach the hours the wind spent in particular directions and in particular wind speed classes has been estimated.

With these adaptions an hourly AUSPLUME file was created for each of the eight days. When a wind speed-wind/wind direction condition was found to occur for more than one hour on a particular day (this was particularly true for NE winds) then the wind direction was "randomised" within the 22.5 degree sector, otherwise the wind direction was set at the centre of the 22.5 degree sector. Wind speeds were taken to be the mid-point of the wind speed classes. No stability information was available with the data set and stability was assumed to be D class for all times.

AUSPLUME requires hourly meteorological data including stability, temperature and mixing height data. The model, as used in this application (namely to predict concentrations in proximity to non-buoyant ground-level sources), is not sensitive to values of temperature and mixing height. Consequently the fact that these data are unavailable is unimportant. The predictions are however very sensitive to wind speed, wind direction, source receptor locations and quarry activities. It is also sensitive, but to a lesser extent to stability class. The difference between predicted concentrations under A and F stability can be large, but in the coastal site in which the quarry is located, the range of stabilities is unlikely to be great.

Clearly had the data been specifically collected for a model calibration study then stability information would have been collected and more precise wind speed and wind direction information would have been retained. This would have greatly assisted the calibration work and would probably have reduced the scatter in the plots of modelled and monitored TSP concentrations.

An example of an AUSPLUME file created for 4/12/92 (Actually 4/5 December 1992) is attached. There is of course some judgement involved in following the above procedure, but without the actual hourly data there is no other alternative.

Table 3D.1 and Figure 3D.1 summarise the predicted and measured concentrations.

In the model runs it was assumed that quarry emissions were as estimated in Appendix 3B and Table 3.5 of the main text, and that the quarry was emitting at the annual average rate for all the time (including day time and night time hours). A comparison between prediction and measurements on Sunday 6/12/92 suggests that the quarry was not in fact working on that day although the model tests assume that it was. (Note: results for 6/7 December 1992 have not been used in estimating the line of best fit nor are they in Figure 3D.1).

It should be noted that modelling for receptors actually on the site inevitably means that the concentrations at some receptors will be dominated by emissions from nearby sources and the accuracy of predictions will depend to a large extent on the accuracy of the emission estimates of individual sources. For off-site receptors, air quality will usually be determined by all emission sources (or generally more than just one source) and there will be an averaging effect so the accuracy of estimated emissions from particular sources will not be as critical. It is therefore likely that the scatter of predicted and measured concentration would be reduced, although the bias may not be.

The line of best fit (Figure 3D.1) indicates that the model predictions can best be matched to what is measured by multiplying the prediction by 0.42 and adding 147 $\mu g/m^3$. The value of 147 $\mu g/m^3$ should not be interpreted as a background concentration although the calibration factor will of course automatically result in an allowance for the existing background TSP, which is not included in the original uncalibrated model predictions.

This approach is not the most suitable approach for estimating the annual average concentrations. Clearly if it were to be applied for annual average estimates it would result in the model predicting a minimum annual average concentration of 147 $\mu g/m^3$ at all receptors. While this may not be an unreasonable background level for sites within the quarry, TSP levels at sites away from the quarry are much lower than this. For this reason no second calibration factor was developed for annual average concentrations.

Assessment using new calibrated predictions

Figure 3D.2 shows the predicted 24-hour maximum TSP concentrations using the new calibration factors. As noted above the data are not considered adequate for annual average calibration.

The maximum predicted 24-hour TSP concentrations at Lo So Shing are approximately 255 $\mu g/m^3$, which is below the AQO of 260 $\mu g/m^3$. For Sok Kwu Wan the maximum predicted 24-hour concentrations are between 290 and 320 $\mu g/m^3$. This is above the 260 $\mu g/m^3$ AQO. To investigate the significance of this, special model runs have been undertaken for a receptor representing the Sok Kwu Wan area (taken as grid reference 31650 m E and 7450 m N) to determine the number of times in a year that the 24-hour AQO is predicted to be exceeded. For the selected receptor there were five predicted 24-hour average concentrations above the 260 $\mu g/m^3$ AQO.

This probably overstates the extent of the impact in the Sok Kwu Wan area because it is likely that the frequency of occurrence of northerly winds that show in the Cheung Chau data used in modelling does not actually occur in Picnic Bay (see discussion in Section 3.4.2). In this regard it is important to recognise that the calibration factors were developed using on-site meteorological data collected during the eight days when the monitoring was undertaken, while the model runs were undertaken using a year of data from Cheung Chau.

The results from this second calibration study show differences in the calculated 24-hour concentrations at Sok Kwu Wan compared with the earlier calibration study using the longer term data available for site HVC. This is not a surprising result considering:

- the limitations of modelling and of estimating the source factors;
- the different meteorological data available, which invited a different calibration approach;
- the limitations of using short-term site measurements (which can be skewed by immediately local sources) rather than longer-term measurements taken more distant from the quarry.

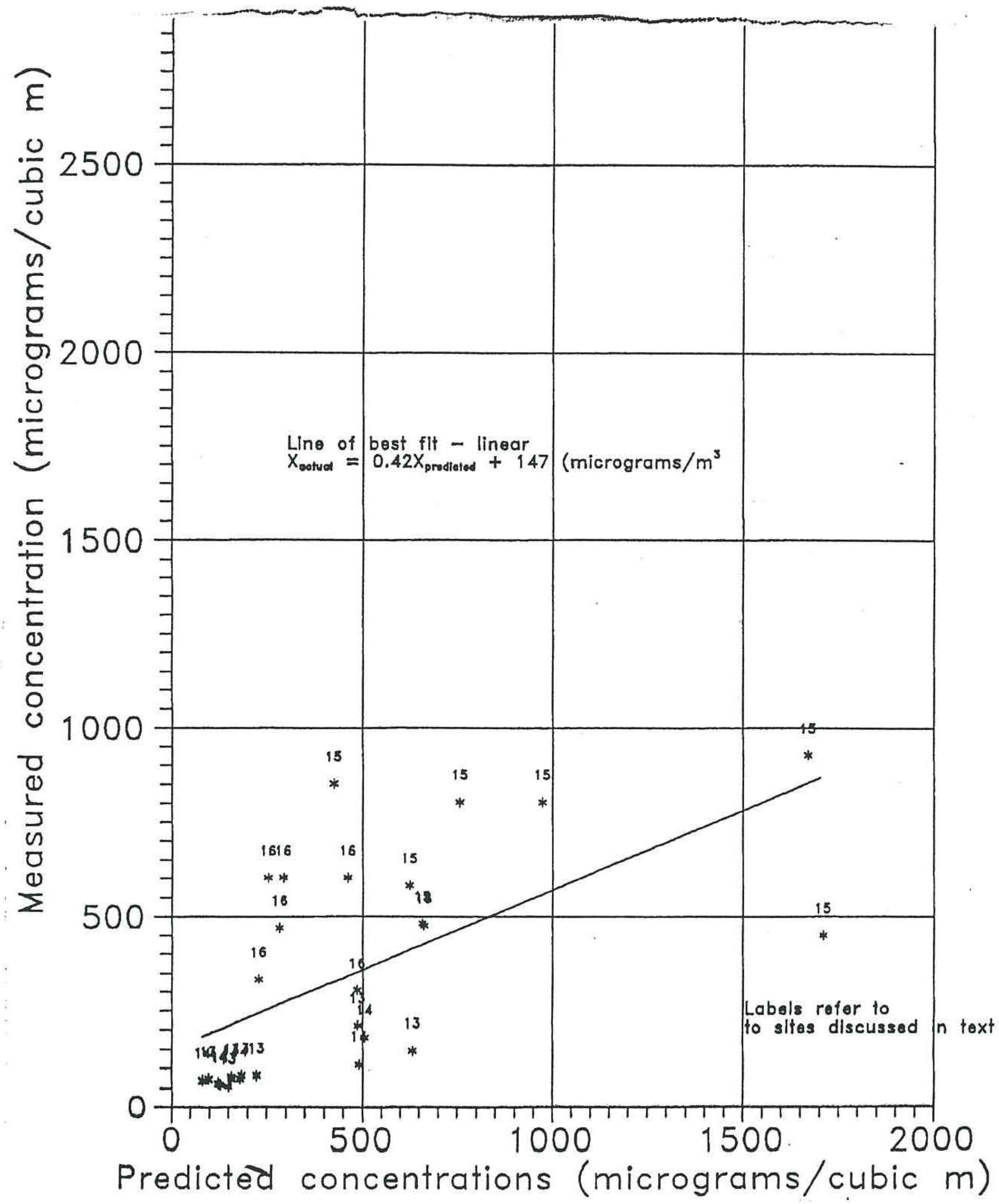
The only way in which the extent that TSP emissions from the quarry affects air quality at Sok Kwu Wan can be reliably quantified is via an air quality monitoring programme at Sok Kwu Wan. The model predictions of this second calibration study indicated a potential for the 24-hour AQO to be exceeded on up to five days per year by a small margin. Some minor reduction in dust emissions from the quarry would bring the predictions back into compliance with the AQO.

