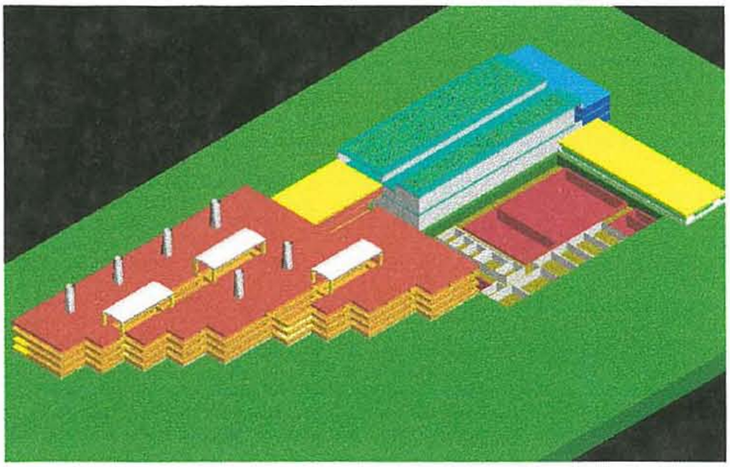

SHEUNG SHUI SLAUGHTERHOUSE

SUPPLEMENTARY ENVIRONMENTAL IMPACT ASSESSMENT

FINAL REPORT

prepared by
ENVIRO-CHEM ENGINEERING & LABORATORY CO., LTD

15 August 1995
(Revision B)

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Report Control Number : 004
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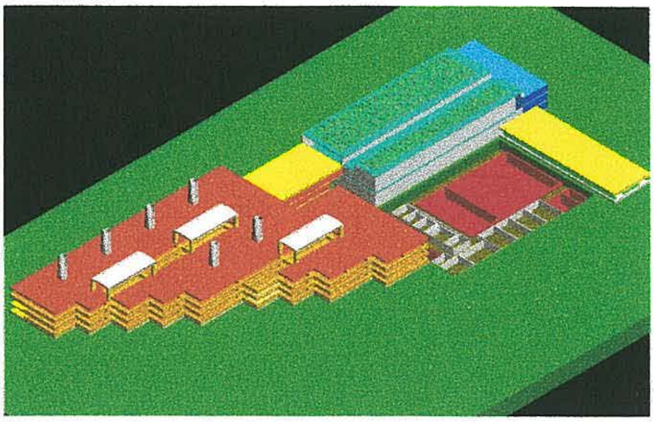
List of Abbreviations

AFD	Agriculture & Fisheries Department
ANL	Acceptable Noise Level
APCO	Air Pollution Control Ordinance
AQO	Air Quality Objective
ASRs	Air Sensitive Receivers
BNL	Basic Noise Levels
BOD	Biochemical Oxygen Demand
BPP	By-Product Plant
CIF	Centralised Incinerator Facilities
CAS	Conservational Activated Sludge
CNL	Calculated Noise Level
CNP	Construction Noise Permit
CNRs	Construction Noise Receivers
COD	Chemical Oxygen Demand
CWR	Waste Disposal (Chemical Waste) (General) Regulation
DAF	Dissolved Air Flotation
DIA	Drainage Impact Assessment
DSD	Drainage Services Department
ECEL	Enviro-Chem Engineering and Laboratory Co. Limited
EIA	Environmental Impact Assessment
EPD	Environmental Protection Department
FDM	Fugitive Dust Model
HSWTF	High Strength Wastewater Treatment Facilities

KCR	Kowloon Canton Railway
KCRC	Kowloon Canton Railway Company
L1	Level 1
L2	Level 2
L3	Level 3
LSWTF	Low Strength Wastewater Treatment Facilities
LWK	Live weight killed
NENT	North East New Territories
NFH	Ng Fung Hong
NSRs	Noise Sensitive Receivers
O&G	Oil and Grease
PRC	People's Republic of China
RBC	Rotating Biological Contractor
SBR	Sequential Batch Reactor
SC	Sewage Charge
SEIA	Supplementary Environmental Impact Assessment
SENT	South East New Territories
SMP	Sewerage Master Plan
SOA	Schedule of Accommodations
SRs	Sensitive Receivers
SS	Suspended solids
SSS	Sewage Strategy Study
SSSH	Sheung Shui Slaughter House
STP	Sewage Treatmant Plants

SWHSTW	Shek Wu Hui Sewage Treatment Works
SWL	Sound Power Levels
TES	Trade Effluent Surcharge
TKN	Total Kjeldahl Nitrogen
TM1	Technical memorandum on Noise from Construction work other than Percussive Piling
TM2	Technical memorandum on Noise from Percussive Piling
TM3	Technical memorandum for the Assessment of Noise from places other than Domestic Premises, public places, or construction sites
TSP	Total Suspended Particulates
TTM	Total toxic metal
WNT	West New Territories
WWTP	Wastewater Treatment Plant



1. INTRODUCTION

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Background to the Supplementary Environmental Assessment

1.1 In August 1993, the Architectural Services Department (ASD) commissioned an Environmental Impact Assessment (EIA) of the proposed Sheung Shui Slaughterhouse (SSSH).

1.2 In May 1995, the ASD commissioned Enviro-Chem Engineering and Laboratory Co. Limited (ECEL) to carry out a Supplementary Impact Assessment (SEIA) of the revised proposals for the SSSH. (Appendix 1)

The Supplementary Environmental Impact Assessment

1.3 The Administration has decided that the SSSH should be a Government-funded project. Management of the SSSH will fall under the auspices of a private operator which will be subject to acceptance and suitable arrangements made with the Government.

1.4 The Environmental Protection Department (EPD) supports the proposition for the SSSH development which will facilitate the closure of the abattoirs at Kennedy Town, Cheung Sha Wan, and Yuen Long. The EPD, after an initial review, deemed the Sheung Shui site to be environmentally suitable but indicated that detailed control measures needed to be set.

1.5 The extensive and detailed SEIA will include necessary mitigation and environmental protection measures required for, and associated with, the slaughterhouse development.

1.6 The slaughterhouse will have daily throughput capacity of 5,000 pigs and 400 cattle. In addition, some goats will be slaughtered in the winter months (overall several hundred). There will be holding spaces for 12,000 pigs (2.5 days supply), 2,200 cattle (5.5 days supply) and 300 goats. Two options for dealing with slaughter by-products will be considered; building a full-scale by-products plant (BPP) as an ancillary facility to the slaughterhouse, and building a reduced scale BPP. No on-site incineration facility shall be built. If the fate of the Centralised Incinerator Facilities (CIF) is indefinitely delayed, the BPP issue shall be re-evaluated.

Purpose of the SEIA Study

1.7 The purpose of the SEIA is to provide specific information on the individual and cumulative environmental impacts resulting from the development and subsequent operation of the SSSH. This information encourages and aids decision-making concerning:-

- the conditions, requirements, and necessary environmental protection measures necessary based upon the given design, implementation and development proposals, and suggested operation as agreed upon by the Government and future private operator; and
- the level of acceptance for any possible residual impacts which occur after the implementation of available mitigation measures.

1.8 The SEIA will have as its focus the SSSH, and the ancillary BPP, but will discuss other on-site and off-site impacts which are associated with the SSSH development and operation.

Objectives of the SEIA Study

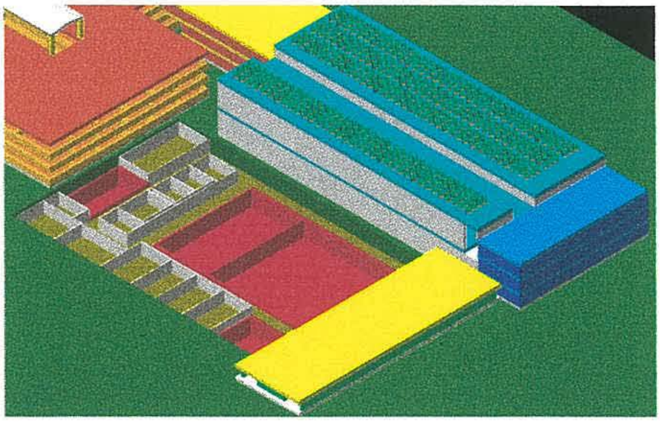
1.9 The objectives of the supplementary environmental impact assessment are as follows :-

- to describe the proposed development and the associated requirements for successful implementation;
- to identify and discuss the aspects of the surrounding community and environment which are likely to be affected by the proposed development;
- to identify, assess, and evaluate the cumulative and net (i.e. after practicable mitigation) environmental impacts expected to arise during the construction and operation phases of the slaughterhouse with due consideration of surrounding land areas and water sources;
- to indicate specific infrastructure provisions and/or mitigation measures capable of minimizing pollution, environmental disturbances, and other nuisances during construction and operation of the slaughterhouse;
- to identify, specify, and evaluate proposed standards and the corresponding measures through which those standards, agreed upon in the contractual agreement between the Government and proponent, may be achieved. Measures which mitigate any negative environmental impacts and reduce them to acceptable levels will also be identified and evaluated;
- to design and specify the environmental monitoring techniques and audit requirements necessary to ensure the efficacy of the environmental protection measures adopted.

General requirements of the SEIA Study

1.10 To meet all of the objectives listed in section 9 above including :-

- the performance of necessary environmental surveys and baseline monitoring tests which will enable the achievement of proposed objectives;
- the quantification of cumulative environmental impacts which may arise during the slaughterhouse development (models or other predictive methods may be used for this);
- the proposition of pragmatic, efficient, effective, and enforceable measures necessary for the mitigation of any significant negative environmental impacts, both short-term and long-term;
- the outlining of a programme through which environmental impacts of the slaughterhouse development may be adequately monitored, audited, and altered, if so required.



2. THE PROPOSED DEVELOPMENT

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Site layout

2.1 The proposed site will be located in Sheung Shui (Figure 2.1a and 2.1b(enlarged)) adjacent to, and north of, the existing Shek Wu Hui Sewage Treatment Works (SWHSTW). The site limit is bounded by the Kowloon Canton Railway (KCR) line to the west and the River Indus to the east. The proposed layout of the slaughterhouse and Schedule of Accommodations (SOA) is given in Appendix B. The slaughterhouse is designed to have a daily slaughter capacity of 5,000 pigs and 400 cattle. In addition, several hundred goats will be slaughtered during winter months. It will consist of specific blocks allocated to the various different activities relating to the slaughterhouse, i.e. lairage, slaughterlines, viscera handling areas, and administration. An operational flow diagram (Figure 2.2) illustrates the sequence of activities in the proposed slaughterhouse.

Kowloon-Canton Railway Siding & Unloading Area

2.2 This area is situated to the west of the slaughterhouse and will contain livestock unloading bays which will be linked to the wholesale lairage area via ramps and livestock walkways. It will accommodate the arrival of two trains per day at 12:00 and 16:00 for an individual duration of 4 hours each. Livestock destined for Tsuen Wan Abattoir can be unloaded to lorries for immediate delivery. The healthy Tsuen Wan pigs pigs may be permitted to be immediately transferred to lorries bound for Tsuen Wan via movable ramps with inspection platforms to transfer the pigs. Livestock designated for the proposed SSSH will be unloaded immediately and directed to the wholesale lairages where Agriculture and Fisheries Department (AFD) officers will make visual and radioactive monitoring inspections. One common office will be provided for AFD's siding and lairage staff. This should be built near the railway siding for easy monitoring and checking of imported livestock.

Lairage Block (3 storeys)

2.3 The lairage will consist of wholesale (ground floor) (L1), holding (L1 to L3), and isolation lairages (L1). Lairage capacity will provide a 2.5 day's supply of pigs and a 5.5 day's supply of cattle. Straw bedding will be provided for cattle only. Pig lairages should be provided with a fine water spray mechanism to reduce stress during hot weather. All lairages will provide drinking and feeding troughs. Fodder for pigs and cattle will be stored on the L1 to roof level. Levels will be connected by ramps and a goods lift. The lairage layout should incorporate modern designs to ensure minimal stress imposed on the animals e.g. use of equipment fitted with noise reduction measures, etc. Since the holding period for livestock will be considerably lengthy, due consideration should be given to ventilation, lighting, and suitable floor surfaces. It may be feasible to semi-enclose the waiting lairage, to reduce excessive noise levels, but to install acoustically treated louvres to ensure sufficient ventilation.

Odour neutralizing sprays will be randomly used in the lairage area, directly administered to the point source by a manually operated fogger or hose set on a sprinkle setting. Government departments have agreed to the usage of odour neutralizing agents, which current research and practice shows, actively improves air quality rather than damaging it They are extremely effective in countering escalating atmospheric ammonia content which causes high-intensity odourous emissions and "red eye" in pigs which is detrimental to the animals well being. It stressed that although the neutralizing agents will be used in areas used for holding the livestock, it will only be utilized when the animals are not present and will not be applied to the animals directly.

2.4 Lairage facilities should also provide hydrant points. Passageways should be sufficiently wide to allow for the routine cleaning of troughs and to facilitate the collection and removal of livestock manure. Livestock will be directed from wholesale lairages via ramps between floors to holding lairages (L1 to L3), and finally to waiting lairages prior to slaughter. Total approximate area allowed for the lairage block is 33500m^2.

There will be dealer's offices among the holding lairage area, and roof offices for private operator's staff and wholesaler's staff who work in the lairage block.

2.5 Manure (livestock waste and bedding) will be removed from all lairages and directed to two manure collection rooms situated at opposite ends of the lairage block. Removal of manure from lairages on the L2 and L3 will be via manure chutes connected to manure collection rooms.

Slaughter Block (2 storeys)

2.6 There will be 4 slaughter lines (3 lines for pigs and 1 for cattle) where pigs and cattle will be slaughtered, dressed, and by-products (blood, bone, offal, etc.) separated. Suckling pigs and goats will be slaughtered in separate small slaughter rooms. The operation hours of slaughter activities along the slaughter lines will be as follows:

Table 2.1: Pattern of generation of slaughterhouse activity

Activity	Pattern of Generation
Cattle Stunning	0200-1000
Pig Stunning	0200-1200
Cattle Slaughter	0200-1000
Pig Slaughter	0200-1200

2.7 The livestock slaughter lines will be located on the L2 which will also accommodate the RSD Health Inspector's office and laboratory situated between the cattle and pig slaughter lines. The L1 will accommodate the blood coagulation room and pig and cattle viscera handling areas.

2.8 Pigs will be directed to the stunning area and hoisted onto an overhead bleeding rail. After bleeding, pigs are scalded, and then scraped to remove hair. Mechanized de-hairers and automatic singeing equipment will probably be required at the slaughterhouse but will ultimately depend upon market specifications. The pig stunning area should be well-ventilated and lighting and suitable non-slip flooring should be installed to minimize stress prior to stunning. A high level of hygiene should be maintained to avoid hide contamination.

By-Products (Assuming a reduced-scale BPP)

2.9 Blood will be collected in blood tanks and transferred to the Blood Coagulation Room situated on the L1. It will then be processed, i.e. centrifugation and coagulation, to achieve a 25% solid content which has been agreed to be acceptable, by EPD requirements, prior to landfill disposal.

2.10 Conveyor corridors and descenders will transfer carcasses from the slaughter hall to the pig and cattle viscera handling areas on the level 1. Approximately 100 working stations will facilitate leg and hide removal, evisceration, pancreas removal, etc. Porkers, roasters, and cattle will be transferred to the porker meat dispatch area, to roaster chiller rooms, and to beef chiller rooms respectively. A continuous, conveyor line system will be used for efficient and systematic dressing of livestock.

2.11 Inedible products, discarded offal (such as entire suckling pig offal), and paunch contents are directly removed and transferred to the manure collection room for storage prior to off-site disposal. As a result of routine washing of the viscera handling areas, discarded offal and paunch contents will also accumulate in the drainage network as fine screenings. These will then be removed and transferred to the manure collection room prior to off-site disposal as solid waste.

Condemned Meat & Dead Carcasses

2.12 After AFD inspection of livestock in the wholesale/holding lairages, the diseased animals will be transmitted via a loading bank to the isolation slaughter area situated on the L1 parallel to the blood coagulation room. This will be completely segregated from the lairage block and from all other slaughter activities by a driveway to ensure that cross-contamination does not occur. The slaughtered carcasses will be then be transferred for storage to freezer facilities located within the isolation slaughter facility. The slaughterhall ventilation system exhaust will remove odour from the hall to be appropriately treated.

2.13 Dead carcasses will be removed from all unloading wagons and trucks upon arrival at the slaughterhouse and also during routine operation from all lairages within the slaughterhouse. Carcasses will be then transferred via trolleys and lift to the condemned meat loading area and on to the condemned chiller room prior to off-site disposal. Disposal of these carcasses would be at the proposed CIF. Condemned meat/offal from the veterinary and inspector's laboratories will also be transferred to the condemned meat loading area.

By-Products Plant Option

2.14 If an indefinite delay occurs in the commissioning and operation of the CIF, the existence of a BPP should be re-evaluated. A BPP, would provide a potential alternative option to the disposal of condemned meat and raw blood. A modern BPP would convert inedible by-products (animal carcasses, condemned meat and offal, and raw blood) to saleable, products i.e. meat and bone meal, blood meal, and tallow. The plant would select modern, efficient process technologies such as dry-batch rendering and continuous blood coagulation.

2.15 Odourous emissions from a BPP are significantly high and are a major environmental concern, particularly odours generated from the cooker/dryer of meat and bone meal, and blood meal plants. Efficient odour control equipment and provision of an odour monitoring program would be required to comply with regulations under the Air Pollution Control Ordinance (Cap.311) for rendering of animal matter.

Meat Dispatch Area

2.16 The meat dispatch area will consist of a single storey building located adjacent to the slaughterhouse. The meat truck washing bay will be separate from the meat loading bay so as to ensure efficient and systematic coordination of meat transfer from meat hooks to transport vehicles. A high standard of hygiene should be maintained in this area at all times.

Administration Block (low-rise)

2.17 The administration block will accommodate staff amenities including a canteen and pantries. Training facilities for meat inspectors such as a classroom and a veterinary laboratory will also be provided. Provision of amenities such as changing rooms, lavatories, etc. for staff working within different areas of the slaughterhouse will also ensure that a high standard of hygiene is maintained and that cross-contamination is avoided.

Wastewater Pre-Treatment Plant

2.18 The wastewater pre-treatment plant will be located on the South-Eastern side of the slaughterhouse. The proposed plant will be situated underground in order to minimize negative odour and visual impact. Contaminated trade effluent from washwaters within working areas of the slaughterhouse, railway siding washing and runoff, by-product handling, and domestic facilities will be treated in compliance with standards of the EPD-recommended "Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters".

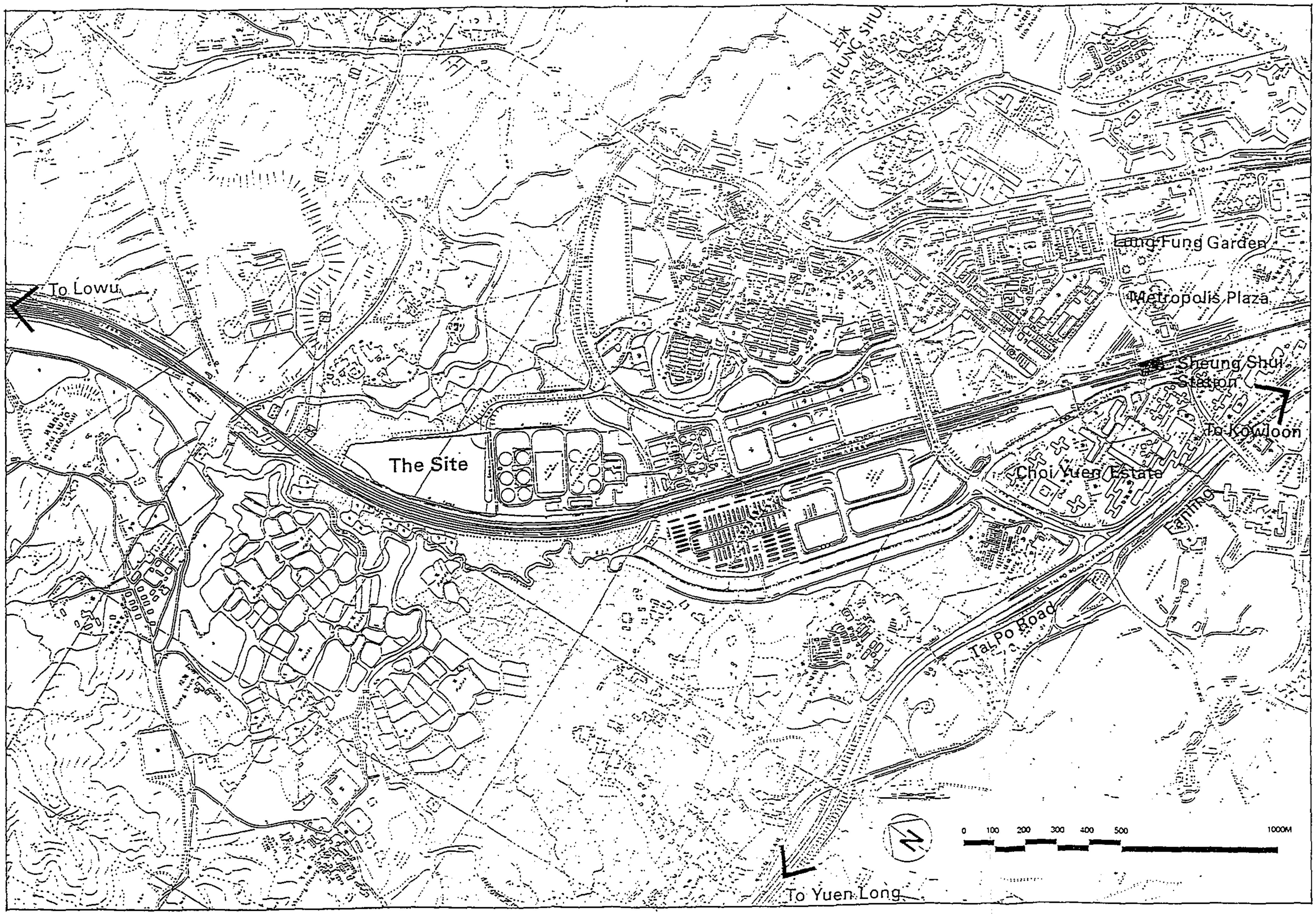


Figure 2.1a Location Map of Sheung Shui Slaughter House

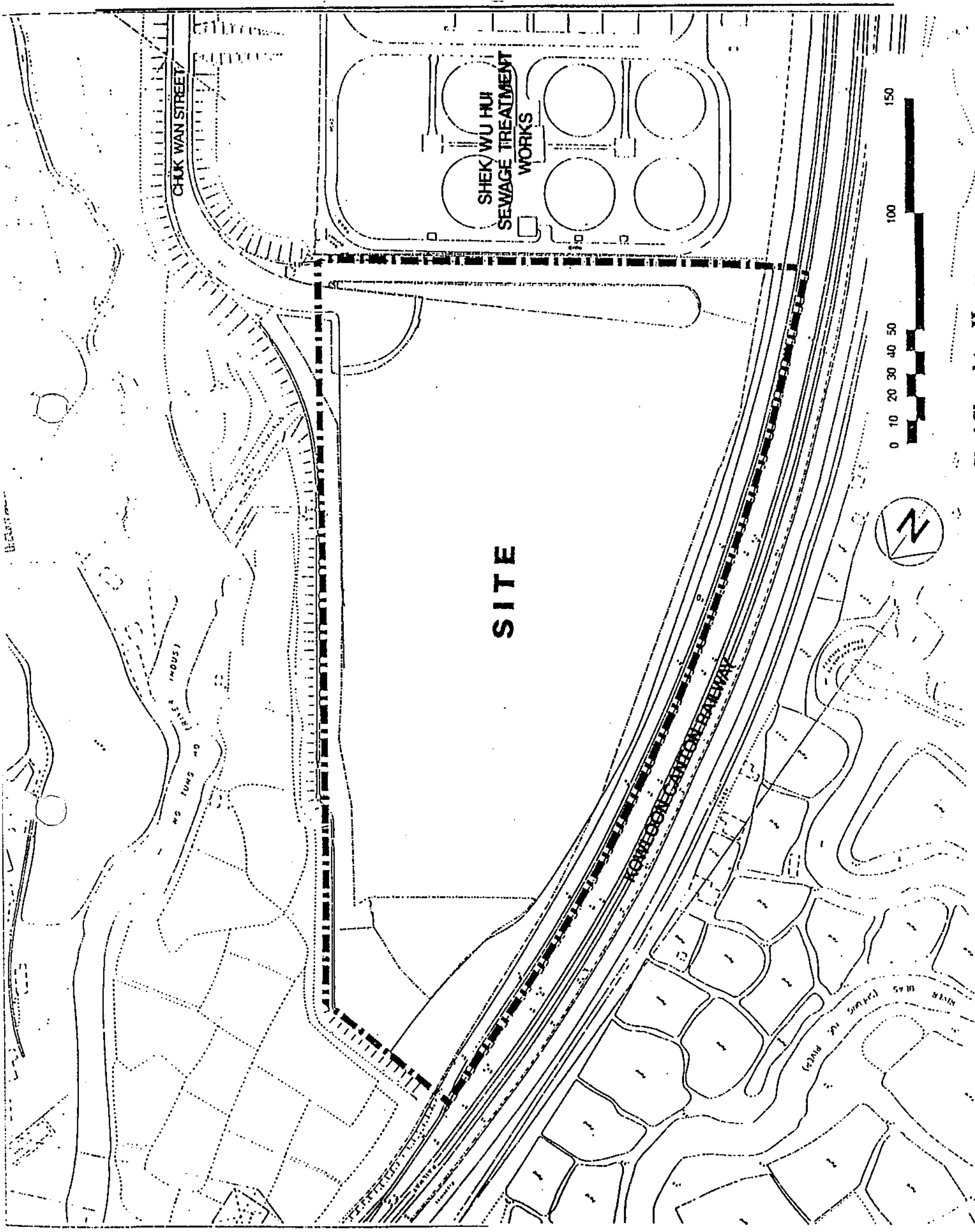
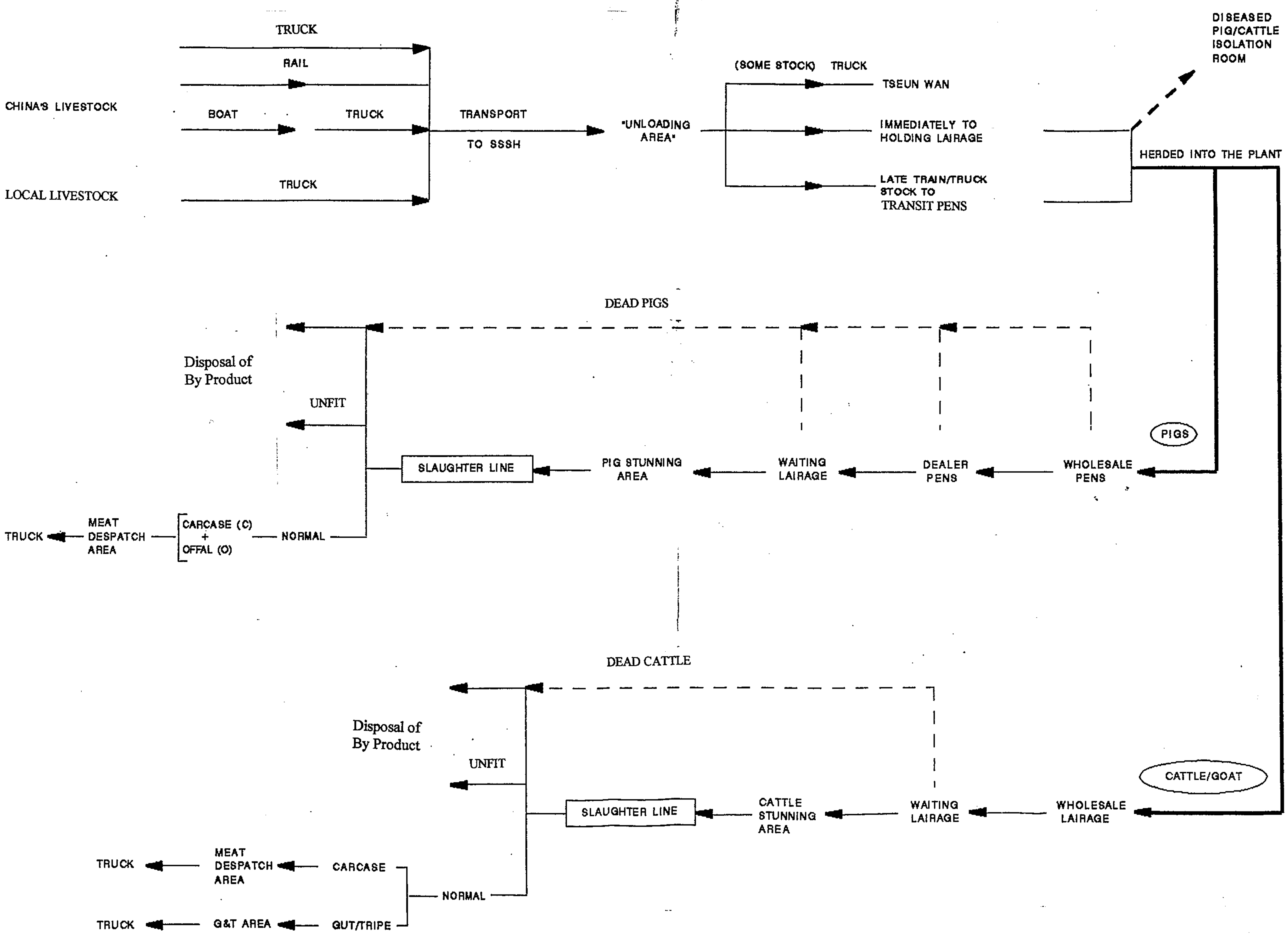
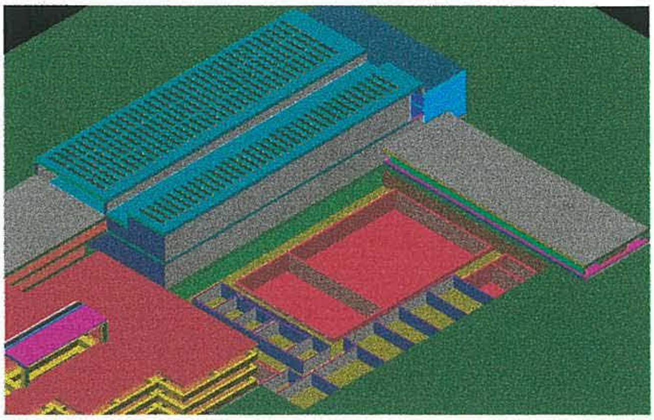


Figure 2.1b Enlarged Location Map of Sheung Shui Slaughter House

Figure 2.2 Operational Flowchart of Slaughter House Activities





3. THE STUDY AREA

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Existing Environment

3.1 The Study Site is situated to the north of the existing SWHSTW on low-lying ground. The KCR forms the western boundary with ponds and agricultural land beyond to the north and east. The existing land uses include fish and duck ponds, farmland, and some low density village houses.

3.2 The Site is derelict and partly fenced. A section of the site has mounding and is grass-covered, the remainder being covered with tarmac.

3.3 The Study Site is situated in a relatively rural area where there are no dominant noise-generating industrial land uses. The only significant noise source in the present environment is that of train noise from the KCR line located to the west of the Site. Apart from train noise, the background noise and level thereof is typical of that of a rural setting.

Baseline Monitoring

Air pollution

3.5 The only industrial activity in the Study Site that contributes to air pollution is the neighbouring SWHSTW. The treatment works services the local area including Sheung Shui and Fanling and consists of a primary and secondary treatment facility. The design capacity of the works is 60,000 m^3/day. The Consultants of the North District Sewerage Master Plan have proposed, in their Interim Report, for an extension of the SWHSTW to cope with the anticipated increase in sewage treatment capacity.

3.6 There are no major roads in the Study Area. The nearest major road is the Castle Peak Road - Kwu Tung Road which is over 1000 m away from any of the Sensitive Receivers (SR's) (Figure 3.1) considered for the Study and the proposed Site.

3.7 Since the slaughter house will now be situated in close proximity to SWHSTW, there may be potential contamination of dispatch areas by micro-organisms. Therefore, the assessment of airborne micro-organisms in SWHSTW is recommended for consideration. Also, odour from the sewage inlet points, aeration tanks, and classifiers affects the present air quality environment. Aerosols released from the water surface in the works during aeration contribute to air quality impact and may have potential public health effects. Micro-organisms including bacteria, viruses, and fungi in aerosol could be dispersed in the direction of the proposed slaughter house site from the treatment works. Should such contamination actually occur, mitigation measures would be necessary, carried out by careful on-site management.

3.8 Background Total Suspended Particulates (TSP) measurements have been performed for the Study Area and the results are summarised in Table 3.1. High volume samplers measured particulate levels for 24-hours. Under the action of the high volume motor, air was drawn through a pre-conditioned filter paper and the concentration of TSP in the air was then determined gravimetrically. Concentration of TSP was determined by the equation:

$$TSP = \frac{(W_f - W_i) \times 10^6}{Q \times T}$$

where TSP = Concentration of TSP, µg/m^3
W_f = Weight of exposed filter paper, g
W_i = Tare weight of filter, g
Q = Average standard flow rate, m^3/ min
T = Sampling time, min

Table 3.1 Results of Background Air Monitoring for TSP at Lo Wu Camp

Date	Tare Weight of Filter Wi (g)	Final Weight of Filter Paper W_f (g)	Flow rate Q (m^3/min)	Duration T (min)	Concentration (µg/m^3)
3/3	2.8243	3.0216	1.77	1440	77.4
4/3	2.8126	3.0003	1.74	1440	74.3
5/3	2.8173	3.0413	1.77	1440	87.9
7/3	2.8239	3.0228	1.74	1440	79.4
8/3	2.8111	2.9730	1.72	1440	65.4
9/3	2.8121	2.9955	1.74	1440	73.2
10/3	2.8224	3.0001	1.74	1440	71.2

Noise Pollution

3.9 The KCR line is used for three train services as follows :-

(a) the high speed electrified train service runs 7 days a week, between Lo Wu and Hung Hom Termini and has a daily patronage of 500,000 passengers. Approximately 550 passenger trains run each day on the commuter services;

(b) the high speed diesel-powered passenger service using People's Republic of China (PRC) rolling stock and locomotives. This service is operated as a non-stop passenger service from Hung Hom to Guangzhou. Approximately five round trips are made daily; and

(c) the diesel powered freight service linking the PRC railway network for transportation of livestock and other using KCR locomotives and PRC rolling stock. Approximately 20 round trips are made daily.

3.10 Table 3.2 presents the measured maximum noise levels arising from KCR trains. This table also shows the speeds at which the noise was from railway lines. It should be noted that these measurements were not taken from the SR's shown on Figure 3.1, but from Sheung Shui Station (see Figure 7.6).

Table 3.2: Range of Maximum Noise Levels arising from KCR Train Pass-by Events at Sheung Shui Station.

Train Type	Train Speed km/hr	Maximum Level	L_{max} dB(A)
Passenger-electric	15-44	60-63	59-66
Freight-diesel	16-36	65-85	65-85

3.11 It should be noted that the diesel train noise remained much the same irrespective of the speed. However, the converse is true for the electrified trains which generate higher noise levels as the speed increases.

3.12 The background level was measured at NSR2 (see Figure 3.1) during baseline studies for this KCR train noise Study. Noise measurements were taken at NSR2 at Sheung Shui from 15 March to 16 March 1994 over a 24-hour period. The results for this are shown in Table 3.3. It was confirmed that the major noise source is that of train noise. The background noise level (24-hour L_{90}) was calculated to be 45.5 dB(A). As NSR2 (Lo Wu Camp) is one of the closest sensitive receivers this location was chosen for measurements.

Table 3.3: Background Noise Measurement at Sheung Shui

Date	Time	Noise Levels dB(A)				
		L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}
15/03/95	1100-1200	53.3	49.1	46.0	51.0	68.0
	1200-1300	53.4	46.8	44.0	49.7	70.1
	1300-1400	51.2	47.0	45.0	48.8	64.3
	1400-1500	50.7	47.5	45.4	49.7	70.4
	1500-1600	53.7	49.0	47.3	52.9	75.9
	1600-1700	52.1	48.5	46.8	51.6	75.0
	1700-1800	52.8	48.3	46.5	51.7	85.6
	1800-1900	53.4	48.5	46.9	51.8	73.2
	1900-2000	53.3	47.5	45.4	52.0	70.4
	2000-2100	53.4	46.8	44.5	50.4	64.3
	2100-2200	53.5	47.8	45.3	50.0	63.4
	2200-2300	52.1	47.2	45.2	50.2	65.5
	2300-0000	51.0	48.0	46.5	49.5	65.1

Continued.....

Table 3.3: Background Noise Measurement at Sheung Shui

Date	Time	Noise Levels dB(A)				
		L_{10}	L_{50}	L_{90}	L_{eq}	L_{max}
16/03/95	0000-0100	47.5	44.4	41.8	45.7	61.0
	0100-0200	43.3	41.3	40.0	42.4	66.7
	0200-0300	42.6	40.9	39.7	41.4	55.9
	0300-0400	41.9	39.9	38.6	40.5	59.0
	0400-0500	44.3	41.6	40.3	42.4	57.0
	0500-0600	48.4	43.3	41.7	44.6	61.2
	0600-0700	51.3	46.4	44.5	49.6	67.0
	0700-0800	51.3	45.7	43.3	49.5	72.2
	0800-0900	52.9	49.2	47.0	51.2	74.9
	0900-1000	55.4	51.6	49.9	53.3	73.6
	1000-1100	59.2	51.2	49.3	54.4	69.7

Water Quality

3.13 The Study Area is located within the River Indus drainage basin. The River Indus is one of the major river systems within the New Territories, which ultimately discharges into Deep Bay via the Shenzhen River. To the Northwest of the new slaughterhouse site, the River Indus bifurcates to form part of the Beas River and Ng Tung River systems, with the Ng Tung River forming the northern and eastern boundaries of the Site.

3.14 As a consequence of effluent discharges from livestock farms and the cottage industries, stream and river water quality within the catchment area is generally poor. A summary of data gathered through the EPD's routine water monitoring programme is provided in Table 3.4. Data were collected from three monitoring stations on the River Indus, identified as IN1, IN2 and IN3 on Figure 3.2.

3.15 The data illustrate the exceedingly low levels of dissolved oxygen observed along the length of the river, with correspondingly high Biochemical Oxygen Demand (BOD), suspended solids, and levels of: heavy metals, ammonia, nitrogen, and bacteria, all of which are indicative of gross pollution within the system.

3.16 River water quality monitoring commenced in 1987 and since then all 3 River Indus stations have been classified as having bad water quality. While an improvement in water quality was observed in 1990, this improvement did not continue.

3.17 Water quality in Inner Deep Bay is predominantly influenced by heavy pollution loadings from the River Indus and other tributaries of the Shenzen River. In the inner reaches of Deep Bay the water column appears to fluctuate between the anoxic and supersaturated states. Both of these conditions are symptomatic of an unhealthy water body.

3.18 An historical contributor to the decline in water quality in the Northern New Territories has been the uncontrolled discharge of livestock waste to the river and stream sources. Under the provisions of the Livestock Waste Control Ordinance, the River Indus was declared a Livestock Waste Control Area in 1989 (as opposed to a prohibition area). The quality of water courses will take some time to recover.

3.19 The cottage industries, including tanning, bleaching, and dyeing, still appear to be thriving on both sides of the Shenzhen River. Operators have little regard for pollution control or prevention of discharges to the adjacent water courses.

Table 3.4: Summary of Water Monitoring Results for River Indus

Parameter	Monitoring stations		
	IN1	IN2	IN3
Dissolved Oxygen (mg/L)	1.5 (0.9 - 4.1)	1.8 (0.9 - 4.5)	2.8 (1.3 - 8.9)
Biochemical Oxygen Demand (mg/L)	21 (10 - 93)	41 (96 -97)	32 (18 - 130)
Suspended Solids (mg/L)	24 (13 - 100)	22 (11 - 330)	44 (23 - 340)
Ammonia derived N (mg/L)	16.83 93.31 - 22.0)	14.0 (2.63 - 22.0)	15.8 (3.15 - 47.0)
pH Value	7.1 (6.9 - 7.6)	7.2 (6.9 - 7.2)	7.4 (7.2 - 7.7)
Aluminium (mg/L)	205 (50 - 440)	50 (50 - 700)	140 (50 -300)
Cadmium (mg/L)	0.3 (0.2 - 0.69)	0.2 (0.1 - 0.4)	0.3 (0.1 - 1.1)
Chromium (mg/L)	3.5 (1.0 - 10.0)	3.0 (2.0 - 18.0)	1.0 (1.0 - 19.0)
Copper (µg/L)	8.5 (2.0 - 57.0)	5.0 (1.0 - 110.0)	26.5 (1.0 - 430.0)
Lead (µg/L)	7.5 (1.0 - 22.0)	5.0 (2.0 - 30.0)	6.0 (1.0 - 300.0)

Continued.......

Table 3.4: Summary of Water Monitoring Results for River Indus

Parameter	Monitoring stations		
	IN1	IN2	IN3
Zinc (µg/L)	135 (10 - 500)	190 (10 - 2800)	55 (10 - 320)
E. coli (no./100mL)	1,350,000 (20,000 - 3,100,000)	700,000 (80,000 - 1,800,000	2,700,000 (120,000 - 8,300,000)
Flow (L/s)	1960 (180 - 4340)	620 (370 - 1570)	27 (5.0 - 400)

Notes:

1. Data presented are annual medians of monthly samples; except those for *E. coli* which are geometric means.
2. Figures presented in brackets are the ranges.
3. Data listed in Table 3.4 are gathered from EPD's routine water quality management programme in 1991.

Sensitive Receivers

3.20 The identified SR's to be used for the purpose of the SEIA are shown on Table 3.5 and Figure 3.1. There are four distinct groups of SR's:-

- Group 1 - north-east of the Study Site on the opposing side of the railway track; however, structures at SR3 and SR4 are uninhabited farm huts and will not be addressed.

- Group 2 - west of the Study Site on the opposing side of the railway track; however, structures at SR5 and SR6 are uninhabited farm huts and will not be addressed.

- Group 3 - south of the Study Site on the same side of the railway track; and

- Group 4 - south-east of the Study Site on the same side of the railway track.

Table 3.5: SR Locations and Distances from the Site

Group	SR	Name/Description	Distance	Notes
1	1	Village houses	250m	East bank of Ng Tung River, small residential houses.
	2	Village houses	150m	East bank of Ng Tung River, small residential houses.
	3	Farm hut	40	Uninhabited
	4	Farm hut	70	Uninhabited
2	5	Farm hut	60	Uninhabited
	6	Farm hut	60	Uninhabited
	7-11	20-30 Village houses	240m-450m	Village located on both sides of River Beas.
	12	Tsung Yuen	660m	Village houses.
	13	Lo Wu Camp	600m	North West from the study site
3	14	Village houses	400m	South of the Study Site, small Village houses.
	15	Sheung Shui Temporary Housing Area	550m	South of the Study Site.
4	16	Village Houses	450m	South east of the Study Site, residential

Note: (i)The distance quoted above are to the nearest site boundary.
(ii)The SR's are of 2-3 storeys high village houses.
(iii)The impacts on SR's 3-6 will not be addressed since they are uninhabited.

3.21 Lo Wu Camp (SR 13) has been unoccupied for a number of years. However, there is a riding school directly adjacent to the Lo Wu camp where several people live. This location would be suitable for inclusion in the assessment but reference should be made to Lo Wu camp (SR 13) for impact data.

Table 3.6: Summary of Domestic Households and Population Details

SR	No. of Domestic Household	Enumerated Resident Populatio
1	59	219
2	53	149
3	NIL	NIL
4	NIL	NIL
5	NIL	NIL
6	NIL	NIL
7 - 11	756	317
12	80	256
13	No Data	No Data
14	203	768
15	1,007	1,998
16	1,165	3,506

3.22 The Sheung Shui Temporary Housing Area was formerly a very densely populated housing area (Table 3.6). The 1991 Census records shows that there were 1,107 households and 1998 enumerated resident population in the housing area. Recently, however, part of the Housing area was converted to low-level industrial use with an estimated remaining population of less than 1,000 people. At present the area seems to be uninhabited. The whole site will be cleared in 1996, and will then be available for sale for industrial use. Furthermore, the study site is screened from this Temporary Housing Area by SWHSTW.

Air Quality/Odour Sensitive Receivers

3.23 Air Sensitive Receivers (ASR's) are shown on Figure 3.1. The movement of dust or odours is by wind dispersion and the wind direction will govern the extent to which the ASR's will be affected. See Section 6 for Air Modelling.

Noise Sensitive Receivers

3.24 NSR's are shown on Figure 3.1. The NSR's at the junction of Po Shek Wu Road and Po Wan Road are village houses of 2 to 3 storeys high. These NSR's are also included in the road traffic noise assessment (Chapter 7) in addition to the identified NSR's 1 to 16. Po Shek Wu Road is approximately 2 to 3 m higher than the local ground level of the NSR's.

Noise predictions indicate that, without mitigation measures, these NSR's will be exposed to noise levels of 68-72 dB(A), which exceed the stipulated noise criterion of 70 dB(A) by 1 to 2 dB(A) (Figure 7.14). This noise exceedance is attributable to the relatively close proximity of Po Shek Wu Road.

The erection of a road-side noise barrier along Po Wan Wu Road will be required to reduce the noise impacts at the NSR's. Calculations indicate that the noise levels will be reduced to 65-69 dB(A) with a 2m high noise barrier, as shown in Figure 7.15, and 63-68 dB(A) with a 3m high noise barrier, with the extent shown in Figure 7.16. Increasing the extent of the 3m high noise barrier to 700m further reduces the noise levels to 52 - 65 dB(A). Hence, it is recommended to erect a 3m high noise barrier alongside Po Wan Wu Road, with the extent shown in Figure 7.17. Further noise reductions can be achieved by adding a cantilever into the design of the barrier and re-surfacing the road with open-textured material.

A computer plot of the road scheme is shown in Figure 7.13.

Water Quality Sensitive Receivers

3.25 During the construction phase, sensitive receivers identified within the area of influence include the River Indus and its tributaries, and therefore, Deep Bay. Deep Bay was declared a Water Control Zone in 1990 and as such is protected under the Water Control Ordinance.

3.26 Other sensitive receivers include the numerous fish and duck ponds located in the north, west, and east of the Site. The standards applied for the protection of water quality for use in fish pond culture are more stringent than those generally used for the control of pollution in Deep Bay. Standards for effluents discharged into Group B inland waters are given in Table 3.7 with the corresponding standards for Group C waters for general pond and fish culture shown in Table 3.8.

3.27 It should be noted that although many of the fish ponds appear to be inactive, or are put to alternative uses, their primary function as natural drainage ponds and flood protection mechanisms should not be ignored. This is particularly pertinent in this low-lying flood plain.