Table 3D.1 Predicted and measured dust concentrations for selected periods $\mu g/m^3$

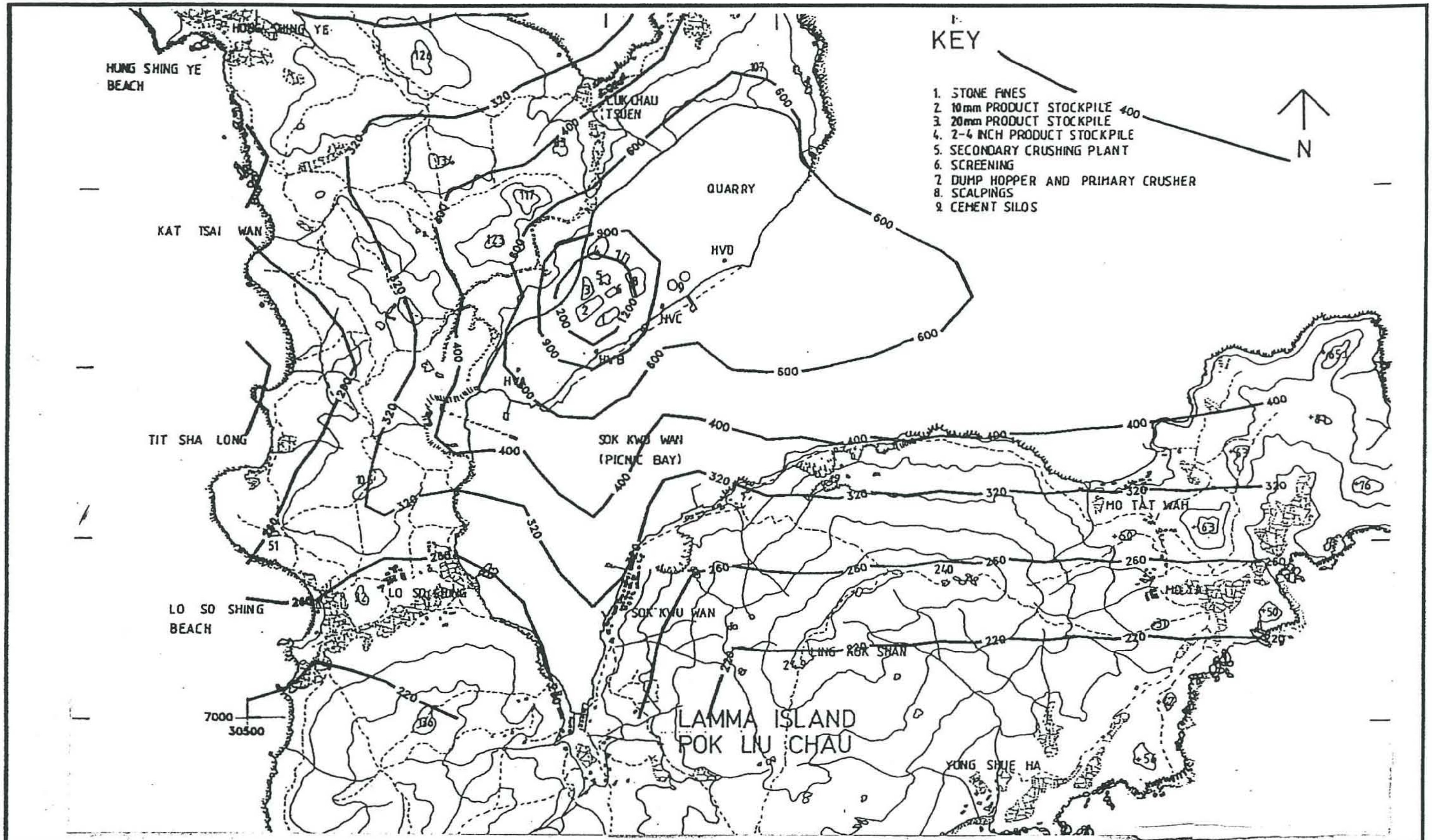
Site	HVD	HVC	HVB	HVA
1/12/92 Predicted	487	491	1670	486
1/12/92 Measured	211	111	928	305
2/12/92 Predicted	223	180	974	461
2/12/92 Measured	82	74	803	603
3/12/92 Predicted	158	128	659	253
3/12/92 Measured	79	59	482	606
4/12/92 Predicted	149	123	625	283
4/12/92 Measured	55	62	582	471
5/12/92 Predicted	184	156	757	293
5/12/92 Measured	82	74	803	603
6/12/92 Predicted	558	483	1440	440
6/12/92 Measured	57	97	180	59
7/12/92 Predicted	633	505	1710	663
7/12/92 Measured	146	180	451	476
8/12/92 Predicted	97	82	425	228
8/12/92 Measured	73	69	852	334

Predicted versus measured 24 - hour average TSP concentrations for four sites and seven days

(Note: Data for 6 & 7 December 1992 excluded



AXIS Environmental	LAMMA ROCK PRODUCTS Ltd.	JOB TITLE LAMMA QUARRY, CASTING BASIN & EXTENSION	FIGURE TITLE PREDICTED vs MEASURED 24hr AVERAGE TSP LEVELS
		FIGURE No. 3D.1	JOB NUMBER 054/000/93
		SCALE N.A.	
		DATE MAY 1993	



AXIS Environmental

LAMMA ROCK PRODUCTS Ltd.

JOB TITTLE	LAMMA QUARRY, CASTING BASIN & EXTENSION EIA
FIGURE No.	3D.2
DATE:	MAY 1993
FIGURE TITLE	TSP - PREDICTED 24hr AVERAGE DUE TO QUARRY µg/m3
SCALE:	N.A.
JOB NO.	054/000/93

Appendix 4A

APPENDIX 4.A

EQUIPMENT INVENTORY

EQUIPMENT INVENTORY

1. EXISTING QUARRY	Number
Rock Drills	
Ingersoll Rand DM25	1
Atlas Copco 712	1
Atlas Copco 742	1
Trucks	
Caterpillar 769 (30 tonnes capacity) Rear Dump Trucks	6
Front End Loaders	
Caterpillar 988 B Loaders (5.4 metre bucket)	3
Primary Crusher	
Kawasaki 70x60 Jaw Crusher	1
Secondary Crushers	
Materials handling associated with the crushers Materials handling associated with the crushers is included in the assessment of the crushers.	
Conveyor system used to load barge	1
• Concrete batching plant	1
• Concrete mixing	2

2. QUARRY EXTENSION AND CASTING BASIN

The construction and operation of the casting basin and the extension of the current quarry operations will not require the use of new plant other than that described below. During construction of the casting basin no new plant will be required. During operation of the casting basin the following plant may be required:

- owing to the small capacity of the current batching plant the existing facility will be upgraded;
- extra concrete mixing trucks may be required;
- a minimum of one tower crane will be required for the casting basin;
- further electric power may be required, which would require an electric generating set to be installed.

Appendix 4B

APPENDIX 4B

CALCULATION OF SOUND POWER LEVELS FROM MEASURED SOUND PRESSURE

CALCULATION OF SOUND POWER LEVELS FROM MEASURED SOUND PRESSURE

Sound Power Level (SWL) = SPL + 10 Log 4 π r^2 - DI

where r = the distance from the source to the receiver

DI = 3, as all measurements were made over ground.

For the measurement of the crushers r = 130m, therefore

SWL = SPL + 54 - 3 dB

For the measurement of the drills r = 10m, therefore

SWL = SPL + 31 - 3 dB

Linear sound pressure levels were determined by converting the A weighted values using the following values.

Frequency	31.5	63	125	250	500	1K	2k	4k	8k	16k
A Weight to Linear	39.4	26.2	16.1	8.6	3.2	0	-1.2	-1.0	1.1	6.6

ENM Single Point Caculations

4.B.1 WEATHER CONDITIONS FOR ALL CALCULATIONS

Temp	20°C
Humidity	70%
Temp Gradient	1-0 °C/100m
Wind Speed	0m/s

4.B.2 CRUSHER NOISE

Position No. 1 Sok Kwu Wan

Frequency Hz	31.5	63	125	250	500	1k	2k	4k	8k	16k
Power Level	129.2	123.7	121.3	119.6	113.3	115.2	114.3	109.0	96.9	.0
Directivity	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Distance	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2	69.2
Barrier Air	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Absortpion	.0	.1	.2	.8	2.2	4.3	7.6	16.2	42.1	34.8
Temp &	-.4	-.4	-.2	.0	-.7	-.7	-.5	-.6	-.6	-.6
Wind Ground	-5.9	-5.6	-3.4	4.3	-3.6	-1.5	-1.1	-1.3	1.1	-1.0
TOTAL	66.3	60.5	55.5	45.3	46.3	43.9	39.1	25.6	-14.9	-100.0

TOTAL 48.6 dBA

Position No. 2 North of Sok Kwu Wan

Frequency Hz	31.5	63	125	250	500	1k	2k	4k	8k	16k
Power Level	129.2	123.7	121.3	119.6	113.3	115.2	114.3	109.0	96.9	.0
Directivity	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Distance	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1	68.1
Barrier Air	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Absorption	.0	.1	.2	.7	2.0	3.8	6.7	14.4	37.6	119.5
Temp &	-.4	-.4	-.2	.0	-.7	-.7	-.5	-.6	-.6	-.6
Wind Ground	-3.1	4.4	-4.3	-1.7	-3.2	-2.0	-2.8	-3.6	-1.2	-.3
TOTAL	64.6	51.5	57.5	52.5	47.2	46.0	42.8	30.7	-7.1	-100.0

TOTAL 51.1 dBA

Position No. 3 Lo So Shing

Frequency Hz	31.5	63	125	250	500	1k	2k	4k	8k	16k
Power Level	129.2	123.7	121.3	119.6	113.3	115.2	114.3	109.0	96.9	.0
Directivity	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Distance	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2	70.2
Barrier Air	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Absorption	.0	.1	.3	.9	2.5	4.9	8.6	18.0	46.9	151.5
Temp &	-.4	-.4	-.2	.0	-.7	-.7	-.5	-.6	-.6	-.6
Wind Ground	-5.9	-5.4	-2.4	4.6	-3.8	-1.2	-1.8	-1.1	.1	-1.5
TOTAL	65.2	59.2	53.4	43.8	45.1	42.0	37.8	22.5	-19.8	-100.0

TOTAL 47.1 dBA

4.B.3 DRILLS LOCATION ON QUARRY FACE

Position No. 1 Sok Kwu Wan

Frequency Hz	31.5	63	125	250	500	1k	2k	4k	8k	16k
Power Level	107.2	110.2	110.7	110.8	102.3	107.3	112.1	113.9	110.9	105.5
Directivity	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Distance	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8	72.8
Barrier Air	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Absortpion	.0	.1	.4	1.2	3.4	6.5	11.5	23.5	61.7	203.1
Temp &	-.4	-.4	-.2	.0	-.7	-.7	-.5	-.6	-.6	-.6
Wind Ground	-1.5	1.9	-3.4	-3.0	-1.8	-1.7	.1	-.7	-2.0	-1.9
TOTAL	36.3	35.8	41.1	39.7	28.7	30.3	28.2	18.9	-21.1	-100.0

TOTAL 36 dBA

Position No. 2 North of Sok Kwu Wan

Frequency Hz	31.5	63	125	250	500	1k	2k	4k	8k	16k
Power Level	107.2	110.2	110.7	110.8	102.3	107.3	112.1	113.9	110.9	105.5
Directivity	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Distance	73.5	73.5	73.5	73.5	73.5	73.5	73.5	73.5	73.5	73.5
Barrier Air	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Absortpion	.0	.1	.4	1.4	3.6	7.1	12.4	25.2	66.5	219.9
Temp &	-.4	-.4	-.2	.0	-.7	-.7	-.5	-.6	-.6	-.6
Wind Ground	-.9	.4	-3.1	-3.1	-1.7	-2.4	-1.5	-.2	-.3	-1.8
TOTAL	35.0	36.5	40.1	39.0	27.5	29.8	28.1	15.9	-28.3	-100.0