Table 3.7: Standards for effluents discharged into Group B inland waters.
(All units in mg/L unless otherwise stated; all figures are upper limits unless otherwise indicated)

Determinand / Flow rate (m^3/day)	≤200	>200 and ≤400	>400 and ≤600	>600 and ≤800	>800 and ≤1000	>1000 and ≤1500	>1500 and ≤2000	>2000 and ≤3000
pH (pH units)	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
Temperature (°C)	35	30	30	30	30	30	30	30
Colour (lovibond units) (25mm cell length)	1	1	1	1	1	1	1	1
Suspended solids	30	30	30	30	30	30	30	30
BOD	20	20	20	20	20	20	20	20
COD	80	80	80	80	80	80	80	80
Oil & Grease	10	10	10	10	10	10	10	10
Iron	10	8	7	5	4	3	2	1
Boron	5	4	3	2.5	2	1.5	1	0.5
Barium	5	4	3	2.5	2	1.5	1	0.5
Mercury	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Selenium	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1
Other toxic metals individually	0.5	0.5	0.2	0.2	0.2	0.1	0.1	0.1
Total toxic metals	2	1.5	1	0.5	0.5	0.2	0.2	0.2
Cyanide	0.1	0.1	0.1	0.08	0.08	0.05	0.05	0.03
Phenols	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sulphide	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Fluoride	10	10	8	8	8	5	5	3
Sulphate	800	800	600	600	600	400	400	400
Chloride	1000	1000	800	800	800	600	600	400
Total phosphorus	10	10	10	8	8	8	5	5
Ammonia nitrogen	5	5	5	5	5	5	5	5
Nitrate + nitrite nitrogen	30	30	30	20	20	20	10	10
Surfactants (total)	5	5	5	5	5	5	5	5
E. coli (count/100ml)	100	100	100	100	100	100	100	100

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Table 3.8: Standards for effluents discharged into Group C inland waters.
(All units in mg/L unless otherwise stated; all figures are upper limits unless otherwise indicated)

Flow rate (m^3/day) / Determinand	≤100	>100 and ≤500	>500 and ≤1000	>1000 and ≤2000
pH (pH units)	6-9	6-9	6-9	6-9
Temperature (°C)	30	30	30	30
Colour (lovibond units) (25mm cell length)	1	1	1	1
Suspended solids	20	10	10	5
BOD	20	15	10	5
COD	80	60	40	20
Oil & Grease	1	1	1	1
Boron	10	5	4	2
Barium	1	1	1	0.5
Iron	0.5	0.4	0.3	0.2
Mercury	0.001	0.001	0.001	0.001
Cadmium	0.001	0.001	0.001	0.001
Silver	0.1	0.1	0.1	0.1
Copper	0.1	0.1	0.05	0.05
Selenium	0.1	0.1	0.05	0.05
Lead	0.2	0.2	0.2	0.1
Nickel	0.2	0.2	0.2	0.1
Other toxic metals individually	0.5	0.4	0.3	0.2
Total toxic metals	0.5	0.4	0.3	0.2
Cyanide	0.05	0.05	0.05	0.01
Phenols	0.1	0.1	0.1	0.1
Sulphide	0.2	0.2	0.2	0.1
Fluoride	10	7	5	4
Sulphate	800	600	400	200
Chloride	1000	1000	1000	1000
Total phosphorus	10	10	8	8
Ammonia nitrogen	2	2	2	1
Nitrate + nitrite nitrogen	30	30	20	20
Surfactants (total)	2	2	2	1
E. coli (count/100ml)	1000	1000	1000	1000

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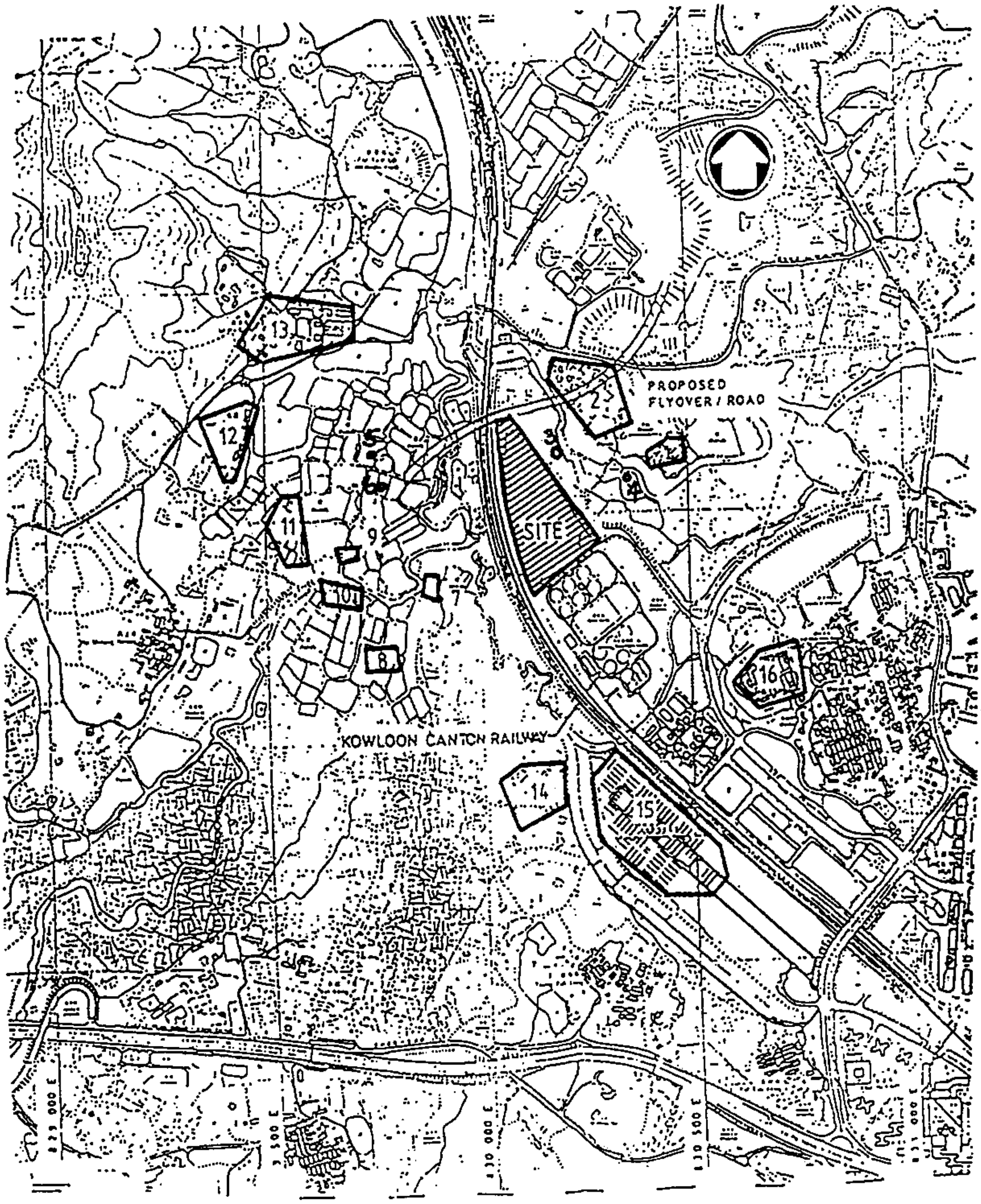


Figure 3.1 Location of Sensitive Receivers

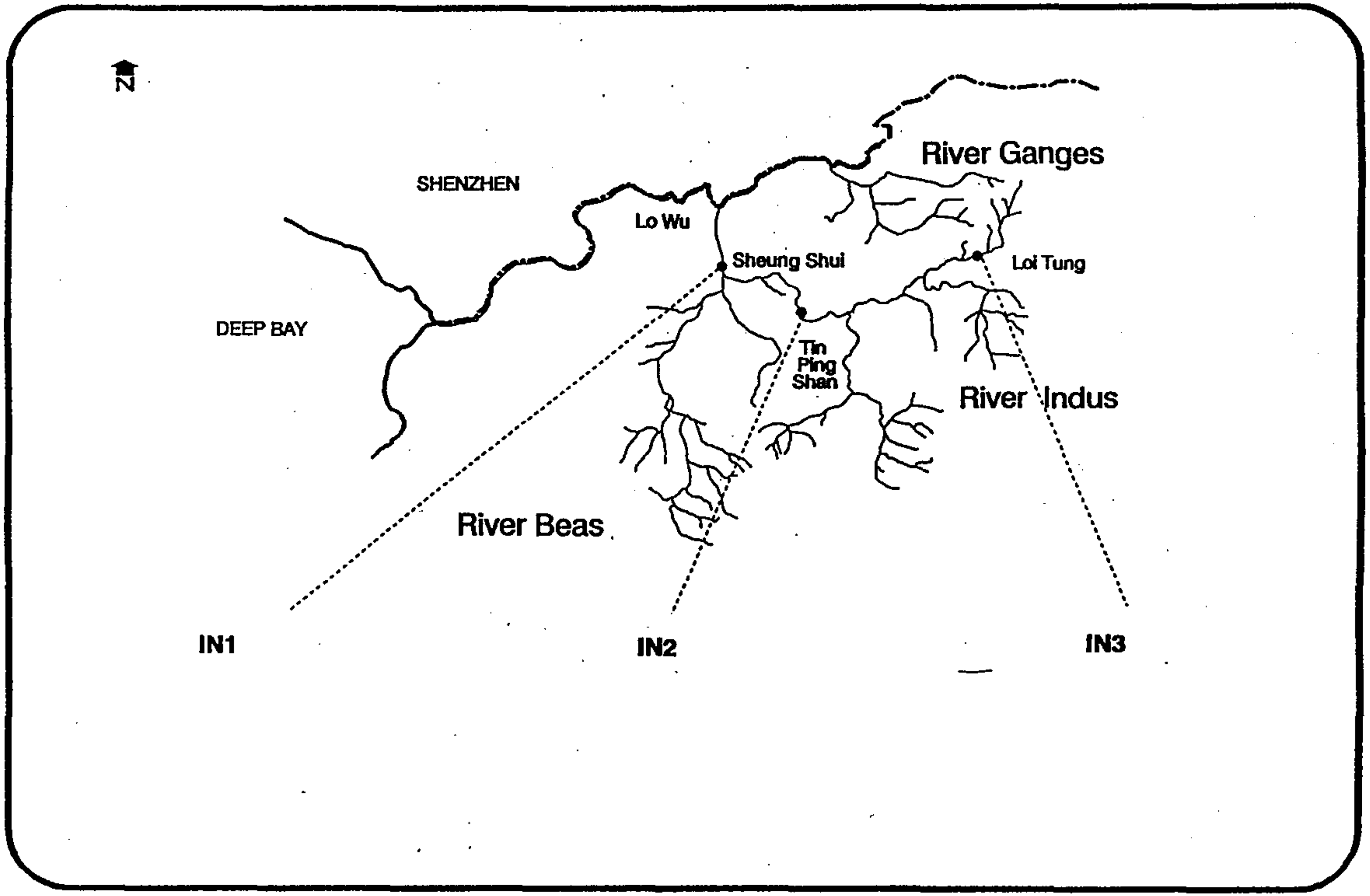
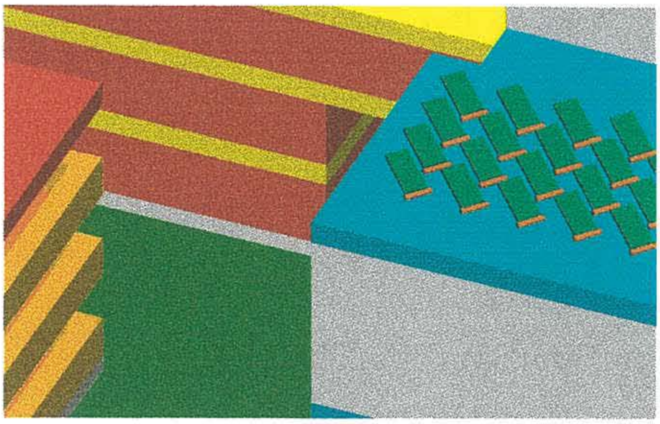


Figure 3.2 EPD River Indus Monitoring Stations



4. ENVIRONMENTAL LEGISLATION

4. ENVIRONMENTAL LEGISLATION

Slaughterhouse operations

4.1 The operations of the slaughterhouse are governed by a number of guidelines, bylaws, and licensing conditions. Requirements of these conditions include suitable siting and design, and humane and hygienic operations. The SEIA (Appendix 1) will be carried out in accordance with the following operational requirements:-

4.2 *Hong Kong Planning Standards and Guidelines*
Chapter 9 sets out guidelines for the siting of abattoir facilities, including distances from sensitive land uses.

4.3 *Public Health & Municipal Services Ordinance*
Slaughterhouses (Regional Council) Bylaws 1991 (Appendix 4.5)
Provides for the licensing and control of slaughterhouses other than public slaughterhouses in the Regional Council area.

4.4 *Slaughterhouses Licensing Requirements and Conditions (Appendix 4.1 & 4.2)*
Details the licensing requirements and conditions for a slaughterhouse in an Urban Council area.

4.5 *Public Health (Animal and Birds) Ordinance, (Cap. 139) and Rabies Ordinance (Cap.421)*
Set out requirements for the prevention of the introduction of infectious disease.

4.6 *Prevention of Cruelty to Animals Ordinance (Cap.169)*
Sets out operational requirements to ensure that animals are not subjected to cruelty.

4.7 *Codes of Practice and Guidelines*
Notes issued by the Hong Kong Government Department of Agriculture & Fisheries including:-

- Guidelines for the transportation, handling, and care of pigs. (Appendix 4.3)
- Codes of practice for the welfare of animals - specifically cattle. (Appendix 4.4)

Air quality

4.8 Control of dust, odour, and other emissions are required in Hong Kong. The SEIA will be carried out in accordance with the following air quality requirements:-

4.9 *Hong Kong Planning Standards and Guidelines*
Sets out the principal framework for planning against air pollution and a summary of common pollution sources and sensitive uses.

4.10 *Air Pollution Control Ordinance (Cap. 311)*
Provides for the control of air pollution from stationary sources and motor vehicles.

4.11 *Air Pollution Control Technical Memorandum*
Specifies principles, methods, standards, and guidelines for assessing air pollution from stationary polluting sources.

4.12 *Air Pollution Control (Fuel Restriction) Regulations 1990*
Prohibits the use of liquid fuels with a sulphur content of more than 0.5% by weight or with a viscosity of more than 6 centistokes at 40 degrees Celsius or of solid fuels with a sulphur content of more than 1% by weight.

4.13 *Air Pollution Control (Vehicle Design Standards) (Emission) Regulations 1991*
Specifies emission standards for vehicle engines.

4.14 *Air Control Zone Statement of Air Quality Objectives*
Provides statutory air quality objectives for all 10 declared Air Control Zones in the Territory. The objectives are listed in Table 4.1.

Table 4.1: Hong Kong Air Quality Objectives (Concentration in $\mu g/m^3$ (i))

Pollutant (i)	**1 hr** (ii)	**8 hrs** (iii)	**24 hrs** (iii)	**3 mths** (iv)	**1 yr** (iv)
Sulphur Dioxide	800		350		80
Total suspended particulates (v)	500		260		80
Respirable suspended particulates (vi)			180		55
Nitrogen dioxide	300		150		80
Carbon monoxide	30,000	10,000			
Photochemical oxidants (vii)	240				
Lead				1.5	

Notes:
(i) measured at 25 degrees Celsius and 1 atmosphere
(ii) not to be exceeded more than three times per year
(iii) not to be exceeded more than once per year
(iv) arithmetic means
(v) EPD recommended maximum TSP levels of 500 $\mu g/m^3$ at the air sensitive receivers during construction, 1 hour TSP level has not got any exceedence allowance
(vi) suspended particulates in air with a nominal aerodynamic diameter of 10 micrometers and smaller
(vii) photochemical oxidants are determined by measurement of ozone only.

4.15 *Air Pollution Control (Furnaces, Ovens & Chimneys) (Installation & Alteration) Regulations*
Requires the submission of plans for the installation and alteration of furnaces, ovens, and chimneys. This is to ensure appropriate designs.

4.16 *Air Pollution Control (Specified Processes) Regulations*
Provides for the licensing of new, specified processes and registration of existing ones.

4.17 *Air Pollution Control (Dust and Grit Emissions) Regulations*
Stipulates the emission standards, procedures, and requirements for assessing particulate emissions from stationary combustion sources.

4.18 *Air Pollution Control (Smoke) Regulations*
Restricts emissions of dark smoke from stationary combustion sources.

4.19 *Road Traffic Ordinance (Cap.374)*
Regulates road traffic, vehicles, and users of roads and related matters. This includes provisions which limit pollution from vehicles.

4.20 *Road Traffic (Construction and Maintenance of Vehicles) Regulations*
Specifies smoke levels for in-service vehicles.

4.21 *Public Health and Municipal Services Ordinance (Cap. 132)*
Makes provision for urban services and public health.

4.22 *Ozone Layer Protection Ordinance*
Effects Hong Kong's international obligations under the 1985 Vienna Convention, the 1987 Montreal Protocol, and any amendments thereof to control the manufacturing and the import and export of any ozone depleting substances.

4.23 *Ozone Layer Protection (Controlled Refrigerants) Regulation*
Requires the conservation of controlled refrigerants used in large scale installations and motor vehicles.

4.24 *EPD criteria*
In odour impact assessment, any odour prediction at a receptor equal to or exceeding 5 odour units, based on a prediction averaging time of 5 seconds, shall be considered as an indication of odour nuisance to the receptors. For odour monitoring, 2 odour units at the receptors shall be the criteria for odour nuisance.

Noise pollution

4.25 Control of construction, transportation, and operational noise is required in Hong Kong. The SEIA will be carried out in accordance with the following noise pollution requirements:-

4.26 *Noise Control Ordinance*
Controls construction noise and the use of powered mechanical equipment (particularly construction works involving percussive piling) and controls noise from commercial activities including ventilation noise. The ordinance is enacted through three Technical Memoranda and two sets of Regulations.

4.27 *Hong Kong Planning Standards and Guidelines*
Sets out the Government's overall policy objectives for noise control, the principal framework for planning against noise, a summary of noise emitters, and noise sensitive and noise tolerant uses.

4.28 *Technical Memorandum on Noise from Construction Work other than Percussive Piling (TM1)*
Prescribes maximum noise levels for all construction activities that include powered mechanical equipment other than those required for percussive piling. Basic Noise Levels (BNLs) (Table 4.2) are set out according to an area's sensitivity rating (ASR) (Table 4.3). The definition of ASR A will apply to the study area, and there will be no effect from Influencing Factors (IF) in this area.

Table 4.2: BNLs for construction noise other than percussive piling (dB(A))

Time period	A	B	C
All days during the evenings (1900 to 2300 hours)	60	65	70
General holidays (including Sundays) during day and evening (0700 to 2300 hours)	60	65	70
All days during night (2300 to 0700 hours)	45	50	55

Table 4.3: Areas Containing NSRs

	Degree to which NSR is affected by IF		
Type of Area Containing NSR	**Not Affected**	**Indirectly Affected**	**Directly Affected**
Rural area, including country parks or village type developments	A	B	B
Low density residential area consisting of low-rise or isolated high-rise developments	A	B	C
Urban area	B	C	C
Area other than those above	B	B	C

4.29 *Technical Memorandum on Noise from Percussive Piling (TM2)*
Regulations for the control of percussive piling include restrictions on piling times and the procurement of a Construction Noise Permit (CNP) issued by the EPD. The permitted hours of operation (Table 4.4) are determined by the amount by which the Calculated Noise Level (CNL) exceeds the Acceptable Noise Level (ANL) (Table 4.5).

Table 4.4: Permitted hours of operation for percussive piling

Amount by which CNL exceeds ANL	Permitted hours of operation
more than 10 dB(A)	0800 - 0900, 1230 - 1330 and 1700 - 1800
between 1 & 10 dB(A)	0800 - 0930, 1200 - 1400 and 1630 - 1800
no exceedence	0700 - 1900

Table 4.5: ANLs for Percussive Piling

NSR Type	ANL (dB(A))
NSR (or part of NSR) with no windows or other openings	100
NSR with central air conditioning system	90
NSR with windows or other openings but without central air conditioning system	85

4.30 *Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places, or Construction Sites (TM3)*
Outlines procedures to be adopted for the measurement and assessment of noise emanating from industrial premises. Different ANLs are applied during the day, evening, and night, as detailed in Table 4.6.

Table 4.6: Acceptable Noise Levels for Commercial Activities in the Study Location

Time	ANL (dB(A))
day (0700 to 1900)	60
evening (1900 to 2300)	60
night (2300 to 0700)	50

4.31 *Noise Control (Hand Held Percussive Breakers) Regulations*
Requires hand held percussive breakers to comply with specified noise emission standards and to be fitted with noise emission labels when in use.

4.32 *Noise Control (Air Compressors) Ordinance*
Requires hand and portable air compressors to comply with specified noise emission standards and to be fitted with noise emission labels when in use.

4.33 *Road Traffic (Construction & Maintenance of Vehicles) Ordinance*
Prohibits the use of motor vehicles without silencers or with a modified or defective silencer.

Water Quality

4.34 Control of water pollution is required in Hong Kong. The introduction of the sewage treatment charges has made it economically and legally essential to use water and dispose of wastewater accordingly. The SEIA will be carried out in accordance with the following water pollution requirements:-

4.35 *Hong Kong Planning Standards and Guidelines*
Sets out the overall objectives and principal framework for preventing water pollution and gives a summary of potentially polluting and sensitive uses.

4.36 *Waste Disposal Ordinance (Cap. 354)*
Provides for the licensing of collection services and disposal facilities for all types of waste, including the control of the discharge or deposit of livestock waste in designated control areas. Also requires the production of a comprehensive plan for the collection and disposal of wastes.

4.37 *Water Pollution Control Ordinance (Cap. 358)*
Provides for the designation of control zones within which discharges of effluent into waters or a foul sewer must be licensed.

4.38 *Technical Memorandum of Effluent Standards*
Sets the limits that make effluents acceptable into foul sewers, storm water drains, inland and coastal waters. The limits control the physical, chemical, and microbial quality of effluents.

4.39 *Sewage Services Ordinance*
Provides for the imposition of sewage charges (SCs) and trade effluent surcharges (TESs) and other related matters.

4.40 *Sewage Services (Trade Effluent Surcharge) Regulation*
Sets out rates for the sewage tariff, TES, and water quality requirements.

4.41 *Technical Memorandum on the Procedures and Methods for Sampling and Analysis of Trade Effluents for the Trade Effluent Surcharge Scheme*
Sets out the procedures and methods to be adopted for sampling, analysis, approval of laboratories, presentation of results, and any other matters relating to the establishment of specific effluent characteristics.

4.42 *Waste Disposal (Livestock Waste) Regulations*
Sets out the precautionary measures in handling livestock waste to guard against dangers to public health or risks of pollution. The River Indus was declared a Livestock Waste Control Area in 1989.

4.43 *Building Ordinance (Cap. 123)*
Allows the Building Authority to require adequate waste treatment facilities in any new building. Provides for control over the design of refuse chutes within buildings, private drainage works, and oil storage facilities.

4.44 *Control on the Operation & Maintenance of Wastewater Treatment Facilities (made under WPCO)*
This regulation is currently in the drafting stage and is scheduled to be enacted by 1996. Upon enactment, it becomes a mandatory requirement that only persons registered under the regulation may operate and maintain wastewater treatment plants. Failing to comply with the regulation would be an offense liable to prosecution.

4.45 *Public Health and Municipal Services Ordinance (Cap. 132)*
Provides for control over the discharge of hazardous materials to sewers and for the control of littering.

4.46 *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*
Table 1 will be adopted for the wastewater management.

4.47 The maximum allowable hydraulic, organic, and TKN (Total Kjeldahl Nitrogen) loadings need to be determined by the Drainage Services Department (DSD).

4.48 The maximum wastewater discharge volume of 500 and 750 m^3/hr, as described in the 1983 Design Report, appear to be no longer applicable.

Solids Disposal

4.49 Waste management planning and control is required in Hong Kong. The SEIA will be carried out in accordance with the following:-

4.50 *Hong Kong Planning Standards and Guidelines*
Sets out the Government's overall objectives for waste management planning, the principal framework for waste management, and a summary of waste reception/transfer facilities and uses with special requirements for waste disposal.

4.51 *Slaughterhouse (Hygiene) Regulations*, 1977, Part IV
Details the hygienic practices expected of a slaughterhouse in Section 47.

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4.52 *Slaughterhouses (Urban Council) Bylaws*, 1990, Part VII
Outlines the requirements for the disposal of carcasses, condemned meat & offal and waste matter of food animal.

4.53 *Abattoirs (Urban Council) Bylaws*, Part IV
Requirements for the marking and transporting of slaughtered food animals.

4.54 *Slaughterhouses (Regional Council) Bylaws*, 1991, Part VII,
Outlines the requirements for the disposal of carcasses, condemned meat & offal, and waste matter of food animal.

Chemical Waste Control

4.55 *Waste Disposal (Chemical Waste) (General) Regulation*
Provides for control on all aspects of chemical waste disposal including; storage, collection, transport, treatment, and final disposal. This regulation also provides for penalties to be imposed on offences such as: failing to register as a waste producer; failing to store, package, label or dispose of waste through a waste collector; indiscriminately discharging chemical waste into sewers; failing to notify change in particulars, produce records or to furnish false information; failure to comply with general precautions, etc.

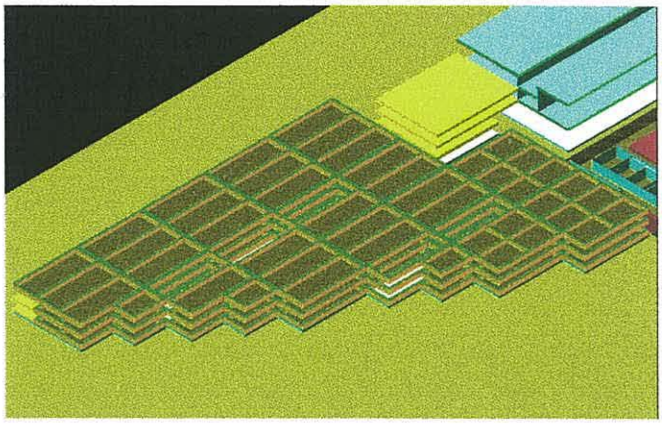
Chemical and hazardous materials controls

4.56 *Waste Disposal (Chemical Waste) (General) Regulation*
(accompanied by the guidelines found in the *Code of Practice on the Packaging, Labeling and Storage of Chemical Wastes*)

4.57 *Dangerous Goods Ordinance; Category 2, 4 & 5 (Town Gas, Bleaching Powder & Paint)*
Defines dangerous goods by category and controls storage and transportation thereof.

4.58 *Pesticides Ordinance*
(Registered low toxicity pesticides)

4.59 *Public Health and Municipal Services Ordinance (Cap. 132)*
Provides for the discharge of hazardous material to sewers.



5. CONSTRUCTION IMPACT ASSESSMENT

5. CONSTRUCTION PHASE OF SLAUGHTERHOUSE

Construction Activities

5.1 The potential impact of construction activities of the proposed slaughterhouse upon the surrounding environment will be determined in specific relation to air, water, noise, and visual impact. Although the detailed engineering design and construction methodology have not been defined at this stage, the potential impact will be assessed in relation to assumptions made. In this case, the worst scenario is considered with regard to the construction phase impacts. See Appendix A for Construction Contract Clause Requirements.

5.2 It is assumed that construction will take place in separate phases in order to minimize costs by reducing manpower and equipment use. These separate phases are outlined as follows:

Foundation/Excavation

5.3 The site will require minimal levelling and no demolition is required. The use of steel piles are required for foundation works as the soil may not be suitable for spread footing foundation. Heavy vehicles will deliver the piling to site and it is assumed that percussive piling and diesel rigging will be used as the piling driving mechanism. Equipment for the construction of the ground beams, ground slabs, and pile slabs will include excavators, concrete vibrators, dump trucks, air compressors, etc.

Infrastructure

5.4 Infrastructure of the proposed slaughterhouse will involve formation of external and internal road surfaces, railway sidings, a railway wagon unloading platform, livestock reception bays, and vehicle parking areas. Construction of the railway sidings will involve base excavation and track-laying with the use of modern purpose equipment. The sleepers required will probably be pre-cast and pre-stressed upon delivery to site and will be installed manually with sledgehammers.

5.5 KCRC will probably construct the railway sidings and associated livestock ramps, unloading bays, etc. Road construction, i.e. excavation, sub-base formation, and surface concreting, will involve the use of a bulldozer, vibratory rollers etc. Small scale construction activity is envisioned for finishings such as street lighting, pave markings, fences and traffic signs. Light vehicles and equipment will be utilized for these purposes.

Assessment of Impacts

AIR IMPACTS

Study of Dust Impact On Air Sensitive Receivers

5.6 The most significant impact in terms of air quality will result from Total Suspended Particulate (TSP) matter (dust) generated from excavation, site leveling, loading, transportation, and movement of equipment. The effects of dust particulates will vary according to local meteorological conditions and the extent of surrounding construction activity.

5.7 The proposed construction of a slaughterhouse at the Sheung Shui site would include several dust raising activities which may give rise to elevated levels of suspended particulate concentrations at nearby residential properties. A study was carried out to determine the possible fugitive dust impact on eight air sensitive receivers (ASR) specified .

The study included the following stages:-

- Estimation of existing background total suspended particulate (TSP) levels at the ASR;
- Estimation of dust emission rates from the construction
- Dispersion modelling to predict worst scenario ground level concentrations TSP levels at ASR;
- Prediction of cumulative TSP levels due to the construction and existing background at the ASR; and
- Comparison of the predicted TSP levels with Environmental Protection Department (EPD) hourly and daily average acceptance criteria to assess environmental acceptability of the construction.

5.7:1 *The Site and ASR*

The proposed slaughter house or abattoir site is adjacent to and north of the Shek Wu Hui Sewage Treatment Works at Sheung Shui. The site can be regarded as flat terrain with isolated trees typical of rural New Territories area.

The eight concerned sensitive receivers (Figure 5.1) and their coordinates are given in Table 5.1 below:

Table 5.1 : Details of ASR

ASR	x-Coordinate	y-Coordinate	Description
1	30420	41601	Small residential village houses at east bank of Ng Tung River about 250m from study site
2	30255	41725	Small residential village houses at east bank of Ng Tung River about 150m from study site
7-11	29850	41320	Village houses located on both sides of River Beas about 250m from study site
12	29442	41652	Tsung Yuen village houses about 660m west of the study site
13	29630	41898	Lo Wu Camp about 600m north west from the study site
14	30155	40942	Small village houses about 400m south of the study site
15	30305	40495	Sheung Shui temporary housing area about 550m south of the study site
16	30625	41140	Residential village house about 450m east of the study site

5.7:2 *Existing Background TSP Level Estimation*

There were no TSP monitoring data for the ASR and it is necessary to resort to published information for estimation of the existing background levels for these New Territories rural areas.

EPD operates two monitoring stations in the New Territories, namely, Tai Po and Shatin and the average of the measured annual mean for these two stations in 1994[1] is about 80 $\mu g/m^3$. However, these stations are located where there are typical urban activities and would likely give TSP levels much higher than those possibly found at the present receptors. On the other hand, a separate study[2] for Lantau Development has adopted a background level of 15 $\mu g/m^3$ which appears to be too small for the present study. A more reasonable estimate of 48 $\mu g/m^3$ (average of 80 $\mu g/m^3$ and 15 $\mu g/m^3$) is thus adopted for the present analysis.

5.7:3 *Dust Emission Rates Estimation*

Precise details of the working methods and machinery are not known at present and hence a global emission rate based on general construction activity operations have to be used.

[1] Environmental Protection Department, "Environment Hong Kong 1995 (a review of 1994)" Government Printer, Hong Kong, 1995.

[2] Territory Development Department South West N.T. Development Office, "Environmental Impact Assessment of the Tung Chung Main Sewage Pumping Station Final Report", North Lantau Development Topic Report TR23, November 1993.

According to USEPA guideline[3], the dust emission would be 2.69 tonnes per hectare per month of activity for construction without mitigation measures. Taking a month of activity to consist of 10 hours per day, 5.5 days per week and 4.2 weeks per month, dust emission rates will then be 0.000323 g/sec./m^2.

5.8 *Dispersion Modelling*

To assess the impact of the proposed construction, the USEPA Fugitive Dust Model (FDM) [4], has been used to calculate ground level concentrations.

The FDM is a Gaussian based model which takes account of the following:

- point, line, area sources
- particle deposition
- surface roughness
- terrain elevation
- meteorology

5.8:1 The Sheung Shui site has been divided into five areas (Figure 5.2) and the global emission rate applied to each. The total dust emission has been divided into four particle size classes as tabulated in Table 5.2.

Table 5.2: Particle size classes

Particle size class	Characteristic diameter (μm)	Fraction in each class
1	5	0.10
2	25	0.30
3	50	0.35
4	75	0.25

5.8:2 The FDM includes the use of a surface roughness component to adjust atmospheric stability due to mechanical turbulence. The present results have been obtained with a surface roughness height of 30 cm. for flat terrain with isolated trees thus allowing safety margin for environmental protection. The relative altitude of the Sheung Shui site and nearby receptors have also been included in the model.

5.8:3 The FDM was also configured to:

- estimate default values of the gravitational settling and deposition velocities from the characteristic particle diameter, particle density and surface roughness. A particle density of 2.5 g/m^3 has been used.

[3] United States Environmental Protection Agency, "AP42 - Compilation of air pollution emission factors", vol.1, 1994.

[4] Winges K D, "User's guide for the Fugitive Dust Model (FDM) (Revised)", EPA-910/9 - 88 - 202R, September 1992.

- to calculate 1-hour average ground level concentrations. 24-hour averages have been estimated using a USEPA factor of 0.4[5].

The FDM is able to use meteorological data in a variety of forms. For this study a USEPA screening set of data was used. This includes a screening combination of wind speed and atmospheric stability for each wind direction in 2° steps. Temperature and mixing height are assumed constant at 25°C and 620 m respectively. A total of 5940 hours of meteorological data were processed.

5.8:4 *Results*

The predicted worst scenario maximum TSP levels from the FDM run is tabulated in Table 5.2a.

Table 5.2a : Worst scenario maximum TSP levels due to construction

ASR	Maximum 1-hour concentration µg.m-3	Wind speed m.s-3	Wind direction ° North	Stability	Maximum 24-hour concentration µg.m-3
1	519	2	258	E	208
2	798	2	212	D	319
7	558	2	56	E	223
12	218	2	100	F	87
13	240	2	126	F	96
14	341	2	356	F	136
15	181	2	350	F	72
16	237	2	308	F	95

To assess the environmental acceptability of the construction, the FDM results are combined with the estimated background level and compared in Table 5.2b with the following criteria as required by EPD:

- Hourly TSP average not greater than 500 $\mu g/m^3$
- 24-hour TSP average not greater than 260 $\mu g/m^3$

It is seen from Table 5.2b that the acceptance criteria would be exceeded for three receptors if mitigation measures are not applied to the construction.

[5] United States Environmental Protection Agency, "Tutorial package for the SCREEN Model", June, 1992.

Table 5.2b : Maximum cumulative TSP levels

ASR	Maximum 1-hour concentration (μg.m-3)	Exceed 1-hour criteria (Y/N)	Maximum 24-hour concentration (μg.m-3)	Exceed 24-hour criteria (Y/N)
1	567	Y	256	N
2	846	Y	367	Y
7	606	Y	271	Y
12	266	N	135	N
13	288	N	144	N
14	389	N	184	N
15	229	N	120	N
16	285	N	143	N

5.8:5 *Study Conclusion*

The proposed construction of Sheung Shui Slaughterhouse has been assessed by dispersion modelling. The predicted cumulative effects of the predicted TSP level due to the construction and background level range from 229 - 846 μg.m-3 hourly average and 120 - 367 μg.m-3 24-hour average at the ASR.

Exceedance of the acceptance criteria for three ASR close to the site are therefore likely unless mitigation measures are applied to the construction. (See 5.20)

5.8:6 *Gaseous Emissions*

On site emissions during the construction phase will not significantly affect air quality; electrical power will be connected to a nearby mains source and on-site generators will not be used. On and off-site vehicles used during this initial stage will have negligible impact on air quality, therefore, vehicle and generator emissions do not need to be assessed.

Noise Impact

5.9 The potential noise impact of the construction phase will depend upon the duration and extent of works, type of construction machinery used, movement of construction vehicles, and activities of the construction site workforce. These factors will be assessed in terms of impact upon Noise Sensitive Receivers (NRS) located in the vicinity of the slaughterhouse taking into consideration the relative locations of noises and their subsequent paths.

Mitigation measures may then be applied to achieve acceptable noise levels in accordance with requirements stipulated in the Noise Control Ordinance.

5.10 The identification of the NSRs and predictions of the potential noise levels are based upon specifications given in the Technical Memorandum on Noise from Construction Work other than Percussive Piling (TM1) and the Technical Memorandum on Noise from Percussive Piling (TM2). For example, these predictions were based upon the type of powered mechanical equipment which will be utilized for each category of construction activity and the estimated usage time for each. The calculated Sound Power Levels (SWL) were as follows: (Table 5.3).

Table 5.3: SWLs of Powered Mechanical Equipment

Activity	Working Duration	Plant and Equipment	SWL	Qty	Total
Piling	restricted periods only	Diesel Hammer-Steel Pile	132	1	132
Building	0700-1900 6 days a week	Circular Saw	106	1	
		Generator	108	1	
		Lorry	112	2	
		Concrete lorry mixer	109	2	
		Poke (petrol)	113	2	
		Pump	109	1	
		Crane	112	1	121
Railway Works	0700-1900 6 days a week	Truck	117	2	
		Crane	112	1	
		Compactor	105	1	121
Road Surface	0700-1900 6 days a week	Back Hoe	112	1	
		Concrete truck	109	1	
		Poker	113	1	116

5.11 The above noise levels have been used to predict the cumulative construction phase noise impact upon each sensitive receiver shown below (Table 5.4). These expected levels apply to unrestricted daytime hours 0700-1900 i.e. the period which permits the use of powered mechanical equipment according to the Noise Control Ordinance. The ordinance also permits the percussive piling between 0700-1900 on any day, not including general holidays and Sundays.

Table 5.4: Maximum Construction Noise Levels

Activity	NSR 1	NSR 2	NSR 7-11	NSR 12	NSR 13	NSR 13	NSR 15	NSR 16
Piling - Steel	74	76	72	64	65	69	69	67
Building, railway work and road construction	72.4	73.5	69.5	63.3	64.3	65.8	65.8	65.5

5.12 The NSRs most affected by piling activities i.e. NSR1, 2 and 7-11 are low village housing which are not equipped with central air-conditioning systems and secondary glazing and therefore the Acceptable Noise Level (ANL) for percussive piling is 85 dB(A). Since the above Construction Noise Receivers (CNRs) do not exceed the ANL at these locations, operation hours of percussive piling will be permitted according to the aforementioned ordinance period.

5.13 Construction activities other than percussive piling will not occur beyond the permitted period of 1900 and also may not exceed the recommended maximum noise level of 75 dB(A). However, mitigation measures to reduce expected construction noise levels will be undertaken to reduce the noise levels, thereby further alleviating nuisance to the construction workforce and the surrounding sensitive receivers.

Wastewater Impacts

5.14 As stated previously, the specific construction methodology and materials usage have not yet been defined. However, the potential sources of impact upon water quality are outlined as follows :

- Surface water run-off may be laden with sediments or organic materials (soils, etc.) which may drain into the receiving waters;
- Run-off from construction or maintenance activities could cause oil or sediment-laden waters to be discharged into the Ng Tung River; and
- Collection, treatment, and disposal of domestic liquid wastes from temporary facilities and kitchen wastes from the construction workforce engaged on-site for the duration of the construction phase.

5.15 Site run-off will include high concentrations of suspended solids particularly after heavy rainfall and in water derived from dust-suppression equipment and concrete batching. Routine maintenance and repair of on-site vehicles and potential accidental discharges of fuel, oil, grease, lubricants, and solvents will also cause water pollution. The amount of turbidity may cause potential problems to the receiving water course and may cause blockages in closed drainage systems.

Solid Waste Impact

5.16 The solid wastes generated from the various construction activities will mainly be comprised of excavation material, building debris, timber hoarding, and domestic refuse generated from the on-site workforce. Workshop and maintenance facilities may give rise to wastes such as spent fuel, lubricating oils, used tyres, solvents, etc. The aforementioned underground wastewater pre-treatment plant will give rise to an increased quantity of excavation wastes.

5.17 Wastes generated from electrical and mechanical activity, i.e. oil, batteries, lubricants, etc., are considered dangerous goods and will be disposed of according to the Dangerous Goods Ordinance (Cap 295). Chemical wastes will be handled following the requirements of the Waste Disposal (Chemical Waste) (General) Regulations. These wastes will be temporarily stored in a segregated area of the allocated refuse collection site. All packaging of this waste will be clearly labelled, indicating the nature of the contents to ensure handling safety.

5.18 All opportunities for recycling of material should be utilized i.e. drums, containers, and scrap metal are all recyclable and used tyres may be shredded and re-melted or, alternatively, crumbled.

5.19 Excavation material and building debris will be routinely collected in skips provided at convenient locations for ease of loading and unloading purposes. Disposal will be to the public dump site, preventing additional reduction in disposal capacity at landfill site. The Contractor will be responsible for construction waste disposal under the Waste Disposal Ordinance (Cap. 354) although the Collection Authority may provide services for waste removal. The contractor will ensure the mode of waste transfer from site and final disposal will be efficient and operator safe. A refuse collection point will be allocated for refuse generated by the workforce and it is recommended that this waste not stored for periods exceeding 48 hours. Preferable time for storage is 24 hours or less.

Mitigation Measures

Air Quality

5.20 Mitigation measures will include the laying of gravel at all site roads prior to the main construction activities and adequate watering of all ungravelled areas. Watering will reduce heavy dust emissions on ungravelled roads significantly as shown below. The contractor will be required to carry out these mitigation measures on a continual basis to ensure compliance with EPD's recommended 24-hr Air Quality Objective (AQO) of 260 $\mu g/m^3$ and maximum 1 hour level of 500 $\mu g/m^3$. These maximum levels are to be based upon levels indicated at the nearest receiver.

Fugitive Dust Modelling for Construction with Mitigation Measures

5.20:1 To assess the impact of the proposed construction, with mitigation measures, the USEPA Fugitive Dust Model (FDM), has been used to calculate ground level concentrations. The results have been obtained using a global dust emission factor of 1.345 tonnes/hectare/month. This assumes an effective watering programme i.e. twice daily with complete coverage for the mitigation measures.

Results

5.20:2 The predicted worst scenario maximum TSP levels from the FDM run with mitigation measures is tabulated in Table 5.4a.

Table 5.4a : Worst scenario maximum TSP levels due to construction with mitigation measures

ASR	Maximum 1-hour concentration µg.m-3	Wind speed m.s-3	Wind direction ° North	Stability	Maximum 24-hour concentration µg.m-3
1	259	2	258	E	104
2	399	2	212	D	160
7	279	2	56	E	112
12	109	2	100	F	44
13	120	2	126	F	48
14	171	2	356	F	68
15	91	2	350	F	36
16	119	2	308	F	47

5.20:3 To assess the environmental acceptability of the construction, the FDM results are combined with the estimated background level and compared in Table 5.4b with the following criteria as required by EPD:

- Hourly TSP average not greater than 500 $\mu g/m^3$
- 24-hour TSP average not greater than 260 $\mu g/m^3$

Table 5.4b : Maximum cumulative TSP levels with mitigation measures

ASR	Maximum 1-hour concentration (µg.m-3)	Exceed 1-hour criteria (Y/N)	Maximum 24-hour concentration (µg.m-3)	Exceed 24-hour criteria (Y/N)
1	307	N	152	N
2	447	N	208	N
7	327	N	160	N
12	157	N	92	N
13	168	N	96	N
14	219	N	116	N
15	139	N	84	N
16	167	N	95	N

Study Conclusion

5.20:4 The proposed construction of Sheung Shui Slaughterhouse has been assessed by dispersion modelling. The predicted cumulative effects of the predicted TSP level due to the construction with mitigation measures and background level range from 139 - 307 μg.m-3 hourly average and 84 - 208 μg.m-3 24-hour average at the ASR.

5.20:5 It is seen from Table 5.4b that the acceptance criteria are not predicted to be exceeded at any of the sensitive receivers with mitigation measures applied to construction activities.

5.21 Other activities with a potential impact on air quality include fuel discharges from excavation and construction equipment exhausts. These exhaust products include emissions of carbon monoxide, hydrocarbons, nitrogen oxides, and particulate matter. These discharges can be minimized by proper cleaning and maintenance of all vehicles and equipment. Due to the distance between the work site and the sensitive receivers, these exhaust products are expected to disperse to non-detectable levels prior to reaching these areas.

Noise Pollution

5.22 The contractor will be ultimately responsible for the application of any mitigation measures and, therefore, acceptable noise level standards should be clearly defined in the noise monitoring plan. Mitigation measures will involve good construction work practices and will include the following options:

- Application of silencing equipment to machinery such as mufflers and linings.
- Route planning and restriction of movement of heavy vehicles to minimize noise and vibration impact on sensitive receivers.
- Scheduling of construction activity to avoid parallel operations of several sets of equipment.
- Situating equipment as far as practicable from the sensitive receivers.
- Extensive use of purpose-built acoustic barriers particularly near the KCR siding and reducing plant teams.
- Possible usage of special acoustic treatment to the external walls. Continuous monitoring will ensure that noise levels do not exceed acceptable levels.
- Use of mains as a power source rather than temporary generators.

Water Quality Impacts

5.23 Mitigation measures will concentrate on methods of minimizing water pollution on-site and ways to prevent contamination of the surrounding water-course. The Practise Note for Professional Persons, ProPECC PN 1/94, which gives guidelines for handling and disposing of construction site discharges should also be followed. To minimize the impact of site run-off it is recommended that drainage from all exposed areas should be channeled to sediment and grease traps which would frequently be dug out and maintained properly to ensure their efficiency.

5.24 Vehicles will be washed down only in suitable allocated areas in close proximity to the location of the aforementioned sediment and grease traps in the drainage network to ensure maximum retainment of suspended solids, debris, oil, and grease. Separated water generated from the sediment traps from the on-site drainage system should be recycled and used for further dust suppression and rinsing purposes.

5.25 Any concrete batching plant areas and areas where finishing is required, e.g. maintenance painting, should be conducted on impervious ground with bunds petrol interceptors provided.

5.26 Accidental spillages at work sites or during transfer of materials on site may be dealt with effectively by application of a specified action plan which would include readily available equipment or materials, e.g. aggregates or cement, for the safe collection and containment of the spillages, particularly for oil and petroleum based materials.

Visual Impact

5.27 During the construction phase of the proposed slaughterhouse every effort will be utilized to limit the visual impact upon the area. Visual impacts resulting from the accumulation of on-site solid wastes during construction activities will be dealt with. Solid wastes will be properly collected and stored as outlined above. The use of a graphically decorated hoarding/cover walkway is an appropriate method of minimising visual impacts during the construction phase.