TOTAL 35.4 dBA

Position No. 3 Lo So Shing

Frequency Hz	31.5	63	125	250	500	1k	2k	4k	8k	16k
Power Level	107.2	110.2	110.7	110.8	102.3	107.3	112.1	113.9	110.9	105.5
Directivity	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Distance	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1	74.1
Barrier Air	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Absortpion	.0	.1	.4	1.4	3.9	7.6	13.2	26.8	70.9	235.2
Temp &	-.4	-.4	-.2	.0	-.7	-.7	-.5	-.6	-.6	-.6
Wind Ground	-4.9	.6	-1.3	-2.4	-1.9	-1.8	-.4	.4	-.9	-1.3
TOTAL	38.3	35.7	37.6	37.6	26.9	28.1	25.6	13.1	-32.7	-100.0

TOTAL 33.7 dBA

Appendix 6A

APPENDIX 6A

WATER QUALITY MONITORING BY AFD AND EPD

Water Quality Monitoring Data
Sok Kwu Wan Fish Culture Zone

Date & Site	Depth m	Temp °C	D.O. mg/l	Salinity o/oo	BOD5 mg/l	NH3-N ug/l	Turbidity N.T.U.
25.6.92	0	29.5	8.83	22	1.44	69.83	1.1
Inner	2	29.3	7.59	22	1.33	90.52	0.8
S.K.W.	4	29.3	6.68	23	1.41	95.69	1.2
25.6.92	0	29.8	8.62	22	2.07	103.45	2.1
Outer	5	27.9	7.40	25	2.06	104.74	1.7
S.K.W.	10	25.7	4.37	26	1.99	99.57	1.4
25.11.91	0	21.5	5.84	33	0.54	115.16	8.16
Inner	4	21.5	4.9	33	0.68	149.71	8.16
S.K.W.	8	21.6	3.27	33	0.78	172.74	8.12
26.11.91	0	21.5	6.28	31	1.16	96.74	8.23
Outer	5	21.4	6.05	32	0.83	93.67	8.24
S.K.W.	11	21.4	4.58	33	0.50	89.06	8.23
29.9.89	0	29.0	2.62	31	1.20	190.24	
Inner	1	28.9	2.71				
S.K.W.	2	28.9	2.58				
	3	28.9	2.61				
	4	28.7	2.77	31	0.92	173.17	
	5	28.7	2.89				
	6	28.5	3.21				
	7	28.3	4.23				
	8	28.2	3.82				
	8.5	28.2	3.51	32	1.02	60.98	
29.9.89	0	29.0	2.79		1.94	202.44	
Outer	1	28.9	2.72				
S.K.W.	2	28.7	2.30				
	3	28.7	2.89				
	4	28.6	3.65				
	5	28.6	4.46	31	0.66	42.68	
	6	28.5	4.50				
	7	28.5	4.56				
	8	28.5	4.64				
	9	28.4	4.84				
	10	28.3	4.61				
	11	28.2	3.69	31	1.16	48.78	
	12	28.1	3.60				

cont./....

Date & Site	Depth m	Temp °C	D.O. mg/l	Salinity o/oo	BOD5 mg/l	NH3-N ug/l	Turbidity N.T.U.
31.8.89	0	28.5	4.10				
Inner	1	28.2	3.51	28	0.61	35.29	
S.K.W.	2	28.1	3.50				
	3	28.1	3.55				
	4	28.1	3.30	28	1.01	55.88	
	5	28.1	2.55				
	6	28.0	3.59				
	7	27.9	3.77				
	8	27.9	3.72	31	0.7	39.71	
31.8.89	0	28.2	4.12	29	1.9	98.53	
Outer	1	28.0	3.36				
S.K.W.	2	28.0	3.41				
	3	28.0	3.46				
	4	28.1	3.65				
	5	28.1	3.72	30	0.71	51.47	
	6	28.1	3.94				
	7	28.1	4.06				
	8	27.9	4.11				
	9	27.6	3.97				
	10	27.5	3.86				
	11	27.4	3.75	32	0.81	19.12	

SM3 1993/01/11 08:45 ** Depth Average **

STATION : SM3
DEPTH : AVERAGE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0005	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1100	0.140	475.707	5.677	77.557	7.763	31.121	1.200	21.600	12.100
24/10/91	1240	0.297	520.333	10.010	142.667	8.210	33.000	1.200	23.367	5.433
11/12/91	1450	1.160	464.322	10.950	133.723	8.666	34.394	1.200	19.624	5.000
25/02/92	1225	0.567	401.267	7.483	90.433	8.050	32.030	2.800	15.200	3.267
01/05/92	1515	1.313	439.767	6.773	93.633	8.213	30.133	2.400	22.067	3.033
17/06/92	1135	1.273	481.833	5.743	82.867	7.893	31.167	1.800	25.267	4.033
10/08/92	1515	1.580	486.967	5.650	85.100	8.077	31.587	1.800	25.367	2.767

SM3 1993/01/11 08:45

STATION : SM3
DEPTH : SURFACE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0005	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1100	0.320	472.200	5.900	80.600	7.770	30.880	1.200	22.000	13.000
24/10/91	1240	0.430	523.900	8.560	124.000	8.200	32.840	1.200	24.200	3.600
11/12/91	1450	1.330	463.199	13.759	170.733	8.617	34.280	1.200	20.398	4.700
25/02/92	1225	0.620	403.000	7.540	91.700	8.060	32.060	2.800	15.400	2.900
01/05/92	1515	1.940	415.000	7.260	102.700	8.270	27.590	2.400	23.200	2.400
17/06/92	1135	2.520	433.100	6.710	98.500	8.030	27.000	1.800	26.400	3.200
10/08/92	1515	2.660	461.200	10.590	165.000	8.330	27.420	1.800	29.100	1.900

SM3 1993/01/11 08:45

STATION : SM3
DEPTH : MIDDLE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0005	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1100	0.080	474.120	5.750	79.870	7.750	30.883			14.000
24/10/91	1240	0.280	518.500	8.080	114.300	8.210	33.040		23.400	5.300
11/12/91	1450	1.080	465.691	9.450	114.371	8.680	34.431		19.346	4.500
25/02/92	1225	0.470	400.400	7.490	90.000	8.040	32.070		15.100	3.200
01/05/92	1515	1.360	442.100	6.850	93.000	8.220	30.540		21.700	2.900
17/06/92	1135	0.770	505.500	5.240	75.200	7.850	32.900		25.100	2.800
10/08/92	1515	1.310	500.600	3.280	46.900	8.030	33.440		23.600	2.100

SM3 1993/01/11 08:45

STATION : SM3
DEPTH : BOTTOM
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0006	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1100	0.020	480.800	5.380	72.200	7.770	31.800		21.200	9.300
24/10/91	1240	0.180	516.600	13.390	189.700	8.220	33.120		22.500	7.400
11/12/91	1450	1.070	464.075	9.640	116.065	8.700	34.472		19.128	5.800
25/02/92	1225	0.610	400.400	7.420	89.600	8.050	31.960		15.100	3.700
01/05/92	1515	0.650	462.200	6.210	84.900	8.150	32.270		21.300	3.800
17/06/92	1135	0.530	506.900	5.280	74.900	7.800	33.600		24.300	6.100
10/08/92	1515	0.770	499.100	3.080	43.400	7.870	33.900		23.200	4.300

SM3 1993/01/11 08:50 ** Depth Average **

STATION : SM3
DEPTH : AVERAGE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1100	0.633	160.000	2.300	1.050	13.333	153.333	1.667
24/10/91	1240	0.433	21.333	1.567	1.267	6.833	18.000	2.167
11/12/91	1450	0.267	151.333	0.633	1.333	6.000	123.333	0.833
25/02/92	1225	0.533	10.667	0.300	0.837	3.667	9.000	2.167
01/05/92	1515	1.767	20.000	0.600	0.933	3.833	10.000	0.833
17/06/92	1135	3.933	94.667	4.400	0.900	4.833	82.333	1.500
10/08/92	1515	1.233	121.333	12.133	1.337	3.333	110.333	1.333

SM3 1993/01/11 08:50

STATION : SM3
DEPTH : SURFACE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1100	0.800	170.000	3.100	1.050	15.000	150.000	2.000
24/10/91	1240	0.500	1.000	2.100	1.300	4.500	1.000	2.000
11/12/91	1450	0.200L	16.000	0.900	1.400	5.000	12.000	0.500
25/02/92	1225	0.800	0.000	0.200L	0.840	2.000	0.000	1.000
01/05/92	1515	1.600	20.000	1.400	1.330	3.000	10.000	1.000
17/06/92	1135	9.100	12.000	7.700	1.320	3.000	5.000	1.500
10/08/92	1515	2.100	4.000	14.000	1.370	2.500	1.000	1.500

SM3 1993/01/11 08:50

STATION : SM3
DEPTH : MIDDLE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1100	0.800	90.000	1.800	1.150	15.000	60.000	2.000
24/10/91	1240	0.300	34.000	1.600	1.300	8.000	28.000	2.000
11/12/91	1450	0.300	78.000	0.500	1.300	6.000	78.000	1.000
25/02/92	1225	0.300	17.000	0.500	0.850	4.500	16.000	3.000
01/05/92	1515	3.200	20.000	0.200L	0.940	4.000	10.000	0.500
17/06/92	1135	1.100	210.000	4.900	0.610	3.500	190.000	1.500
10/08/92	1515	0.500	110.000	8.400	1.450	3.500	110.000	1.500

SM3 1993/01/11 08:50

STATION : SM3
DEPTH : BOTTOM
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1100	0.300	280.000	2.000	0.950	10.000	250.000	1.000
24/10/91	1240	0.500	29.000	1.000	1.200	10.000	25.000	2.500
11/12/91	1450	0.300	360.000	0.500	1.300	7.000	280.000	1.000
25/02/92	1225	0.500	15.000	0.200L	0.820	4.500	11.000	2.500
01/05/92	1515	0.500	20.000	0.200L	0.530	4.500	10.000	1.000
17/06/92	1135	1.600	62.000	0.600	0.770	8.000	52.000	1.500
10/08/92	1515	1.100	250.000	14.000	1.190	4.000	220.000	1.000

SM3 1993/01/11 08:58 ** Depth Average **

STATION : SM3
DEPTH : AVERAGE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1100	0.094	0.036	0.128	0.032	0.230	0.063	0.337	0.077
24/10/91	1240	0.047	0.028	0.039	0.017	0.350	0.065	0.347	0.080
11/12/91	1450	0.028	0.023	0.264	0.029	0.200	0.075	0.223	0.120
25/02/92	1225	0.013	0.034	0.043	0.002			0.063	0.130
01/05/92	1515	0.064	0.008	0.082	0.013			0.243	0.083
17/06/92	1135	0.032	0.029	0.070	0.018	0.340	0.050	0.517	0.047
10/08/92	1515	0.089	0.017	0.045	0.022			0.410	0.130

SM3 1993/01/11 08:58

STATION : SM3
DEPTH : SURFACE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1100	0.092	0.036	0.130	0.033	0.350	0.070	0.350	0.090
24/10/91	1240	0.064	0.034	0.050	0.019			0.300	0.040
11/12/91	1450	0.022	0.063	0.309	0.033			0.210	0.140
25/02/92	1225	0.015	0.034	0.044	0.002L			0.060	0.130
01/05/92	1515	0.060	0.011	0.143	0.016			0.310	0.080
17/06/92	1135	0.066	0.017	0.137	0.025			0.670	0.040
10/08/92	1515	0.108	0.002L	0.009	0.015			0.510	0.120

SM3 1993/01/11 08:58

STATION : SM3
DEPTH : MIDDLE
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1100	0.092	0.034	0.135	0.033	0.240	0.050	0.320	0.070
24/10/91	1240	0.042	0.026	0.030	0.017	0.460	0.070	0.470	0.120
11/12/91	1450	0.037	0.002L	0.274	0.027	0.190	0.060	0.250	0.110
25/02/92	1225	0.015	0.032	0.035	0.002L			0.080	0.120
01/05/92	1515	0.065	0.008	0.085	0.013			0.250	0.090
17/06/92	1135	0.015	0.035	0.043	0.012			0.470	0.030
10/08/92	1515	0.107	0.013	0.054	0.022			0.370	0.150

SM3 1993/01/11 08:58

STATION : SM3
DEPTH : BOTTOM
PERIOD BETWEEN : 1/ 8/1991 09:00
AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1100	0.099	0.038	0.118	0.031	0.100	0.070	0.340	0.070
24/10/91	1240	0.036	0.024	0.037	0.015	0.240	0.060	0.270	0.080
11/12/91	1450	0.025	0.003	0.268	0.028	0.210	0.090	0.210	0.110
25/02/92	1225	0.008	0.035	0.049	0.002L			0.050	0.140
01/05/92	1515	0.067	0.004	0.017	0.011			0.170	0.080
17/06/92	1135	0.015	0.034	0.030	0.016	0.340	0.050	0.410	0.070
10/08/92	1515	0.051	0.035	0.071	0.026			0.350	0.120

SOUTHERN WATERS 1992/09/26 10:00 ** Depth Average **

STATION : SM4

DEPTH : AVERAGE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0005	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1120	0.180	474.767	5.607	76.700	7.760	30.933	1.000	21.767	11.333
24/10/91	1425	0.320	518.800	5.900	84.333	8.203	33.067	1.800	23.733	4.800
11/12/91	1440	1.427	466.367	11.272	137.304	8.652	34.362	1.200	19.580	4.900
25/02/92	1240	0.690	400.967	7.367	89.433	8.053	32.050	2.000	15.267	3.367
01/05/92	1500	1.350	433.533	7.120	99.200	8.213	29.377	2.400	22.300	2.933