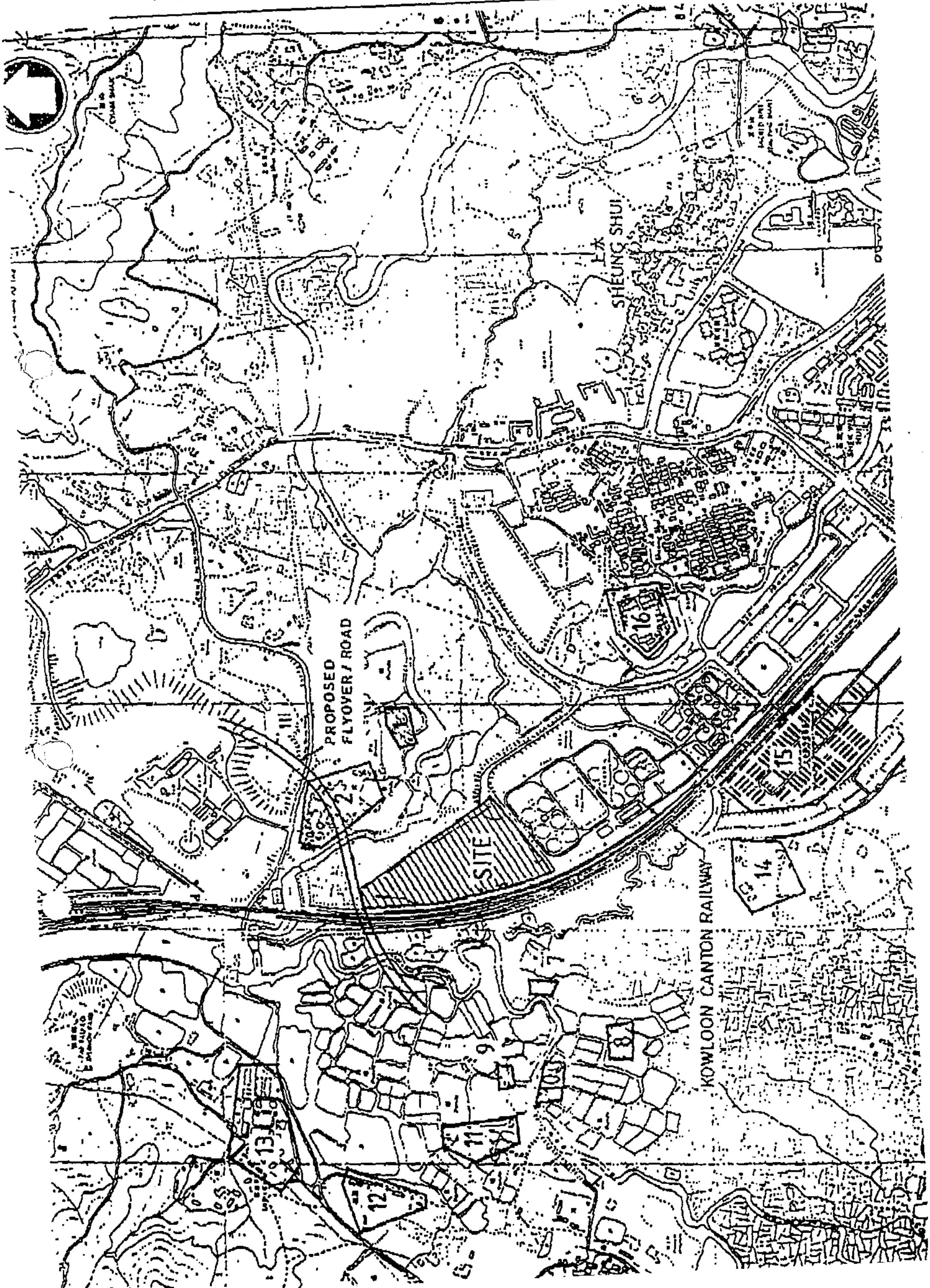


Figure 5.1 The Site and Air Sensitive Receivers

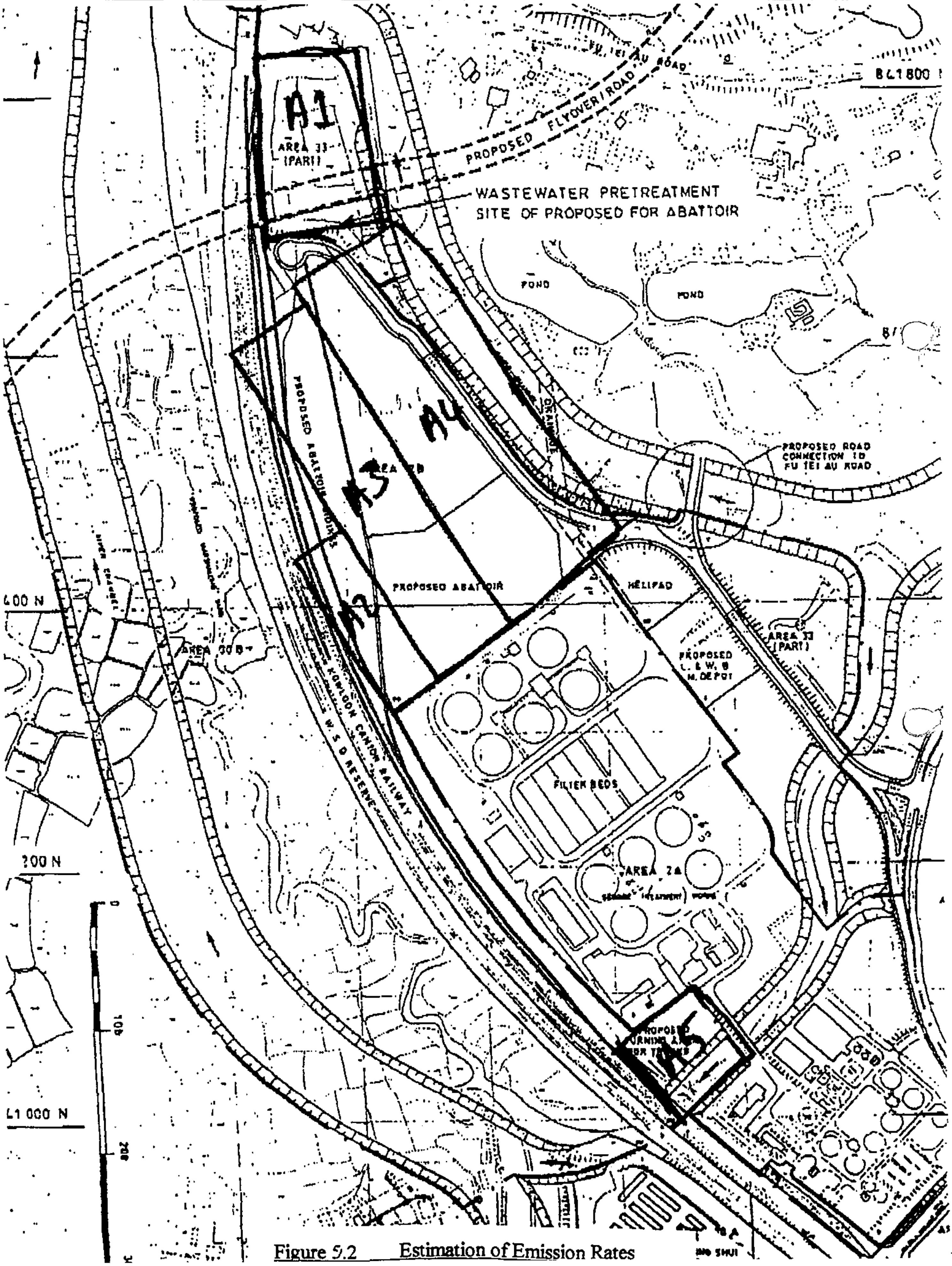
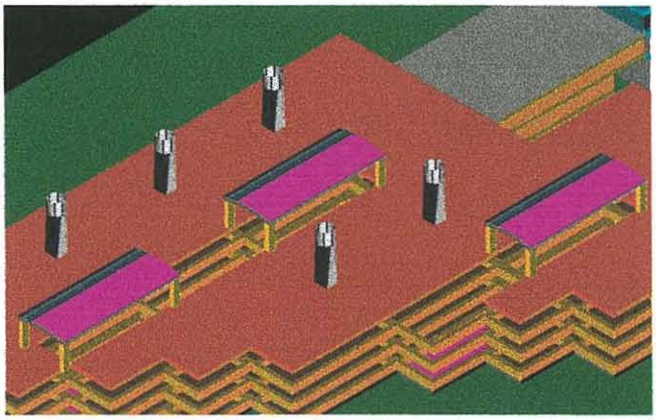


Figure 5.2 Estimation of Emission Rates



6. AIR POLLUTION IMPACT STUDY

6. AIR POLLUTION IMPACT STUDY

Introduction

6.1 Odour from slaughterhouses can be a problem because of accompanying potential odour sources, including:

- by-products from slaughtering processes, particularly rendering and blood handling;
- animals and their waste;
- wastewater treatment processes; and
- easily putrefying organic matter(manure) in areas (lairages, transit pens, unloading areas).

6.2 The distance between the odour source and people of the nearby area is basic to determining the nuisance potential of the odour emissions and has planning implications. The site is in a rural area, but some low-storey residences are nearby: Sheung Shui is the nearest town. The air sensitive receivers are shown in Figure 6.1.

6.3 The local topography and wind patterns are important in assessing the potential for odour nuisance. The site is at 8 m Principal Datum.

Odour Constituent Characterisation

6.4 The odour constituents are readily degradable compounds. They include ammonia (from urine), sulphur compounds (notably mercaptans and hydrogen sulphide), amines, and organics such as acids, aliphatics, and alcohol's, etc. The odour constituents from heat processing are similar except that they contain more degradable compounds.

6.5 Typical odourous gases from animal manure decomposition and animal rendering are shown in Tables 6.1 and 6.2, respectively.

Table 6.1 Odourous Gases from Decomposition of Livestock Manure

Alcohol's	Acids	Sulphur compounds	Amines	Fixed Gases*	Others
Methyl Propyl Butyl Alcohol's	Butyric Acetic Propionic Isobutyric Isovaleric	Hydrogen sulphide Dimethyl sulphide Mercaptans Disulphides	Methylamine Ethylamine Trimethylamine Diethylamine	Carbon dioxide Methane Ammonia	Alcohols Carbonyls Esters Nitrogen heteracycles Skatole Aldehydes

*CO2 is highly soluble in urine of the animals, thus it indirectly facilitates the volatilisation processes of VOCs. Methane mixes with air readily and is slightly soluble in water. Its presence will act as indicator of fugitive gas metabolism.

Table 6.2 Odours Gases from Animal Rendering

Sulphides	Other Sulphur Compounds	Amines	Other Nitrogen Compounds	Organic Acids	Other Oxygenated Compounds	Hydro-carbons	Other odorants
-sulphides	-trace S compounds	-tri-ethyamine	-trace N compounds	-butyric, valeric, caproic and higher fatty acids	-various carboxyl compounds	-Aliph-atic hydro-carbons	-Reducing substances
-methyl sulphide	-methyl and ethyl mercaptans	-butyl-amine	-Quinoline		C_4 to C_7 aldehydes, ketones and alcohols		-fats
-methyl disulphide -propylene sulphide	$-H_2S$	-monoeth-ylamine mono di- and tri-ethyl -amine	-pyrazine NH_3				
-SH compound		-diamines (e.g.cad-averine)					
-organic sulphides		alkyl-amines					

6.6 The concentration at which humans can detect some of these compounds, i.e. the threshold detection limit, is shown below (Table 6.3).

Table 6.3: Threshold Detection Limit of Selected Odorous Gases

Compound	Threshold Detection Limit, ppm
ammonia	46.8
methyl mercaptan	0.002
ethyl mercaptan	0.001
hydrogen sulphide	0.0005
dimethylsulphide	0.001
sulphur dioxide	0.47
dimethyl amine	0.047
trimethylamine	0.0002
acetaldehyde	0.21
butyric acid	0.001

Reference : Warren Spring Laboratory (1980) Odour Control - a concise guide.

On-Site Odour Sources and Emission Characterisation

6.7 The following Table 6.4 shows the main odour sources for the SSSH.

Table 6.4: Summary of Main Odour Sources

Source	Odour Intensity	Affected Air Volume	Odour Emission	Air Boundary Type
Animal Unloading Areas*	low	large	medium	open
Pig Lairage* Manure Rooms	low low-med.	very large low	high low	partially enclosed totally enclosed
Slaughter Rooms Blood Coagulation Room. Isolation. Lairage* Manure Pump Room By-Products Collection	low-med. low low-med low-med.	low low very low low	low very low very low low	totally enclosed
Wastewater Treatment Plant	low	large	medium	totally enclosed
BPP cooker exhausts(a	high	high	high	totally enclosed

* i) Fitted with mist spray for the cooling of the animals.
ii) Isolation lairage need not be totally enclosed.
a) Full scale BPP (Optional)

Lairage

6.8 The lairage floors (pens, walkways and ramps) and the manure chutes have manure/urine contamination (Fig. 6.2 and 6.3). The fodder and feed stores, and the pen feed troughs are sources of feed odour. Odour sources in the lairage include:

- manure/urine of pigs, cattle and goats;
- body of pigs, cattle and goats; and
- feed of pigs, cattle, and goats.

6.9 The manure rooms on the level 1 (Fig. 6.2) contain the manure collected from the lairage, but also solid waste. The solids are the fine screenings from the slaughter block drainage system, discarded offals, and hair/bristles. Odour sources in the manure rooms include:

- manure/urine of pigs, cattle and goats
- stomach and intestinal solids

- mixture of animal tissues

6.10 The pig lairage is a substantial odour source mainly due to it's large size. Cattle and goats, which are herbivores, produce substantially less ammonia, and thus less odour, than poultry or pigs. Close correlation between the rate of odour and ammonia emissions for untreated manure has been proven by research. This will become important later in the discussion of monitoring of ammonia to indicate odour level during facility operation.

6.11 The emission from the pig lairage is continuous over 24 hours, but fluctuates due to varying amount of manure/urine and the time/temperature of it's exposure.

6.12 The air from the lairage is controlled via a ventilation system which continuously draws air through the ceiling vents of each floor to vertical ducts which take the air through roof-mounted centrifugal fans and exhausts it. The duct system for the pig lairage is separate from the duct system for the cattle lairage. This enables efficient odour control at the pig lairage ventilation exhaust points because the odorous air is not diluted with the negligible odour air from the cattle lairage, which reduces the size and cost of the odour control units.

6.13 The pig lairage exhaust points are distributed evenly on the roof (Figure 6.3). It is proposed that their will be 10 such exhausts points to provide the required ventilation. The lowest number is preferred for the lowest number of odour control units, but the exit diameter and velocity must follow general design practice. Replacement air intake is through the openings and louvres throughout the external perimeter of the building.

6.14 The manure collection rooms, which are located on each end of the lairage, are considered minor emission sources because of the low air volume and ventilation rate. The odour level will depend upon the amount of material and it's degree of decomposition. The odour level inside will vary reaching a maximum just before disposal.

6.15 The manure collection rooms will be completely enclosed with the exhaust connected to the ventilation ducting for odour treatment and dispersion.

6.16 The pattern of odour emission for the lairage and unloading areas is shown below (Table 6.5) :

Table 6.5: Lairage & Unloading Areas Odour Emission Daily Pattern

Time		No. of Hours	Location Pig Lairage	Unloading Area train/pens	Unloading Area lorries
Daytime	7:00 - 12:00	5	Y		Y
	12:00 - 16:00	4	Y	Y	Y
	16:00 - 17:00	1	Y	Y	Y
	17:00 - 20:00	3	Y	Y	
Evening	20:00 - 23:00	3	Y		
Night	23:00 - 7:00	8	Y		
	Total Hours:	24	24	8	10

These operation hours are acceptable to the RSD

Livestock Unloading Areas

6.17 The animal unloading area at SSSH must be in the open for safety reasons, since most of the animals are delivered by KCR train which requires clearance from buildings, fire service access, etc.. Also, it would be difficult to control airflow of any building openings during large scale animal unloading. The trains from China are quite odourous: animals may have been inside for up to 10 days. The lorries from China and Hong Kong contribute to the odour. Thus, this odour source is also a major one.

6.18 The KCR wagons, unloading ramps, transit pens, and raceways into the lairage emit odour from the animals and manure/urine. The livestock delivery vehicles emit odour. Location of odour sources is at the KCR tracks G1 and G2 for the train, the row of platform transit pens, and the few parking/unloading spaces at the north end of the lairage. Odour sources from these areas include:

- manure/urine of pigs, cattle and goats
- body of pigs, cattle and goats

6.19 The unloading area causes a substantial odour level because the odour is dispersed at level 1 from a fairly large area.

6.20 About 60% of the total animal deliveries are by train (4,500 animals) and 40% by lorry (2,000 animals). However, about 33% of the train delivered animals (1,500 animals) are re-loaded into lorries to be delivered to the TW Abattoir. Healthy pigs may be permitted to be immediately transferred to trucks bound for Tsuen Wan using suitable ramps with inspection platforms to transfer the pigs. A summary of these activities follows:

- KCR train unloading takes 2-4 hours twice a day
- KCR train is removed immediately after unloading
- 2/3 of the animals are moved into the lairage quickly
- Tsuen Wan pigs will be immediately unloaded via a movable ramp to lorries for instant spraying by mist system

- negligible odour at other times because of immediate washing

6.21 The total time of odour emission is about 10 hours for the parked livestock delivery lorries (Table 6.5). They deliver animals mostly from China continuously during the day (07:00 to17:00). The animals are moved directly into the lairage.

Slaughter Block

6.22 In most slaughterhouses, by-products are converted into saleable meat/bone meal and blood meal in a by-products plant. The rendering of the meat/bone poses the most difficult odour problem for these slaughterhouses because of the extremely high odour level from the cooker. Thus, modern rendering equipment usually includes extreme odour treatment, e.g. boiler incineration, incinerator followed by condensation and also biofiltration, etc. Care must be taken that the raw material is processed when fresh to avoid further pungent odours being generated. Blood processing is also quite odorous, in particular the drying phase.

6.23 Biofilters are unsuitable for sighting in a rooftop location due to their size and can require large areas to adequately neutralise organic wastes from the rendering process. Successful operation of this biotechnology can be hindered by temperature fluctuations (range 20-50 °C, optimum 35 °C), pH values (range pH 6.5-7.5) and water content (range 40% -60%). The viability of this process is inappropriate at the SSSH site because of the operational difficulties in maintaining the biomass communities in constant dynamic equilibrium. These outlined problems would be exacerbated by the Hong Kong climate and would require a highly trained and skilful workforce.

6.24 For the proposed SSSH, a reduced-scale by-products plant would be built. Minimal blood coagulation and dewatering would then be required prior to disposal to landfill. An odour concern would, thus, be minimised. However, full scale by-products plant will be considered as an option, and assessed as such for odour impact.

6.25 Slaughterhouses generally control material carefully, and use warm water for cleaning of organic material, and sanitizers to reduce the microbes on surfaces and in the drainage system. At SSSH, warm water will be used which is an improvement over the cold water presently used.

6.26 The rooms emitting odour and the type of odour are listed below, except that odour emission may also occur from the condemned cattle chute. These rooms are all located on the L1 of the slaughter block (Fig. 6.4).

- Blood Handling Room: blood processing (blood coagulation/dewatering)
- Isolation Lairage: manure/urine of pigs, cattle and goats, and feed
- Manure Pump Room: manure/urine of pigs, cattle and goats
- By-Prod. Collect/Loading: condemned offal & carcasses, and dead animals

6.27 The new facility will have modern blood coagulation and dewatering equipment (e.g. continuous enclosed equipment set), but odour leakage incidents may occur from the equipment. During the transfer of blood coagulum to the transportation lorry, odour will escape into the room, etc. However no odour leakage is expected to occur once the coagulate has been placed in sealed containers or during the transportation process which occurs in a sealed vehicle. Emission is only expected to occur during the slaughter processing time since the blood is processed continuously as it is collected, i.e. 02:00 to 12:00. The proposed slaughtering hours for pigs and cattle are from 02:00 to 12:00, and 02:00 to 10:00 respectively.

6.28 The isolation lairage will have similar manure odour to the main lairage, but is much smaller in size. The blood handling room is enclosed, and the air from it and the adjacent isolation lairage may be collected into one exhaust duct to the roof and there treated for odour and dispersed. The manure pump room will have fugitive odour.

6.29 The by-products will be handled quickly, with large items being transported directly to the condemned chiller, and small items such as condemned offal being collected in closed containers first and then transported to the chiller, until time for disposal. Thus, the chiller/freezer rooms will have a low odour level. A high level was recorded at KTA in the condemned meat and offal room just because no cooling is available and the by-products had been stored for several hours at ambient temperature.

6.30 Condemned items arise during the processing time of 02:00 to 12:00. Dead animals must be handled at any time. The collection room and loading bays for the disposal of the cold by-products are not cooled, but are enclosed, and material will be collected and loaded quickly for a short residence time.

FULL-SCALE BY-PRODUCTS PLANT (BPP) (OPTIONAL)

Process Description

Blood Processing

Batch Blood Coagulation

6.31 Raw blood is initially coagulated by injecting direct steam into an open tank containing raw blood. The blood coagulum of around 25% total solids is then separated by draining or hand pressing for further processing.

6.32 This method of coagulation is generally not satisfactory since the optimum coagulation temperature of 90°C is difficult to achieve uniformly throughout the process. This leads to incomplete coagulation which results in the loss of some blood.

6.33 The disadvantages of this method are that it requires manual labour for separating the blood coagulum, and the waste stream from the separation step carries a high proportion of the raw blood thus in turns gives rise to downstream effluent treatment problems.

Continuous Blood Coagulation/Dewatering

6.34 Strained blood from a blood holding tank is pumped into an intermediate pre-heating tank equipped with a slow-speed agitator. The pre-heated blood (60°C) is then passed to a coagulator where steam is injected at several points to ensure intimate mixing of blood and steam. By temperature sensing and automatic control, blood reaches the exit of the coagulator is at the optimum temperature of 90°C.

6.35 After coagulation, the coagulum is separated from the aqueous fraction in a horizontal scroll-type (decanter) centrifuge. The amount of dewatering depends upon the initial water content. Usually about half of the water in the raw blood is mechanically removed in this step to give a coagulum with over 30% solids content.

6.36 An alternative continuous blood dewatering device which could produce a higher coagulum solids content is belt filter press.

Batch Blood Drying

6.37 Raw blood or coagulated blood is charged into a horizontal batch dryer that is equipped with a steam-jacketed shell. Some batch dryers are also equipped with a steam-heated beater shaft to increase heat transfer area and to reduce the drying time. These blood batch dryers have a capacity varying from 1 to 3 tonnes per batch.

6.38 In this process, blood tends to form a scale on the hot heat-transfer surfaces of the dryers, and consequently the heat transfer rates are poor and blood drying times are long. Typically, for a 2.5 tonne batch a total drying time would require 4-6 hours.

Continuous Blood Drying

6.39 Blood coagulum is continuously charged into a dryer. The most common dryer used is the ring dryer. Drying is accomplished by simultaneously grinding and dispersing the wet product into a high velocity (10-20 m/s) air steam. Other commonly used dryers include direct-fired rotary dryer, indirect steam-heated dryer and spray dryer.

6.40 Compared to batch drying, blood drying time for the continuous process is much less, i.e. about an hour. Also, the continuous system is more energy efficient and more compact.

Condemned Meat/Bone Rendering

6.41 Since significant portion of raw material handled by the rendering plant is diseased animal carcasses, product sterilization is a overwhelming concern. The main disadvantage of the processes continuous dry-rendering and low-temperature rendering is that completed sterilization is not guaranteed, and therefore is considered as not acceptable in this case.

6.42 It is necessary to outline the procedure by which the condemned cattle and pig carcasses will enter the by-products plant process. In the case of the bovine carcasses, firstly the hide is removed from the flesh and separated from the process at this point. Secondly, the remaining carcass is dissected and then placed into the pre-breaker before feeding through to the by-products plant. The condemned swine carcasses are scraped first to yield their hair and bristle and then placed whole into the pre-breaker before entering the by-products plant process.

Digestor Wet Rendering

6.43 This method is being phased out, but a few still in use. It was the original wet-rendering procedure. Raw materials is coarsely broken and then loaded into the batch digestor. Water is added if the product is dry and steam is injected directly into the material through perforated plates at the bottom of the digestor. The addition of steam increases the internal pressure of the digestor and raises the temperature of the material. The heat causes the cells of the material to cook and fat is released and floats to the top of the digestor. When sufficient heat is added, the steam input is reduced, and the digestor is held under pressure for some time to complete the cooking, soften the bones and to sterilize the cooked material. At the end of the cooking cycle, the fat is floated off from the top and the cooked defatted solids are manually removed and dried in a separate dryer to produce meat and bone meal. In between the top fat layer and the bottom solids, there is a "gravy" layer of solubilized fat, protein and minerals.

6.44 Digestor wet-rendering has the advantage of producing good quality tallows. However, its disadvantages are that this batch system requires long processing times (4-6 hours for a batch of 3 tonnes), very labour intensive and up to 25% of the meal is lost in the gravy which subsequently causes an effluent problem.

Dry-Batch Rendering

6.45 This is one of the most common methods of rendering used throughout the world. A batch cooker is a horizontal steam-jacketed vessel. In the centre of the vessel there is a shaft to which arms with wide paddles are attached. Standard size batch cookers are generally of 1.52m in diameter and 3.66m in length having a capacity around 3,000 kg. The heat transfer area of the jacket of a standard-size cooker is 25 sq.m. The steam-heated agitator may provide a further 8 sq.m. As the shaft turns, the paddles stir the material in the cooker and simultaneously scrape the sides of the cooker.

6.46 Standard cookers are designed for loads of up to 2,500-2,800 kg. Loading is usually carried out by using screw conveyors or pneumatically blowing the charge in a blow pot. When the cooker is partially full, steam is turned on. The cooking times vary, depending on the type of raw material. With soft material containing excessive amounts of added water, cook time of up to 6 hours is required.

6.47 At the end of the cook, the cooked load is discharged from the cooker by opening the unloading door at the front of the cooker and reversing the agitator. The cooked load, or tankage, is dropped from the cooker into a percolator pan to separate the free-draining tallow from the crax (cooked proteinaceous material). The crax are conveyed into a pressing or expelling devices, such as screw press or a centrifuge to extract the tallow from the crax. The tallow from this operation is combined with the freely drained tallow and refined on settling tanks or in a decanter centrifuge to remove protein fines and other impurities. The crax from the press is ground in a hammer mill to produce the final meat and bone meal.

Advantages of dry-batch rendering are as follows:

- compared to digestor wet-rendering, this system does not lose material from the cooker; and

- cooking, pressurising and sterilizing can be carried out in the same vessel.

Disadvantages of dry-batch rendering are as follows:

- dry-batch rendered tallows are darker in comparison to wet-rendered tallows;

- it is not easy to keep the plant neat and tidy as the process has many open vessels and the cooked products can easily be contaminated;

- labour intensive; and

- the process is high steam-consumption unless the cooker vent system is recovered as hot water.

Continuous Dry-Rendering

6.48 In this process, dry rendering is carried out continuously in one cooker. Raw material is continuously charged into a horizontal, cylindrical cooker around which satellite steam-heated tubes are arranged. The shaft is divided by two discs at right angles to the shaft, forming three compartments within the cooker. A small opening in each disc allows the material to pass from one compartment to the next in a restricted manner, which prevents undercooking and short circuiting of material through the cooker. Each of the compartments carries out a different stage of the process. The cooker operates under atmospheric pressure. From the cooker, the tankage is discharged into a percolator to drain the free- draining tallow. The crax is screw-pressed as in batch-dry rendering.

Advantages of continuous dry-rendering are as follows:

- being a continuous process the labour requirement is low;

- compared to digestor wet-rendering there is no loss of material from the cooker; and

- vent steam can be recovered to produce hot water or can be pressed and used a steam for process itself.

Disadvantages of continuous dry-rendering are as follows:

- this system cannot be pressurised; therefore, it cannot sterilize and cannot hydrolyze wool or feathers;
- the tallows produced are of darker colours from those of dry-batch rendering due to higher temperatures used; and
- other disadvantages are the same as listed under batch dry-rendering.

Low-Temperature Rendering

6.49 The traditional high-temperature dry-rendering process is compared with a low-temperature rendering process. In the high-temperature process, fat- and protein-bearing material are heated together and at the end of the cooking process the protein is deep fired in the hot fat. This deep frying process degrades the quality of both the tallow and the meal. In addition, at temperatures above 100°C, impurities in the raw material, such as chlorophylls and other colour substances, are fixed in the tallow and cannot be removed by bleaching.

6.50 In low-temperature rendering, the tallow is separated from the protein faction at temperatures of around 70-95°C in a relatively short time. Then the liquid phase (a mixture of tallow and water mainly) is separated from the proteinaceous wet solids phase by the use of presses or horizontal centrifuges. The liquid phase is purified into tallow by the use of vertical centrifuges, while the solids phase is dried in steam-heated or direct-fired dryers. Thus, unlike conventional high-temperature rendering, where the proteinaceous meal is fired in hot fat, in low-temperature rendering, drying is carried out in the absence of free tallow.

Advantages of low-temperature rendering are as follows:

- being a continuous process, the labour requirement is low;
- better quality tallows are produced as the fat-bearing raw material is subjected to short times (4-30 min) at temperatures below the boiling point of water;
- higher nutritive values of meals are produced;
- less thermal energy is required;

- as low temperature are used in the process, and as the proteinaceous meals are not heated in contact with fat/tallow at temperatures above the boiling point of water, odour are minimised.

Disadvantages of continuous dry-rendering are as follows:

- as drying is generally carried out at atmospheric pressure. Thus, the core temperatures of the wet proteinaceous fraction do not reach the temperatures required to meet internationally accepted time/temperature criteria of sterilization. More recently, BSE (bovine spongiform encephalopathy) and other outbreaks of diseases in cattle, sheep and poultry have been blamed on low- temperature systems.

Odour Consideration

6.51 As a general rule, continuous drying/rendering processes are comparatively less odorous than batch processes since odours could be properly contained by processing machinery. For the batch-wise operation, odours would be emitted constantly during the transfer of products from one place to another place.

6.52 For meat and bone rendering, low temperature rendering is considered as the least odorous process since the intensity of odour is suppressed by reducing the rendering temperature.

Preferred Processes for New (Full-Scaled) By-Products Plant

Blood Processing

6.53 If a full-scale BPP is considered continuous blood coagulation and drying is more preferable compared with batch process for the following reasons:

- energy efficient
- less laborious
- compact layout
- less raw blood loss
- less odour nuisance
- less effluent treatment problem

6.54 In the case of full scale plant being adopted at SSSH, coagulated blood will be transported from the Tsuen Wan Slaughter House for treatment and/or disposal at SSSH. The coagulated blood will be sealed into air tight buckets at Tsuen Wan and placed inside an enclosed van for transport purposes. Once the coagulum reaches it's destination, adept on site management and skilful staff should ensure it's swift conveyance through to the blood handling room and finally into the by-products plant system. Due to the fact that the blood coagulate will remain in sealed containers inside an enclosed van during it's transference, it is not anticipated that there should be any adverse odourous emissions generated by this process. Hence, this procedure should not cause any significant impact, in terms of odours, on the resident population.

Preferred processes

6.55 In summation the processes preferred for installation if a full-scale BPP is built at SSSH are continuous blood coagulation/dewatering and continuous blood drying for raw blood, and dry-batch rendering for condemned meat. If there is only to be a reduced-scale BPP then it is considered that the only process necessary is continuous blood coagulation/dewatering.

Wastewater Treatment Plant

6.56 The raw sewage screening, equalisation tanks, treatment processes, and sludge handling and storage emit sewage odour (hydrogen sulphide, sulphides, amines, etc.). The plant is underground and located near the slaughter block (Fig. 6.2).

6.57 The total odour emission will be significant because of the size of the plant. However, biological treatment processes emit little odour if the process is operated properly. Thus, most of the odour will be emitted during the raw sewage screening, and the sludge (screenings, DAF and biological sludges) handling/dewatering units.

6.58 The pattern of odour generation will generally follow the pattern of wastewater generation (Fig. 6.5), except that the contribution from the sludge handling/dewatering units will be fairly steady throughout most of the day since they have a relatively continuous operation.

6.59 The plant is located underground and completely enclosed, enabling the air to be easily collected and directed to an odour treatment location. For residual odour dispersion, the exhaust ducts can be routed to the roof level of adjacent higher buildings, e.g. the slaughter block.

Odour Control Technologies

6.60 The primary methods of controlling odour are:

- reduce the odour generated
- contain the odour in as small a volume of gas as possible
- treat to the required level
- disperse the residual odour

6.61 Methods of reducing the odour generated will be discussed for each of the previously identified odour emission areas: Lairage, Unloading Areas, BPP (full-scale or reduced scale), Slaughter Block, and Wastewater Treatment Plant. This includes design measures and operational controls. Specific treatment technologies best applicable to each area will then be identified and discussed. First, however, treatment technologies identified for odour control will be discussed in general in regard to their performance, cost: capital & recurrent, ease of operations & maintenance, and space requirements.

6.62 Treatment technologies identified for odour control are:

- odour neutralising sprays
- possible treatment units at ventilation exhaust
  - ozone
  - scrubbers
  - biofilters
  - activated carbon
  - incinerators
- stack dilution at ventilation exhaust

Odour Neutralising Sprays (Appendix 6.6a; Figure 6.8a)

6.63 Products are available on the market that neutralise odourous gases. These are not masking agents, but chemically dissolve and neutralise odorous gas from the air. Most are applied by spraying over the surfaces after being diluted with water. The neutralisers are composed of organic chemicals and other agents which are biodegradable. They are non-toxic, non-corrosive, non-flammable and have no effect on bacterial activity in the downstream activated sludge treatment plants.

6.64 Some neutralisers have been approved by agencies such as the USDA (United States Department of Agriculture), Japanese EPA, etc. for agricultural use. Examples of related usage's are shown below:

- swine houses in U.S.
- human/swine waste transport trucks in Japan
- in scrubber for the above vacuum trucks
  - slaughterhouses in Canada
  - slaughterhouses in U.S.(cow blood/waste)

6.65 It was reported for the 1st usage listed above, that almost 90% of NH_3 was eliminated immediately upon application, and that the majority of remaining odours were eliminated after 2-3 hours. Application was twice daily. Laboratory head space tests show reductions of 90% for ammonia, trimethyl amine, hydrogen sulphide, and methyl mercaptan.

The composition of one of the odour neutralising sprays is as below:-

•	Glycine Betaine	22.0%
•	Organic Acid Sodium Salt	3.5%
•	Salt of Phosphoric Acid	13.0%
•	Alcohol Amine Compound	8.0%
•	Amphotelic Surfactant	1.5%
•	Indigo Carmine	0.25%

- Essential Oil 0.7%
- Water 51.05%

6.66 The effectiveness, non-toxicity, and common usage of it is shown for reference (Appendix 6. 6a). There are other such agents on the market however, and no specific one is recommended. The description of one with laboratory odorous gasses removal tests, reports on similar applications (including a university research study in poultry houses), material safety data sheets, and USDA approval are included.

6.67 Tests on one agent were carried out at laboratories in the U.S.A. in compliance with U.S. EPA data requirements (appendix 6.6a). An acute inhalation toxicity study was conducted in 1989 and results showed no clinical observations during the tests and concluded that there was no obvious detrimental effect of exposure . Further on site studies have been carried out under working conditions over a number of years, the collated data results show odour neutralising agents to be extremely effective, reducing ammonia levels by up to 90% in the first 5 mins. after spot spraying with a fogger.

6.68 The cost is estimated at ~\$200/1000m^2 for each application of an odour neutralising agent. Fogger units can be purchased for \$16,000 each: one for each different area sprayed may be most convenient. Operation is easy and there is no maintenance. Space required would be for the drums of neutraliser and the fogger units which are small enough to sit on the top of a drum.

6.69 The use of odour neutralising spray at the proposed SSSH takes advantage of a recent trend in odour control technologies which promise to advance substantially in the near future. Present agricultural techniques already employ odour neutralising sprays as an integral part of odour control.

Ozone (Appendix 6.6b)

6.70 Ozone is an extremely potent oxidizing agent, only second to Fluorine. Thus, it can be used to destroy micro-organisms and odorants. The odorous air must be trapped with the ozone for reaction, e.g. in a duct, and the ozone must be continuously generated since it has a half life of ~30 minutes. Ozone removal efficiency depends upon the amount of ozone generated, and can theoretically be very high.

6.71 Ozone emits a characteristic odour and is readily detectable by most people at 0.003 to 0.010 ppm. It is also harmful in high amounts and is limited to 0.050 ppm indoors. Low ozone levels are used when treated air is returned to occupied areas (0.005 to 0.030 ppm). High levels of ozone can be generated otherwise. Many units have manual regulators: some have an automatic feedback control to maintain constant ozone level. The flexibility of these ozone generating systems is paramount in the control of potentially harmful levels of ozone.

6.72 Cost of the system is moderate, but depends upon the control system option. Recurrent cost is for the power consumed and for the periodic cleaning of the plates. Operation would be easy with an automatic control system, and maintenance is minimal. Space is minimal as the units are installed partially within the ventilation ducting system.

6.73 Ozone will be used for odour control. It is the intention of this report to strongly recommend the use of ozone for odour abatement and disinfection as it is being successfully employed in this capacity internationally. There is no question of ozone being harmful to humans when applied within stipulated guide lines and when used in an environment which actively dilutes any residual ozone content. Ozone's capacity to attach itself and so neutralise organically generated odours and micro-bacterial organisms relies on it's high content of free radicals. These free radicals scavenge for suitable compounds to bond with in order to balance the unstable compounds, thus creating a balanced environment. Therefore the residual ozone will be minimal and the assessment on the dispersion of ozone should be considered as unnecessary.

6.74 Pilot tests at the existing KT abattoir are being conducted in order to assess the optimum levels of ozone required to effectively treat odourous emissions under working conditions coupled with the Hong Kong climate. Ozone is affected by pH, UV and the quantity of organic compounds (odour and bacteria) present in the surrounding atmosphere to mop up the free radicals.

6.75 It has therefore been established that ozone will be an extremely effective method of eradicating odour emissions and micro-bacterial organisms. By skilful on-site management and the wearing of ozone monitoring cards (colour co-ordinated), all staff working within the rooms being cleansed with ozone. A further expansion of safety regulations can be found in Appendix 6.6b.

Scrubbers (Figure. 6.8b)

6.76 Design variations are numerous. The conventional multi-stage treatment for complex mixtures of odorants consists of three stages: 1) dilute sulphuric acid to remove amine and basic doors, 2) alkaline sodium hypochlorite for the acid and organic type doors, and 3) dilute sodium hydroxide for residual chlorine removal. This removes about 95% of rapidly degradable odorous gasses.

6.77 A scrubber system that incorporates ozone into the water instead of chemicals is used for odorous air from sewage treatment plants. The unit can be a packed tower with countercurrent air/scrubber liquid flow . New, more efficient designs include a catalytic single stage process and tests of this process resulted in data showing an extremely efficient removal of odour in sewage applications. The packing design is also important for air/liquid contact (removal efficiency).

6.78 Particulates or fat aerosols must be removed as they tend to deposit in the packings, etc. Venturi scrubbers are often used to pre-treat the air. Scrubbers are most suitable for the mid range of odour emissions. The chemicals used are corrosive and hazardous to handle. For example, sulphuric acid is effective in removing the basic (amine) odorants, but presents explosion and handling problems in Hong Kong because it is only available in the most concentrated form. There is a continual outflow of spent waste water which costs in terms of water/chemicals and disposal costs.

6.79 Scrubbers are mid-range in regard to capital cost. The chemicals consumed, waste water treatment, a small power requirement, and maintenance are the recurrent costs. To minimise the amount of oxidant/chemicals, a control system (oxidation reduction potential) can be utilised. The more efficient designs, particularly the catalytic, reduces the amount of chemicals. Operation requires periodic restocking of the chemicals and periodic monitoring of the scrubber's function. Space required is moderate and depends upon the volume of air that must be treated and the complexity (i.e. stages) for the compounds to be removed.

Biofilters

6.80 Biofilters are beds of moist soil, compost, etc. that remove odour from gases via adsorption and microbial oxidation. They can be mono-layer or multi-layer silo. The efficiency of removal for rapidly biodegradable gases can be 99+% if the bed is properly designed/operated. Three factors are critical:

- sufficient bed volume for the required gas retention time;
- continuous gas flow with somewhat constant odour constituents; and
- moisture, temperature and pH control, during operation.

6.81 An example is a soil bed for the cooker exhaust of a rendering plant which achieves 99.9% removal, and is multi-layer and enclosed with automatic moisture control. Another example is a soil bed which relies on natural rainfall and achieves 95% removal of extremely odorous air when the bed is too wet or too dry, and 99% at intermediate moisture content. Biofilters are best suited to relatively small airflows due to their space requirements.

6.82 Biofilters require relatively large space because the gas retention time must be long as this is a natural (i.e. relatively slow) process. Multi-layer biofilters requiring less area have been developed and can be in the form of round silos Capital cost is low at $200 for each m3/hour of air treated (multi-layer and does not include installation). The only other equipment required is an air blower in the supply ducts to overcome the back pressure, and the automatic moisture control.

6.83 Operating costs for the multi-layer biofilter is extremely low because there are no consumables used, no waste generated, and only a small power requirement for the blower. Maintenance cost for soil beds is extremely low because, unlike compost, it does not need replacement or mixing. The mesophilic bacterial communities of these multi-layer biofilters however, do need careful monitoring to achieve their optimum neutralising plateau, therefore skilful operators will be required.

6.84 As discussed earlier in this chapter (para 6.22 & 6.23) the employment of this technology is perceived as an unsuitable process for operation at the SSSH site.

Activated Carbon

6.85 Activated carbon absorbs 90-95% of rapidly degradable gases. An advantage is the ability to adsorb many gases even at very low concentrations in the air. The efficiency is not steady, but declines as the carbon becomes saturated, thus, the carbon must be regenerated or replaced regularly. Moisture and higher temperature reduces the adsorption capacity of carbon filters.

6.86 Activated carbon is expensive to buy and replace: regeneration is not normally cost-effective. Thus, they are most cost-effective for low odour emission situations. No power expense is involved. Maintenance is easy since it only involves changing the filter, but maintenance must be diligent. Space requirements are reasonable.

Incinerators

6.87 Incinerators are quick and 99+% complete for all organics. Also, performance is not affected by initial odour intensity and the system is flexible in operation. Air with particulates or moisture present no problem. There is no secondary disposal problem. Typical combustion air pollutants (including odour) are produced and emission regulations must be met.

6.88 Incinerators are best suited to a high odour level and low air flowrate because of fuel expense. Some systems use catalysts and heat recovery to significantly reduce the fuel costs: these add to the equipment purchase and maintenance cost. Also, careful assessment of the inlet pollutants is necessary for catalytic incinerators because certain compounds foul the catalyst. Incinerator equipment is expensive to purchase and parts need replacement due to the extreme operating conditions. Operation is easy with little routine maintenance work required. They require relatively little space.

Stack Dilution

6.89 This is usually an inexpensive method which relies on sufficient dilution at a higher elevation from a point(s) discharge. A constant and high air flowrate is required which depends on the ventilation system and operation. Structural considerations are important. This method is not recommended as the sole mitigation method, yet can be useful when employed as one part of a mitigation package. It is more favourable that methods remove odour from the air at or near the source.

Odour Modelling Requirements

6.90 Air Sensitive Receivers (ASRs) must be identified and the odour emission modelled to verify <5 OU cumulative odour for 5 seconds at nearest ASR. The following model assessments are to be provided as agreed with EPD:

- odour impacts on ASRs by all sources (cumulative effect), without any mitigation;
- odour impacts on ASRs by all sources (cumulative effect), with mitigation measures/devices implemented; and
- odour level contours in the 1-km radius study area at all receptors (located in grid), at levels with 10m increment from ground to 60m level, with mitigation measures/devices implemented.

6.91 Computer Modelling using the "Industrial Source Complex-Short Term" ISCST model was done to predict the odour level at the air sensitive receivers (ASRs) from the identified odour emissions on the site. Hourly meteorological data from the Royal Observatory Ta Kwu Ling weather station for the year of 1994 were used for the model runs. A description of the ASRs, including distance from the site, is provided in Table 3.5 and Figure 3.1 in Section 3.

Odour Modelling Inputs

6.92 The inputs to the model are:

- odour level in Odour Units (OU);
- air flow rate;
- type and configuration of emission (volume, point, etc.);
- elevation of emission;
- emission air temperature; and
- meteorological data.

6.93 Few applicable data on odour levels for this Modelling is available. Design of an odour treatment system is based upon the air flowrate, the nature of the odour, and previous design experience: odour unit data can be helpful, however. Lack of data is also because the odour panel testing is expensive, tedious, and only semi-quantitative. To obtain data for this modelling, odour levels have been previously measured at existing abattoirs and unloading depot with the following results (Table 6.6):

Table 6.6: Odour Unit Measurements at Existing Facilities

Location	Odour Unit (OU) 8/1/94	29/1/94	30/1/94	2/2/94	3/2/94	4/2/94	5/2/94
Pig Lairage:							
Kennedy Town Abattoir	360	110	260	290	190	270	180
Cheung Sha Wan Abattoir	180	170	180	175	68	86	70
Livestock Unloading Area: Ho Man Tin	-	-	-	125	105	65	85
Blood Drier Area: KTA	530	270	-	230	130	230	320
Condemn Meat Area: KTA	-	-	-	210	2300	1680	2050

6.94 Airflow and affected volume data should be taken at the same time as the odour sample. Modelling is based upon odour emission rate which is odour units multiplied by air volumetric flowrate of the air that contains that level of odour. Generation of odour such as from animal manure is dependent upon the manure amount, temperature and time, and the odour units will be high if airflow is low, and low if airflow is high, etc. Thus, care must be taken in using the above data when estimating odour emission rate.

6.95 Air flow measurements are straightforward for closed systems, e.g. at an exit, such as a stack, the exit velocity can be easily measured and the odour sample taken. Ideally, for surface emissions, such as manure on a floor, or the liquid surface of a wastewater treatment tank, hoods are available with controlled air blowers, such that the exit odour sample can be directly correlated with the volumetric air flow. Multiplication for the whole emission surface yields the total odour emission.

6.96 Inputs to the model are listed in Figure 6.6. Rationale for each of the inputs is given below. Usage is made of the above previous data, and conservative estimates made in other cases, pending more information.

Lairage

6.97 Rationale behind the inputs in Figure 6.6 and Table 6.17 is listed below:-

- The 180 OU (7 day maximum) from CSW Abattoir is used because the generally better conditions would be more similar to a new facility than the KT Abattoir.
- The size and headspace were obtained from the Architect's layout and the Schedule of Accommodations (Appendix B)
- A ventilation rate of ten (10) ACH will be assumed since it is an average, common rate. Also, ventilation at the SSSH lairage is to be 10 ACH per the Architect, which is based upon Australia/New Zealand practice. (Additional cooling for the pigs is to be provided via a cooling spray.)

- The model type is point discharge at roof because the ventilation system is extractive with the collected air vented at the roof. The system is operated at constant air change rate throughout the year.
- The exhaust point height is 3 meters above the roof per the Best Practical Means for odour exhausts.
- The OU for the two manure collection rooms is initially estimated at 500 OU. The size and headspace were obtained from the Layout and Schedule. The ventilation rate is low and assumed to be 10 ACH.
- The model type is point discharge at roof.
- All assumed air changes per hour for respective plant area's has already been agreed and confirmed with Government departments, ASD and AFD.

Unloading Areas

6.98 Rationale behind the inputs in Figure 6.6 is listed below:-

- The 125 OU (7 day maximum) from the Ho Man Tin unloading area is used. Note that the SSSH will be completely paved and cleaned regularly.
- The train and the occupied transit pens are the odour sources since the animals and their waste, in those areas where they are held for any length of time, are the main source of odour. (Note that the area is cleaned before unloading.)
- The volume of the train, and the transit pen area were obtained from the Architect's layout. The height at which the 125 OU is assumed valid for the transit pens is 3 meters. Odour is high near ground level and decreases rapidly with height in an open area.
- The delivery lorry parking area has seven (7) spaces per the layout, thus the lorry volumes were multiplied by seven.
- Airflow will be extremely variable in an open area. Ten (10) ACH is assumed.
- The train is split into two and occupying tracks G1 and G2, so the train is modelled as volumes added together to form lines (G1 and G2). The transit pens are similarly modelled. Emission is from top and sides.
- The lorries are modelled as volume sources: emission is from all sides.
- The emission release height is from the top for the train and lorries (i.e. 3 meters), and from the 3 meter height for the transit pens.
- All assumed air changes per hour for respective plant area's has already been agreed and confirmed with Government departments, ASD and AFD.

Slaughter Block Rooms

6.99 Rationale behind the inputs in Figure 6.6 is listed below:-

- All of the room volumes were obtained from the Layout and Schedule. All of the discharges are modelled as point sources from the roof.
- The Blood Handling Room is assumed to have an OU of 530 based upon the maximum value measured at the KT Abattoir blood drier area. Ten ACH is assumed.
- The Isolation Lairage is assumed to have an OU of 180 which is the same as that used for the main Lairage. Ten ACH is assumed.

- The Manure Pump Room is initially estimated to have an OU of 500. Ten ACH is assumed.
- The manure collection rooms in the lairage block were estimated to have an odour level of 500, i.e. the same as in the manure pump room in the slaughter block. Since the manure collection would be done several times a day, it is reasonable to keep a low ventilation rate - 10 air change per hour.
- The Pig Bristle Chute Room is estimated to deliver an odour level of 200 OU's with accompanying air changes of 10 ACH.
- The By-Products Collection and Loading Bay is initially estimated to have an OU of 500 because the material is not left at ambient temperature for long before load-out, and is cold from the chiller storage. Ten ACH is assumed.
- All assumed air changes per hour for respective plant area's has already been agreed and confirmed with Government departments.

Wastewater Treatment Plant

6.100 Rationale behind the inputs in Figure 6.6 is listed below:-

- The Plant is initially estimated to have an OU of 100. Most of the area is for biological aeration tanks which have a low odour: the odour from the screening and solids handling, however, increases the overall odour level.
- The area is from the Layout. Ten ACH was assumed.
- The model is point discharge from the enclosed underground plant, with a release height of 3 meters above roof level.
- All assumed air changes per hour for respective plant area's has already been agreed and confirmed with Government departments.