SOUTHERN WATERS 1992/09/26 10:00

STATION : SM4

DEPTH : SURFACE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0005	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1120	0.120	473.900	5.690	77.600	7.760	30.850	1.000	21.800	11.000
24/10/91	1425	0.260	519.600	5.970	85.600	8.210	33.040	1.800	23.900	4.200
11/12/91	1440	1.620	467.926	12.855	158.434	8.621	34.184	1.200	20.115	4.600
25/02/92	1240	0.740	402.400	7.410	90.300	8.050	32.030	2.000	15.500	3.100
01/05/92	1500	1.780	415.900	7.460	105.500	8.270	27.480	2.400	23.300	2.100

SOUTHERN WATERS 1992/09/26 10:00

STATION : SM4

DEPTH : MIDDLE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	BOD5 (MG/L) 0001	COND (UMHO/CM) 0003	DO (MG/L) 0004	DO(%SAT) (%) 0005	PH 0011	SALINITY (%) 0015	SD (METRE) 0016	TEMP Degree C 0020	TURB (NTU) 0025
16/08/91	1120	0.340	474.000	5.650	77.100	7.760	30.850		21.900	11.000
24/10/91	1425	0.340	518.200	5.820	83.200	8.210	33.030		23.700	4.900
11/12/91	1440	1.200	465.922	10.528	127.724	8.647	34.367		19.448	5.200
25/02/92	1240	0.710	400.000	7.420	89.900	8.060	32.040		15.200	3.200
01/05/92	1500	1.430	432.700	7.370	102.700	8.210	29.230		22.300	2.600

SOUTHERN WATERS 1992/09/26 10:00

STATION : SM4

DEPTH : BOTTOM

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

BOD5 (MG/L)	COND (UMHO/CM)	DO (MG/L)	DO(%SAT) (%)	PH	SALINITY (%)	SD (METRE)	TEMP Degree C	TURB (NTU)

DATE	TIME	0001	0003	0004	0005	0011	0015	0016	0020	0035
16/08/91	1120	0.080	476.400	5.450	75.400	7.760	31.100		21.600	12.000
24/10/91	1425	0.360	515.600	5.910	54.200	5.190	33.130		23.600	5.300
11/12/91	1440	1.460	465.254	10.432	125.754	5.687	34.535		19.176	4.900
25/02/92	1240	0.620	400.500	7.270	95.100	5.050	32.050		15.100	3.900
01/05/92	1500	0.540	452.000	6.530	39.400	5.160	31.420		21.300	4.100

SOUTHERN WATERS 1992/09/26 10:12 ** Depth Average **

STATION : SM4

DEPTH : AVERAGE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1120	0.700	68.000	3.100	1.090	12.333	69.000	1.000
24/10/91	1425	0.333	15.000	1.433	1.233	5.167	11.000	2.167
11/12/91	1440	0.267	50.333	0.567	1.333	6.833	43.667	1.167
25/02/92	1240	0.267	9.000	0.467	0.863	3.167	7.000	1.333
01/05/92	1500	1.433	25.333	0.433	1.007	4.000	21.000	1.333

SOUTHERN WATERS 1992/09/26 10:12

STATION : SM4

DEPTH : SURFACE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1120	0.800	68.000	2.600	1.110	12.000	68.000	1.000
24/10/91	1425	0.200	5.000	1.600	1.200	4.000	2.000	2.000
11/12/91	1440	0.300	49.000	0.500	1.400	6.500	37.000	1.500
25/02/92	1240	0.300	0.000	0.500	0.850	2.500	0.000	1.000
01/05/92	1500	1.100	6.000	0.400	1.400	3.000	5.000	1.000

SOUTHERN WATERS 1992/09/26 10:12

STATION : SM4

DEPTH : MIDDLE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0018	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/08/91	1120	0.600	68.000	4.200	1.090	12.000	68.000	1.000
24/10/91	1425	0.500	23.000	1.500	1.300	5.000	17.000	2.000
11/12/91	1440	0.300	63.000	0.300	1.300	7.000	63.000	1.000
25/02/92	1240	0.200L	12.000	0.700	0.880	3.000	10.000	2.000
01/05/92	1500	2.700	60.000	0.300	1.020	4.500	50.000	2.000

SOUTHERN WATERS 1992/09/26 10:12

STATION : SM4

DEPTH : BOTTOM

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	CHY (MG/M**3) 0002	FC (NO/100ML) 0006	PHAE (MG/M**3) 0012	SIL (MG/L) 0017	SS (MG/L) 0015	E.COLI (NO/100ML) 0029	TVS (MG/L) 0033
16/05/91	1120	0.500	63.000	2.500	1.070	13.000	65.000	1.000
24/10/91	1425	0.300	17.000	1.200	1.200	6.500	14.000	2.500
11/12/91	1440	0.200L	39.000	0.900	1.300	7.000	31.000	1.000
25/02/92	1240	0.300	15.000	0.200L	0.560	4.000	11.000	1.000
01/05/92	1500	0.500	10.000	0.600	0.600	4.500	5.000	1.000

SOUTHERN WATERS 1992/09/26 10:16 ** Depth Average **

STATION : SM4

DEPTH : AVERAGE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1120	0.083	0.034	0.118	0.030	0.277	0.050	0.340	0.057
24/10/91	1425	0.067	0.029	0.047	0.017	0.200	0.060	0.473	0.137
11/12/91	1440	0.023	0.042	0.332	0.035	0.197	0.090	0.217	0.127
25/02/92	1240	0.058	0.026	0.067	0.002			0.123	0.117
01/05/92	1500	0.064	0.007	0.076	0.011			0.250	0.073

SOUTHERN WATERS 1992/09/26 10:16

STATION : SM4

DEPTH : SURFACE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1120	0.080	0.032	0.119	0.033	0.280	0.050	0.340	0.060
24/10/91	1425	0.055	0.028	0.036	0.015			0.320	0.090
11/12/91	1440	0.023	0.060	0.348	0.041	0.220	0.090	0.220	0.140
25/02/92	1240	0.080	0.021	0.073	0.003			0.160	0.100
01/05/92	1500	0.054	0.011	0.123	0.012			0.290	0.070

SOUTHERN WATERS 1992/09/26 10:16

STATION : SM4

DEPTH : MIDDLE

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1120	0.088	0.037	0.116	0.028	0.300	0.050	0.360	0.050
24/10/91	1425	0.090	0.029	0.059	0.019			0.520	0.260
11/12/91	1440	0.025	0.038	0.314	0.034	0.190	0.100	0.220	0.120

25/02/92	1240	0.057	0.030	0.062	0.002L			0.120	0.130
01/05/92	1500	0.074	0.006	0.078	0.011			0.270	0.080

SOUTHERN WATERS 1992/09/26 10:16

STATION : SM4

DEPTH : BOTTOM

PERIOD BETWEEN : 1/ 8/1991 09:00

AND : 31/ 8/1992 18:00

DATE	TIME	NH4-N (MG/L) 0008	NO2-N (MG/L) 0009	NO3-N (MG/L) 0010	PO4-P (MG/L) 0014	TKNS (MG/L) 0022	TPS (MG/L) 0024	TKN(S+P) (MG/L) 0026	TP(S+P) (MG/L) 0027
16/08/91	1120	0.082	0.033	0.120	0.028	0.250	0.050	0.320	0.060
24/10/91	1425	0.065	0.029	0.047	0.018	0.200	0.060	0.280	0.060
11/12/91	1440	0.022	0.008	0.334	0.030	0.180	0.080	0.210	0.120
25/02/92	1240	0.036	0.027	0.065	0.002L			0.090	0.120
01/05/92	1500	0.063	0.005	0.026	0.011			0.190	0.070