Table 6.7 FULL-SCALE BPP WITH MITIGATION MEASURES

ASRs	Overall Odour Level (OU) (Cumulative odour impact)
1	5.57
2	8.31
7	7.60
12	1.05
13	1.60
14	2.87
15	0.39
16	1.96

Table 6.8 FULL-SCALE BPP WITHOUT MITIGATION MEASURES

ASRs	Overall Odour Level (OU) (Cumulative odour impact)
1	269.8
2	375.9
7	448.5
12	49.0
13	70.7
14	122.5
15	15.8
16	78.5

Table 6.9 REDUCED-SCALE BPP WITH MITIGATION MEASURES

ASRs	Overall Odour Level (OU) (Cumulative odour impact)
1	1.39
2	2.14
7	1.68
12	0.26
13	0.46
14	0.68
15	0.10
16	0.46

Table 6.10 REDUCED-SCALE BPP WITHOUT MITIGATION MEASURES

ASRs	Overall Odour Level (OU) (Cumulative odour impact)
1	19.4
2	30.6
7	24.0
12	4.5
13	7.8
14	9.3
15	1.4
16	6.1

Table 6.11 FULL-SCALE BPP WITH 5 STACKS AT 30M ABOVE GROUND LEVEL

ASRs	Ground Level Impact (OU) (Cumulative odour impact)
1	3.93
2	5.62
7	4.40
12	0.99
13	1.49
14	2.42
15	0.37
16	1.76

Table 6.12 FULL-SCALE BPP WITH5 STACKS AT 40M ABOVE GROUND LEVEL

ASRs	Ground Level Impact (OU) (Cumulative odour impact)
1	2.86
2	3.91
7	2.99
12	0.92
13	1.37
14	2.04
15	0.36
16	1.58

Table 6.13 Odour Input at Respective Sites of Sheung Shui Slaughter House with Full-Scale By-Product Plant

Area	Odour Output (OU)	Air Change/hr.	References
Pig lairage	180	10	Direct measurement at CSW pig lairage. More representative of new facility.
Manure Collection Rooms	500	10	An estimate from Warren Spring Laboraory[a].
Blood Handling Room	530	10	With reference to CSW odour measurement.
Isolation Lairage	180	10+water spray system	It is a lairage which should have the same odour unit as pig lairage.
Manure Pump Rooms	500	10	An estimation from Warren Spring Laboratory[a].
By-Product Chill Room	200	0	An estimation from Kingston Morrision and W&O; odor will be treated by ozoniser
Pig Bristle Chute Room	200	10	Walsh, 1978[b]
Wastewater Treatment Plant	100	10	An estimation of the odour generated from sludge handling operation.
Livestock Transit Pens	125	10	Direct measurement at HMT unloading depot.
Train(G1 & G2)	125	10	Direct measurement at HMT unloading depot.
Livestock Truck Unloading Area	125	10	Direct measurement at HMT unloading depot.
Full-scale By-Products Collection Room & Unloading Bay	2300	10	Odour generated from condemned animals would be slightly higher than live pigs.
Full Scale BPP Room (animals cutting)	2300	15	The data measured at KT By-Product plant.
BPP Process Exhaust	200000	-	Warren Spring Laboratory[a], 1980 *Ventilation: 200000 OU at 8.5 m^3/s for flowrate *Process: 42000 OU at 0.75 m^3/s for flowrate
Blood Coagulation Room	530	15	The data measured at KT blood coagulation room

Sources : [a]*'Odour Control - A Concise Guide', Warren Spring Laboratory, 1980, pp 28.*
[b]*R.T. Walsh, ;Reduction of inedible rendering matter.' Air Pollution Engineering Manual, 2nd ed., J.A. Danielson (Ed.); U.S. Environmental Protection Agency, Research Triangle Park. NC. Publication No. AP-40, May 1973, pp 823.*

Table 6.14 Odour Input at Respective Sites of Sheung Shui Slaughter House with Reduced-Scale By-Product Plant

Area	Odour Output (OU)	Air Change/hr.	References
Pig lairage	180	10	Direct measurement at CSW pig lairage. More representative of new facility.
Manure Collection Rooms	500	10	An estimate from Warren Spring Laboraory[a].
Blood Handling Room	530	10	With reference to CSW odour measurement.
Isolation Lairage	180	10+water spray system	It is a lairage which should have the same odour unit as pig lairage.
Manure Pump Rooms	500	10	An estimation from Warren Spring Laboratory[a].
By-Product Chill Room	200	0	Kingston Morrision and W&O
Pig Bristle Chute Room	200	10	Walsh, 1978[b]
Wastewater Treatment Plant	100	10	An estimation of the odour generated from sludge handling operation.
Livestock Transit Pens	125	10	Direct measurement at HMT unloading depot.
Train(G1 & G2)	125	10	Direct measurement at HMT unloading depot.
Livestock Truck Unloading Area	125	10	Direct measurement at HMT unloading depot.
Reduced-Scale By-Products Collection Room & Unloading Bay	150	10	Odour generated from condemned animals would be slightly higher than live pigs.
Reduced Scale BPP Room (blood coagulation)	530	15	The data measured at KT By-Product plant.

Sources : [a] *'Odour Control - A Concise Guide', Warren Spring Laboratory, 1980, pp 28.*
[b] *R.T. Walsh, ;Reduction of inedible rendering matter.' Air Pollution Engineering Manual, 2nd ed., J.A. Danielson (Ed.); U.S. Environmental Protection Agency, Research Triangle Park. NC. Publication No. AP-40, May 1973, pp 823.*

6.101 The above-mentioned odour emissions are summarised in Table 6.13 & 6.14. Furthermore, all the air change/hour at respective sites have been agreed by EPD, who were satisfied with all data presented, confirming the calculations.

By-Product Plant

6.102 With reference to the Warren Springs Laboratory Report (Warren Springs Laboratory "Odour Control - a Concise Guide" prepared on behalf of the Department of the Environment 1980), a cooker with the approximate capacity of 100 tonnes per week (14 tonnes per day) is quoted to have an odour emission of 202,000 OU. This figure is achieved with reference to the following calculation data of typical odour emissions, before abatement. Ventilation with a dilution factor of 20,000 and a flowrate of 8.5 (m3 s–1) and process, dilution factor of 42,000 and flow rate 0.75 (m3 s-1). It is concluded that odour emissions at SSSH will further be depressed by the employment of modern rendering process techniques such as the flo-dryer. The flo-dryer is specifically designed to dry the decanted solids from low temperature rendering and blood processing systems. It operates at high temperatures with low air flow rates which gives high efficiency low wear rates and minimal dust and exhaust fumes. The system offers partial recycling of exhaust gases in heat recovery, while the remainder are usually exhausted into an incinerator.

6.103 The temperature of the exhaust from blood and bone meal cookers were estimated under the assumption that odour control device(s) would be used and hence the exhaust temperature would be lowered significantly after abatement by, for example, incineration, ozone, deodourization and wet scrubbers. Further, in Prokop's research into odour removal from the rendering process by boiler incineration, an odour removal system with control efficiency up to 99.5% is qualified (Table 6.15).

Meteorological Data

6.104 Meteorological data from the Ta Kwu Ling weather monitoring station for the year 1994 was used. Morning mixing heights and maximum mixing heights measured at the King's Park weather monitoring station of Royal Observatory were interpolated according to the user's guide of the ISCST model to obtain the hourly mixing heights. On-site measurement of meteorological data was also taken by utilising a wind anemometer at height mast of 10m situated at Shek Wu Hui Government Sewage Treatment Works located adjacent to the site. The data collected (Appendix 6.1) was cross-checked with the data from Ta Kwu Ling for verification, while u represents wind blowing towards west, v represents wind blowing towards south and w represents wind blowing downwards. These data are minutely averaged and separate interval is 1 second. Also relative humidity and

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temperature are recorded. It is prudent to point out that this data was merely used for reference only to provide a loose framework as a cross check for extrapolated results.

6.105 Detailed results of the modelling are given in Appendix 6.2 and Appendix 6.3 while a summary of these results are presented in Tables 6.7 - 6.12:

- Tables 6.7 and 6.8 show the odour level at each of the ASRs by all odour source with and without (worst case cumulative levels) mitigation measures respectively, including full-scale BPP.
- Tables 6.9 and 6.10 show the odour level at each of the ASRs by all odour source with and without (worst case cumulative levels) mitigation measures, respectively, assuming reduced-scale BPP.
- Tables 6.11 and 6.12 show the odour level at each of the ASRs by all odour source with the mitigation measures of five stacks 30 metres above ground level and five stacks at 40 metres above ground level (worst case cumulative levels), assuming full-scale BPP.

6.106 The cumulative odour level at the ASRs varied from 1.4 OU to 30.6 OU without mitigation measures (assuming reduced-scale BPP). With the reductions in odour of 90% to 97.5%, the odour level at the ASRs were acceptable and varied from 0.10 OU to 2.14 OU. However, full-scale BPP without mitigation measures will have intense odour impact. It is anticipated that even with normal abatement techniques ASRs 1, 2 and 7 will have an odour level exceedance of 5.57, 8.31 and 7.60 OU respectively. Under these circumstances, a full-scale BPP would exceed the 5 OU limit.

6.107 A full-scale BPP at Sheung Shui will impact on the surrounding area, yet there are two further mitigation methods which would solve this problem. After running further data modelling assessments, it is learned that with extreme mitigation techniques, odour impact on ASRs 1, 2 and 7 can be brought down within the stipulated guidelines of 5 OU. In order to achieve this goal it is necessary to build five stack exhausts to expel emissions from the full-scale BPP. Under these conditions and with a stack height of 40 meters, ASRs 1, 2 and 7 are modelled as receiving 2.86, 3.91 and 2.99 OU respectively. The second technique would be for the government to purchase the land containing sensitive receivers 1, 2 and 7 and so negate the need for such harsh mitigation methods to be employed.

6.108 Odour level contours in the 1-km radius study area for the cumulative odour levels with the mitigation measures/devices in place are illustrated in Figure 6.7.
The contour maps are for each 10 meter increment from ground to 60 meter height and different scenarios with full-scale BPP (Figure 6.7-A) and a reduced-scale BPP (Figure 6.7-B) are shown. Detailed data used to create the contour maps is given in Appendix 6.4

6.109 As can be seen from the contour maps the mitigation measures will effectively reduce the odour impact to acceptable levels. The background odour level is assumed low. During site visits to the adjacent Shek Wu Hui sewage treatment plant (aerobic process), a light odour was detectable which, under certain transient atmospheric conditions, may be detectable at the SSSH site. The surrounding area rivers and fish ponds may emit a very low level of odour. The transient emissions from the diesel engine trains is considered negligible. No industrial processing or other intensive activities are near.

Mitigation Measures Evaluation

Lairage

6.110 The design of the flooring will emphasise minimal trapping of material and ease of cleaning. Drainage must be well planned to eliminate standing water, trapping, etc.. Overall design for housekeeping is emphasised. A combination of hydro-mist systems will be employed for the cooling and cleaning of the pigs.

6.111 The ventilation system is designed to capture and direct the air from each floor to the roof exhaust points for odour treatment (via distributed ceiling intake vents arrangement and collection ducting). The negative pressure extraction type ventilation system will be operated at a constant airflow throughout the year. Air is replaced via the openings and louvres throughout the external perimeter of the building. Operational controls include the following:

- clean frequently
- incorporate the detailed operational controls into the EMS
- include odour monitoring and action plan in the EMS

6.112 Treatment technologies to achieve 97.5% reduction may optimally be a combination of odour reduction at floor level via spraying with potable water/neutralising agents followed by treatment of the large air volume by ozone or wet scrubbing. Spraying is flexible and may be used, for example, on one side of the building if significant air leakage from the louvers occurs due to transient air conditions, etc.. Spot spraying will be a manual task performed away from live animals and randomly with a fogger to maintain high intensity odours at the 50% level. It is stated that odour neutralising spray can achieve 90% removal efficiency, however, maintaining a 50% odour reduction level is a cost effective measure to control odour at source.

6.113 The fogging unit is a totally self -contained ULV(ultra low volume) fogging system capable of emitting uniform atomization, dispersing a fine non wetting fog of neutralising agents over the odour source, the fogger can also be adjusted to a sprinkle setting much like a hose pipe. If animals are present in near proximity to spot spraying it is advised to switch to the sprinkle setting for odour control. It is suggested that this flexible system should be operated at random, as necessary to avoid superfluous use and needless cost. The technology of the approach is shown below:

- Provide portable odour neutralising sprayers for spot spraying to reduce and maintain odour at the 50% level
- add odour control units to ventilation system to achieve 95% reduction in odour. Two options are given below:
  - ozone units/control system within ducts, or
  - state-of-the-art wet scrubbers at exhaust

6.114 The most effective odour neutralising products, dilution, and frequency of application would need to be determined by testing. Measurement of an indicator gas, e.g. ammonia, with a portable instrument could be used to quantify the tests and to develop a monitoring system for verification and management of spraying operations (seasonal changes, etc.) to maintain 50% reduction. However, the detection of a chemical indicator such as ammonia is not always an accurate measure of disagreeable odour intensity. It is therefore suggested that odour sampling should be conducted in an ad hoc manner, utilising monitoring equipment and the human nose, to supply a cross check of data radiating from the source. Cost per day of the spraying is estimated at $3250 based upon similar usages and 50% odour reduction level. Capital cost and space requirements are small. Operation and maintenance is easy. A horizontal, ionizing, wet scrubber may be an option. For five (5) wet scrubbers, the capital cost is $15 Million and the total space required is 118 m^2. A biofilter is not feasible since it would be too large. Incineration and activated carbon would be extremely expensive for this application.

Leakage

6.115 In consideration of mitigating measures to reduce odour impact on air quality and localised air sensitive receivers, odour leakage as a potential source of odour impact must be addressed. Atmospheric pressure within the slaughter blocks and especially the pig lairage, will be maintained under normal weather conditions at negative pressure, thus presenting no leakage problem. However it is expected that under adverse weather conditions e.g high winds, a leakage of 5 - 10% should be expected from these areas. At these times it is not expected that this will present an odour impact to localised sensitive receivers as odour emissions generated within the slaughter blocks will be highly controlled by effective on-site management and the employment of the suggested control technologies, listed below:

- Effective on-site management and labour deployment.
- Efficient removal of wastes generated by livestock.
- Treatment of odour source areas with water and/or odour control neutralising spray.

Livestock Unloading Areas

6.116 The unloading areas will be completely paved with proper drainage for minimal trapping of material and ease of cleaning. The location of the main unloading train track, G1, has been located as close to the lairage as possible. The ramps, transit pens, and raceways have been arranged to achieve the most efficient and quick movement of the animals into the lairage, and to occupy the least space. This minimises odour emission.

6.117 The livestock delivery lorry parking area has been located very close to the lairage and is small (7 spaces for 42 lorries per day). A modern lorry wash is provided on-site for 1) the TW lorries before loading , and 2) the SSSH lorries after unloading into the lairage.

6.118 A spray system at the delivery lorry parking area could be incorporated to spray the lorry exit air after unloading, e.g. a row of spray nozzles with manual operation for each parking space. Operational controls include the following:

- limit exposure time of trains and lorries
- spray neutraliser at most effective times
- wash paved area and lorries
- incorporate the detailed operational controls into the EMS
- include odour monitoring and action plan in the EMS

6.119 To maintain ≤4 hours total train unloading time per train (two are scheduled), per day via the agreed-upon train manoeuvring plan. Remove the train immediately after unloading. Move the SSSH animals from the trains to the lairage and load the TW animals into the waiting trucks via movable ramps with inspection platforms for safe, humane and immediate transfer to TW. Prohibit the SSSH delivery lorries to remain in the parking space after unloading, and prevent the TW loaded lorries from remaining in the area longer than necessary. Application of neutralising sprays for the following issues:

- empty transit pens
- empty trains and wagon
- delivery lorry's once empty

The on-site management will be required for the following cases :

- unloading area immediately after unloading is completed and animals are gone for negligible residual odour
- require TW lorries to be washed in the lorry wash before entering the area
- encourage SSSH lorries to be washed in the lorry wash before exiting the site

6.120 Treatment technology to achieve 90% reduction is to use odour neutralising spray as described above, and as required. Cost per day of the spraying is estimated at $3250: Capital cost and space requirements are small. Operation and maintenance is easy.

- transit pen area:	$500
- train wagon exits:	$2,400
- lorry exits:	$350
	$3250

6.121 It should be stated that the odour neutralising spray's effectiveness is determined quantitatively and by the sum total of applications made. Odour neutralising sprays operate proactively with the odour source, degrading it's chemical make-up to combat pervasive odours not mask them. These qualities allow for flexibility and control in it's usage (Table 6.17).

Slaughter Block

6.122 Design of the rooms, ventilation system, flooring/drainage, surfaces, and equipment will be modern for control of the odorous air and for ease of cleaning. Special self-closing doors or open-door alarms could be considered.

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- Blood Handling Room
- Isolation Lairage
- Manure Pump Room
- By-Products Chill Room
- By-Prod. Collect/Loading

6.123 Air collection and treatment for the above rooms could be 1) individual for each room, or 2) combined in various ways. Combination systems are more economical, depending on location and other parameters. The rooms are all located on the L1, but for best residual odour dispersion, the exhausts will be ducted to roof discharge point(s).

6.124 In the Blood Handling Room, the blood will be coagulated and dewatered to 25% total solids for disposal to landfill. Modern equipment will minimise odour as the process is automatic and enclosed from blood input to final output, and drying is not required.

6.125 Odour emission is high at the KTA blood handling area because the equipment is old with much manual operation wherein material is frequently open to the air. Material is manually transferred (coagulation to dewatering tanks, to drier, and to output) and pressed during dewatering. Also, the blood is dried for bloodmeal production, which generates substantial odourous air.

6.126 The Blood Handling Room is adjacent to the Isolation Lairage on the L1, but a driveway separates them from the rest of the L1 slaughter block (the L2 slaughterhall, however, extends above them), thus, a combined air system could be considered. The Isolation Lairage design goals are similar to the main lairage.

6.127 The Manure Pump Room and By-Products Collection Room & Loading Bay are located in the same general area of the slaughter block and the air may be combined for treatment, depending upon final location, etc. Note that the Collection Room and Bay are confluent and enclosed for odour control. The use of the Chill Room for storage of the by-products is a major improvement in the reduction of odour. Odour from by-products is highly temperature dependent. Putrefication of by-products stored at ambient temperature and humidity is evident at KTA, particularly for the condemned offal.

6.128 Operational controls include the following:

- move by-products quickly to cold rooms and keep contained otherwise
- limit time period in the collection room
- limit number and duration of disposal loading and transport operations
- limit access to rooms and train staff to close doors
- spray neutraliser for spot control, if needed
- clean rooms and equipment frequently
- incorporate the detailed operational controls into the EMS
- include odour monitoring and action plan in the EMS

6.130 Treatment technologies to achieve 99% removal are listed below:

- individual room: ozone units or carbon filters
- combined room system:
  - biofilter
  - ozone
  - wet scrubber

Incineration would be too expensive for any of these applications. Carbon filters could be most cost-effectively used for individual rooms with low odour removal requirements.

6.131 The capital cost for a multi-layer biofilter to treat air from the Blood Handling Room and the Isolation Lairage is estimated at $2 Million. The biofilter would be a silo of 12 m diameter and 4.6 m high. This system is not recommended however, with reference to the discussion paragraph earlier 6.22.

6.132 The capital cost of a wet scrubber (ionizing type) for the Blood Handling Room and the Isolation Lairage is estimated at $1 Million. Recurrent costs include the chemicals and power (ionization, pumps, fans) consumed, and the treatment of the wastewater. Space required is 12 m^2. Operation involves handling of hazardous chemicals. Maintenance schedule is fairly detailed as the several pieces of equipment are involved.

Wastewater Treatment Plant

6.133 Modern equipment and design will minimise odour emission, e.g. enclosed sludge handling equipment, tank designs with low exposed surface areas, aerobic biological process, etc.. An enclosed plant room is a major design feature for control of the odorous air. Exhaust will be ducted to the nearby building roof for roof installed odour treatment and effective (i.e. high) dispersal of the residual odour.

6.134 Proper operation of the plant is essential in minimising odour, and will be stipulated in the operations manual, and monitored per the EMS. Treatment technologies to achieve high odour removal are listed below:

- wet scrubbers (including ozonated water type)
- biofilters
- ozone

Recommendation for Mitigation Measures of Odour Control

6.135 The odour level from the various sources identified range from 100 to 530 OU for SSSH having a reduced-scale BPP (Table 6.14). The compounds are easily degradable natural organic compounds.

6.136 Incineration is not suitable in any of the applications, except in the case of the BPP process exhaust (if there is a full-scale BPP) because it is expensive, and only used for very high intensity odours, 202,000 in this case. Biofilters require large areas and are too heavy for roof-top locations. Activated carbon filters are not very suitable as the humidity reduces effectiveness substantially and they are expensive to maintain.

6.137 Effective mitigation measures identified are sprays (chemical and/or biological), wet scrubbers, and ozone units. These may be used in combination. The general approach for odour removal is to use odour neutralising agents to control the high intensity odours by reducing the odour at source, and scrubbers and/or ozone to treat collected air.

6.138 In the open areas which are devoid of animals such as KCR/lorry unloading, transit pens, etc. the odour neutralising agents will be used frequently to achieve 90% odour reduction. In the lairage, a combination of neutralising agent and wet scrubbers will be used. The neutralising agent will be used less frequently to achieve 50% odour reduction and the wet scrubbers can achieve 95% reduction (as quoted by supplier and verified by their tests) for a total overall reduction of 97.5% (Table 6.17).

6.139 "Wet scrubbing of plant ventilating air is particularly suited to rendering plants located near sensitive populations." This is Prokop's conclusion to substantial research into air pollution generated by rendering plants (Table 6.16 and Table 6.17), he is a prolific American author and researcher into this specialised subject. Wet scrubbing is particularly recommended at the SSSH not only for their effectiveness in the removal of high-intensity odours, but also their proven capacity to provide proper ventilation of the plant operating areas. Although it is essential to have adequate distribution and flow of air within the plant to capture the ventilating air, ideally a slight negative pressure should be maintained within the rendering plant. These are also the conditions which perfectly suit the use of ozone to successfully combat high-intensity odourous emissions and why the appliance of this duel system at the SSSH site is strongly recommended.

6.140 For the following confined rooms and areas, the blood coagulation room, by-products collection area, by-products chill room, manure collection room, manure pump room, pig bristle chute and the BPP room, ozone will be used to clean the air of odours and micro-organisms. Ozone has been shown to have a high destruction efficiency depending upon the amount used and the contact retention time. The room exhaust air will be treated by scrubbers also to achieve a high efficiency throughout the day since ozone is often used intermittently. This combination will result in removal efficiency of 95%.

6.141 The odour level from the wastewater treatment plant can be easily handled by a wet scrubber achieving 95% removal of hydrogen sulphide.

6.142 If a BPP is built, the odour treatment of the process exhaust must be extreme because the rendering process produces intense odours. In this case, the incinerators are best suited to a high odour level and low air flowrate. It is recommended to have incinerator for 99% removal of most odourous gases. Further, it is also recommended practice to use boiler incineration of the high-intensity process odours since all rendering plants require the generation of steam for the cooking and drying process.

6.143 Two basic choices are available for the odourous air to be introduced into the boiler: primary combustion air (that mixed with fuel before ignition) or secondary combustion air (that mixed with the burner flame to complete combustion). Generally, maximum fuel economy is achieved by using the odourous steam as primary combustion air. However high-intensity odours can be extremely effectively dealt with when the odourous steam comes into intimate contact with the burner flame when used as secondary combustion air. Conditions for achieving 99% odour removal require a temperature of 1200°F or more to be obtained in the firebox and a residence time at maximum fuel rate of more than one second. Results (Table 6.15) of tests clearly show that boiler incineration is a very efficient method of odour control for treating the high-intensity odours from the rendering process. Detailed data obtained with the IITRI dynamic olfactomter shows odour dilution of exhaust stack emissions to threshold values of combustion gases only, odours from the rendering process were not detected.

6.144 Multistage scrubber systems (see Figure 6.8b) for treating the high-intensity odours can be used as an alternative or an effective secondary system and can be successfully employed to neutralise selected/remaining odourous compounds. From overall tests (Tables 6.16 and 6.17) scrubber systems are considered to be a most effective method for the removal of odourants present in plant rendering emissions. Their use for mitigation measures of odour control is encouraged and recommended for the Sheung Shui Slaughter House site. Their effectiveness coupled with By-Product Plant (BPP) boiler incineration will enhance the "good neighbour" strategy

6.145 It will be desirable to employ ozone deodourisation systems for ensuring in-situ removal of odour gases. Two ways of ozone deodourisation will be performed in parallel at the same time i.e. a) ozone aeration from ceiling (Figure 6.8d) ozonised water for washing floors (Figure 6.8c). In principle, the ozonised air from the ozone generator will be pumped out (showering) through PVC pipes installed on the ceiling. The ozone is continually injected to achieve in-situ oxidation of odour gases generated from the rendering process. Furthermore, ozonised air from the ozone generator will be mixed with water from the water tap by the mixing valve, and ozonised water is flushing out on the floor through PVC pipes installed on the floor. This ozonised water will also satisfactorily remove the odour contaminants and have disinfection effect. From the BPP, the air will finally be carried through the ventilation system and passed through scrubbers, which have an odour removal efficiency of 99.5%. The combination of the exhaust incineration and scrubber processes should in theory result in 99.95% removal efficiency, however the accepted removal efficiency is 99.5%

Off-Site Odour Emission Sources

6.146 It is important to stress that once the pigs destined for Tsuen Wan arrive at SSSH they will be thoroughly cleaned under the hydro- mist system in the ramp with potable water. This cleansing will also include the removal of all animal generated wastes from the surrounding environment, thus reducing animal odour. The lorries which take livestock directly from the trains to the Tsuen Wan Abattoir are considered to have negligible odour impact since they are empty when travelling to the site and they will be washed in the truck washing bay prior to loading and subsequent departure from site. It will be assured that efficient on-site management will enforce the appropriate control measures to make sure that the pigs and lorries are cleansed thoroughly.

Table 6.15 Boiler Incineration of Rendering Process Odors

Plant	Fuel Used	Fire Box Temperature (°F)	Odor Dilution to Threshold Values[a] Boiler Inlet	Stack Exhaust	Odor Removal (%)
B	No. 6 oil	-	56,000-138,000	234-650	99.5
B	Natural gas	-	7,600-13,200	88-128	99.0
C	No. 6 oil	1,400	21,600-73,000	76-157	99.6
D	Natural gas	1,250	28,100-59,200	202-356	99.3

[a]IITRI dynamic olfactometer

Source : *W. H. Prokop, 'Control methods for treating odor emissions from inedible rendering plants,' Paper 91-146.8 at Annual Meeting of AWMA, Vancouver, B.C., Canada, 1991.*

Table 6.16 Multistage Scrubbing of Rendering Process Odors

Scrubber Category	Exhaust Flow (ft^3/min)	Scrubber Solutions First	Second	Third	Odors (Units/scf[a]) Inlet	Outlet
Venturi and one packed tower	32,000	Water	NaOCl		5000-20,000	50-100
Venturi and two packed tower	7,500	Na_3PO_4	H_3PO_4	NaOCl	14,000	185

[a]ASTM syringe method

Source : *W.H. Prokop, 'Wet scrubbing of high intensity odors from rendering plants,' Proceedings AWMA Specialty Conference on Odor Control Technology II, Pittsburgh, PA, March 1977, pp 153-166 and 1974, pp 132-150.*

Table 6.17

Area	Control Technology			Incineration[d]	Removal Efficiency (%)	References
	Neutralizing Spray[a]	Ozone[b]	Wet Scrubber[c]			
Pig Lairage	x		x		97.5	PROKOP, 1974 & 1977
Manure Collection Rooms		x	x		95	
Blood Handling Room		x			90	
Isolation Lairage	x				90	
Manure Pump Rooms		x			90	
Pig Bristle Chute Room		x			90	
Wastewater Treatment Plant			x		95	PROKOP, 1974 & 1977
Livestock Transit Pens	x				90	
Train (G1&G2)	x				90	
Livestock Track Unloading Area	x				90	
By-product chill room		x				
By-product collection Room & Unloading Bay		x			90	FREGA & PROKOP, 1981
BPP Process Exhaust			x	x	99.5	PROKOP, 1992
BPP Room		x			90	FREGA & PROKOP, 1981

Sources : [a] *Takashima, 'Epoleon News, Technical Information,' 1987, pp 51. (see supplementary information)*
[b] *(see Appendix 6.66b)*
[c] *W.H. Prokop, 'Wet scrubbing of high intensity odors from rendering plants,' Proceedings AWMA Specialty Conference on Odor Control Technology II, Pittsburgh, PA, March 1977, pp 153-166 and 1974, pp 132-150. (see Table 6.16)*
[d] *W.H. Prokop, 'Control methods for treating odor emissions from inedible rendering plants,' Paper 91-146.8 at Annual Meeting of AWMA, Vancouver, B.C., Canada, 1991. (see Table 6.15)*

6.147 Off-site odour emissions are generated from the livestock delivery trucks. Therefore the roads considered in the off-site assessment are the access route leading from the proposed development to the main road (Po Shek Wu road), including Chuk Wan Street and Po Wan road, which have air sensitive residential areas located to the east side, as shown in Figure 6.9.

6.148 It is estimated that approximately 38 vehicles carrying livestock from China to the SSSH site will arrive via Man Kam Road daily; of these 10 will be used for the delivery of cattle and the rest for pigs. To avoid any odour being emitted from these trucks it will be necessary to thoroughly wash them before they enter Hong Kong. Although it is current practice to wash the trucks at this point, there is no Hong Kong jurisdiction in this area and it may be that a contract would have to be entered into with the future operators to enforce this routine. The livestock they are carrying should also be washed at this point in the journey to avoid high-intensity odours impacting on neighbouring residential areas. However, vehicles entering the site through this access point will be few, and the mitigation methods recommended, if followed properly, will effectively deal with the possible impact on the surrounding environment, therefore no off-site odour impact is anticipated.

Odour Modelling

6.149 Skilful on-site management of the procedures outlined (para. 6.112 and 6.113) will efficiently counter any undesirable odour impact to residential air sensitive receivers. Concerning the transportation of the blood coagulate and condemned by-products as outlined (para. 6.27) this activity will have no adverse odour impacts, no odour will be emitted. The off-site emission predictions do not justify further investigation due to no anticipated odour impact. It is therefore unnecessary to employ a modelling system to assess the environmental impacts of odour emission to localised air sensitive receivers.

AIR QUALITY IMPACTS

Stack Emissions

Assumptions and Design Specifications

6.150 Light diesel consumption rate at the Kennedy Town Abattoir is 1700 Kg/day for slaughtering operation and 1425 Kg/day for BPP process respectively. The slaughtering capacity for the Kennedy Town Abattoir is 2000 pigs and 70 cattle per day.

Considering the slaughtering capacity of 5000 pigs and 400 cattle per day, the light diesel consumption rate for the SSSH is prorata as follow:

- Light diesel consumption rate (slaughter operation) = 1700 Kg/day x (5400/2070)
  = 4434.8 Kg/day
  = 185 Kg/hr

- Light diesel consumption rate (BPP process) = 1425Kg/day x (5400/2070)
  = 3717.4 Kg/day
  = 154.9 Kg/hr

Note: assume 1 pig equal to 1 cattle

- Light diesel consumption rate (with full-scale BPP) = (185 + 154.9) Kg/hr
  = 339.9 Kg/hr
- Light diesel consumption rate (with reduced-scale BPP) = 185 Kg/hr

- Liquid fuel sulphur content = 0.5% w/w

- SO_2 emission rate (with full-scale BPP) = 3.4 Kg/hr
  (with reduced-scale BPP) = 1.85 kg/hr

- Hours of operation : 0300 - 15:00

- No. of chimney = 1

- Chimney height = 20 m above ground

- Stack diameter = 0.6 m

- Stack temperature = 175 degree Celsius

- Stack gas velocity = 16 m/s

- Volume flow rate = 271.43 cu. m/min.

The Dispersion Model

6.151 The Short Term Industrial Source Complex (ISCST2) air quality model was used in the air quality assessment. Hourly meteorological data from the Ta Kwu Ling weather station for the year of 1994 were used for modelling.

Results

6.152 The modelling results show that the predicted SO_2 concentration at all air sensitive receivers are well within the 1-hour and 24-hour criteria as stipulate in the AQOs which is 800 $\mu g/m^3$ and 350 $\mu g/m^3$ respectively. The modelling results for the scenarios of full-scale and reduced-scale BPP are shown in Tables 6.18 & 6.19 below.

Table 6.18 Predicted SO_2 Concentrations With Full-Scale BPP

ASR	SO_2 Concentrations ($\mu g/m^3$) Averaging Time	
	1 Hour	24 Hour
1	23.5	2.2
2	23.7	4.3
7	24.0	3.8
12	16.4	2.1
13	19.5	2.0
14	20.1	2.2
15	18.0	1.4
16	18.1	4.7

Table 6.19 Predicted SO_2 Concentrations With Reduced-Scale BPP

ASR	SO_2 Concentrations ($\mu g/m^3$) Averaging Time	
	1 Hour	24 Hour
1	12.8	1.2
2	12.9	2.3
7	13.1	2.1
12	8.9	1.1
13	10.6	1.1
14	10.9	1.2
15	9.8	0.8
16	9.9	2.5

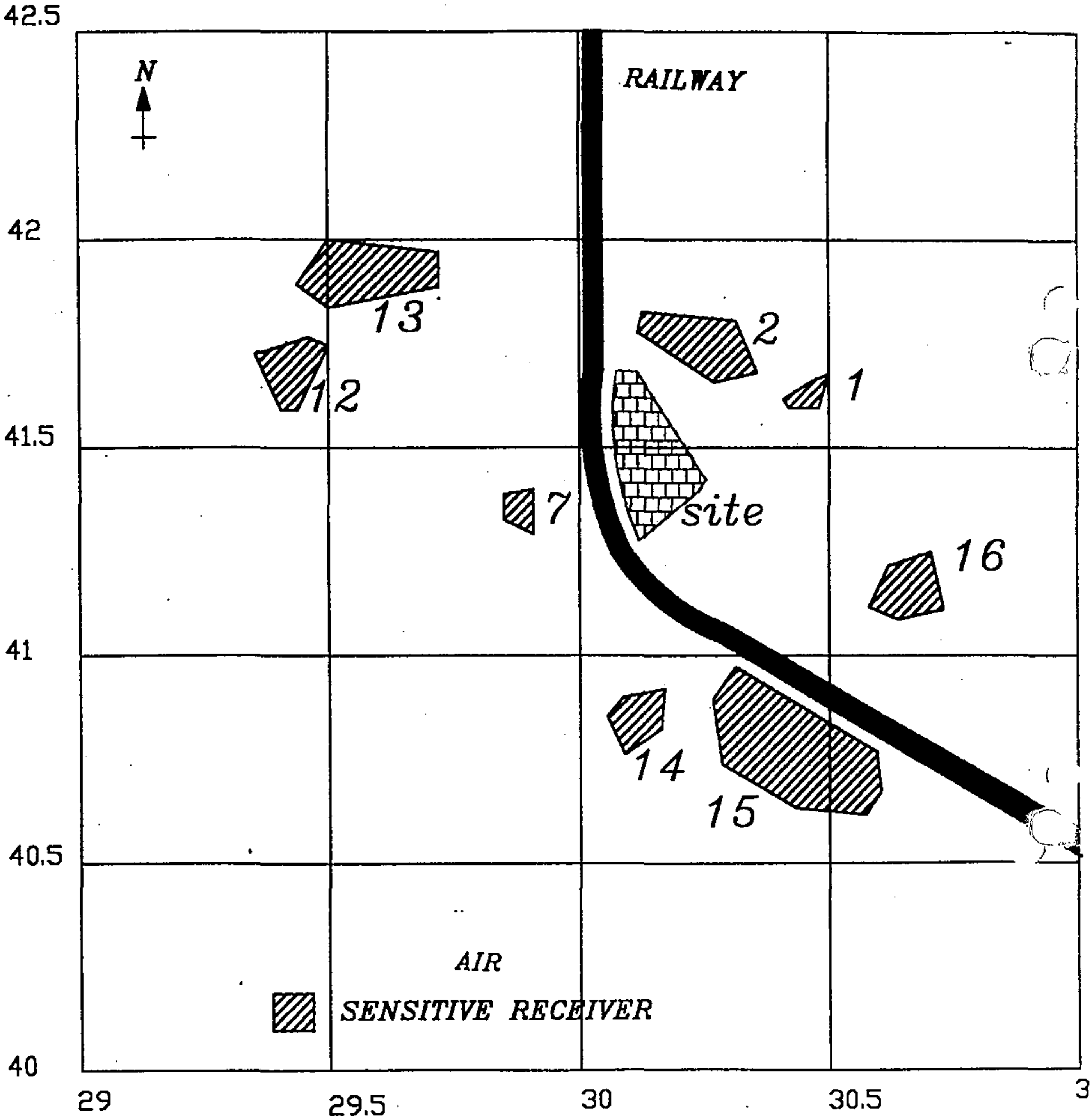


Figure 6.1 Air Sensitive Receivers

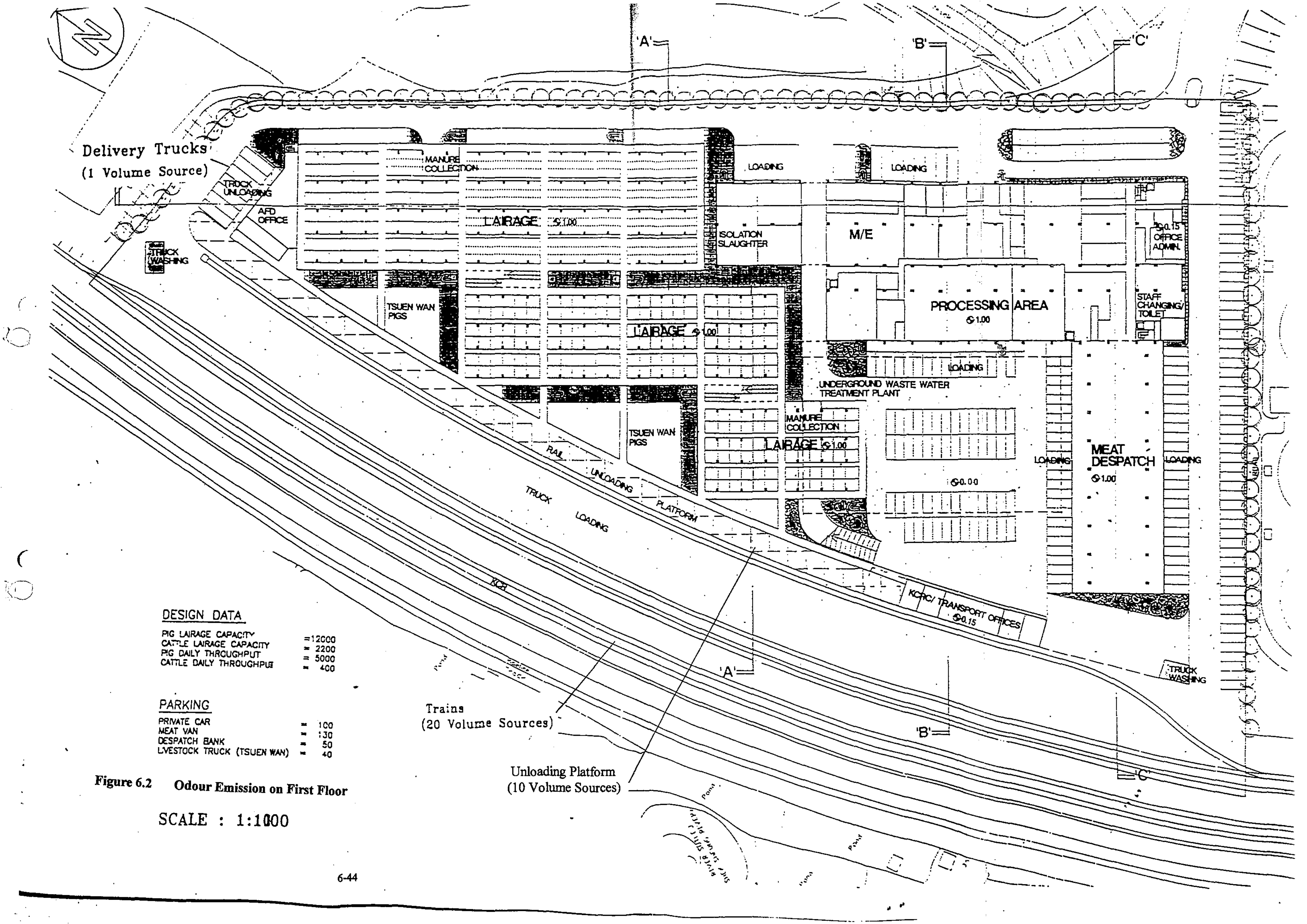


Figure 6.2 Odour Emission on First Floor

SCALE : 1:1000

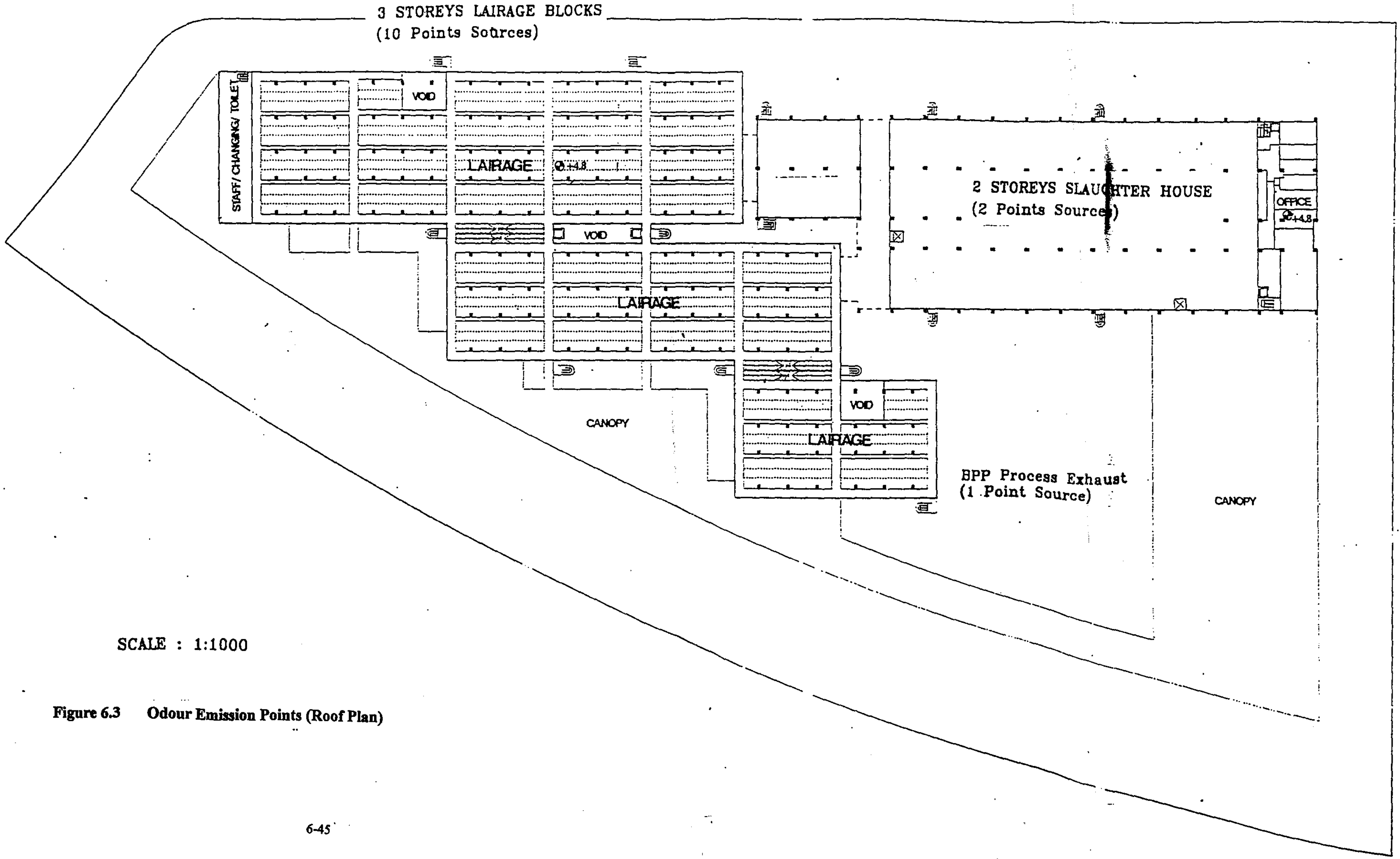


Figure 6.3 **Odour Emission Points (Roof Plan)**

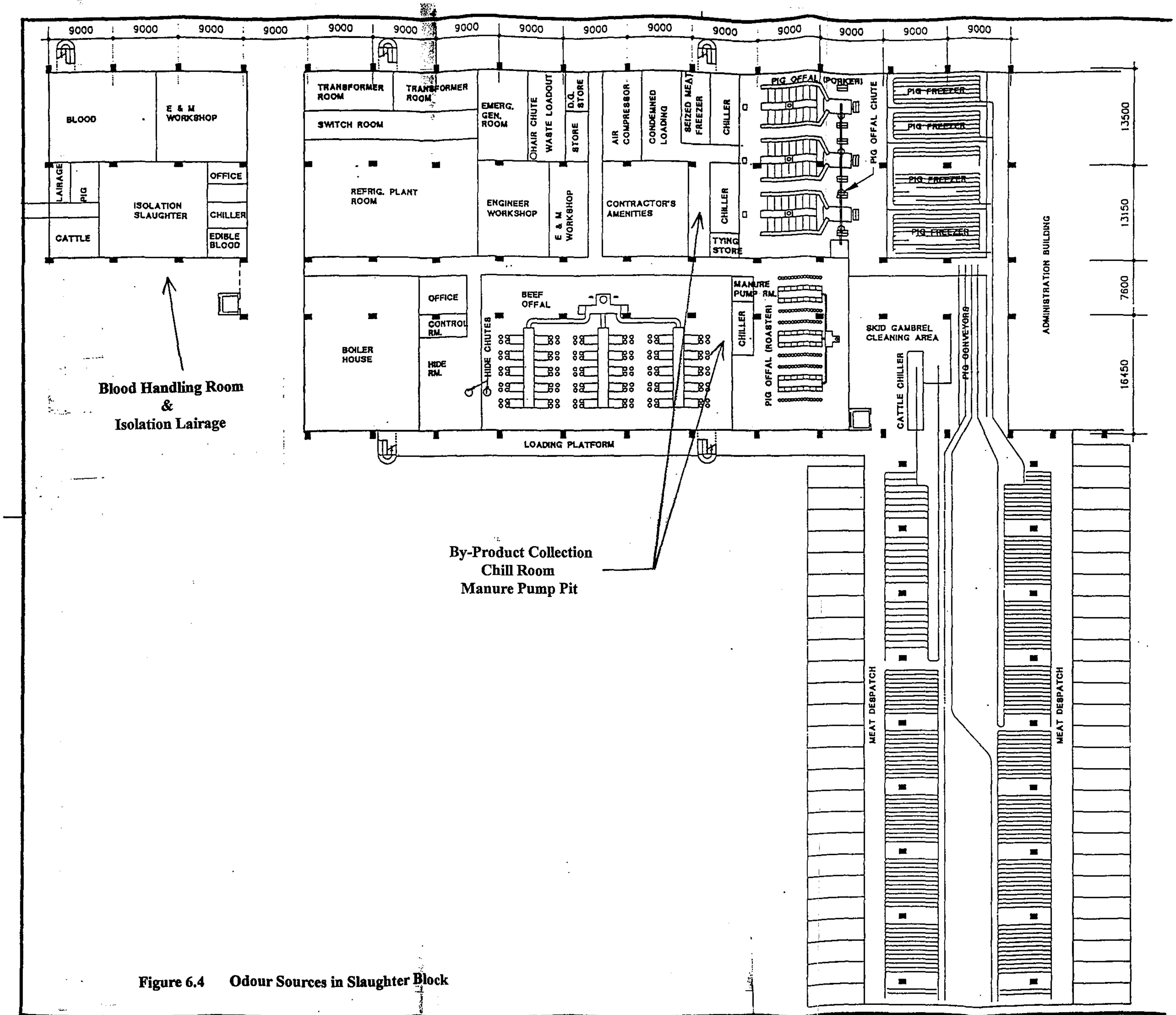


Figure 6.4 Odour Sources in Slaughter Block

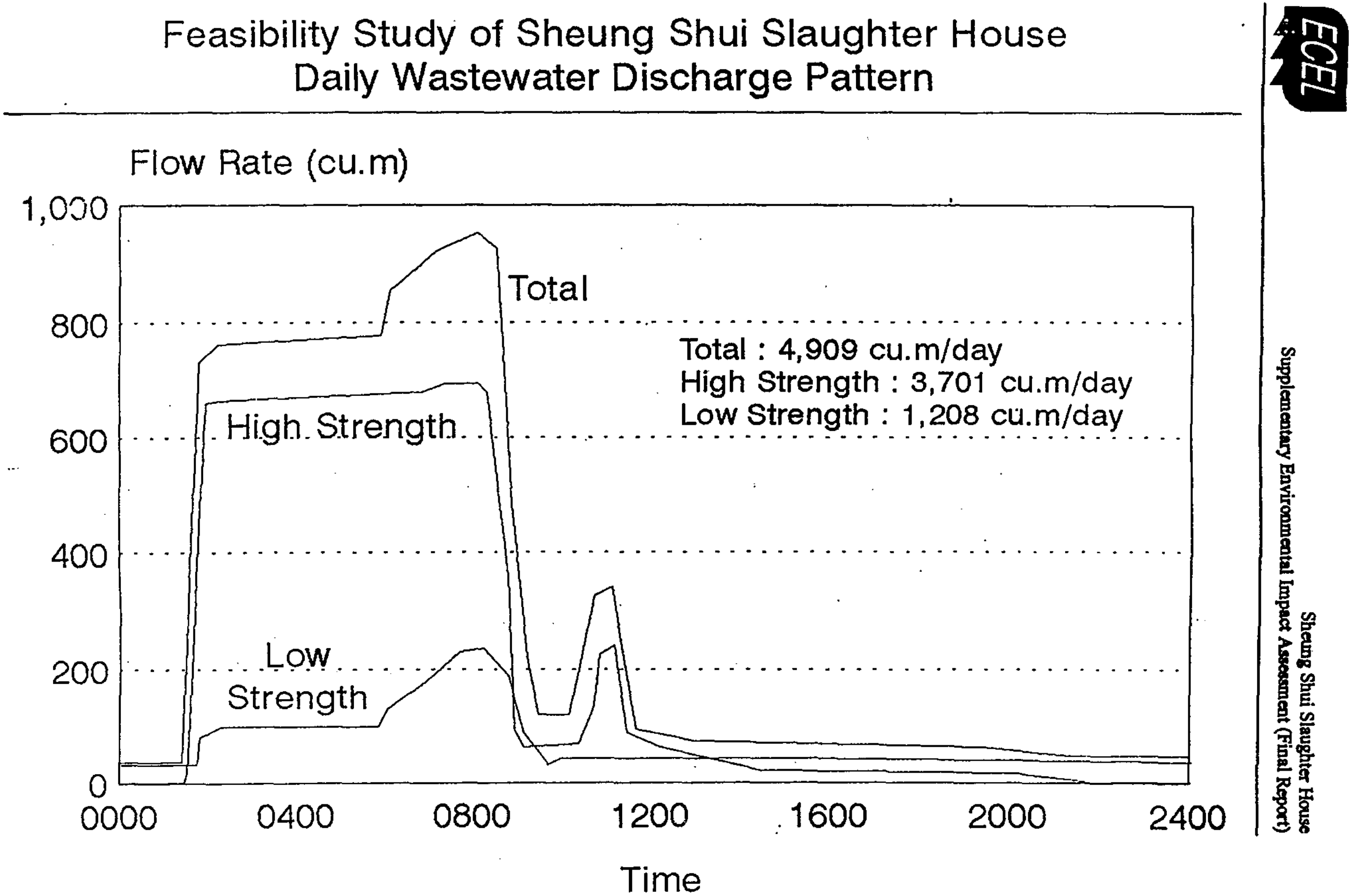


Figure 6.5 Sheung Shui Slaughterhouse Daily Wastewater Discharge Pattern

Figure 6.6 ODOUR MODEL INPUT DATA

Lairages

Pig lairage	- total pig lairage area = 12,400 sq. m - headroom = 3.5 m - no. of air changes per hour = 10 - air flow rate = 121 cu. m/s - odour output = 180 OU - odour emission rate = 121x 180 = 21,700
Manure Collection Rooms	- total area = 225 sq. m - headroom = 3.5 m - no. of air changes per hour = 10 - air flow rate = 2.19 m/s - odour output = 500 OU - odour emission rate =2.19 x 500 = 1095
	points sources: combined exhaust from pig lairage and manure collection rooms discharged at roof - no. of discharge points = 10 - discharge point velocity = 10.4 m/s - volume flow rate = 739.14 cu. m/min. per point - internal flue diameter = 1.25 m - odour emission rate = 21,700+ 1095 = 2279.5 - building & emission height = 14.4 m - base elevation = 8 m - emission temperature = 300 K

Recycled Paper

Slaughter Block Rooms

Blood Handling Room	- total area = 200 sq. m - headroom = 7 m - no. of air change per hour = 10 - air flow rate = 3.89 cu. m/s - odour output = 530 OU - odour emission rate = 3.89x 530 = 2062
Isolation lairage	- total area = 50 sq. m - headroom = 7 m - no. of air change per hour = 10 - air flow rate = 0.972 cu. m/s - odour output = 180 OU - odour emission rate = 0.972 x 180 = 175
	point source : combined exhaust from blood handling room and isolation lairage discharged at roof - no. of discharge point = 1 - discharge point velocity = 9.72 m/s - volume flow rate = 293.15 cu. m/min - opening diameter = 0.8 m - odour emission rate = 2237 - building & emission height = 17 m - base elevation = 8 m - emission temperature = 300K
Manure Pump Rooms (2)	- total area = 10 sq. m - headroom = 7 m - no. of air change per hour = 10 - air flow rate = 0.194 cu. m/s - odour output = 500 OU - odour emission rate = 0.194 x 500 = 97.2
Pig Bristle chute room	- total area = 40 sq. m - headroom = 3.5 m - no. of air change per hour = 10 - air flow rate = 0.389 cu. m/s - odour output = 200 OU - odour emission rate = 0.389x 200 = 77.8
By-Product Collection Room & Unloading Bay	- total area = 90 sq. m - headroom = 3.5 m - no. of air change per hour = 10 - air flow rate = 0.875 cu. m/s - odour output (Full-Scale) = 2300 (Reduced- Scale) = 150 - odour emission rate (Full-Scale) = 0.875x2300 = 2012.5 (Reduced-Scale)= 0.85x150 = 131.3

	Point source: combined exhaust from manure pump, pig bristle chute room, and by-product collection/unloading rooms discharged at the roof
	- no. of discharge point = 1 - discharge point velocity = 7.43 - volume flow rate = 87.5 cu. m/min. - internal flue diameter = 0.5 m odour emission rate (Full-Scale) = 2187.5 (Reduced-Scale) = 306.3 - building & emission height= 17 m - base elevation is 8 m - emission temperature = 300K

By-Product Plant

BPP Process Exhaust (Full-Scale BPP only)	- air flow rate (Process) = 0.75 cu. m/s (Ventilation) = 8.5cu. m/s - odour output (Process) = 420,000 OU (Ventilation) = 20,000 OU Point source discharged from boiler stack - no. of discharge point = 1 - discharge point velocity = 15.59 m/s - total volume flow rate = 90 cu. m/min. - internal flue diameter = 0.35 m - odour emission rate = 200,000 x 2 = 400,000 - building & emission height = 17 m - base elevation = 8 m - emission temperature = 723K
BPP Room	- total area = 1092 sq. m - headroom = 7 m - no. of air change per hour = 15 - air flow rate = 31.9 cu. m/s - odour output (Full-Scale) = 2300 + 530= 2830OU (Reduced-scale) = 530 - odour emission rate (Full-Scale) = 31.9 x 2830 = 90277 (Reduced-Scale) = 31.9 x 530 = 16907
	Point source combined exhaust from WWTP and BPP room discharged at roof of adjacent buildings - no. of discharge point = 4 - discharge point velocity = 16.95 m/s - volume flow rate = 1350 cu. m/min. - internal flue diameter = 1.3 m - odour emission rate per point (Full-scale) = (90277+5800)/4 = 24019 - odour emission rate per point (reduced-Scale) = (16907+5800)/4 = 5676.8 - building & emission height = 17 m - base elevation = 8 m - emission temperature = 300K

Wastewater Treatment Plant

Wastewater Treatment Plant	- total area = 6,000 sq. m - headroom = 3.5 m - no. of air change per hour = 10 - air flow rate = 58 m/s - odour output = 100 OU - odour emission rate = 58 x 100 = 5800
	point sources discharge at roof of adjacent buildings - no. of discharge point = 4 - discharge point velocity = 9.42 m/s - volume flow rate = 870 cu. m/min. per point - internal flue diameter = 1.4 m - odour emission rate = 1450 - building & emission height = 17 m - base elevation = 8 m - emission temperature = 300K

Livestock Unloading Areas

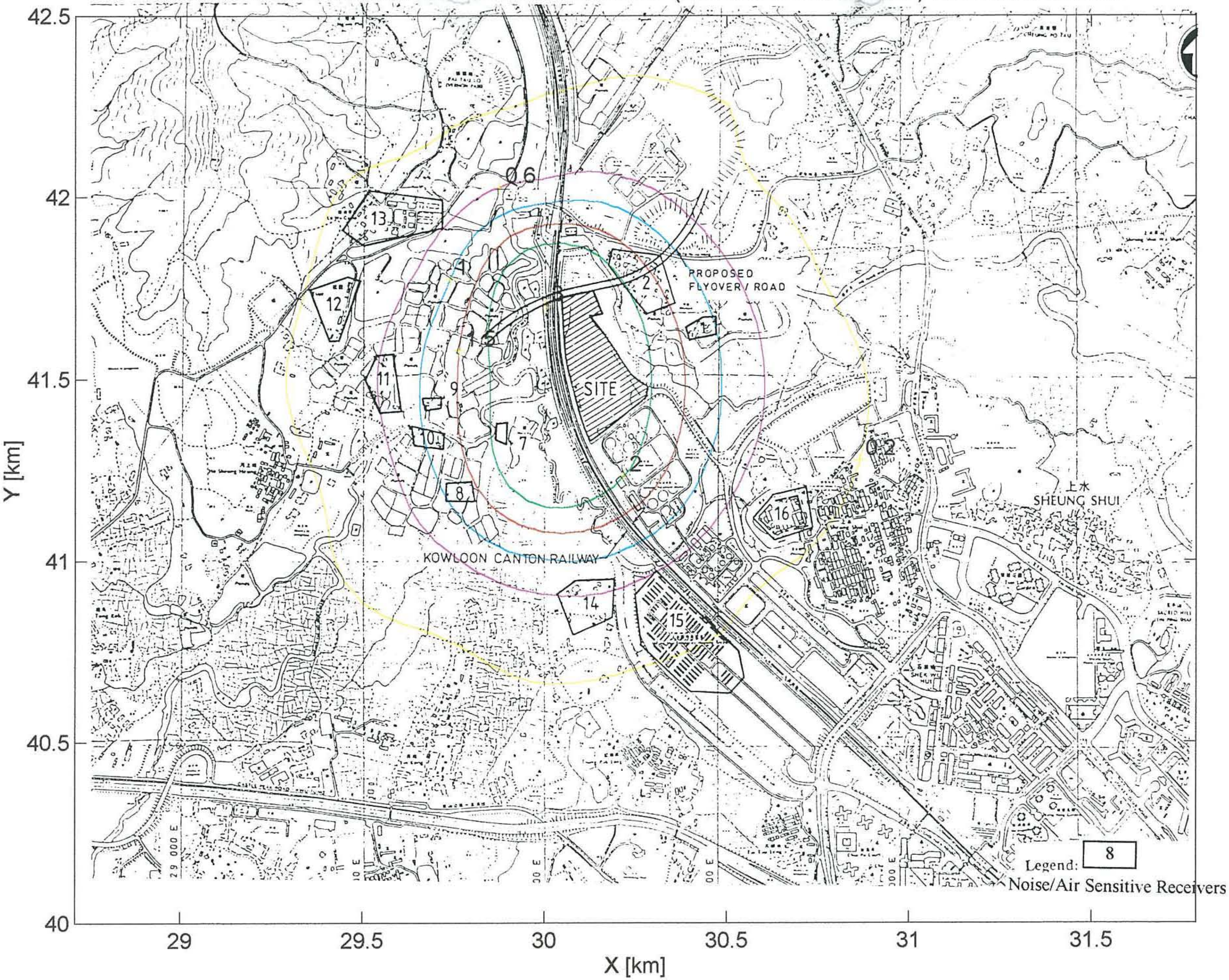
Live stock transit pens	- total area = 5m(W) x 250m(L) = 1250 sq. m. - headroom = 3 m - no. of air change per hour = 10 - air flow rate = 10.4 cu. m/s - odour output = 125 OU - odour emission rate = 10.4 x 125 = 1300 10 volume sources (T1 - T10) is used to simulate this line source - individual emission rate = 130 - base elevation = 8 m - release height = 3 m - lateral dimension = 11.6 m - vertical dimension = 1.4 m - active from 12:00 - 16:00 & 16:00 - 20:00
Train (G1 & G2)	- lenght = 250 m for each track - width = 3 m per track - height = 3 m - no. of air change per hour =10 - air flow rate = 6.25 cu. m/s - odour output = 125 OU - total emission rate (each track) = 6.25 x 125 = 781 10 volume sources per track, i.e. total 20 volume sources (T11 - T30) to simulate 2 line sources - individual emission rate = 78 - base elevation = 8 m - release height = 3 m - lateral dimension = 11.6 m - vertical dimension = 1.4 m - active from 12:00 - 16:00 & 16:00 - 20:00
Livestock truck unloading area	- total area = 2.1 m x 9.6 m x 7 (spaces) = 141 sq. m - assume effective height = 3 m - no. of air change per hour = 10 - air flow rate = 1.175 cu. m/s - odour output = 125 OU - odour emission rate = 1.175 x 125 = 146.9 volume source - base elevation =8 m - release height = 3 m - lateral dimension = 5.52 m - vertical dimension = 1.4 m - active from 07:00 - 17:00

Figure 6.7

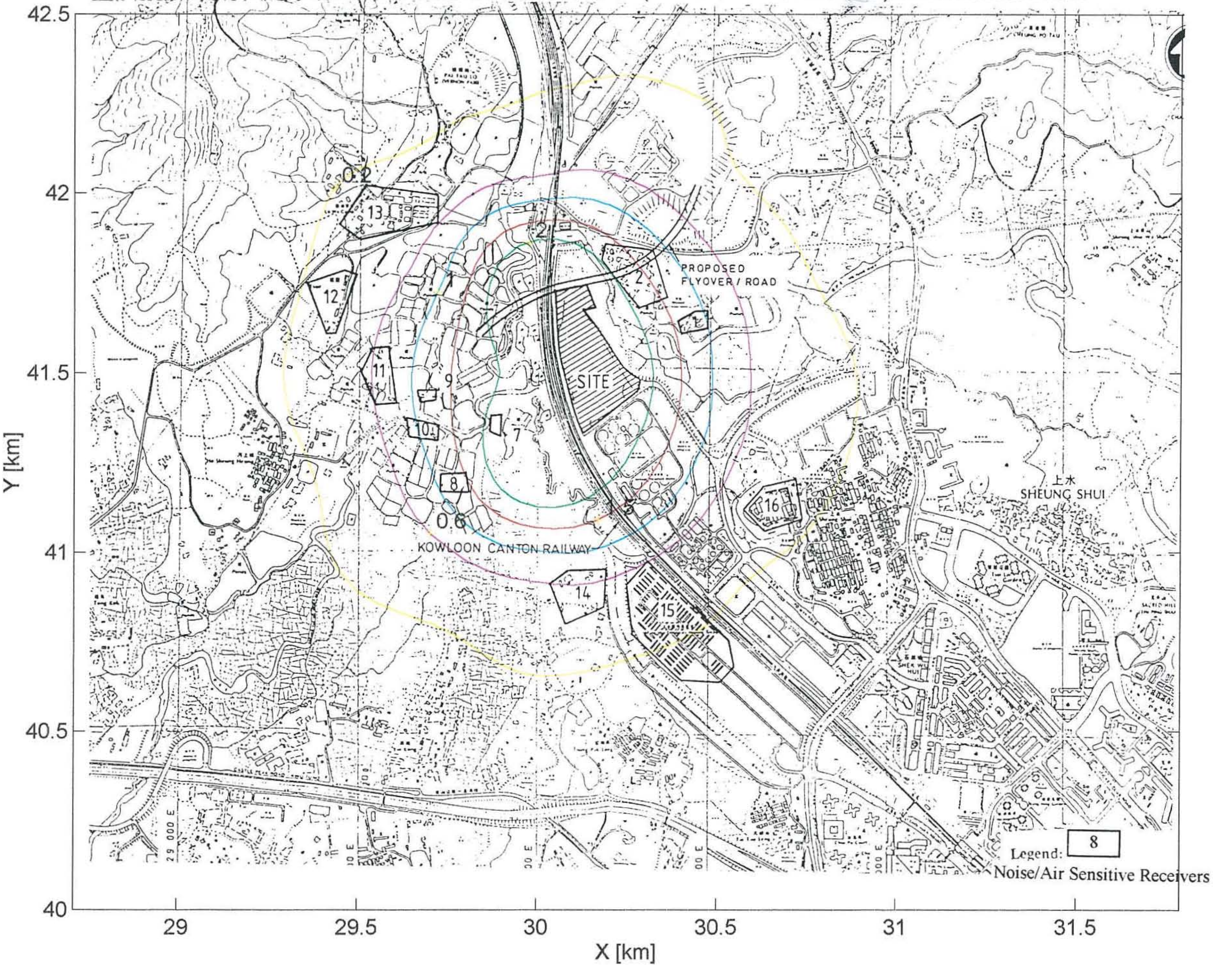
A

Site Layout Odour Impact Contour Maps With Reduced-Scale By-Products Plant With/Wihtout Mitigation Measures

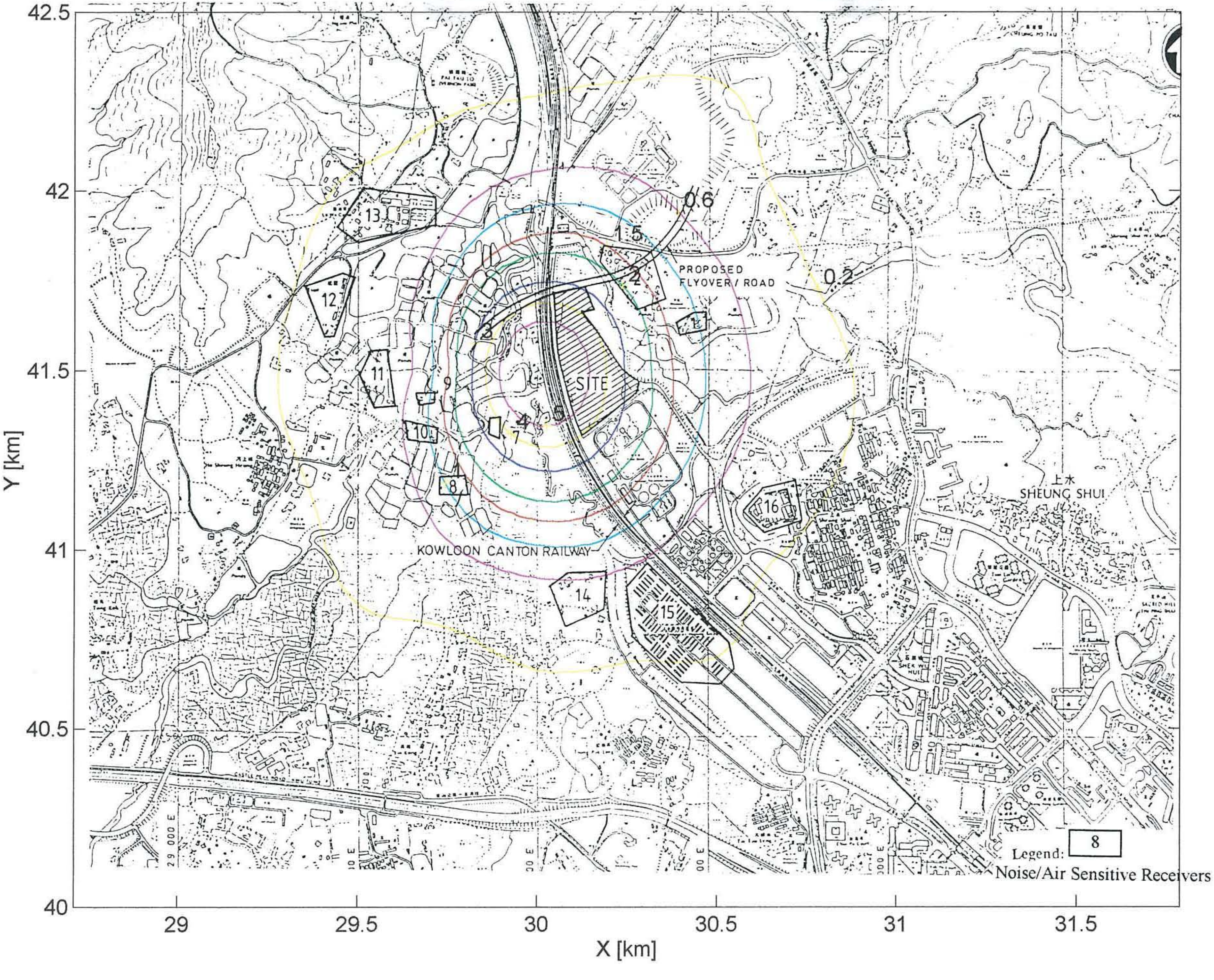
GROUND LEVEL ODOUR IMI CT CONTOUR MAP (REDUCED-SCAL PP) WITH MITIGATION



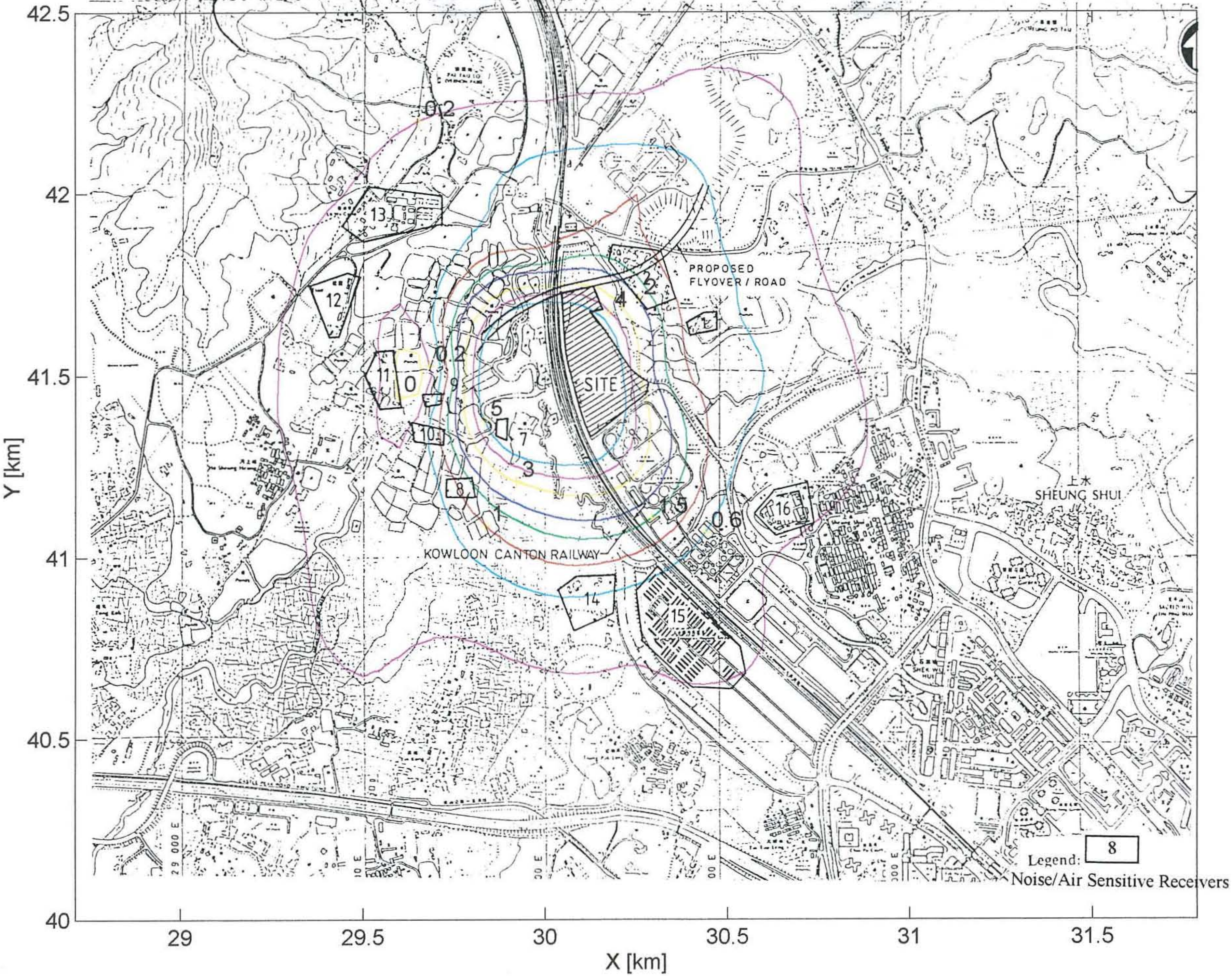
10M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE B P) WITH MITIGATION



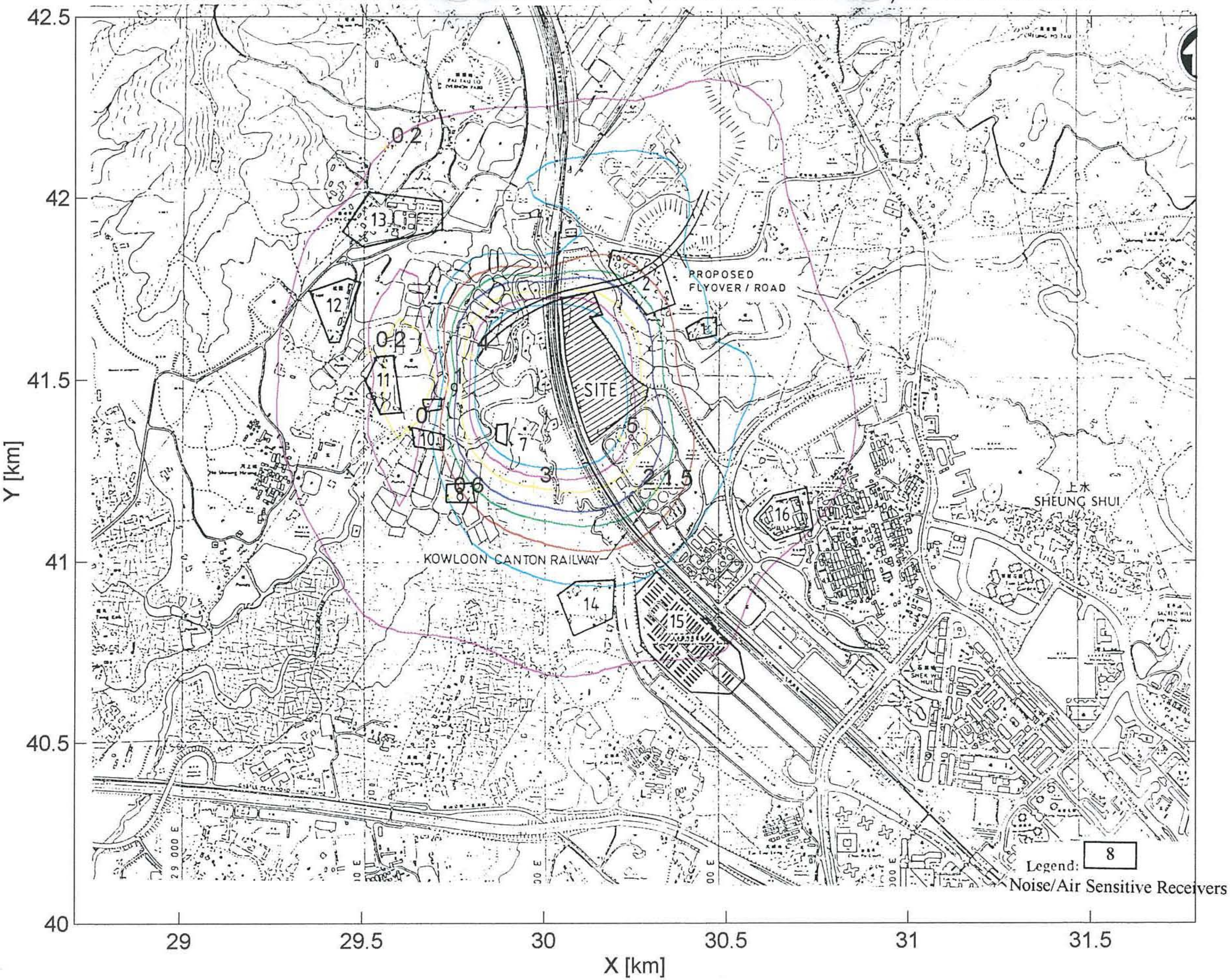
20M LEVEL ODOUR IMPA[illegible] CONTOUR MAP (REDUCED-SCALE [illegible]) WITH MITIGATION



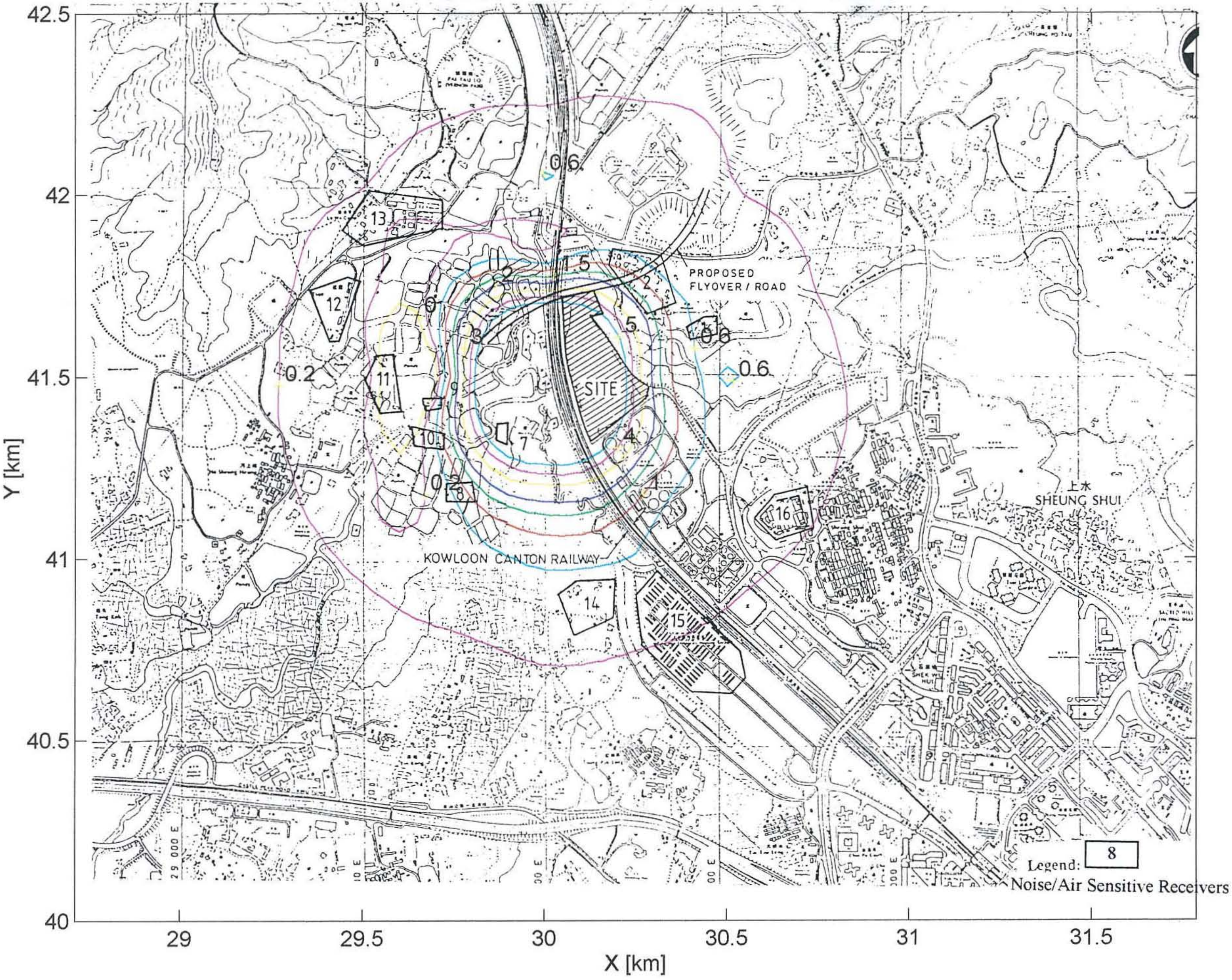
30M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE B...) WITH MITIGATION



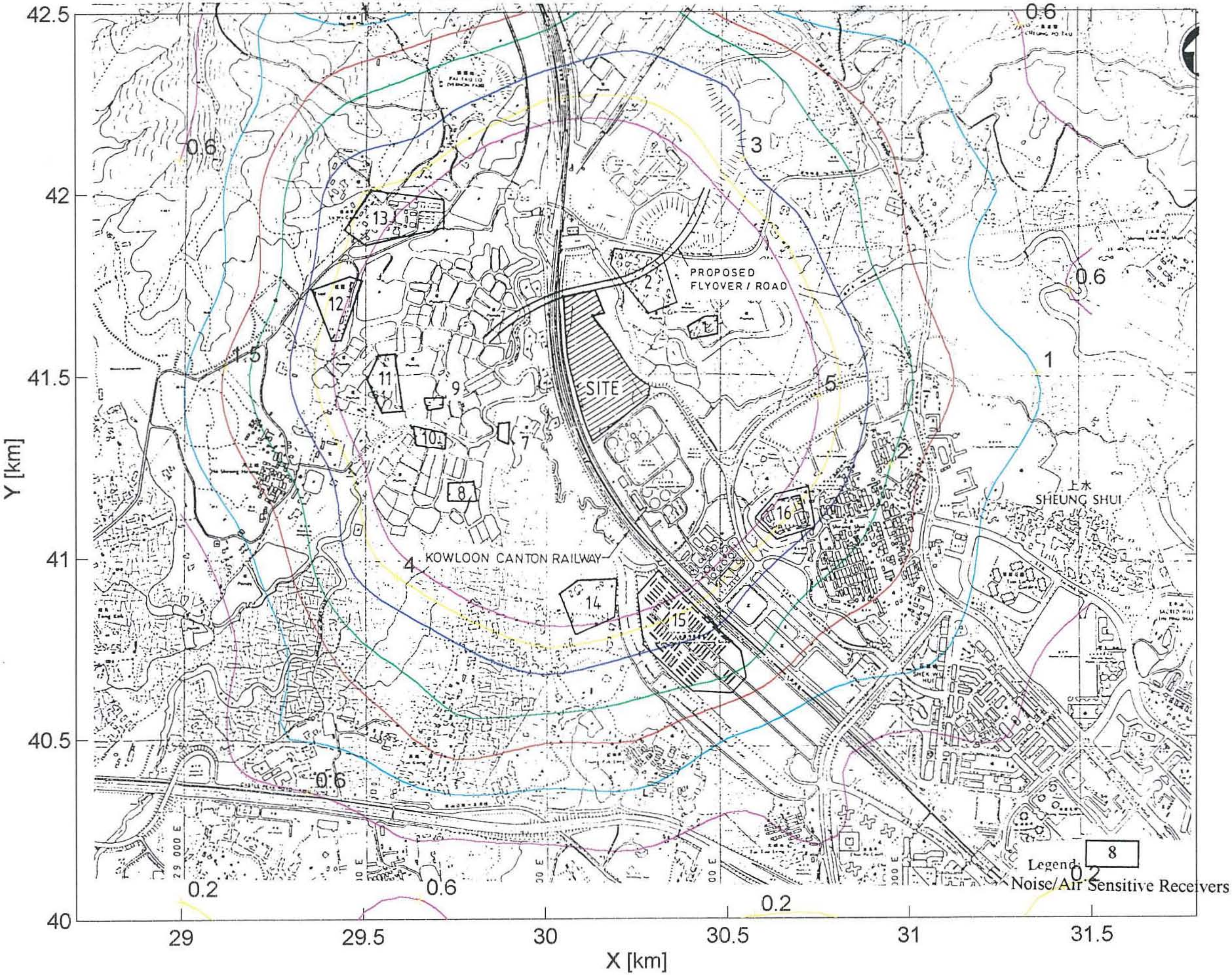
40M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BMP) WITH MITIGATION



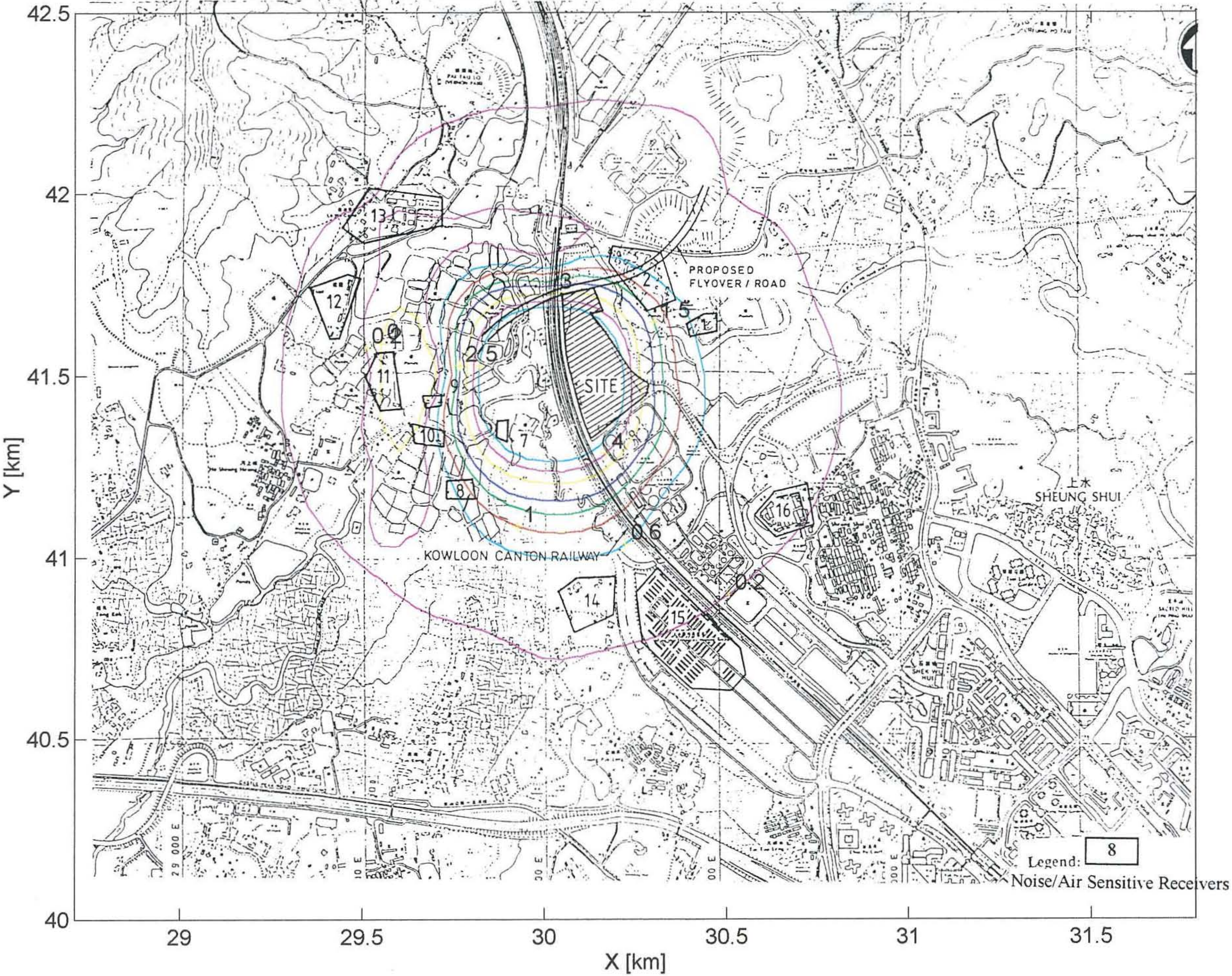
50M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE B P) WITH MITIGATION



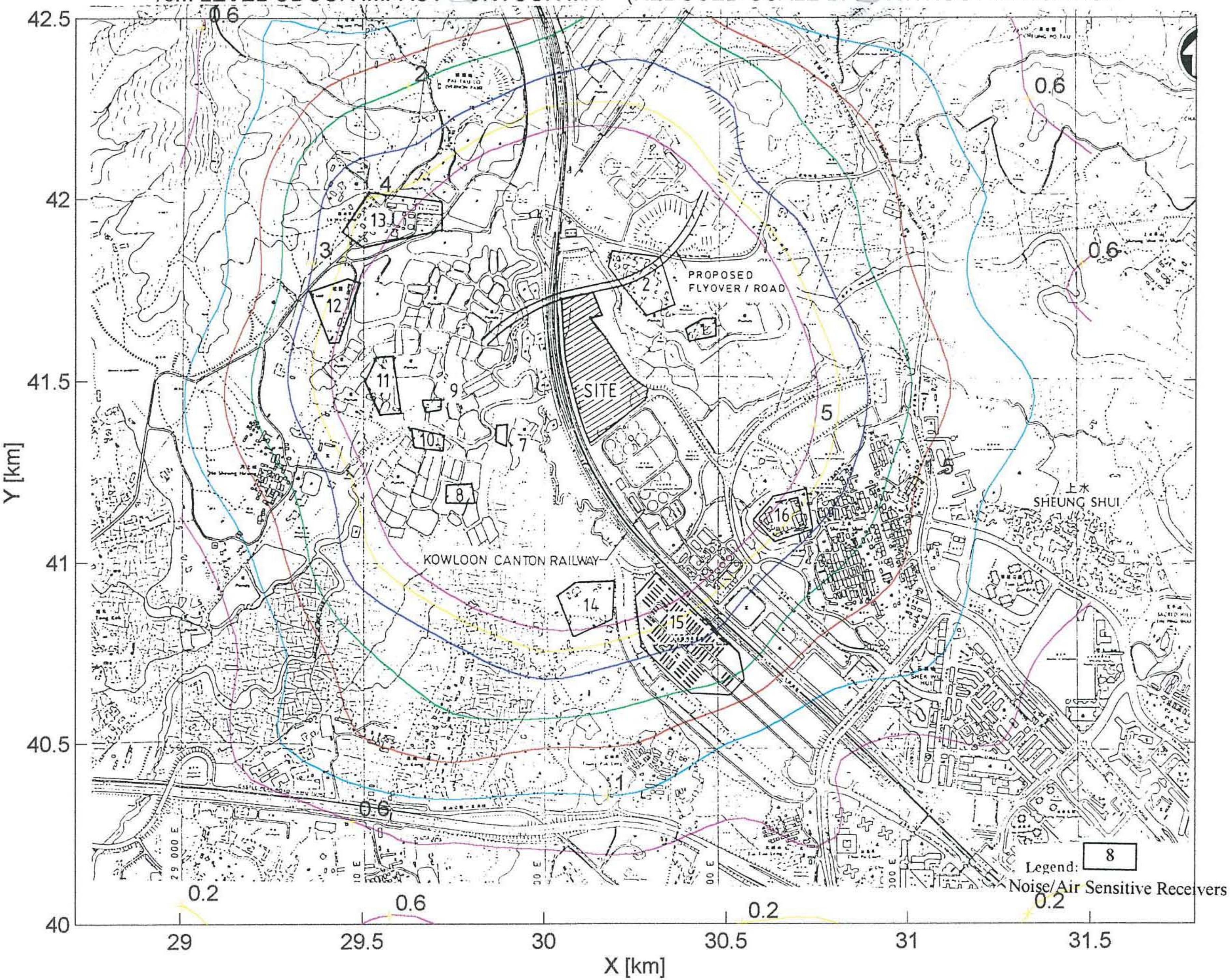
GROUND LEVEL ODOUR IMPA CONTOUR MAP (REDUCED-SCALE P) WITHOUT MITIGATION



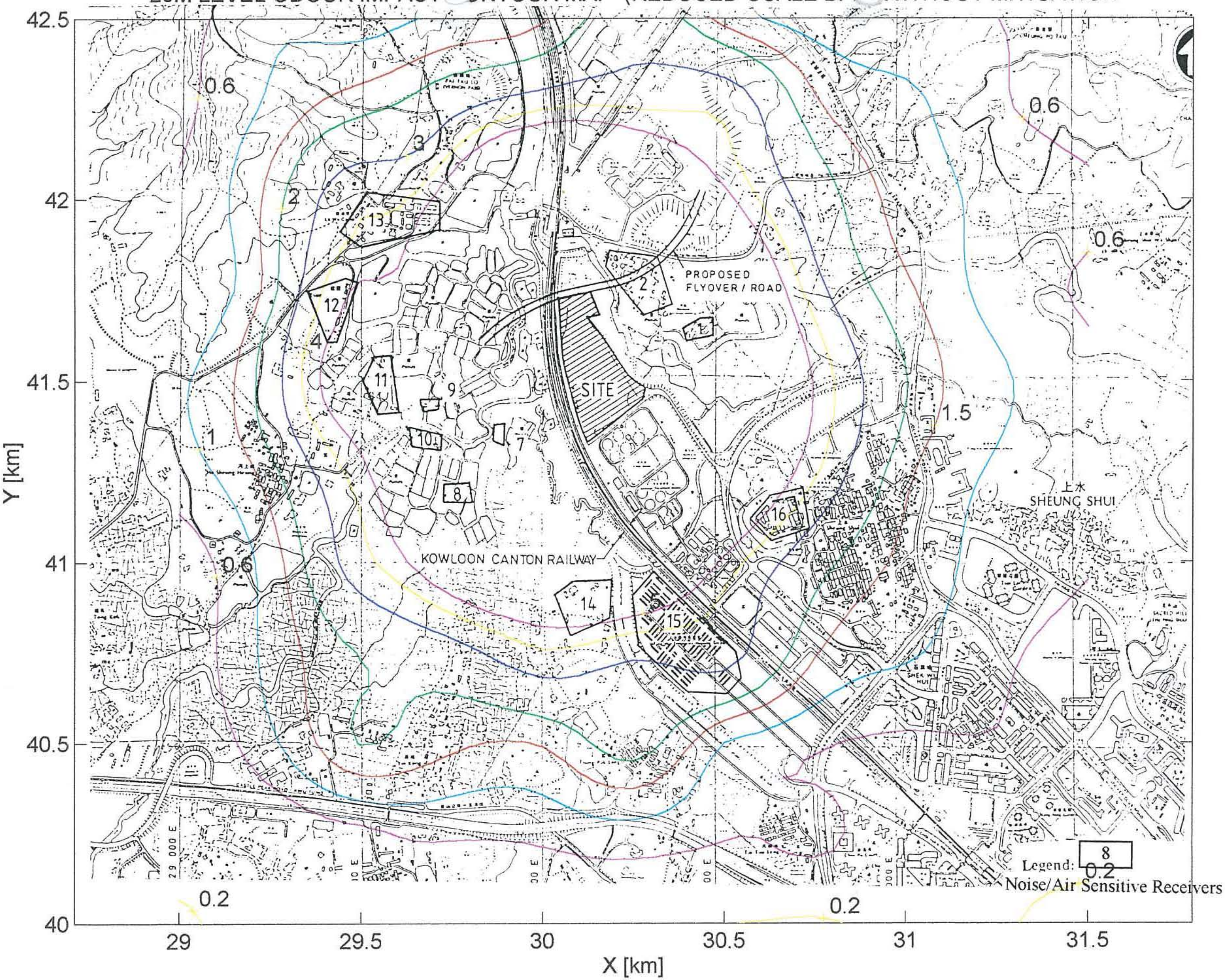
60M LEVEL ODOUR IMPAC CONTOUR MAP (REDUCED-SCALE B) WITH MITIGATION



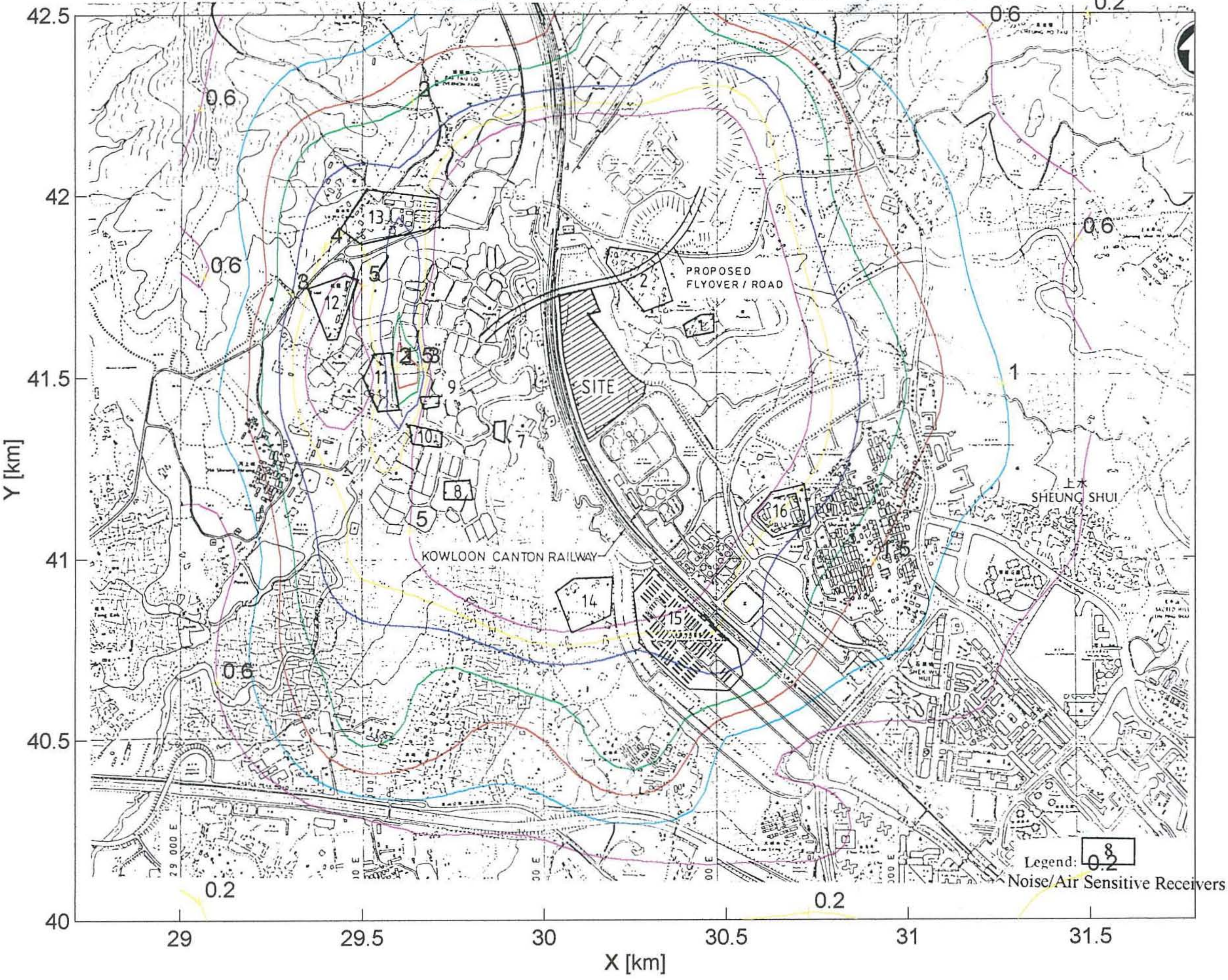
10M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BP) WITHOUT MITIGATION