END OF LISTING OF FILE :X16EPAW.ARCHIVEOUTLIB(1,*,1).SM1DETA(1) FOR USER :X16EPAW AT 1992/09/26__10:27:05

Appendix 6B

APPENDIX 6B

WATER QUALITY MONITORING BY

LAMMA ROCK PRODUCTS LTD

UNDER SUPERVISION OF

AXIS ENVIRONMENTAL

Table 6B.1 Date of Sampling - January 12th, 1993

Parameter	Units	Point 1			Point 2			Point 3			Point 4		
		S	M	B	S	M	B	S	M	B	S	M	B
Aesthetic Appearance	n/a	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
D.O.	mg/l	6.8	6.7	6.8	6.8	6.8	6.8	5.6	5.7	6.1	5.5	5.5	5.9
pH		-	8.0	-	-	8.0	-	-	7.9	-	-	7.9	-
Salinity	ppt	-	32	-	-	32	-	-	32.5	-	-	32.5	-
S.S.	mg/l	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-
NH_3-N	mg N/l	-	0.12	-	-	0.15	-	-	0.18	-	-	0.25	-
Inorganic - N	mg N/l	0.22	0.19	0.24	0.14	0.21	0.15	0.34	0.31	0.24	0.45	0.44	0.30
Phenols	mg/l	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-
E. coli	No./100ml	-	83	-	-	24	-	-	21	-	-	26	-

Table 6B.2 Date of Sampling - February 23rd, 1993

Parameter	Units	Point 1			Point 2			Point 3			Point 4			Point 5		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Aesthetic Appearance	n/a	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
D.O.	mg/l	6.1	6.1	6.2	5.9	5.9	6.0	5.6	5.5	5.6	5.2	5.3	5.2	5.6	5.6	5.6
pH		-	8.2	-	-	8.2	-	-	8.2	-	-	8.1	-	-	8.2	-
Salinity	ppt	-	32	-	-	31.5	-	-	31.5	-	-	31.5	-	-	32	-
S.S.	mg/l	-	3.8	-	-	4.4	-	-	3.4	-	-	3.2	-	-	N.D.	-
NH_3-N	mg N/l	-	0.08	-	-	0.16	-	-	N.D.	-	-	0.31	-	-	0.05	-
Inorganic - N	mg N/l	0.31	0.14	0.35	0.23	0.23	0.11	0.23	0.08	0.13	0.36	0.37	0.41	0.17	0.07	0.19
Phenols	mg/l	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-
E. coli	No./100ml	-	8	-	-	7	-	-	6	-	-	5	-	-	27	-

Table 6B.3 Date of Sampling - March 30th, 1993

Parameter	Units	Point 1			Point 2			Point 3			Point 4			Point 5		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Aesthetic Appearance	n/a	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
D.O.	mg/l	7.3	7.3	7.4	7.1	7.3	7.4	5.3	6.3	7.3	6.0	6.0	7.2	5.6	7.3	7.3
pH		-	8.0	-	-	8.0	-	-	8.0	-	-	7.9	-	-	8.0	-
Salinity	ppt	-	32.5	-	-	31.5	-	-	32.5	-	-	33.0	-	-	33.0	-
S.S.	mg/l	-	4.6	-	-	5.4	-	-	6.4	-	-	4.2	-	-	6.2	-
NH_3-N	mg N/l	-	0.05	-	-	0.09	-	-	0.10	-	-	0.25	-	-	0.05	-
Inorganic - N	mg N/l	0.40	0.39	0.31	0.40	0.29	0.33	0.51	0.32	0.29	0.50	0.47	0.31	0.49	0.24	0.24
Phenols	mg/l	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-
E. coli	No./100ml	-	4	-	-	21	-	-	18	-	-	18	-	-	21	-

Table 6B.4 Date of Sampling - April 27th, 1993

Parameter	Units	Point 1			Point 2			Point 3			Point 4			Point 5		
		S	M	B	S	M	B	S	M	B	S	M	B	S	M	B
Aesthetic Appearance	n/a	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
D.O.	mg/l	7.2	7.2	6.9	6.8	7.1	6.9	5.1	7.0	6.7	6.3	6.4	5.6	7.3	7.1	6.6
pH		-	8.0	-	-	8.0	-	-	8.0	-	-	8.1	-	-	8.1	-
Salinity	ppt	-	32.0	-	-	31.0	-	-	32.5	-	-	32.0	-	-	32.5	-
S.S.	mg/l	-	3.2	-	-	ND	-	-	2.8	-	-	3.6	-	-	3.0	-
NH_3-N	mg N/l	-	0.06	-	-	0.10	-	-	0.12	-	-	0.15	-	-	0.09	-
Inorganic - N	mg N/l	0.43	0.29	0.27	0.40	0.25	0.35	0.57	0.29	0.31	0.48	0.30	0.53	0.31	0.23	0.35
Phenols	mg/l	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-	-	N.D.	-
E. coli	No./100ml	-	48	-	-	12	-	-	43	-	-	26	-	-	17	-

Notes:
S - 1m below surface
M - Mid-depth
B - 1m above sea bed

Detection Limits:
Phenols - 0.1mg/l
Suspended solids - 2.5mg/l
Ammonia - 0.05
N.D. - None detected
ppt - parts per thousand
mg/l - milligrams per litre

Appendix 7

APPENDIX 7

ABBREVIATIONS

ABBREVIATIONS

Measurements

Technical units of measurement in this report are based on the International System of Units (SI) wherever possible. These technical units may be broadly grouped as prefixes and measurements. A prefix applies to the unit of measurement that immediately follows it - for example microgram is abbreviated as μg. Superscripts ^{2} and ^{3} following a linear unit indicate area and volume - for example m^2 (square metres) and m^3 (cubic metres). Different units are combined by a full stop (.) to differentiate units of the same exponential sign, and a solidus (/) to indicate 'per'. For example, kilometres per hour is abbreviated as km/h, while megalitres per day per square kilometre is $Ml/d.km^2$.