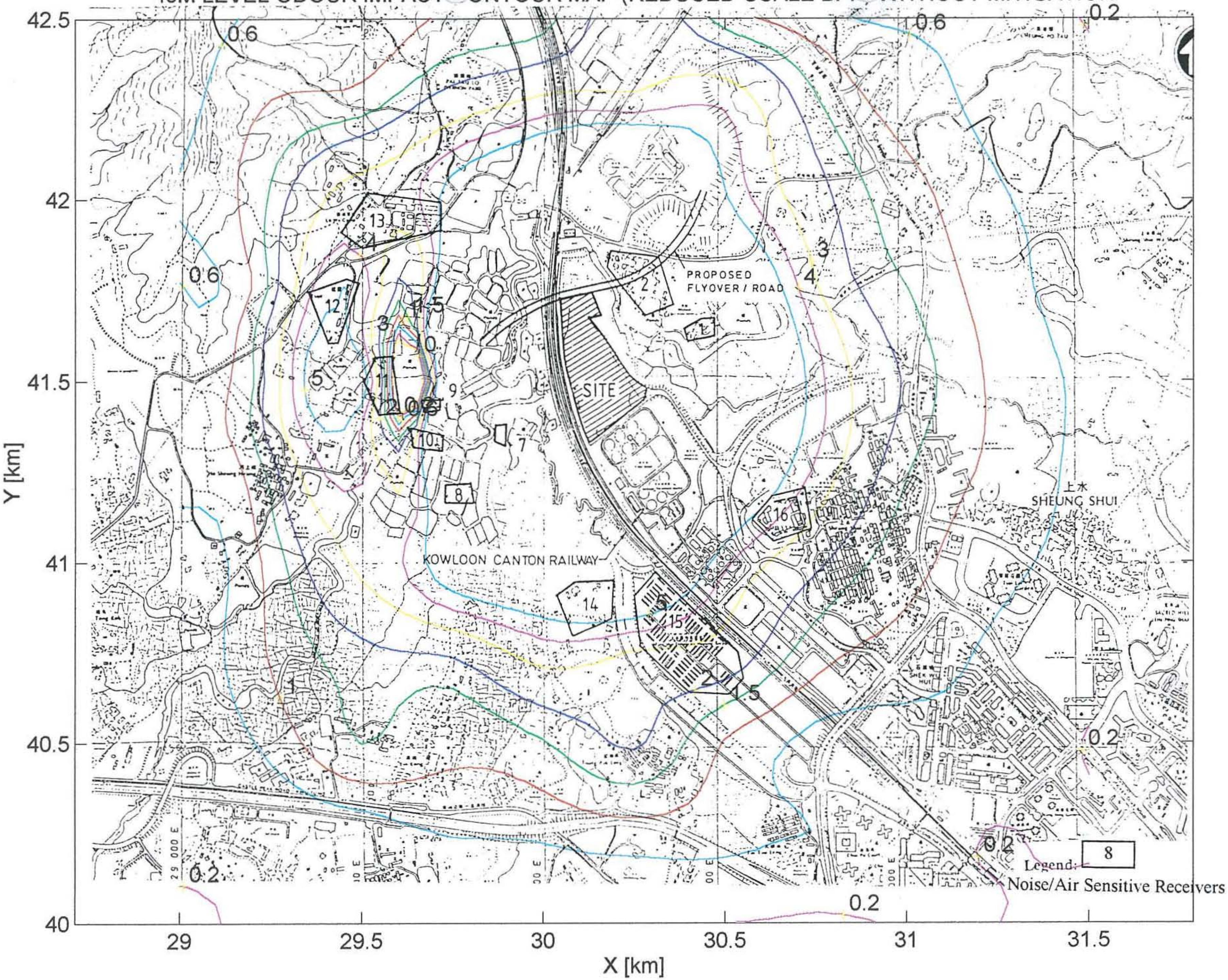
20M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BP) WITHOUT MITIGATION



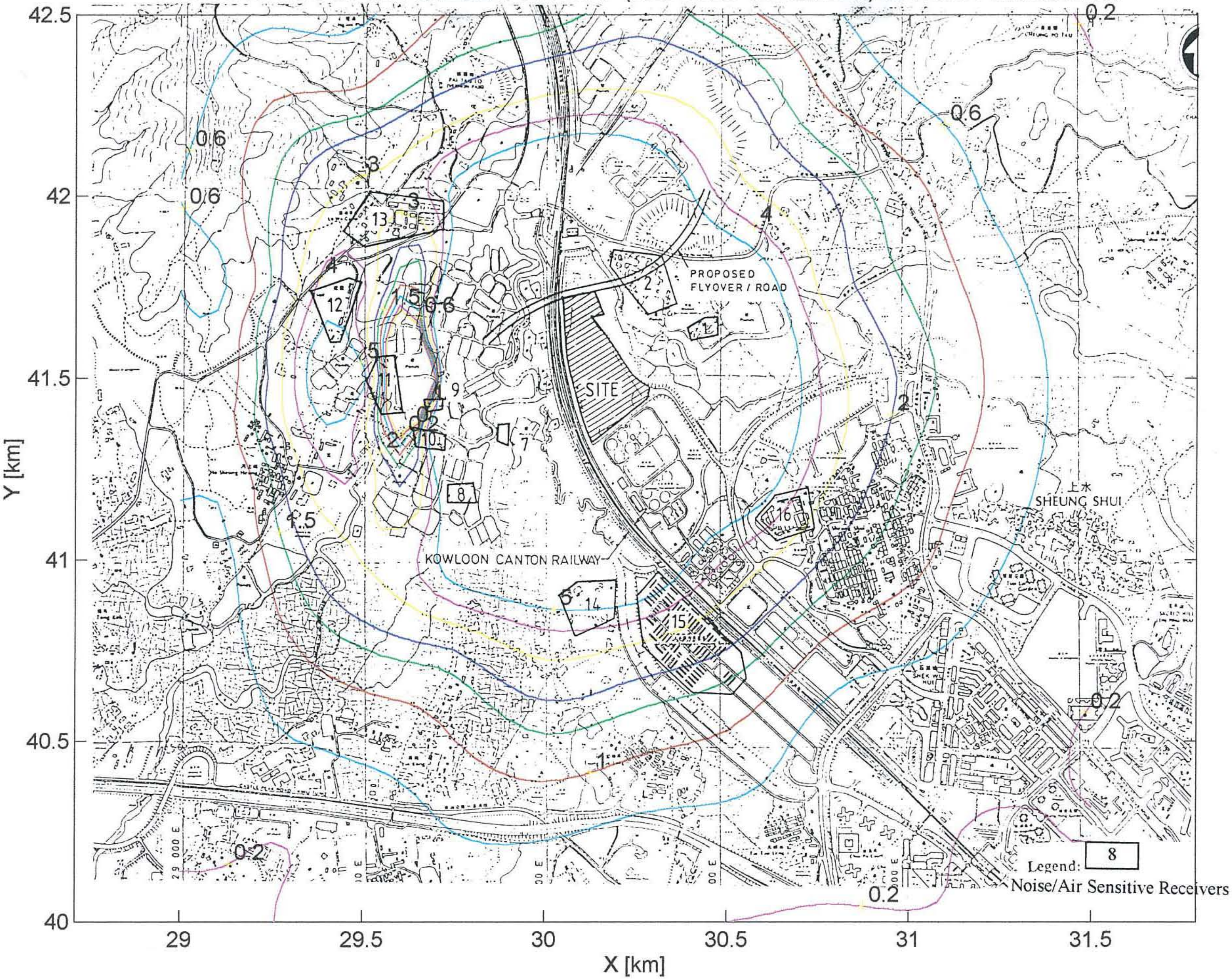
30M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BPF WITHOUT MITIGATION



40M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BPP) WITHOUT MITIGATION



50M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BPP) WITHOUT MITIGATION



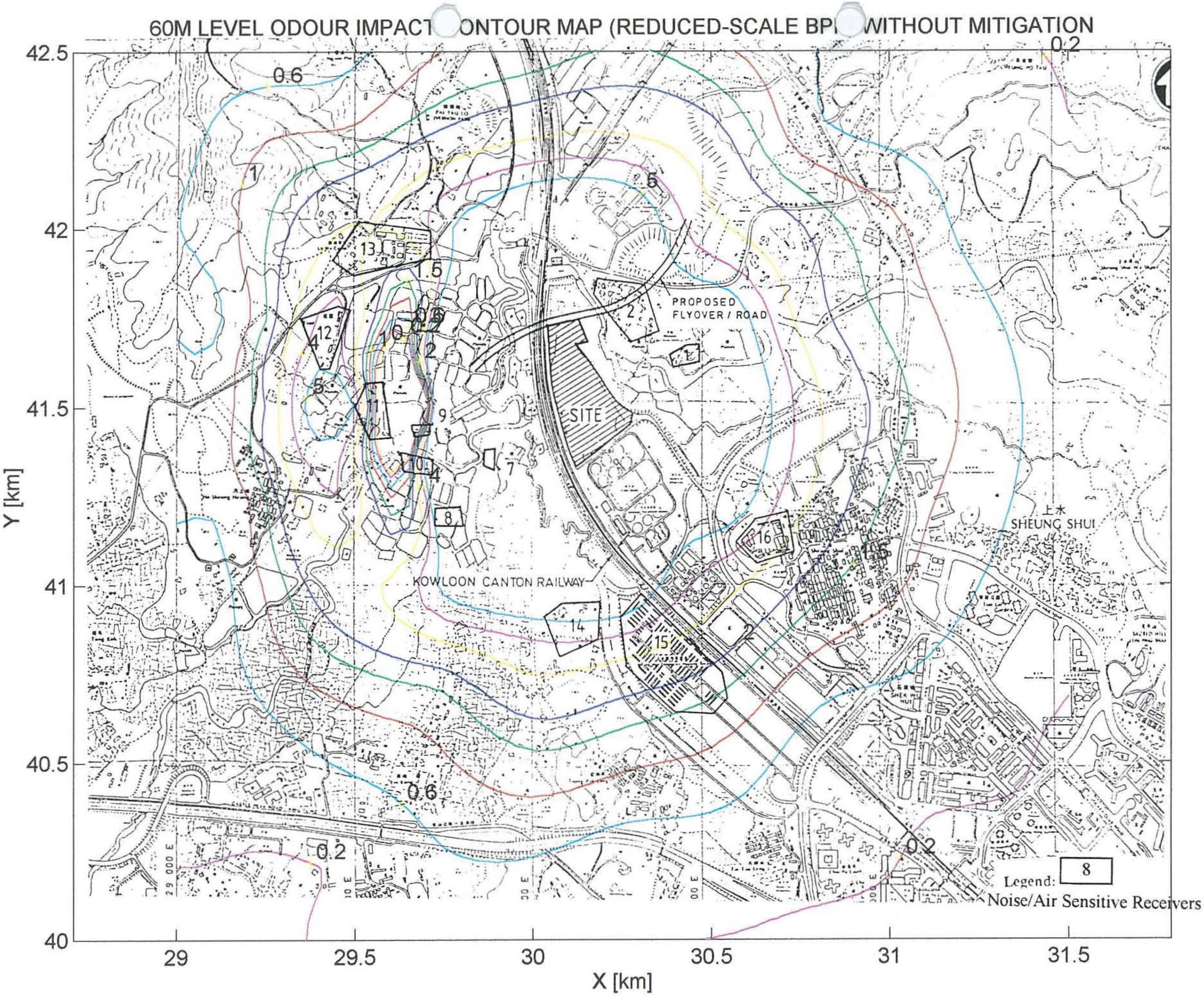
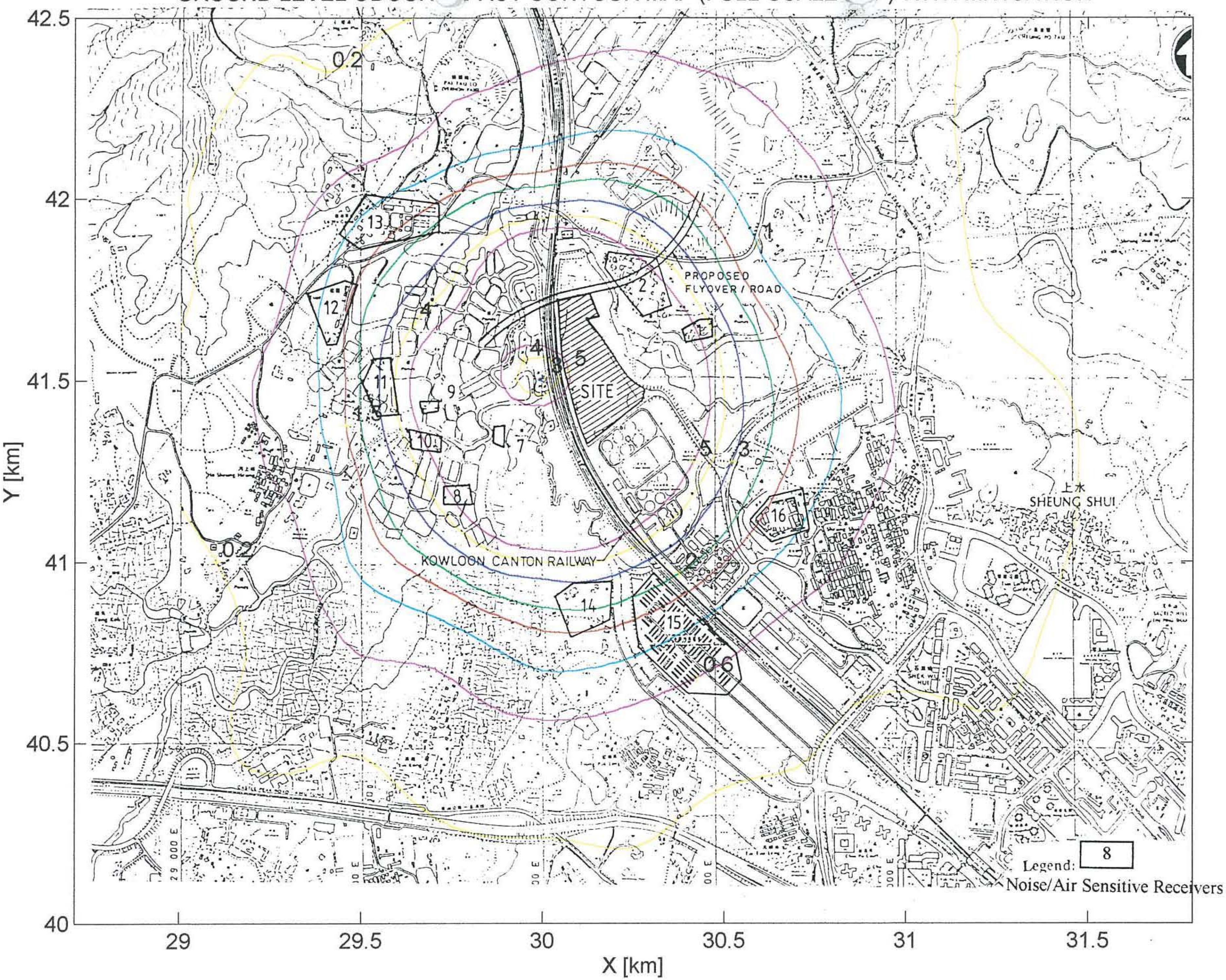

60M LEVEL ODOUR IMPACT CONTOUR MAP (REDUCED-SCALE BPI) WITHOUT MITIGATION
Y [km]
X [km]
42.5
42
41.5
41
40.5
40
29
29.5
30
30.5
31
31.5
0.2
0.6
1
1.5
5
2
10
4
SITE
PROPOSED FLYOVER / ROAD
KOWLOON CANTON RAILWAY
SHEUNG SHUI
Legend:
8
Noise/Air Sensitive Receivers

Figure 6.7

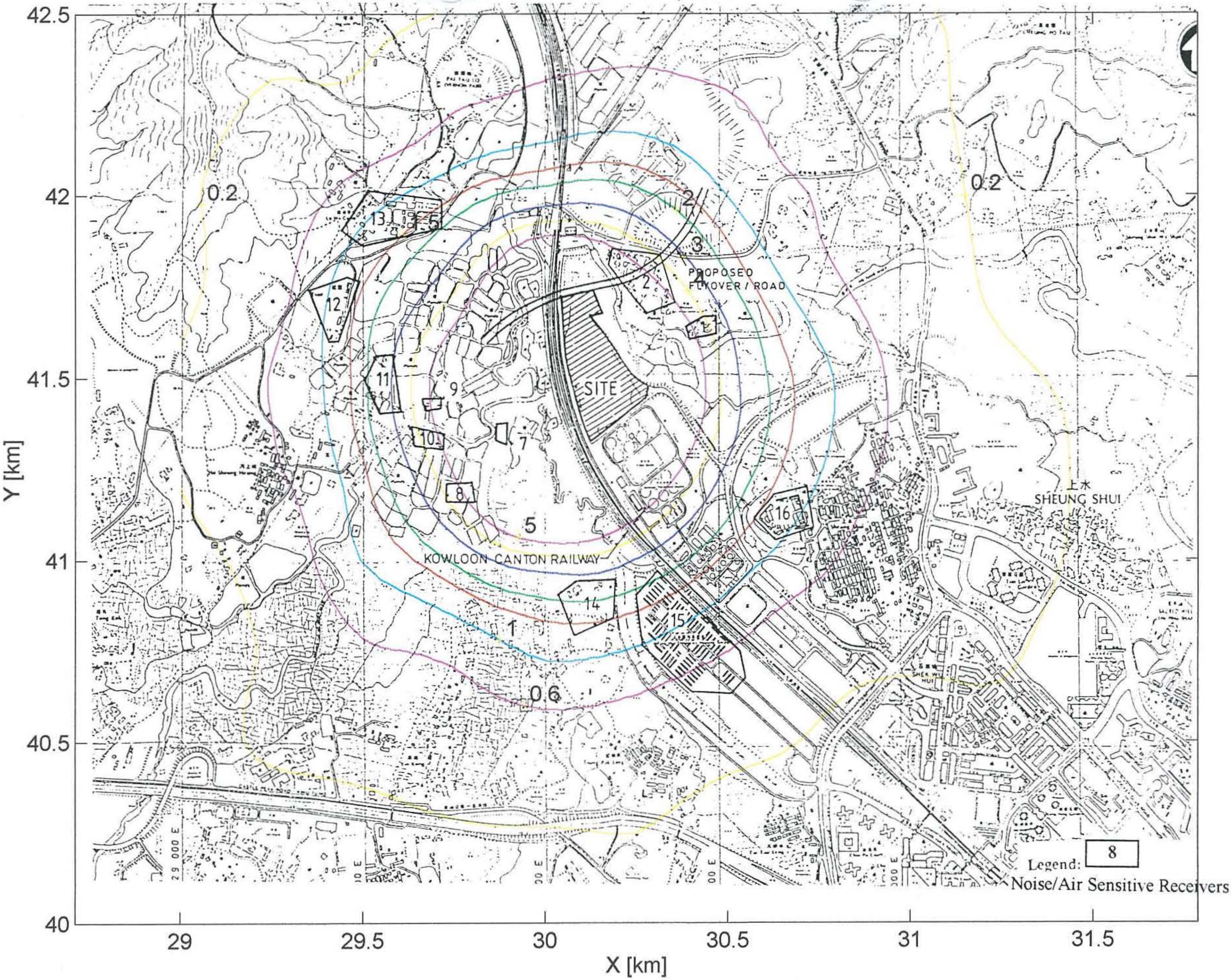
B

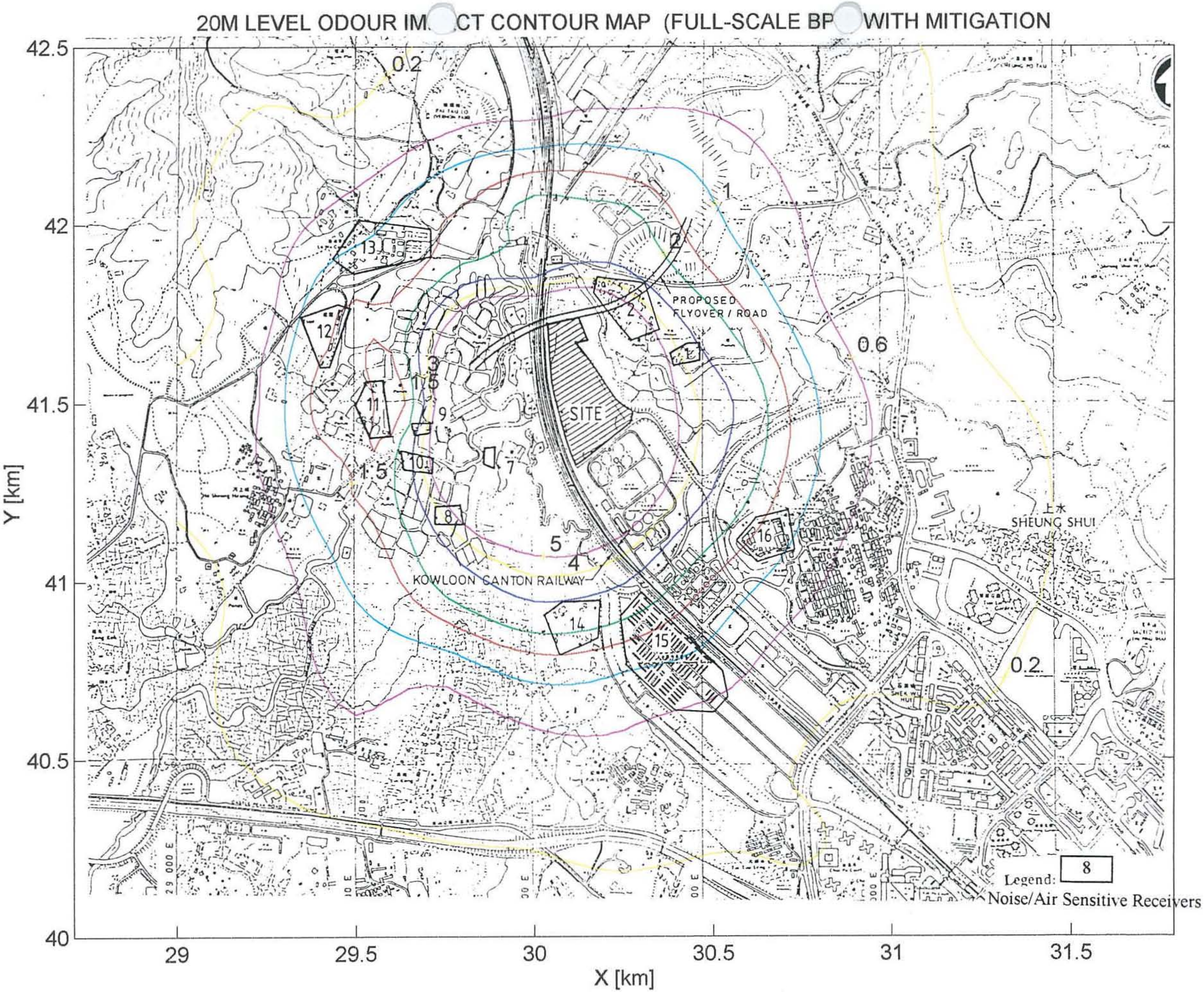
Site Layout Odour Impact Contour Maps
With Full-Scale By-Products Plant
With/Wihtout Mitigation Measures

GROUND LEVEL ODOUR PACT CONTOUR MAP (FULL-SCALE P) WITH MITIGATION



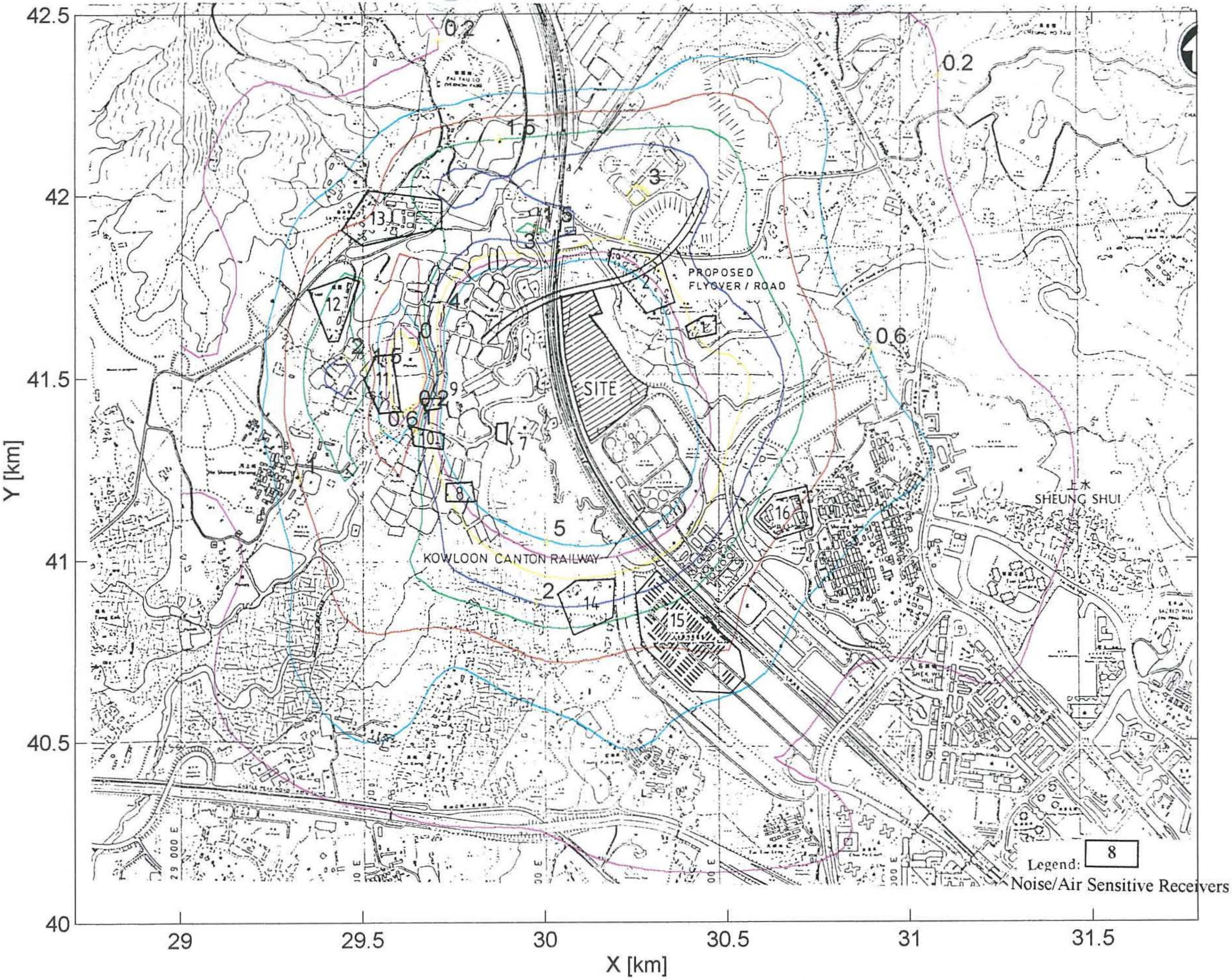
10M LEVEL ODOUR IM ACT CONTOUR MAP (FULL-SCALE BP WITH MITIGATION



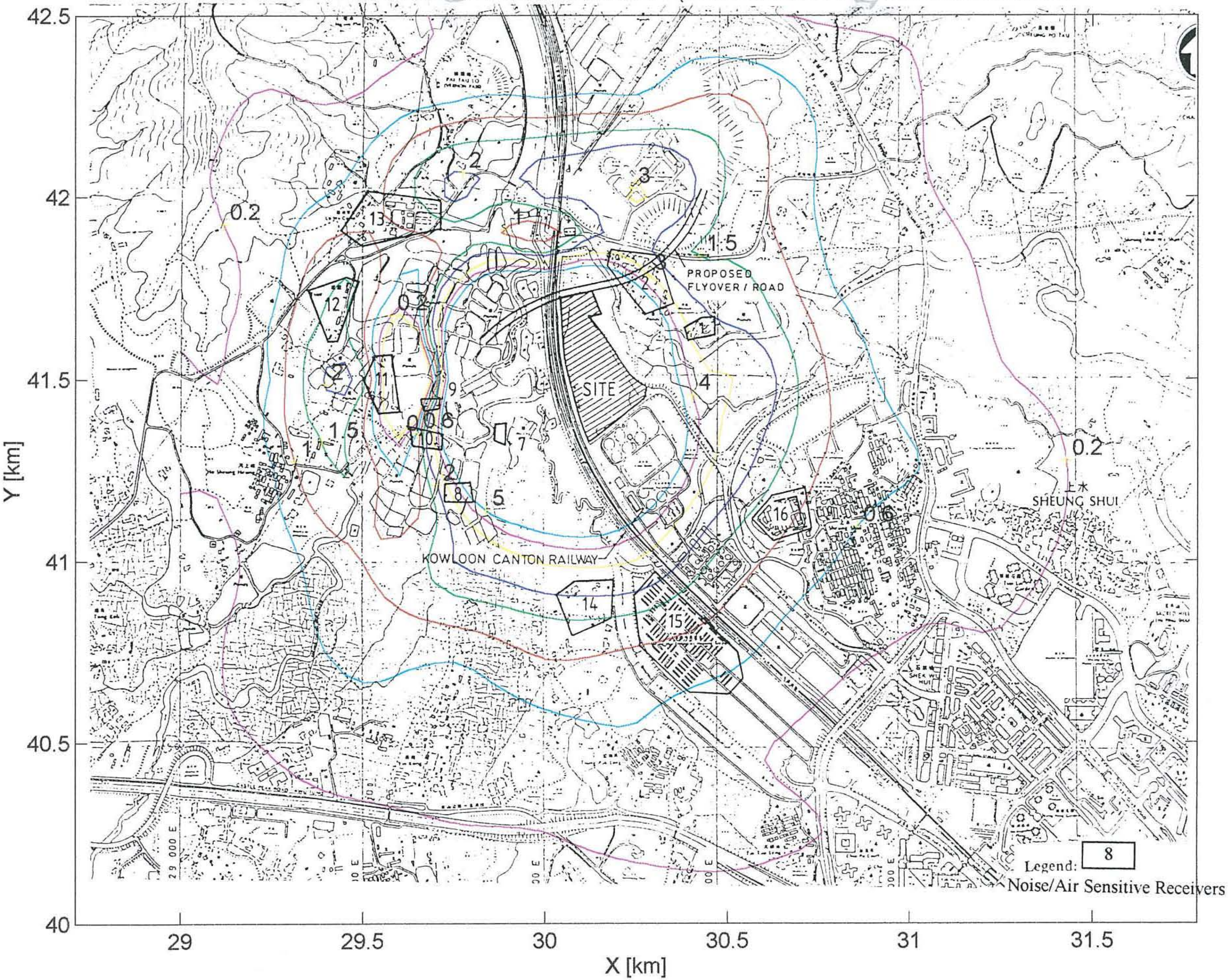


20M LEVEL ODOUR IM CT CONTOUR MAP (FULL-SCALE BP WITH MITIGATION
Y [km]
X [km]
42.5
42
41.5
41
40.5
40
29
29.5
30
30.5
31
31.5
0.2
1
2
3
1.5
4
5
0.6
0.2
PROPOSED FLYOVER / ROAD
SITE
KOWLOON CANTON RAILWAY
SHEUNG SHUI
上水
Legend: 8
Noise/Air Sensitive Receivers

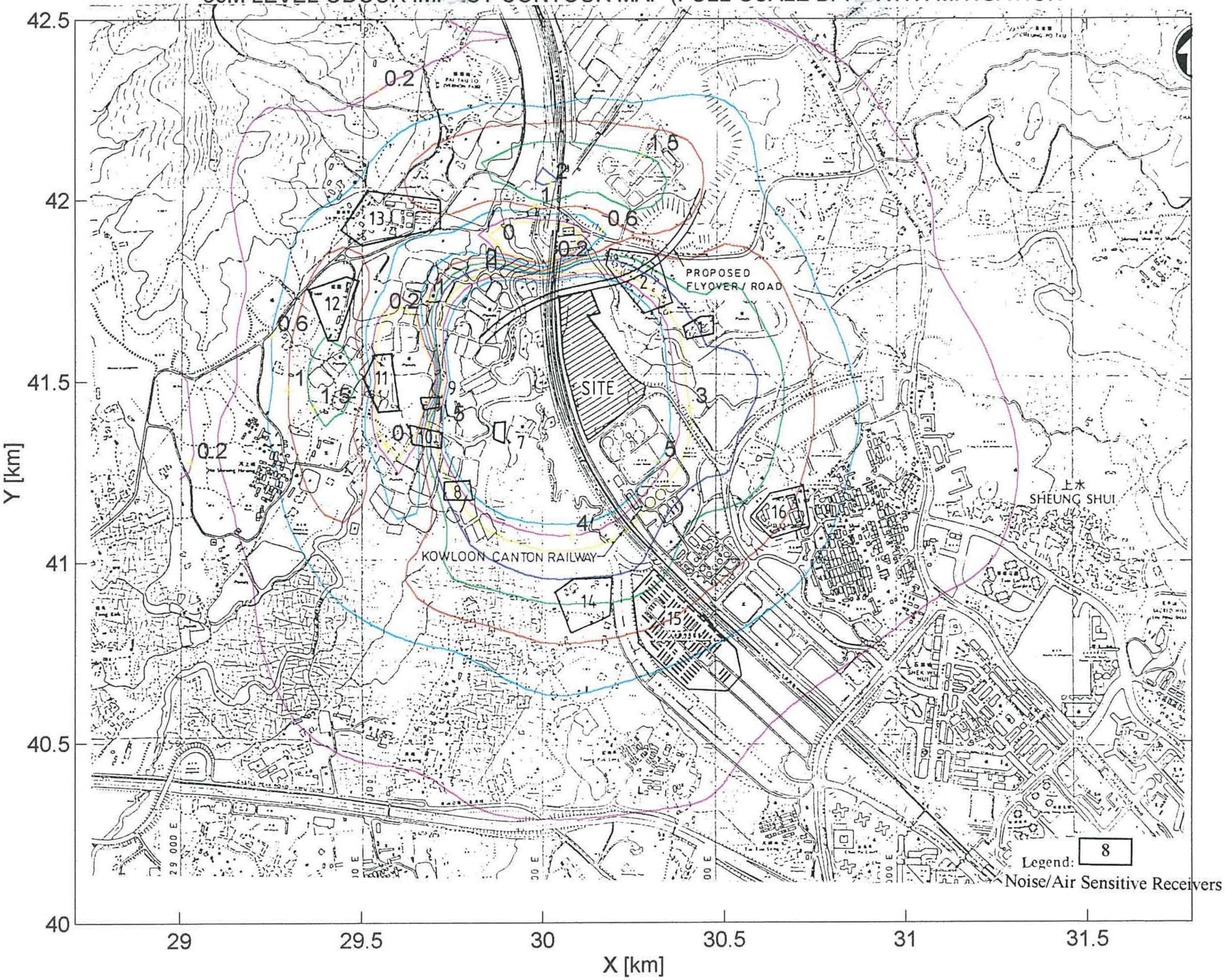
30M LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BP) WITH MITIGATION



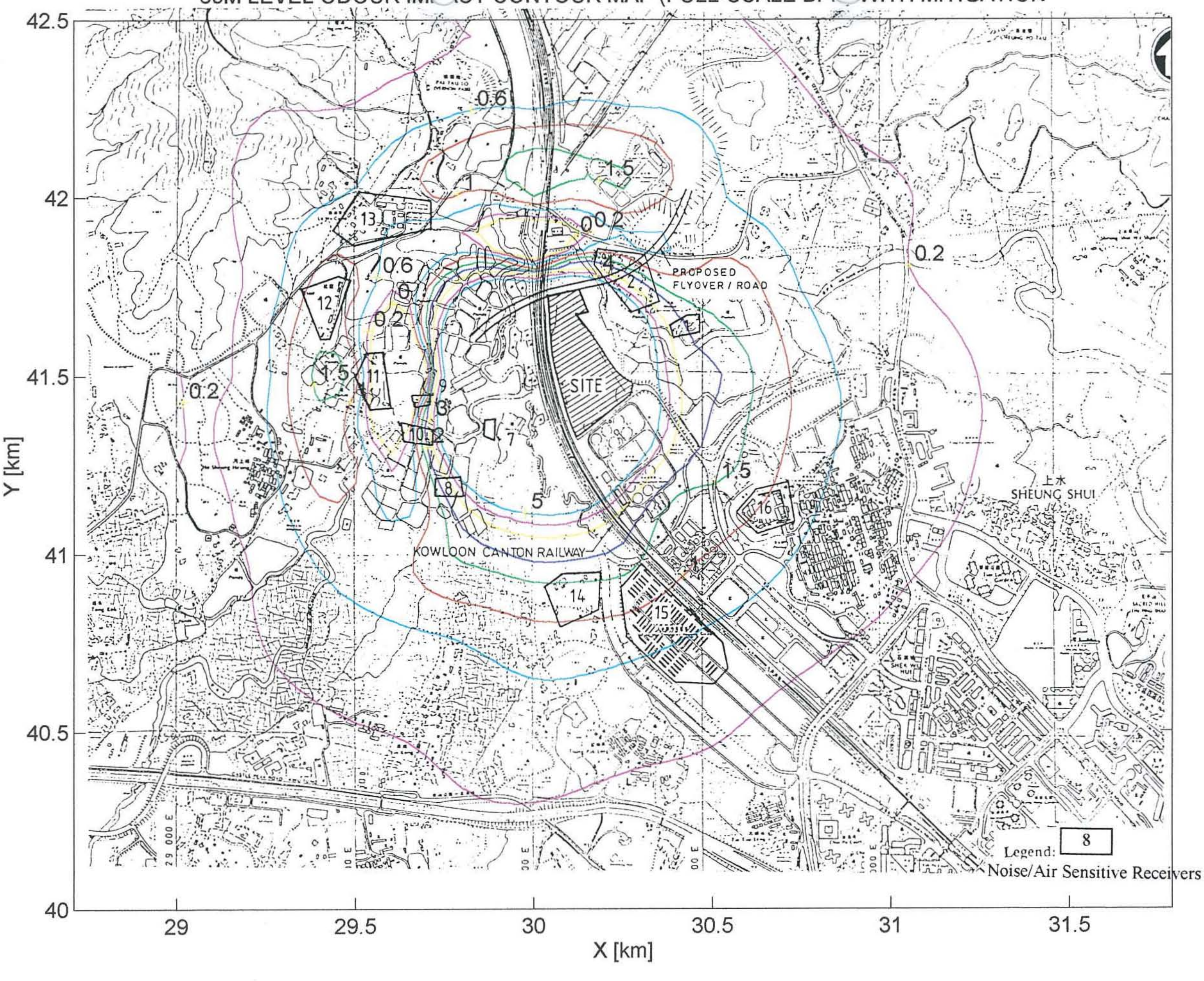
40M LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BP) WITH MITIGATION

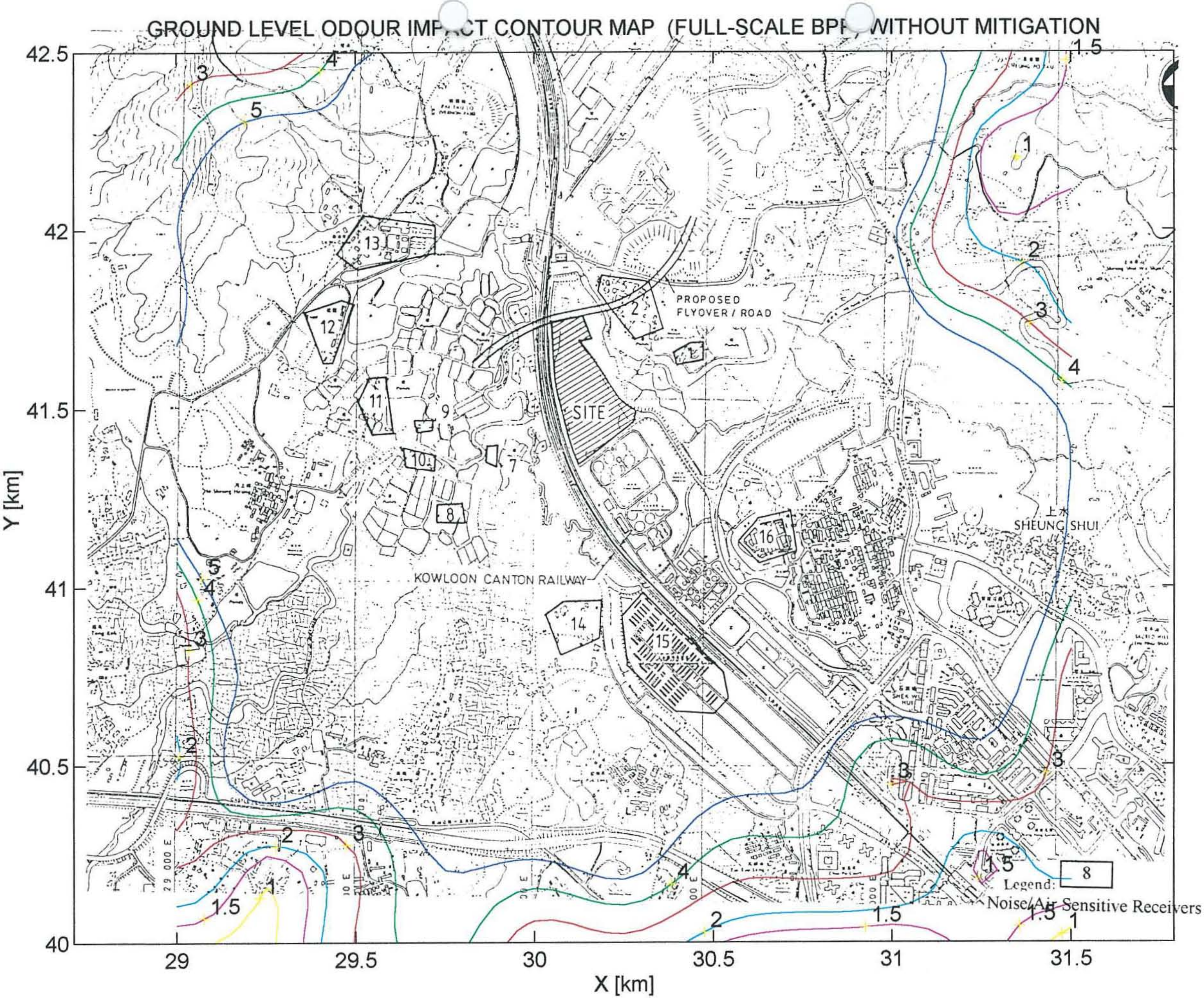


50M LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BPP) WITH MITIGATION

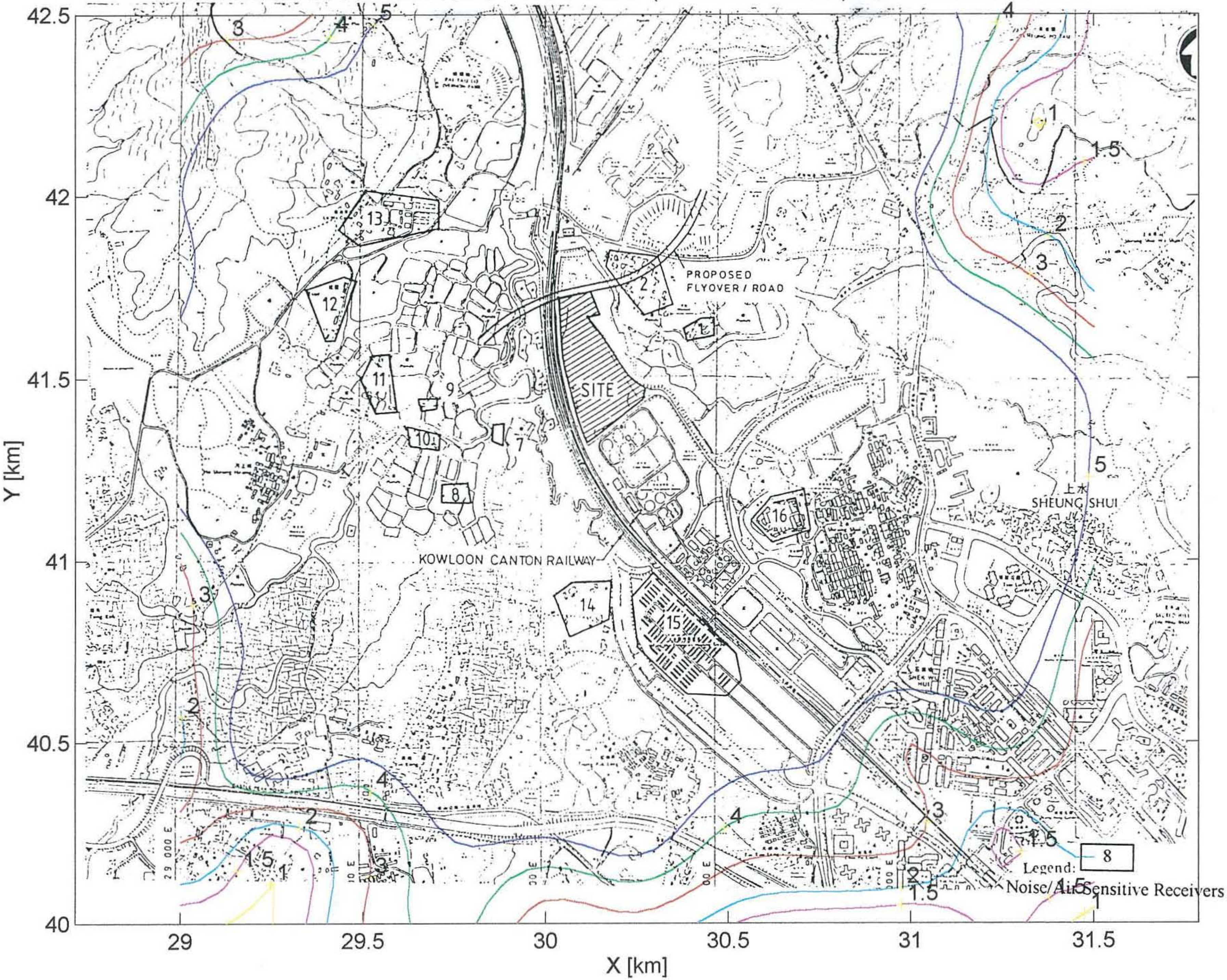


60M LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BPF) WITH MITIGATION

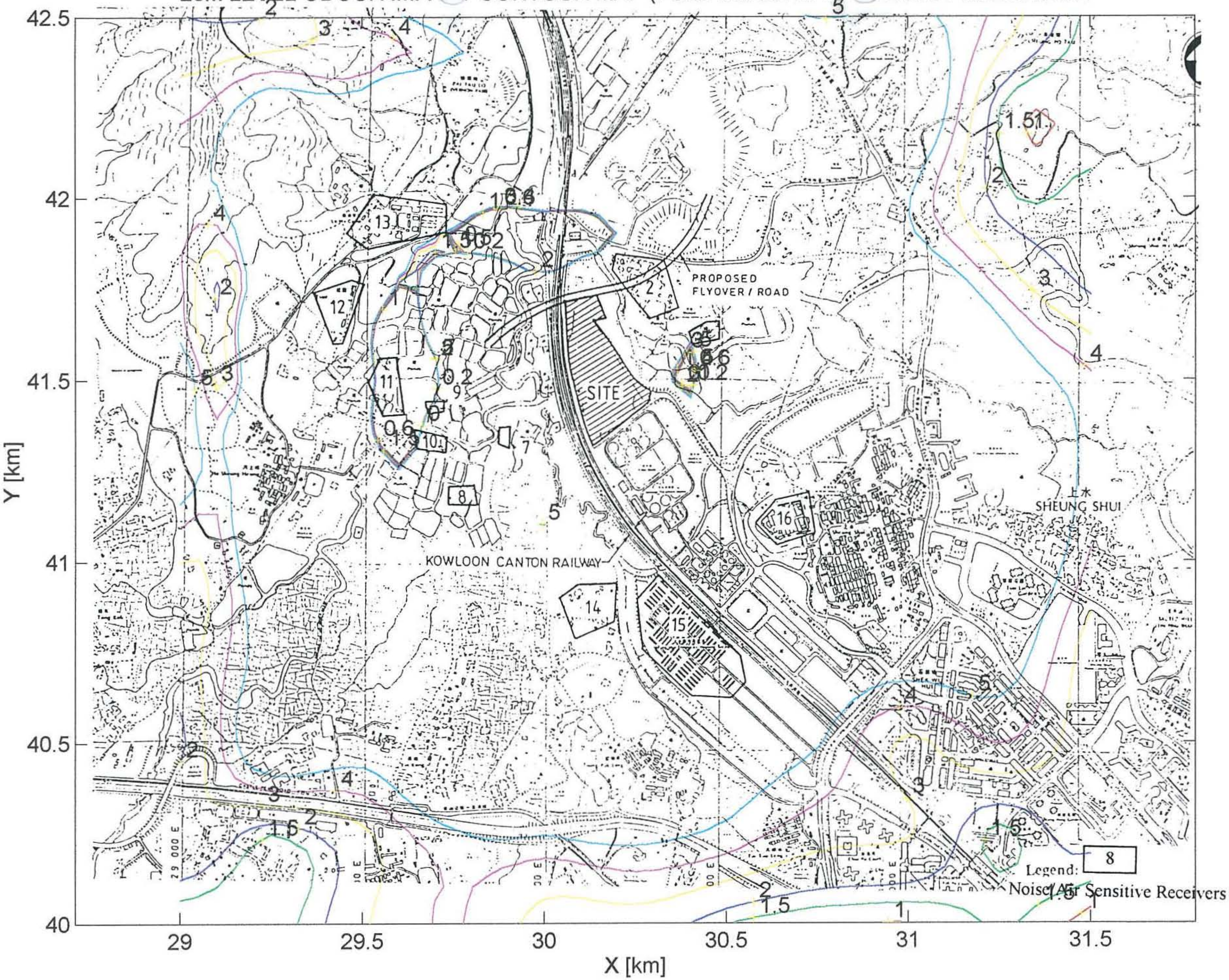



GROUND LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BPP) WITHOUT MITIGATION
PROPOSED FLYOVER / ROAD
SITE
KOWLOON CANTON RAILWAY
SHEUNG SHUI
Legend:
8
Noise/Air Sensitive Receivers
Y [km]
X [km]
42.5
42
41.5
41
40.5
40
29
29.5
30
30.5
31
31.5

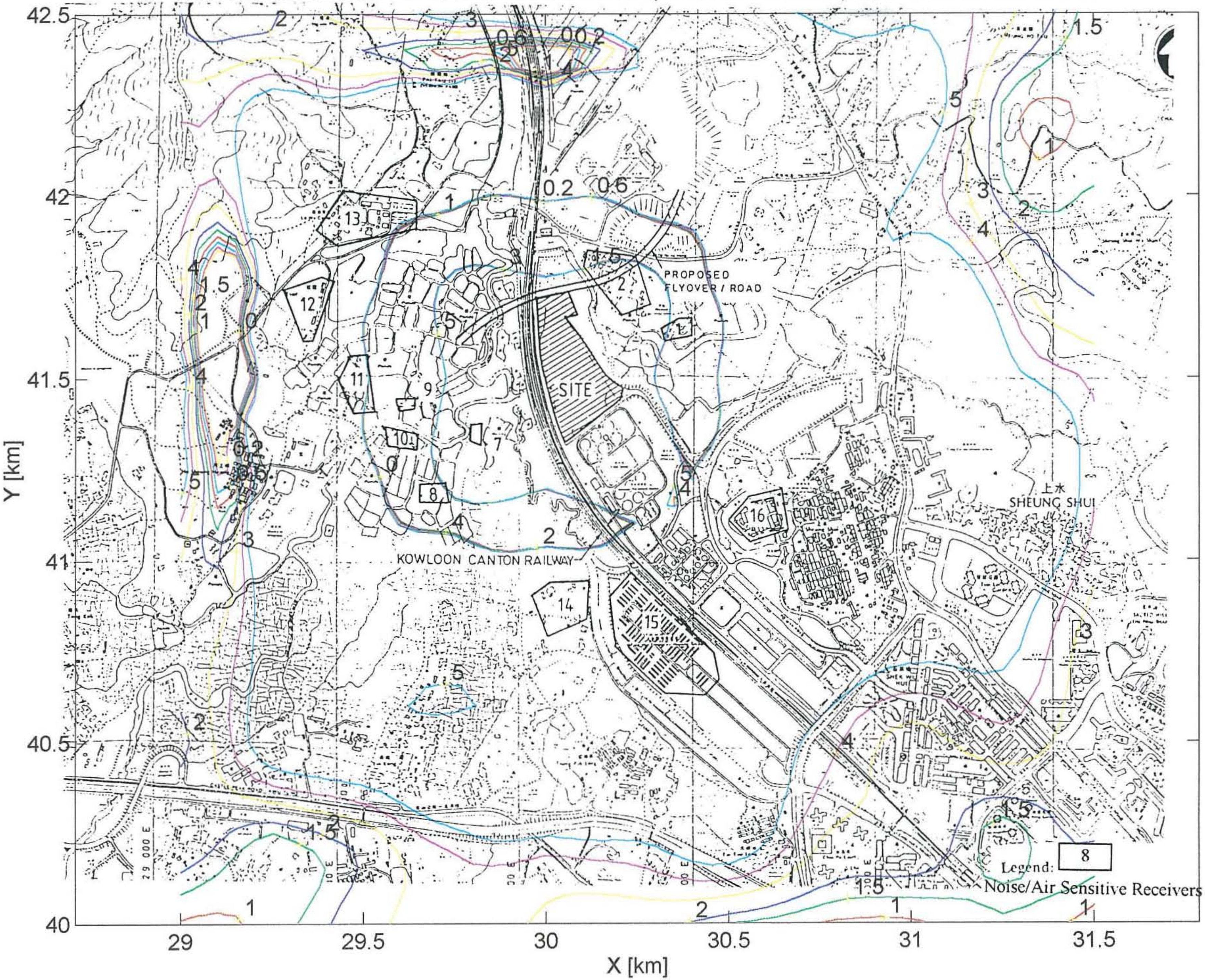
10M LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BPP) WITHOUT MITIGATION



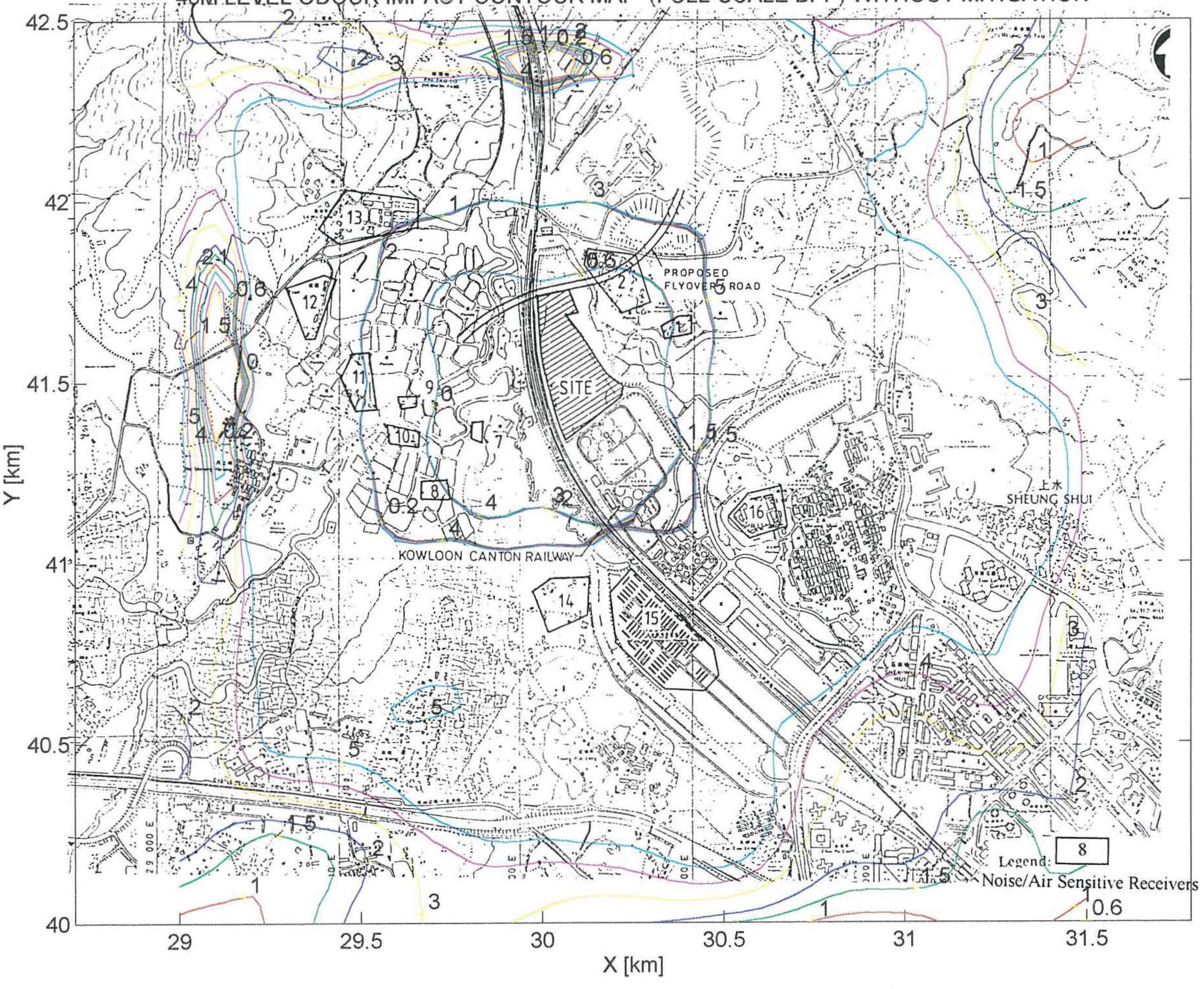
20M LEVEL ODOUR IMPA T CONTOUR MAP (FULL-SCALE BPP) THOUT MITIGATION



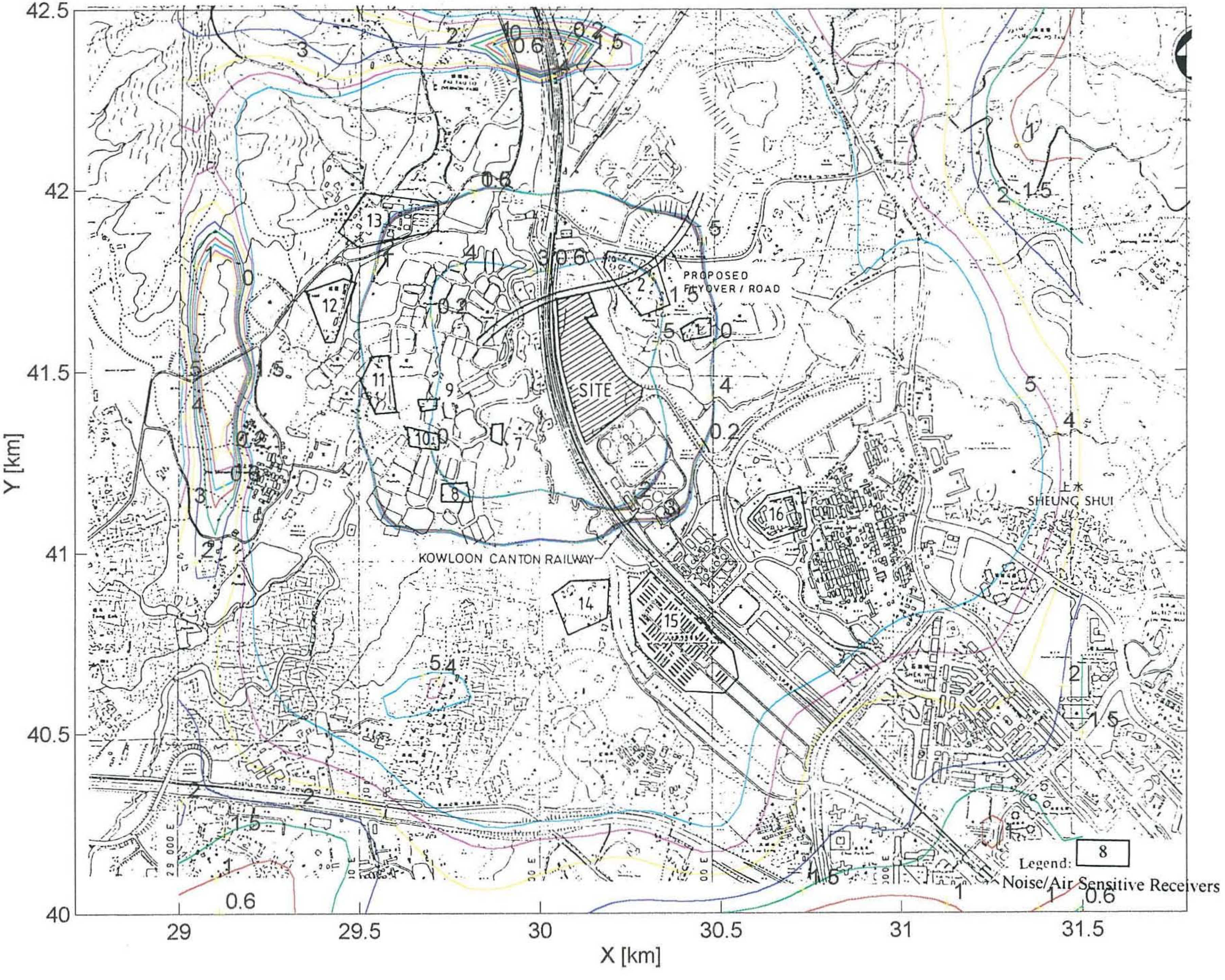
30M LEVEL ODOUR IMPA[?]T CONTOUR MAP (FULL-SCALE BPP) [?]ITHOUT MITIGATION



40M LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BPP) WITHOUT MITIGATION



50M LEVEL ODOUR IMPA[illegible]T CONTOUR MAP (FULL-SCALE BPP) [illegible]ITHOUT MITIGATION



60M LEVEL ODOUR IMP[illegible]T CONTOUR MAP (FULL-SCALE BPP) [illegible]ITHOUT MITIGATION

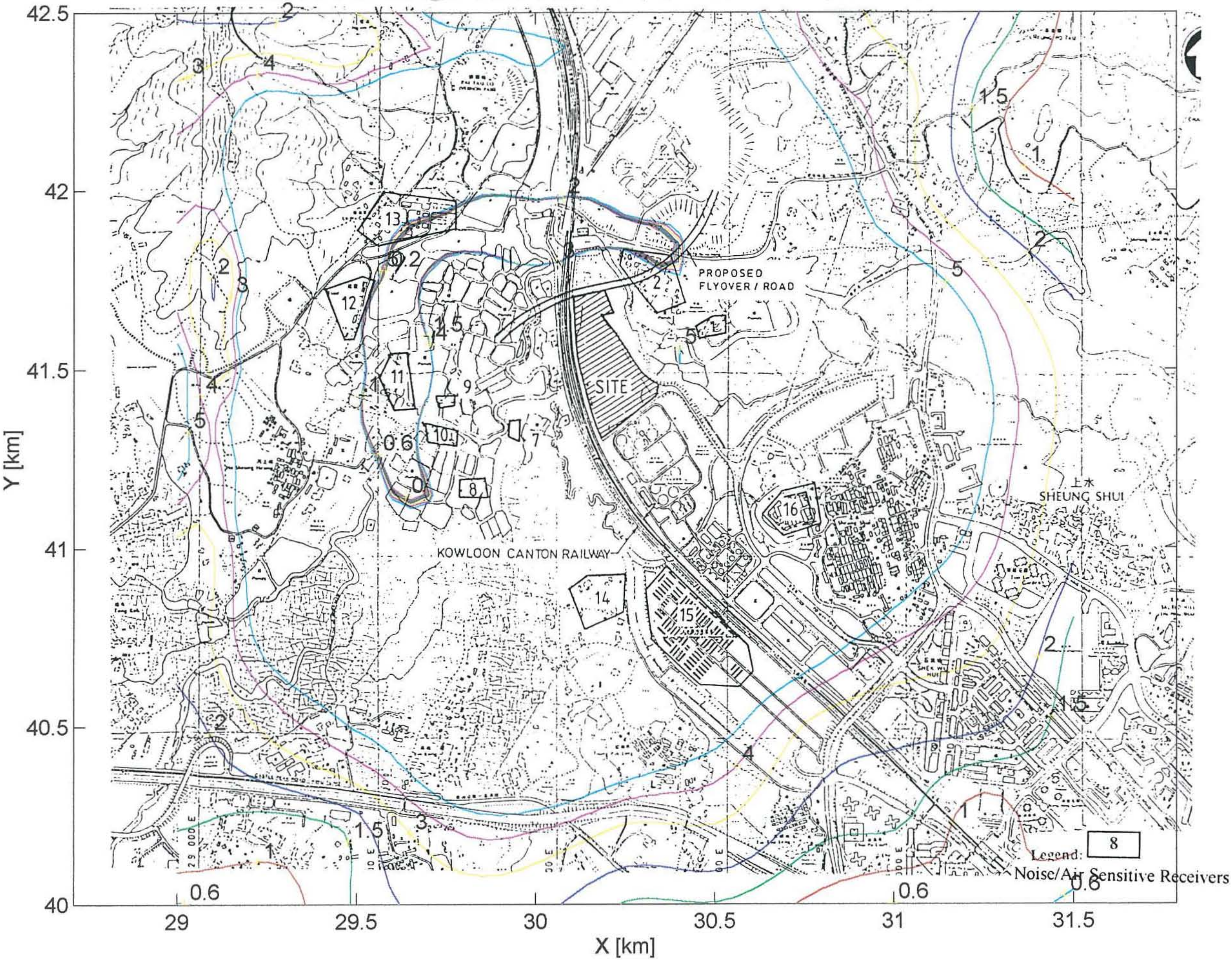
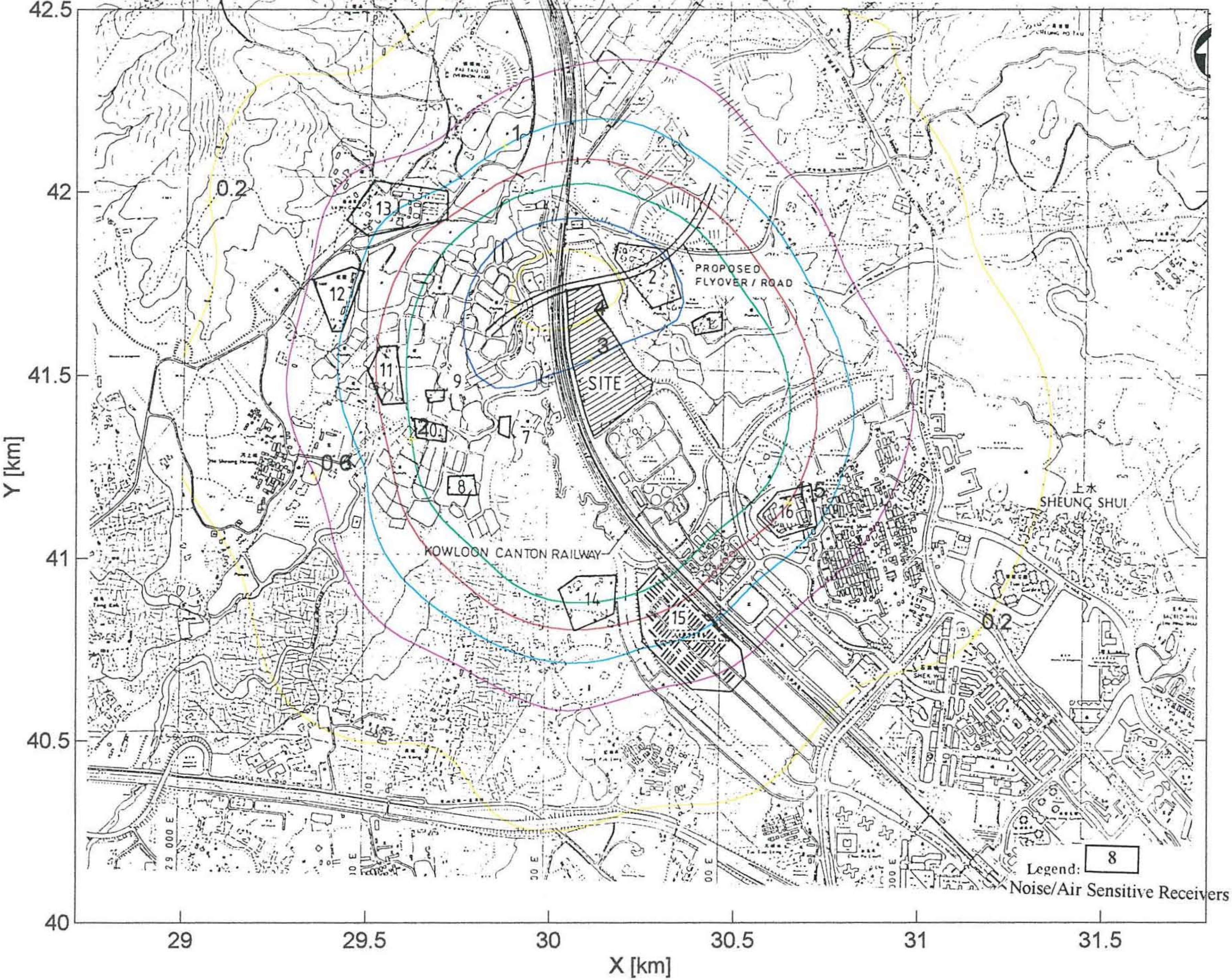


Figure 6.7

C

Site Layout Odour Impact Contour Map
With Full-Scale By-Products Plant
With Mitigation Measures and 5 Stacks at 40m

GROUND LEVEL ODOUR IMPACT CONTOUR MAP (FULL-SCALE BPP) WITH MITIGATION, with 5 stacks at 40m



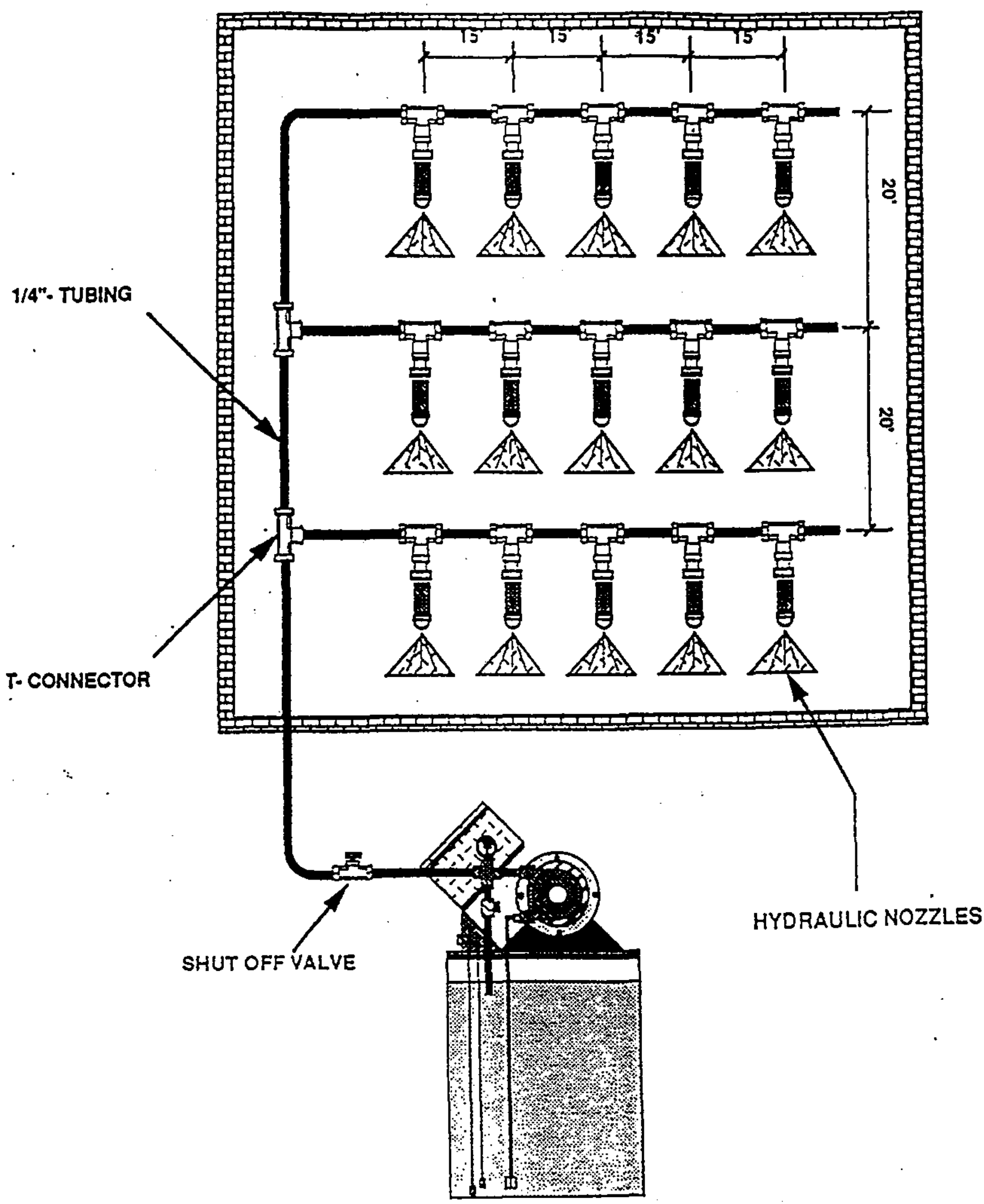


Figure 6.8a A Typical Pump Spray System

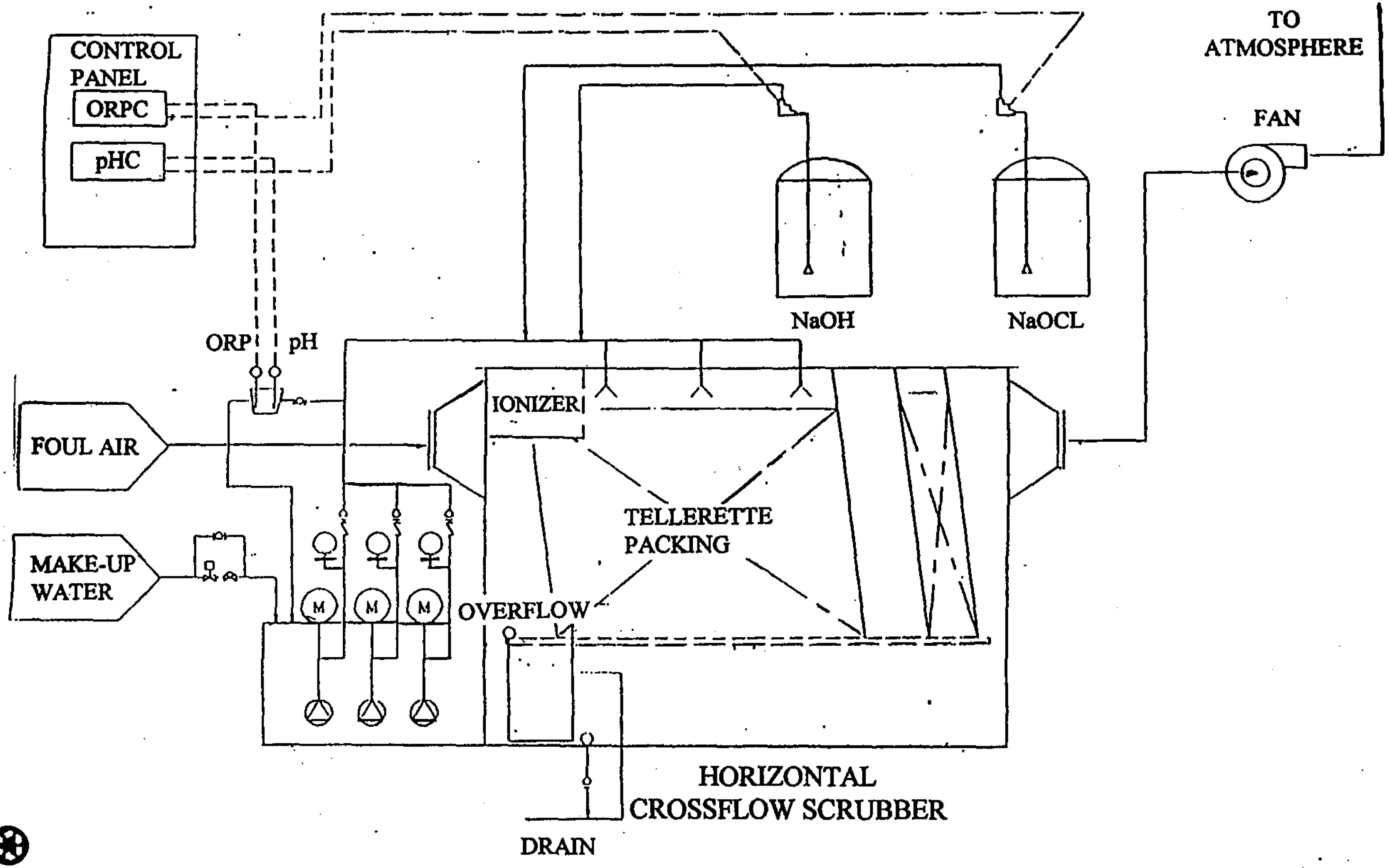


Figure 6.8b Schematic Diagram of Scrubber

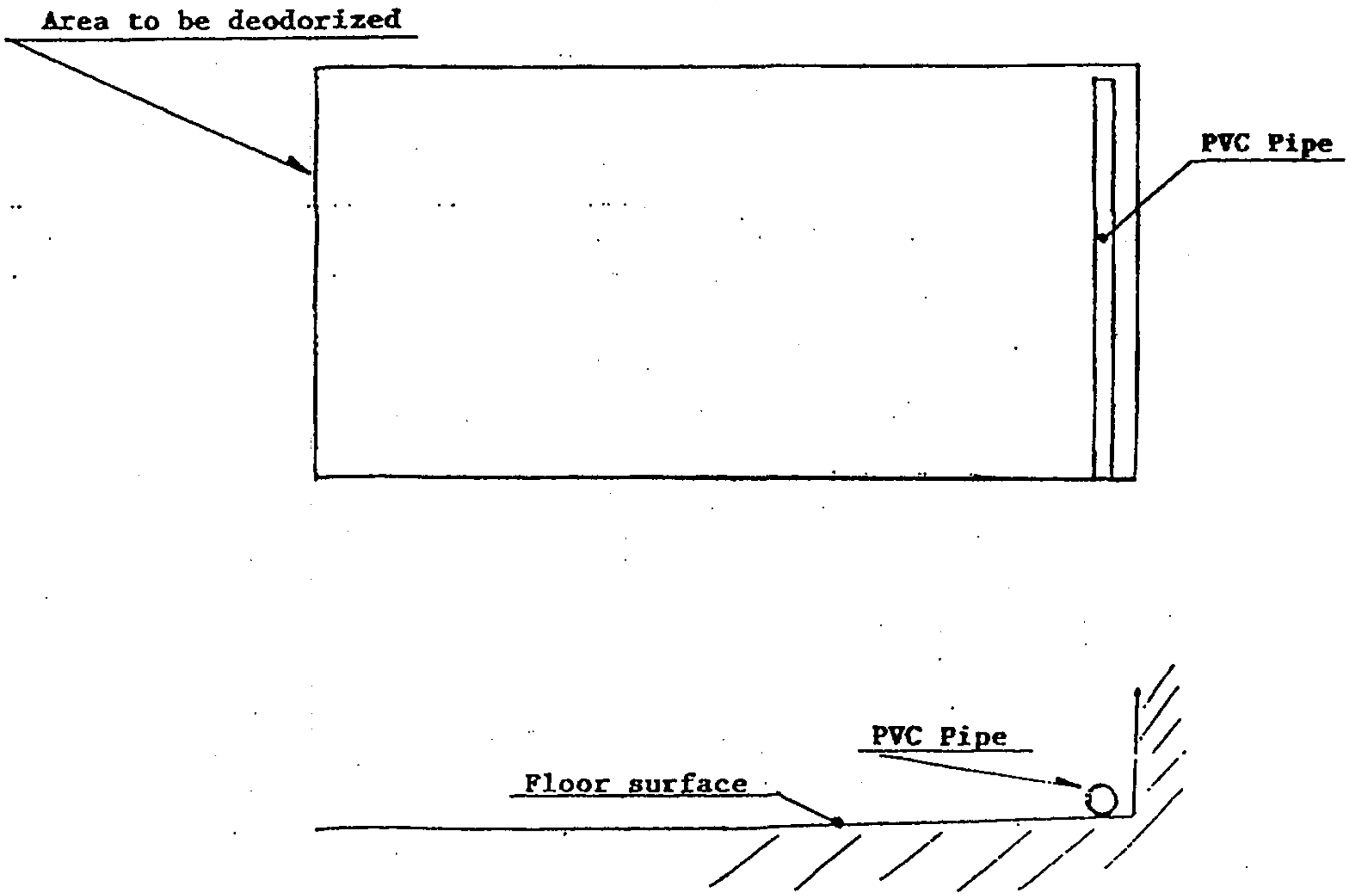
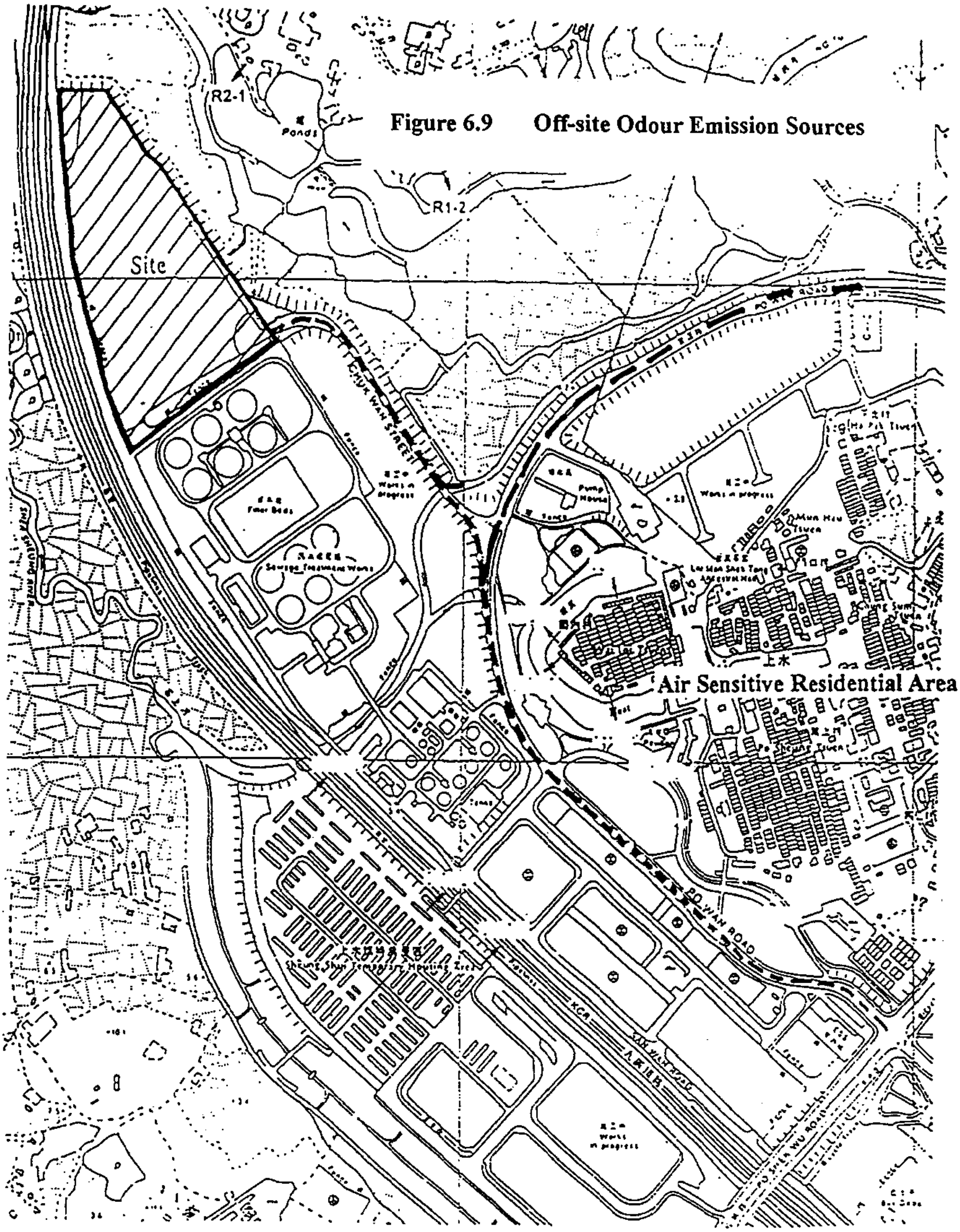


Figure 6.8c Deodorization with Ozonised Water

Figure 6.9 Off-site Odour Emission Sources



LEGEND :

---- Access Routes from Proposed Slaughterhouse

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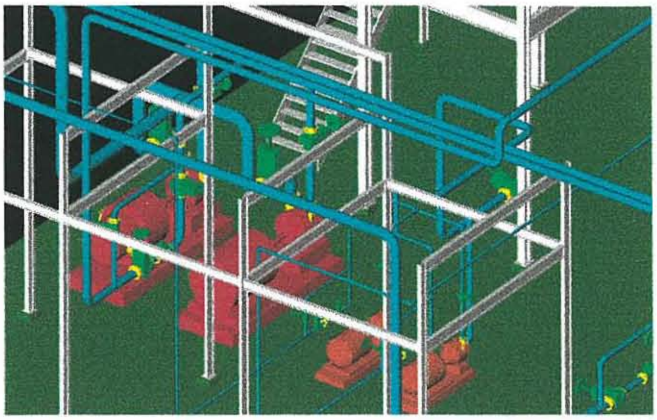

7. NOISE IMPACT ASSESSMENT

7. PLANT OPERATION NOISE IMPACTS

Sources of Noise

7.1 The layout plans and sections of the proposed slaughter house are shown in Figure 7.1 to 7.7. Noise from the proposed slaughter house is likely to arise from the following:-

Transport noise:
- lorries dispatching freshly slaughtered meat
- empty dispatch lorries returning to the slaughterhouse for cleaning and parking;
- lorries dispatching livestock to Tsuen Wan Abattoir;
- lorries delivering condemned meat and blood from Tsuen Wan Abattoir;
- Vehicular movements within site boundary;
- empty livestock lorries returning to the slaughterhouse for cleaning and parking;
- livestock lorries leaving the slaughterhouse and returning from Man Kam To border crossing;
- PRC diesel trains carrying livestock arriving and leaving the sidings; and
- miscellaneous traffic.

Slaughterhouse noise:-
- lairage, in particular from pigs squealing in the waiting lairage; and
- slaughtering process, in particular from both the pig and cattle stunning area.

Unloading area noise:-
- livestock dispatch lorries;
- PRC diesel trains;
- livestock, particularly pigs squealing; and
- personnel (livestock handlers), in particular shouting and banging of the lorries when herding the animals into the lairage, platform holding pens or lorries.

Plant noise:-
- by-products plant (if required);
- boilers; and
- air conditioning plant, and from fans.

Human activities:-
- livestock dealers in wholesale lairages;
- dispatch vehicle drivers; and
- livestock handling staff.

The Assessment

7.2 In the absence of data relevant to Hong Kong slaughterhouse activities it was necessary to conduct a noise survey of an operational plant in Hong Kong. Kennedy Town Abattoir was chosen for this survey and this was conducted on 3 and 4 of February 1994. These levels were then taken to be representative of the noise levels likely to arise at the proposed slaughterhouse. Additionally, a noise survey of the Homantin Livestock

Unloading Depot was carried out on 22 February 1994 to represent the unloading area at the proposed railway sidings. The purpose of these surveys was to identify the major noise impact activities which are assumed to be similar at the new slaughterhouse. A noise survey of the Study Site was also carried out in order to determine the baseline conditions.

7.3 The instrumentation used to measure the ambient noise levels included two sets of integrated sound level meters, conforming with the International Electro-mechanical Commission Publications 651:1980 and 804:1895 for Type 1 precision sound level meters. Table 7.1 lists the equipment used for the survey.

Table 7.1 List of Equipment for the Noise Survey

Equipment	Manufacturer & Model
Sound Level Meter	Bruel and Kjaer 2231 RION NL -14
Condenser Microphone	Bruel and Kjaer 4155 RION UC - 53A
Preamplifier	Bruel and Kjaer 2639 RION UC - 53A
Windshield	Bruel and Kjaer UA0237 RION WS - 02
Acoustic Calibrator	Bruel and Kjaer 4231
DAT Recorder	Denon DTR - 100P
1/3 - 1/1 Filter Set	Bruel and Kjaer 1625

7.4 The monitoring locations were chosen depending on the activities thought to be major sources of high noise levels. For a full description of the respective locations and operations, see Section 2.

- Pig/Cattle unloading area;.
- Pig stunning area;
- Pig waiting lairage
- Pig holding lairage
- Cattle lairage
- Cattle stunning area
- Pig and cattle slaughtering lines
- Meat dispatch area
- Boiler room
- Bonemeal/bloodmeal products plant (optional)
- Odour Treatment Plant Equipment

Pigs/cattle unloading area

7.5 Noise is made up of a combination of activities which include squealing pigs, lorry movements, and personnel.

7.6 The results of the noise survey are shown in Tables 7.2 and 7.3. The measurements at the unloading area were taken between 1100 and 1300 hours on a normal working day and all others at the Kennedy Town Abattoir were taken between 0400 - 0700 hours on a normal working day. These were peak activity periods which were chosen specifically to give the worst case scenarios.

The operation of Sheung Shui Slaughter House will be quite dissimilar to that at Ho Man Tin (HMT) Livestock Depot. The livestock will be unloaded from the trailers using a team of workers. Improvements in this method, however, include, specifically designed ramps and movable ramps with inspection platforms to ensure safe, humane and immediate unloading of livestock arriving from trains. This together with adaptation to better facilities by the on-site management and a structured operation system will ensure an efficient unloading process.

Table 7.2 Results of Noise Measurement at Ho Man Tin Livestock Unloading Depot

Location	L_{90} dB (A)	L_{eq} dB (A)	L_{max} dB (A)	Remarks
Pig Unloading	65.7	78.8	94.7	5m from the source animals lorries,
	65.3	79.2	98.4	people noises only Train engines are o
Cattle Unloading	67.7	73.7	88.8	as above
	67.6	73.3	87.4	

Table 7.3 Results of Noise Measurements at Kennedy Town Abattoir

Location	L_{90} dB (A)	L_{eq} dB (A)	L_{max} dB (A)	Remarks
Pig Stunning	85.2	95.6	109.8	2m from the source, 3 to 4 mins to process 15 to 20 Pigs
	84.8	94.5	107.6	
Pig Waiting Lairage	84.3	95.5	108.7	3m from the source, and 6m from the other source. 15 to 20 pigs in the two nearest lairage pens.
	85.3	95.0	108.0	
Pig Holding Lairage	64.3	75.0	109.8	2m form the two lairage pens. Each consisted of 20 pigs.
	64.3	75.3	107.6	
Pig & Cattle Slaughter Lines	79.6	83.5	93.9	2m from both the pig and cattle slaughter lines. Both operational.
	79.3	83.6	92.1	
Cattle Lairage	69.8	81.1	105.2	2m from the source
	69.8	80.6	100.2	
Cattle Stunning	71.8	84.2	107.3	3m from the source.
	71.8	84.8	107.0	
Meat Dispatch Area	71.2	81.9	100.1	Approximate room size 20m x 8m x 4m 8 lorries and 20 men on site.
	71.3	81.5	98.2	
Boiler Room	82.3	83.3	94.3	3 boilers in operation. 5m from the middle boiler.
	82.3	83.5	89.8	
Bone Meal Rendering Plant	81.8	82.5	92.8	Approximate room size 10m x 7m x 4m
	81.8	83.2	102.9	
Blood Meal Rendering Plant	78.0	83.8	97.3	Approximate room size 15m x 10m x 5m
	78.3	83.7	96.4	

Pig stunning area

7.7 The highest noise levels are experienced in the very early hours, probably between 0200-0700 hours which is the peak slaughtering period. The duration of this noise from squealing is dependent on the number of pigs in a process batch.

Pig waiting lairage

7.8 The admission of pigs to the waiting lairage normally takes place during daytime hours on the day before the slaughter.

Pig holding lairage

7.9 The place at which the animals are herded is usually much slower than that in the waiting lairage. Therefore, animal stress is reduced the resulting squealing is not as great.

Cattle lairage

7.10 In comparison with the other activities occurring in the slaughterhouse, the area where cattle are housed is relatively quiet. The noise levels recorded in this area were not directly from the cattle but were instead caused by running water, dripping taps, and movement of personnel. This resultant noise impact, in terms of this assessment, is considered to be negligible and has not been included in the modelling.

Cattle stunning area

7.11 The dominant noise comes from the pen base plate which crashes open as the stunned cattle roll onto the floor ready to be hoisted and bled.

Pig and cattle slaughtering lines

7.12 Note that in this assessment the noise level measured is a combination of the pigs and cattle slaughtering lines running simultaneously. The new plant is likely to have separate processing halls.

Meat dispatch area

7.13 The meat dispatch area has been identified as one of the principal noise sources highlighted in S. 7.1.

Boiler room

7.14 This room is likely to be a solid wall plant room structure with no windows and therefore the noise generated will be contained. Noise from this source is thus negligible and has not been considered further.