The prefixes used in this report are:

k	kilo	1,000
m	milli	0.001
μ	micro	0.000,001

Units of measurement which have been used are:

yr	year
dBA	decibel, frequency weighting network A
°C	degrees Celsius
g	gram
hr	hour
ha	hectare
Hz	hertz
l	litre
L_{eq}	equivalent sound power level
L_{90}	sound power level exceeded 90% of the time
m	metre
pH	degree of alkalinity/acidity
%	per cent
s	second
t	tonne

Miscellaneous

AFD	Agriculture and Fisheries Department
AQO	Air quality objective
ANL	Acceptable noise level
AS	Australian Standard
ASR	Area Sensitivity Rating
BNL	Base Noise Level
BOD	biochemical oxygen demand
BOD_5	biochemical oxygen demand (five-day test)
BS	British Standard
CED	Civil Engineering Department
CNP	construction noise permit
DO	dissolved oxygen
EIA	Environmental Impact Assessment
EM&A	Environmental Monitoring and Audit
ENM	Environmental Noise Model
EPD	Environmental Protection Department
FCZ	fish culture zone
HKPSG	Hong Kong Planning Standards and Guidelines
LAR	Lantau Airport Railway
N/A	not applicable
N/D	not detected by analysis in sample
NTU	nephelometric turbidity units
NSR	noise sensitive receiver
PD	principal datum
®	registered trade name
SWL	Sound Power Level

SPL	Sound pressure level
SS	suspended solids
TSP	total suspended particulate
USEPA	United States Environmental Protection Agency
VEPA	Victorian Environment Protection Authority
WPCO	Water Pollution Control Ordinance
WQCZ	Water quality control zone
WQO	Water quality objective
ZVI	Zone of visual Influence

Appendix 8

APPENDIX 8

GLOSSARY

Atmospheric stability	-	A measure of the tendency of a vertically displaced parcel of air to return to its original position (stable conditions), increase its displacement (unstable conditions), or remain where it is (neutral conditions). Strong heating of the land surface lends to instability (convection); strong cooling leads to stability (inversions).
AUSPLUME	-	Air modelling software package developed on behalf of the Victoria Environment Protection Authority, from the US EPA's Industrial Source Complex Model (ISCST) used to simulate the dispersion of dust in the present study.
Baseline Data	-	Data collected, to be used as a reference for all work or changes occurring from that time on.
Batter angle	-	Angle of inclination from the perpendicular of a constructed wall e.g. drop cut/basin walls.
Bedrock	-	Solid rock underlying alluvial deposits.
Caisson	-	Vertical hole drilled for the purpose of laying foundations.
Dewatering pumps	-	Pumps that allow removal of water from bulk fill material or the ground by suction pumping to provide a dry working environment within trenches and open cuts.
Dispersion model	-	Computer software used to predict dispersion of pollutants.
Drop cut	-	A normal and typical quarry process consisting of vertical excavation into a horizontal surface.
Equivalent noise level (L_{eq})	-	The constant noise level equivalent to the A-weighted sound pressure level of the actual noise at the measurement site over the sampling period.
ISCST	-	Industrial Source Complex Model. US EPA air dispersion modelling software.
Kicker wall	-	Reinforced concrete structure that vertically projects from a horizontal concrete slab. It allows add-on concrete structures to be formed.
Mitigation measures	-	measures incorporated into an operation to minimize environmental impact.

Mixing height	- Height through which ground level emissions would ultimately be mixed if particle deposition was not taking place.
Pasquill - Gifford	- a relative index used to define atmospheric stability.
Respirable suspended particulates (RSP)	- fine atmospheric particulate matter of nominal aerodynamic diameter of 10μm and smaller. These particulates, after inhalation, can penetrate deeply into human respiratory tract.
Rock armour	- large quarried rocks used for marine break waters and piers.
Sound power level (SWL)	- a measure, in decibels, of the acoustic power radiated by a given noise source. It is independent of any reference distance or other extraneous factors.
Sound pressure level (SPL)	- a measure, in decibels, of the sound pressure at a particular point. It is dependent upon distance from the source and many other extraneous factors.
Total suspended particulates (TSP)	- atmospheric particulate matter comprising size fractions less than about 75μm in diameter.
Windrose	- Circular graphical representation upon which wind direction, speed and frequency are plotted.

Appendix 9

APPENDIX 9

REFERENCES

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Appendix 10

APPENDIX 10

RECOMMENDATIONS OF ENVIRONMENTAL CLAUSES TO BE INCLUDED IN THE CASTING BASIN CONTRACT

APPENDIX 10.

RECOMMENDATIONS FOR ENVIRONMENTAL CLAUSES TO BE INCLUDED IN THE QUARRY LEASE AND CASTING BASIN CONTRACT CONDITIONS

A list of recommendations for inclusion as environmental clauses in the quarry lease and casting basin contract conditions are provided below:

Air Pollution Control

-	the operator shall take all necessary steps to ensure that fugitive dust from the premises do not exceed the *Air Quality Objectives* when measured at or beyond the boundary of the premises	*Quarry*
-	the operator shall undertake a site inspection audit to determine an action list prioritizing the measures for control of fugitive dust	*Quarry*
-	the operator shall comply with relevant legislation regarding "specified processes" including compliance with associated "Best Practicable Means (BPM) requirements	*Casting Basin & Quarry*
-	comply with the EM & A schedules	*Casting Basin & Quarry*

Noise

-	ensure that prior to any night-time work being undertaken monitoring is carried out to confirm the acceptability of the noise produced by the casting basin operations	*Casting Basin*
-	where ever possible to utilise electrically powered plant e.g. cranes	*Casting Basin*
-	construction and industrial additional overall equipment noise levels to be <45dBA and <50dBA respectively at the nearest NSR	*Casting Basin*
-	comply with the EM & A schedules	*Casting Basin & Quarry*
-	ensure a Construction Noise Permit be obtained prior to undertaking any work within restricted hours	*Casting Basin*

Waste

-	ensure that prior to the basin being flooded a full and thorough manual clean-up of the casting basin is carried out and subsequently checked by a senior member of staff	*Casting Basin*
-	ensure that prior to the basin being flooded and after the manual clean-up the casting basin is washed down. The waste water generated by the basin washdown must be transferred to the surface treatment tank before discharge	*Casting Basin*
-	ensure that after the casting basin is flooded and prior to the seagates being fully opened any floating materials are removed and are disposed of in an appropriate manner	*Casting Basin*
-	ensure that the monitoring programme as specified in the EM & A schedules is followed and complied with	*Quarry & Casting Basin*

Water

-	ensure that the use of phenolic compounds is, if possible, prohibited	*Casting Basin*
-	ensure that the location of the sewage treatment plant (STP) discharge point is agreed with AFD and EPD	*Casting Basin*
-	ensure that the discharge licence requirements for the STP and the surface treatment tank are complied with	*Casting Basin*
-	ensure that any refuelling of the plant equipment is, where possible, carried out outside the basin	*Casting Basin*
-	ensure that any water pumped out of the basin passes through the surface treatment tank prior to discharge	*Casting Basin*
-	ensure that any maintenance of the plant equipment is carried out outside the basin	*Casting Basin*
-	ensure that the preparation of the formwork is carried out outside the basin, including the cleaning and application of mould oils/release agents	*Casting Basin*
-	ensure that the concrete curing process employed is, where possible, carried out through the use of curing membranes	*Casting Basin*
-	ensure that the casting basin seagates are only opened on an ebb tide	*Casting Basin*
-	ensure that prior to the casting basin being flooded and the seagates opened AFD, EPD and Marine Department are informed	*Casting Basin*
-	ensure that the monitoring programme as specified in the EM & A schedules is followed and complied with	*Casting Basin & Quarry*

AXIS

Environmental

Environmental Consultants Ltd.