Bonemeal/bloodmeal products plant (optional)

7.15 Principal noise sources will be mechanical.

Noise from Odour Treatment Plant Equipment

7.16 In the odour impact assessment several mitigation options have been proposed, all of which have noise impact consequences. To summarize the noise environment, Table 7.4 shows the odour mitigation measures and the possible types of equipment to be used. Further details regarding the treatment options can be found in the Air Pollution Impact Study (Section 6).

Table 7.4: Sound Power Level of the Proposed Odour Treatment Options, dB(A)

Location of Odour Treatment Plant	Equipment	Sound Power Level dB(A)
Lairage	scrubbers	117
Unloading Depot	fans	103
Condemned Meat Store	scrubbers	105
BPP Room (optional)	scrubbers	108

Notes

(i) The sound power level of each scrubber unit has been assumed to be 105 dB(A).

(ii) The sound power level of each fan unit has been assumed to be 93 dB(A).

(iii) The lairage will be semi-enclosed with acoustically treated louvres and the unloading depot will be an open area with reef shelter only.

7.17 The whole equipment chain was calibrated at 1 kHz both before and after each measurement to ensure the validity of the measured data. Standard acoustic principles and practices were followed in the measurement and analysis of the measured noise data.

Assessment Methodology

7.18 The most intrusive noise at the proposed plant will be wherever there are pigs being transported and at the meat dispatch and unloading areas. This is due to the loud squealing of the pigs during stressful periods. Such stressful situations include herding from the unloading area to the holding lairage or herding from the waiting lairage to the stunning area. The noise survey shows that for these activities the L_{eq} ranges from 79 dB(A) to 96 dB(A). The meat dispatch area and unloading areas are problem areas at the Kennedy Town Abattoir because they are open-air.

Sound Power Levels - Intensity of Noise Sources

7.19 The first step in the assessment was to calculate the intensity of the individual noise sources. This was carried out by calculating the SWLs of the separate activities.

7.20 The methodology outlined in the Hong Kong Government Noise Control Ordinance states that assessments should be based upon $L_{eq\ (30\ mins)}$. This methodology has been adopted for this noise assessment study. The following formula was used to calculate the SWLs.

$$SWL = SPL - 10\log_{10}\left(Q/4\pi r^2 + 4/R\right) \qquad (1)$$

where SWL = Sound Power Level (Intensity of noise sources) dB(A)
SPL = Sound Pressure Level, dB(A) (see measured data)
Q = Directivity Factor
r = Distance of measurement, m
R = Room Constant, m^2

7.21 Table 7.5 shows the predicted SWLs of noise sources of concern in the proposed slaughterhouse. These were used for modelling purposes.

Table 7.5 Sound Level of Activities

Activity	Sound Power Level dB (A)
Cattle Stunning	102
Pig Stunning	112
Pig Waiting Lairage	117
Pig Holding Lairage	79
Pig & Cattle Slaughter Line	113
Meat Dispatch Area	106
By-Product Plant	103
Unloading area	101

Corrected Noise Levels

7.22 According to the "Technical Memorandum for the Assessment of Noise from places other than Domestic Premises, Public Places or Construction Sites" (TM3), section 3.3.2, the measured noise level must be corrected if the source is either tonal, impulsive, or intermittent in nature.

7.23 The activities relating to cattle stunning, pig stunning, pig waiting lairage, pig holding lairage are considered to be tonal. A correction of 6 dB(A) for tonality is considered appropriate, in accordance with the TM3, and will be taken into consideration with the operation noise prediction at the NSR locations.

Sound Pressure Levels at NSR's

7.24 Using the sound power levels presented in Table 7.5 the predicted noise levels at the sensitive receivers (Figure 7.8) were modelled based on the following equations. Distance attenuation, tonality correction, and facade correction were taken into account in the modelling. Photographs taken on site are given in Appendix 7.1.

For enclosed activities or areas

$$SPL_2 = SPL_1 - SRI + 10\,Log(S) - 20log(r) - 14 + C_g + C_{Tonality} + C_{facade} \qquad (2)$$

where

SPL_1	= Sound pressure inside room
SPL_2	= Sound pressure at NSR
SRI	= Sound reduction index for building envelope
r	= Distance between the wall and NSR
S	= Noise radiating surface
C_g	= Correction for soft ground absorption
$C_{Tonality}$	= Correction for tonality

C_{Facade} = Correction for facade effects (ie 3dB(A))

For open activities or area

$$SPL_2 = SWL - 20\ Log(r) - 8 + C_g + C_{Screening} + C_{Silencer} + C_{Tonality} + C_{facade} \quad (3)$$

where

SWL	= Sound power level of plant / activity
SPL_2	= Sound pressure at NSR
r	= Distances between the wall and NSR
C_g	= Correction for soft ground absorption
$C_{Screening}$	= Correction for barrier screening
$C_{Silencer}$	= Correction for silencer attenuations, if any
$C_{Tonality}$	= Correction for tonality
C_{Facade}	= Correction for facade effects (ie 3dB(A))

7.25 The following assumptions were made in calculating the SPLs at the sensitive receivers.

- the tonality correction is 6 dB(A) for pig squealing;
- the slaughter hall lairage and BPP (if required) are housed in a reverberant enclosure. The room constant of this enclosure is given in Table 7.6.

The noise emission from activities involving livestock screams given out during stunning, unloading, marshalling and waiting are anticipated to contain a tonal characteristic. As noise measurements were made at each of these activities, the measured noise levels need to be corrected for tonality. The worst scenario, with the maximum correction of 6 dB(A) tonality correction according to TM3, has been applied for these activities. The noise prediction combines the contributions of the tonal-corrected noise from individual activity and gives a realistic indication of noise impact without over-estimating the noise characteristic in the case when the predominant noise element does not contain a tonality whilst acting as the masking noise to conceal the elements with a tonal characteristic.

It should be pointed out that the TM3 methodology applies to a 'measured' noise level with a spectrum which is employed in the test for tonality severity and hence the 3 or 6 dB(A) correction. The addition of the maximum 6 dB(A) tonal correction to every activity that will involve animal squeal is considered to be reasonable and adequate, given that there is a practical difficulty to formulate the total noise spectrum at the SR location.

Table 7.6 Room Constant R of enclosed areas

Activities / Areas	R (m^2)
Pig Stunning Area	37
Pig Waiting Lairage*	37
Pig Holding Lairage*	200
Pig & Cattle Slaughter Hall	297
Cattle Stunning Area	37
By-products Plant	82

Note: Calculations of the values of Room Constant used are shown in Appendices 7.2, 7.3, 7.4 and 7.5. The areas applied in the calculations of the Room Constant are estimated values. However, the sensitivity of the Room Constant is very low, as a small or large value does not significantly affect the predicted noise levels using Equation (1).

* The pig waiting lairage and pig holding lairage are semi-enclosed areas.

The activity areas are marked on the layout plans shown in Figures 7.1 to 7.7.

7.26 In this assessment it is important to consider the fact that some processes will be enclosed due to the nature of the operation of the plant and its particular building design requirements. The building design chosen for this assessment has been based on the following requirements:-

- operational preference;
- welfare of the animals;
- requirements for natural ventilation; and
- general comparison with other slaughterhouses.

7.27 The building design of the proposed plant used for the noise assessment has been assumed to be as follows:-

- building fabric and all openings treated with silencers or 600mm thick acoustic louvres with 50% free area (see Figure 7.7:1). The ceiling of the waiting lairage will be acoustically treated with sound absorptive fully enclosed by a thin Melinex or Mylar sheet and externally faced by a perforated metal sheet with 20% perforation. The acoustic louvres shall be adequately sized so that the total free opening areas on the walls will be sufficient to provide the necessary air ventilation. The glazed area should have an adequate noise insulation with a thick glass pane of 10mm minimum;
- the holding lairage will have <u>all</u> wall openings acoustically treated with 50% free area acoustic louvres offering minimum 7dB(A) noise attenuation. A suitable louvre construction will have sound absorptive blades housing sound absorbent fully enclosed by a thin Melinex or Mylar sheet and externally faced by a perforated metal sheet with 20% perforation;
- the overall area percentage of wall opening for both the waiting lairage and the holding lairage will be 50%;
- the slaughter hall will be enclosed, with manually operated windows at high level for emergency ventilation;

- the by-products plant (if required) will be a totally enclosed area with no windows, enhanced ventilation will remove the build up of heat; and
- the meat dispatch and unloading areas will not be enclosed. For the lairage, however, the assessment will include the noise impact of the odour mitigation option.

7.28 The attenuation of noise by the fabric of the building will depend on the type and thickness of construction materials used and whether or not there are any openings in the structure. Such openings may include windows or louvres. It has been assumed that the building will consist of single leaf brick construction with plaster on both sides and with small openable windows at high level where they face towards any Sensitive Receivers. Windows will consist of double glazed glass panels in separate frames. Table 7.7 shows the assumed form of construction and the sound transmission loss likely to occur from this type of construction.

Table 7.7 Airborne Sound Transmission Loss (dB)

Construction	Thickness	Sound Transmission Loss (dB)							
		Frequency (Hz)							
	(mm)	63	125	250	500	1K	2K	4K	8K
single leaf brick, plastered on both sides	125	30	36	37	40	46	54	57	59
6 mm double glass pane in separate frame 100mm cavity	112	20	28	30	38	45	45	53	50

7.29 The sealed double glazing offers a good noise reduction, which is comparable to that of the single leaf brick construction at middle and high frequencies. With the sealed 6 mm double glazing, at high level, covering a total area of not more than 33% of the total wall surface, the combined sound reduction index of the building facade is 36 dB(A) minimum. The noise attenuation from each of the process areas are shown in Table 7.8.

Table 7.8 Noise Attenuation from the Building Fabric

Activity	Noise Attenuation dB(A)
Waiting Lairage (i)	-36
Holding Lairage (v)	-7
Slaughter hall (iii)	-36
By-products plant, if required (iii) (iv)	-36
Meat Dispatch Area (ii)	0
Livestock Unloading Area (vi)	0

Notes
(i) Openings in the structure acoustically treated by building fabric and silencers.
(ii) An open area therefore no attention offered.
(iii) These are in a reverberant field.
(iv) No windows are required for these areas.
(v) Semi-enclosed with acoustically treated openings.
(vi) An open area with roof shelter.

Predicted Noise Levels Without Mitigation

7.30 The impacts arising from the slaughterhouse without any form of mitigation were modelled and the breakdown of predicted noise levels caused by the various activities at each sensitive receiver are shown in Table 7.9 & 7.10. The noise calculations have included all the major noise sources in the development. In-door stationary noise sources will be acoustically treated to reduce the plant noise by the plantroom building fabric or acoustic enclosures and by acoustic silencers fitted to air-intake side and discharge side of a fan or plant. The calculations sheets for the daytime and night-time periods are given in Appendices 7.2 & 7.3.

Table 7.9 Daytime Noise Levels caused by each activity at the Sensitive Receivers (without mitigation)

Activities/Area	Status	Noise Sensitive Receiver (NSR)							
		1	2	7	12	13	14	15	16
Pig Stunning Area	✓	28	33	30	20	24	22	21	21
Pig Waiting Lairage	✓	33	38	35	25	29	27	26	26
Pig Holding Lairage	✓	23	28	25	<20	<20	<20	<20	<20
Pig & Cattle Slaughter Hall	✓	22	28	24	<20	<20	<20	<20	<20
Cattle Stunning Area	✓	<20	23	20	<20	<20	<20	<20	<20
By-Product Plant	✓	<20	<20	<20	<20	<20	<20	<20	<20
Meat Despatch Area	✓	27	28	49	37	38	43	43	42
Pig & Cattle Unloading Area	✓	44	54	46	40	44	38	38	30
Roof Fans for Unloading Area	✓	<20	25	<20	<20	<20	<20	<20	<20
Lairage Scrubbers	✓	33	38	35	25	29	27	26	26
Scrubbers for Condemned Meat Area	✓	<20	<20	23	<20	<20	<20	<20	<20
Scrubber for By-Product Plant	✓	21	23	26	<20	<20	20	<20	<20
Vehicular Movement within Site	✓	<20	<20	37	26	23	30	28	25
Train Noise from Sidings	✓	28	30	41	32	34	34	35	23
Total Noise Levels (CNLs) at NSR, dB(A)		**45**	**54**	**52**	**43**	**45**	**45**	**45**	**43**

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Table 7.10 Night-time Noise Levels caused by each activity at the Sensitive Receivers (without mitigation)

Activities/Area	Status	Noise Sensitive Receiver (NSR)							
		1	2	7	12	13	14	15	16
Pig Stunning Area	✓	28	33	30	20	24	22	21	21
Pig Waiting Lairage	✓	33	38	35	25	29	27	26	26
Pig Holding Lairage	✕	0	0	0	0	0	0	0	0
Pig & Cattle Slaughter Hall	✓	22	28	24	<20	<20	<20	<20	<20
Cattle Stunning Area	✓	<20	23	20	<20	<20	<20	<20	<20
By-Product Plant	✓	<20	<20	<20	<20	<20	<20	<20	<20
Meat Despatch Area	✓	27	28	49	37	38	43	43	42
Pig & Cattle Unloading Area	✕	0	0	0	0	0	0	0	0
Roof Fans for Unloading Area	✕	0	0	0	0	0	0	0	0
Lairage Scrubbers	✓	33	38	35	25	29	27	26	26
Scrubbers for Condemned Meat Area	✕	0	0	0	0	0	0	0	0
Scrubber for By-Product Plant	✓	21	23	26	<20	<20	20	<20	<20
Vehicular Movement within Site	✓	<20	<20	37	26	23	30	28	25
Train Noise from Sidings	✕	0	0	0	0	0	0	0	0
Total Noise Levels (CNLs) at NSR, dB(A)		**37**	**42**	**49**	**38**	**39**	**43**	**43**	**42**

7.31 The acceptance criteria relevant to this Study is the Acceptable Noise Level (ANL) as quoted in TM3 minus 5dB(A). These are shown in Table 7.11.

Table 7.11 Acceptable Noise Levels (ANLs) at the Study Site

Time of Day	Duration (hours)	ANL-5, L_{eq} dB(A)
Day-time	0700-1900	55
Evening	1900-2300	
Night-time	2300-0700	45

7.32 The impacts on NSRs will be due to a combination of activities of the slaughterhouse operations. The breakdown of the activities over a 24 hour period is shown on Figure 7.9.

7.33 The activities in the nighttime period occur between 0100 - 0700 hours. At this time of highest noise levels the activities include:-

- movement of pigs from the waiting lairage to the stunning area;
- the stunning of pigs;
- slaughterhall operations;
- cattle stunning;
- dispatch of meat by lorries;
- operation of the bloodmeal rendering plant (if required) or blood coagulation room;

- operation of the deodorisation equipment; and
- vehicular movement within site boundary.

The noise generated by the movements of vehicles have been predicted using the calculation method as given in BS5228 Part 1 and the RoadNoise computer software (version 1992) licensed to use by WS Atkins, Surrey, U.K. The noise calculations have been based on noise measurements taken on heavy lorries manoeuvring in industrial sites. The noise impact has included the noise contribution from vehicular movements. With the proposed noise barriers, the vehicular noise contribution is relatively small when compared with the noise from plant and activities of the future slaughter house. The calculation sheets are shown in Appendix 7.4.

7.34 The following activities in the daytime period occur between 0700 - 2000 hours with the highest noise levels occurring at approximately 1500 - 1600 hours:

- pig stunning;
- cattle stunning;
- slaughterhall operations;
- meat dispatch;
- bloodmeal and bonemeal rendering plant (if required) or blood coagulation room;
- arrival of livestock by road and by rail;
- herding of animals into the holding lairage;
- herding of animals from the holding lairage to the waiting lairage; and
- operation of the deodorisation equipment.

7.35 It should be noted that between 1500-0200 hours the by-product plant will not be operating and there will be no trains delivering livestock, (livestock unloading activities are normally between 1145-2000 hours). Also, all pigs to be slaughtered that day are likely to be moved to the waiting lairage during the daytime perhaps between 1200-1700 hours. The slaughtering starts at about 0200 hours, therefore, the meat will only be ready for delivery after 0200 hours. At this time the lorries will be preparing to dispatch meat and animals will be moved from the waiting lairage to the stunning area while the slaughtering is underway.

7.36 The daily activities taking place in the slaughterhouse are summarized in Figure 7.9 and the calculated peak noise levels at the sensitive receivers in the daytime and night-time without any form of mitigation are shown in Tables 7.9 and 7.10 respectively.

7.37 During the evening period the only activity is the operation of the lairage scrubbers (if installed for the full enclosure option). The noise levels are negligible and noise levels at this period will not be further discussed.

7.38 During the daytime period the Calculated Noise Levels (CNLs) do not exceed the ANL-5 of 55 dB(A) at all sensitive receivers. During the night time operations the CNLs exceed the ANL-5 of 45 dB(A) at only one NSR location.

Mitigation Measures

7.39 The main problem areas as illustrated in Tables 7.9 and 7.10 have been identified to be from the meat dispatch area, the pig waiting lairage, unloading area noise and the deodorisation plant equipment. Therefore, the noise emanating from these areas require some form of mitigation.

7.40 The meat dispatch area has the greatest impact on NSR 7 during night-time. The unloading areas also have significant impact on NSRs 7 and 2 during daytime. It is necessary to erect barriers to screen the NSRs from these areas. Calculations indicate that noise barriers with heights 2m to 4m are required in order not to exceed the night-time noise limit. The proposed barriers will be within the site boundary with the locations shown in Figure 7.10. Calculation sheets are given in Appendices 7.5 & 7.6. The total noise levels shown in these calculation sheets have included the contributions from the vehicular movement within site boundary (Appendix 7.7) and the train activities in the sidings (See Train Noise Assessment in this Chapter).

7.41 It is recommended that the fans be encased with silencers be added to the ventilation scrubbers. Such measures would reduce the noise level by 25 dB(A). The results of the implementation of these mitigation measures are summarized in Tables 7.12 and 7.13. The predicted daytime and night-time noise levels at site boundary are shown in Figure 7.11.

Table 7.12 Predicted Noise Levels after the Implementation of Mitigation Measures for the Daytime Period ($L_{(eq\ 30min)}$ dB(A))

Activities/Area	Status	Noise Sensitive Receiver (NSR) 1	2	7	12	13	14	15	16
Pig Stunning Area	✓	28	33	30	20	24	22	21	21
Pig Waiting Lairage	✓	33	38	35	25	29	27	26	26
Pig Holding Lairage	✓	23	28	25	<20	<20	<20	<20	<20
Pig & Cattle Slaughter Hall	✓	22	28	24	<20	<20	<20	<20	<20
Cattle Stunning Area	✓	<20	23	20	<20	<20	<20	<20	<20
By-Product Plant	✓	<20	<20	<20	<20	<20	<20	<20	<20
Meat Dispatch Area	✓	27	28	42	29	31	36	35	34
Pig & Cattle Unloading Area	✓	34	43	38	30	36	31	30	30
Roof Fans for Unloading Area	✓	<20	25	<20	<20	<20	<20	<20	<20
Lairage Scrubbers	✓	33	38	35	25	29	27	26	26
Scrubbers for Condemned Meat Area	✓	<20	<20	23	<20	<20	<20	<20	<20
Scrubber for By-Product Plant	✓	21	23	26	<20	<20	<20	<20	<20
Vehicular Movement within Site	✓	<20	<20	29	<20	<20	23	21	20
Train Noise from Sidings	✓	28	30	31	22	24	24	25	23
Total Noise Levels (CNLs) at NSR, dB(A)		**40**	**46**	**45**	**35**	**39**	**38**	**38**	**37**

Table 7.13 Predicted Noise Levels after the Implementation of Mitigation Measures for the Night-time Period ($L_{(eq\ 30min)}$ dB(A))

Activities/Area	Statu	Noise Sensitive Receiver (NSR)							
		1	2	7	12	13	14	15	16
Pig Stunning Area	✓	28	33	30	20	24	22	21	21
Pig Waiting Lairage	✓	33	38	35	25	29	27	26	26
Pig Holding Lairage	✕	0	0	0	0	0	0	0	0
Pig & Cattle Slaughter Hall	✓	22	28	24	<20	<20	<20	<20	<20
Cattle Stunning Area	✓	<20	23	20	<20	<20	<20	<20	<20
By-Product Plant	✓	<20	<20	<20	<20	<20	<20	<20	<20
Meat Despatch Area	✓	27	28	42	29	31	36	35	34
Pig & Cattle Unloading Area	✕	0	0	0	0	0	0	0	0
Roof Fans for Unloading Area	✕	0	0	0	0	0	0	0	0
Lairage Scrubbers	✓	33	38	35	25	29	27	26	26
Scrubbers for Condemned Meat Area	✕	0	0	0	0	0	0	0	0
Scrubber for By-Product Plant	✓	21	23	26	<20	<20	20	<20	<20
Vehicular Movement within Site	✓	<20	<20	29	<20	<20	23	21	20
Train Noise from Sidings	✕	0	0	0	0	0	0	0	0
Total Noise Levels (CNLs) at NSR, dB(A)		37	42	44	32	35	37	36	36

7.42 The unloading area which gives rise to noise from the livestock and trains will be screened by the proposed 2 to 4m high noise barriers, which will be within the site boundary. The construction will require an impervious skin of material employing concrete blockwork, brickwork or sheet metal with surface density of 20 kg/m^2 minimum. Gaps will not be allowed on the barriers and all joints have to be adequately sealed. The barriers can be made to have absorptive surface with details worked out in detail design stage.

7.43 The results indicate that (ANL-5) noise levels can be achieved with the mitigation measures including noise barriers, silencers and building facade insulation (Tables 7.12 & 7.13). A summary of the recommended noise mitigation measures is given in Table 7.14.

Table 7.14 Recommended noise mitigation measures

Level	Code	Areas / Activities Mitigation Measures
L3	EA-1	**Pig Stunning Area** Building fabric and acoustically treated vents with silencers.
L3	EA-2	**Pig Waiting Lairage** Building fabric and all openings treated with silencers or double acoustic louvres. Glazed area should have 10mm (min.) thick glass panes in well gasketted frames.
L2 & L3	EA-3	**Pig Holding Lairage** Building fabric and all openings treated with 50% free area acoustic louvres.
L3	EA-4	**Pig & Cattle Slaughter Hall** Building fabric and acoustically treated vents with silencers.
L3	EA-5	**Cattle Stunning Area (Knocking Box)** Building fabric and acoustically treated vents with silencers.
L1	EA-6	**By-Products Plant (If Provided)** Building fabric and acoustically treated vents with silencers.
L1	UE-7	**Meat Dispatch Area** 4m high noise barrier erected along western site boundary & 3m high noise barrier erected along southern site boundary (refer to Figure 7.10 for extent of barriers)
L1	UE-8	**Pig & Cattle Unloading** Area 4m high noise barrier erected along western site boundary & 2m high noise barrier erected along northern site boundary (refer to Figure 7.10 for extent of barriers)
L2	UE-9	**Roof Fans for Unloading Area** Acoustically treated with silencers
L4	UE-10	**Lairage Scrubbers** Acoustically treated with silencers
L4	UE-11	**Scrubbers for Condemned Meat Area** Acoustically treated with silencers
L2	UE-12	**Scrubbers for By-Products Plant** (If BPP is provided) Acoustically treated with silencers

Operation Traffic Noise Impacts

Road Traffic Noise Assessment

7.44 The roads considered in the road traffic noise assessment are Route 1: along Chunk Wan Street, eastbound along Po Wan Road, joining the Jockey Club Road to Po Shek Wu Road; and Route 2: along Chuk Wan Street, then Po Wan Road, southbound to Po Shek Road, as shown in Figure 7.12. The NSRs at the junction of Po Shek Wu Road and Po Wan Road are village houses of 2 to 3 storeys high. These NSR's are also included in the road traffic noise assessment in addition to the identified NSRs 1 to 16 in Figure 7.8. Po Shek Wu Road is approximately 2 to 3 m higher than the local ground level of the NSRs. Apart from the two routes mentioned above, no further routes would be suitable for truck movement.

After comparison of the two route options, it has been determined that Route 2 is preferred. The reasoning can be summarised as follows:
- Route 1 is longer and includes a sharp and potentially dangerous corner;
- a 3m high noise barrier will be erected along Po Wan Road between Chuk Wan Street and Po Shek Wu Road to protect residents in Po Shang Tsuen and Wai Loi Tsuen; and
- since Route 1 is longer, this may also encourage drivers to take 'short-cuts' and create noise nuisance in unprotected areas.

7.45 A peak hour maximum noise level of 70dB(A) L_{10} is recommended by the Hong Kong Planning Standards and Guidelines (1990) at the building facade of noise sensitive receivers. This noise limit applies to residential properties and office buildings relying on opened windows as the primary means of ventilation.

7.46 The road traffic noise prediction has been conducted by employing the RoadNoise computer software (version 1992) licenced to use by WS Atkins, Surrey, U.K.

7.47 Traffic noise calculations have been carried out based on future traffic flow data which are considered to be an upper bound for the proposed slaughter house in Year 2011. A maximum traffic flow of 300 vehicles per hour has been assumed. Slaughtering operations will commence at approximately 0200 hours. Meat delivery will begin at 0400 hours. The load-out rate (i.e. the rate at which trucks are loaded and leave the premises) will be about 50 vehicles per hour on average during operation. Each meat delivery vehicle is capable of handling 30 pig carcasses or 5-6 cattle carcasses. This provides sufficient handling capacity for the development, as the slaughter house will have a planned capacity to process approximately 5000 pigs and 400 cattle per day. Livestock vehicles transporting local pigs will begin to arrive at 0700 hours.

7.48 The traffic noise levels at the NSRs have been calculated, based on the peak traffic flows in Year 2011 and calculation method in accordance with the UK Department of Transport "Calculation of Road Traffic Noise". The predicted noise levels at the building facade include 2.5 dB(A) facade reflection and correction factors for effects due to gradient, distance, view angle and barriers.

7.49 The computer plot of the road scheme comprising Chuk Wan Street and Po Wan Road is shown in Figure 7.13. The predicted noise levels caused by the road scheme at the facades of the NSRs are presented in Figure 7.14 and in Appendix 7.8. The input data files of the RoadNoise computation is presented in Appendix 7.9.

7.50 Noise predictions indicate that, without mitigation measures, these NSRs will be exposed to noise levels of 68 - 72dB(A), which exceed the stipulated noise criterion of 70dB(A) by 1 to 2dB(A) (Figure 7.14). This noise exceedence is attributable to the relatively close proximity of Po Wan Road.

As the measured background noise levels are in the range of 40-42dB(A) L_{90} measured at Sheung Shui area during 0400 to 0600 hours, noise mitigation is preferred if it is practicable. The erection of a road-side noise barrier along Po Wan Road will be required to reduce the noise impacts at the NSRs. Calculations indicate that the noise levels will be reduced to 65 - 69dB(A) with a 2m high noise barrier, with the extent shown in Figure 7.15 and 63 - 68dB(A) with a 3m high noise barrier, with the extent shown in Figure 7.16. Increasing the extent of the sound barrier to 700m, as shown in Figure 7.17, would further reduce the noise levels substantially. Hence, it is recommended to erect a 700m long, 3m high noise barrier alongside Po Wan Road. The facade noise levels will be reduced to 52-65dB(A) assuming that the full extent of 700m long barrier can be erected.

A further assessment was conducted to investigate the effectiveness of the 3m high barrier with a 1m cantilever towards the road, as shown in Figure 7.17:1. The barrier attenuation will only be improved by an insignificant amount of 0.1 to 1.0dB(A) with the 1m cantilever. There will be an additional 2.5dB(A) noise reduction if open textured road surface is applied to Po Wan Road between the junctions with Po Shek Wu Road and Chuk Wan Street.

The scenario with the full extent of the sound barrier therefore offers the most effective sound reduction whilst the combination of mitigation measures mentioned above would provide the optimum noise reduction.

The computer output files are given in Appendices 7.10 & 7.12, and the input files are attached in Appendices 7.11 & 7.13.

Train Noise Assessment

7.51 The noise contributions from the train operations within the sidings have been predicted in Appendices 7.14 & 7.15 and included in Tables 7.9, 7.10, 7.12 & 7.13.

7.52 Train noise measurements were taken on site with the microphone locations given in Figure 7.18. The distance between the KCRC railway and the microphone was approximately 80m. Twenty eight train events were observed during the survey. These train events included KCRC passenger trains, freight trains and China Through train events.

7.53 The instrumentation used for the train noise survey is listed below (Table 7.15).

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Table 7.15 Equipment used for train noise survey

Manufacture	Type
Bruel and Kjaer	Precision Sound Level Meter Type 2236
Bruel and Kjaer	1/2" Prepolarised Condenser Microphone Type 4188
Bruel and Kjaer	Noise Calibrator Type 4231
Bruel and Kjaer	Foam Windshield Type UA0237

The sound level meter was calibrated before use and further checks on completion of the tests confirmed that there had been no significant drift of calibration.

7.54 The measured SEL for freight train events on the main lines are in the range of 84 - 87dB(A) (Figure 7.18). These measured levels have been corrected for the low speed at the sidings as shown in Appendices 7.14 & 7.15.

7.55 It is envisaged that the livestock trains will arrive during the daytime and there will be no delivery by trains during the night-time period. External public address system will not be required for the proposed slaughter house.

7.56 The predicted train noise levels at the NSR's are presented in Appendices 7.14 & 7.15 and summarized in Table 7.16 below. These train noise levels have been included in the predicted total noise levels in Tables 7.9, 7.10, 7.12 & 7.13 to obtain the cumulative Total Noise Levels.

Table 7.16 Predicted Train Noise Levels at NSR's (from sidings) , dB(A)

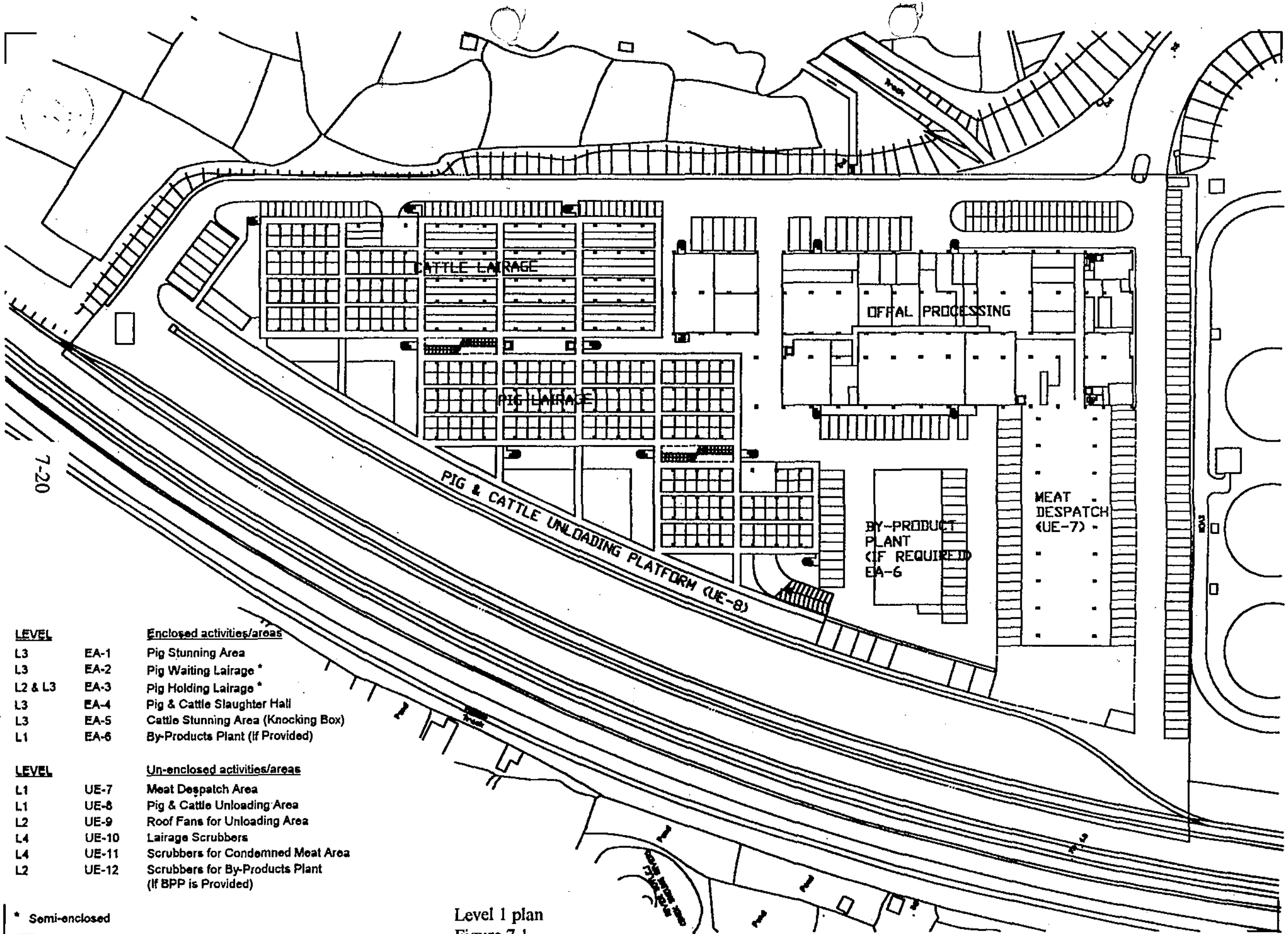
	NSR's							
$L_{eq,\ 0.5\ hr}$ (Daytime)	1	2	7	12	13	14	15	16
Without mitigations	38	40	41	32	34	34	35	33
With 2-4m barriers (see Figure 7.10)	28	30	41	32	34	34	35	23

7.57 With the proposed 2m to 4m high noise barriers erected, the Total Noise Levels at the NSR's will be within the noise criteria.

7.58 The office blocks will be centrally air-conditioned and do not rely on open windows for ventilation. An adequate noise insulation will be provided with the glazing and hence, there will be no train noise restrictions on the proposed office buildings.

Noise Monitoring

7.59 As detailed in Chapter 12, Environmental Management Systems.

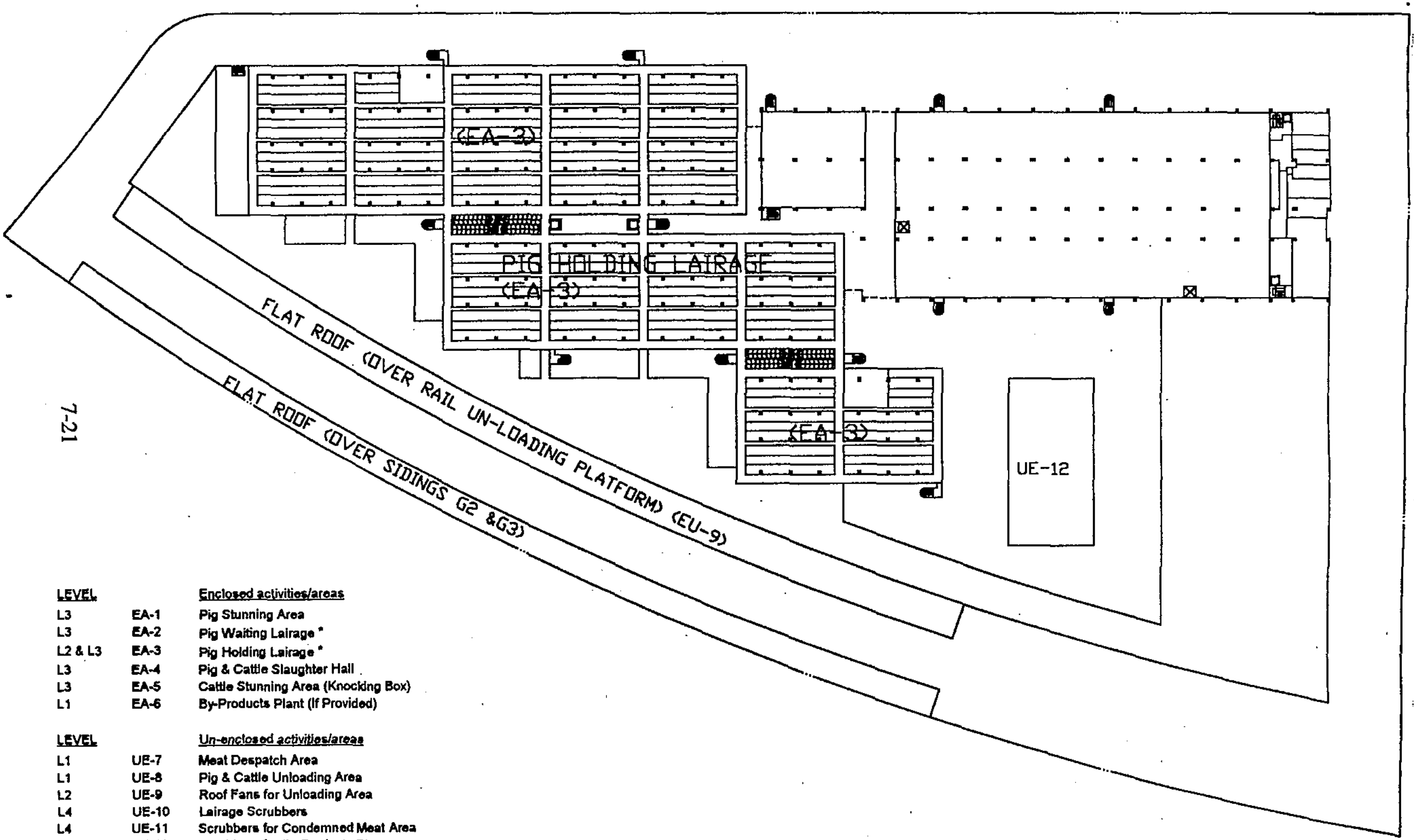


LEVEL		Enclosed activities/areas
L3	EA-1	Pig Stunning Area
L3	EA-2	Pig Waiting Lairage *
L2 & L3	EA-3	Pig Holding Lairage *
L3	EA-4	Pig & Cattle Slaughter Hall
L3	EA-5	Cattle Stunning Area (Knocking Box)
L1	EA-6	By-Products Plant (If Provided)

LEVEL		Un-enclosed activities/areas
L1	UE-7	Meat Despatch Area
L1	UE-8	Pig & Cattle Unloading Area
L2	UE-9	Roof Fans for Unloading Area
L4	UE-10	Lairage Scrubbers
L4	UE-11	Scrubbers for Condemned Meat Area
L2	UE-12	Scrubbers for By-Products Plant (If BPP is Provided)

* Semi-enclosed

Level 1 plan
Figure 7.1

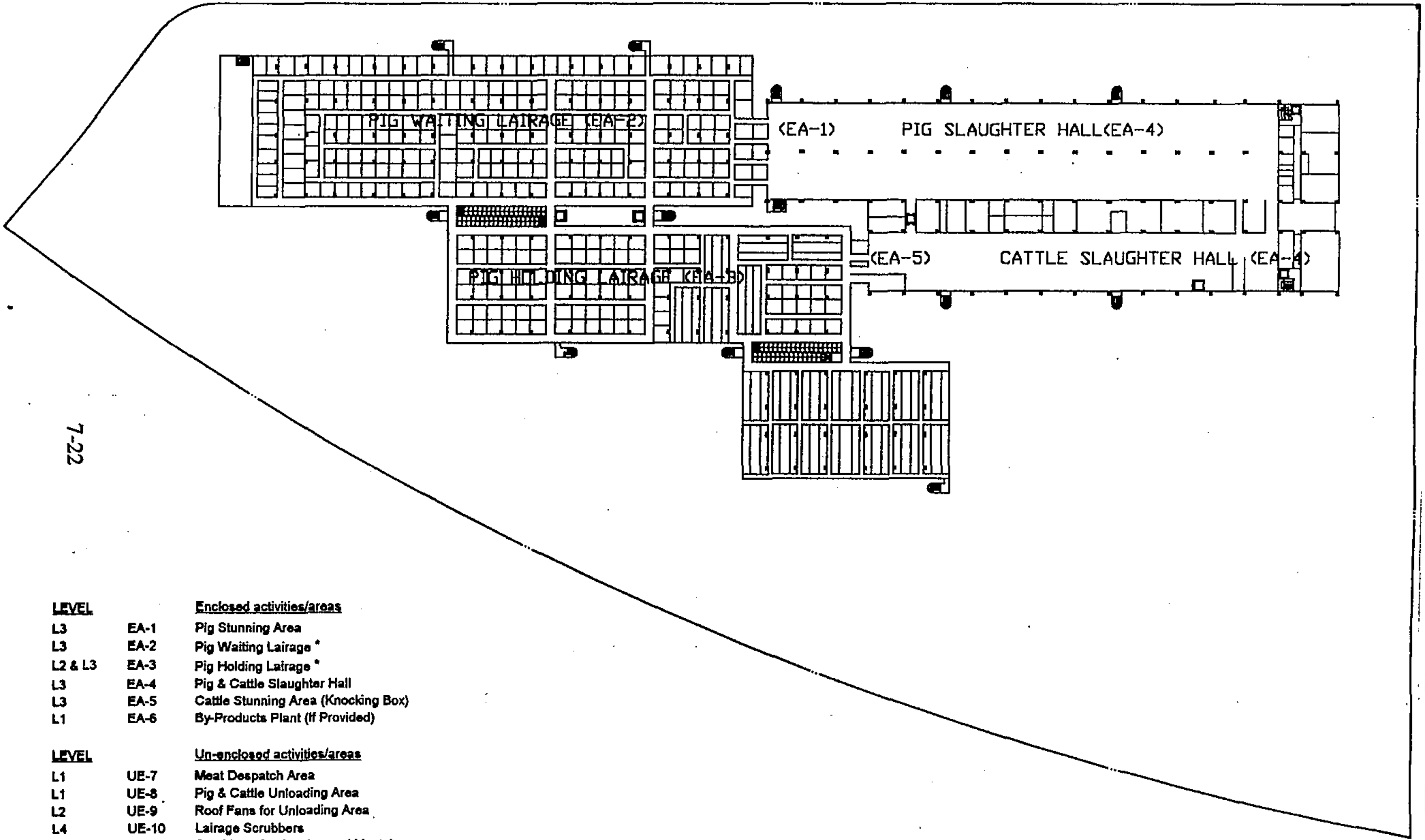


LEVEL		Enclosed activities/areas
L3	EA-1	Pig Stunning Area
L3	EA-2	Pig Waiting Lairage *
L2 & L3	EA-3	Pig Holding Lairage *
L3	EA-4	Pig & Cattle Slaughter Hall
L3	EA-5	Cattle Stunning Area (Knocking Box)
L1	EA-6	By-Products Plant (If Provided)

LEVEL		Un-enclosed activities/areas
L1	UE-7	Meat Despatch Area
L1	UE-8	Pig & Cattle Unloading Area
L2	UE-9	Roof Fans for Unloading Area
L4	UE-10	Lairage Scrubbers
L4	UE-11	Scrubbers for Condemned Meat Area
L2	UE-12	Scrubbers for By-Products Plant (If BPP is Provided)

* Semi-enclosed

Level 2 plan
Figure 7.2

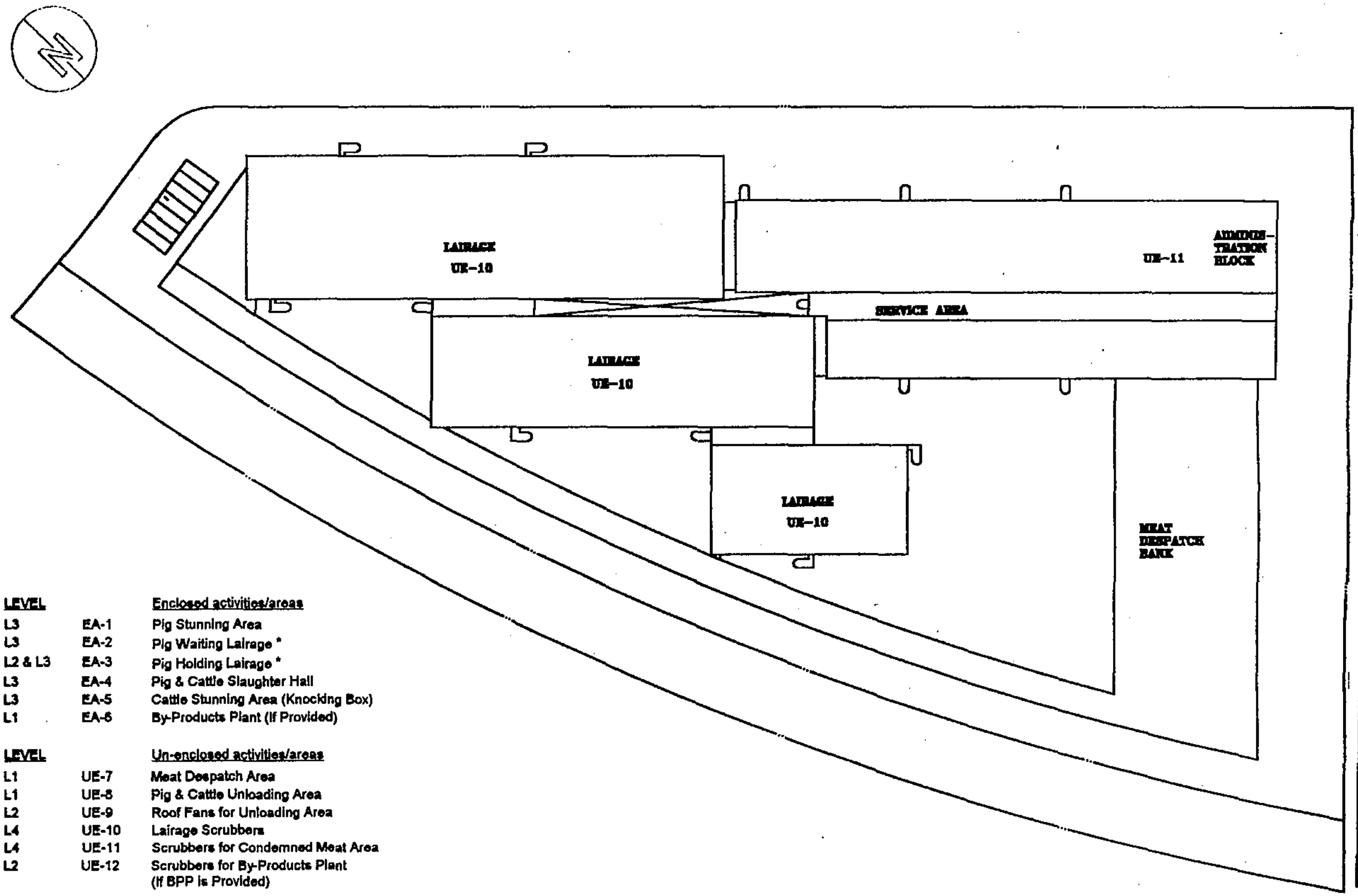


LEVEL		Enclosed activities/areas
L3	EA-1	Pig Stunning Area
L3	EA-2	Pig Waiting Lairage *
L2 & L3	EA-3	Pig Holding Lairage *
L3	EA-4	Pig & Cattle Slaughter Hall
L3	EA-5	Cattle Stunning Area (Knocking Box)
L1	EA-6	By-Products Plant (If Provided)

LEVEL		Un-enclosed activities/areas
L1	UE-7	Meat Despatch Area
L1	UE-8	Pig & Cattle Unloading Area
L2	UE-9	Roof Fans for Unloading Area
L4	UE-10	Lairage Scrubbers
L4	UE-11	Scrubbers for Condemned Meat Area
L2	UE-12	Scrubbers for By-Products Plant (If BPP is Provided)

* Semi-enclosed

Level 3 plan
Figure 7.3



LEVEL		Enclosed activities/areas
L3	EA-1	Pig Stunning Area
L3	EA-2	Pig Waiting Lairage *
L2 & L3	EA-3	Pig Holding Lairage *
L3	EA-4	Pig & Cattle Slaughter Hall
L3	EA-5	Cattle Stunning Area (Knocking Box)
L1	EA-6	By-Products Plant (If Provided)

LEVEL		Un-enclosed activities/areas
L1	UE-7	Meat Despatch Area
L1	UE-8	Pig & Cattle Unloading Area
L2	UE-9	Roof Fans for Unloading Area
L4	UE-10	Lairage Scrubbers
L4	UE-11	Scrubbers for Condemned Meat Area
L2	UE-12	Scrubbers for By-Products Plant (If BPP is Provided)

* Semi-enclosed

Level 4 plan (main roof)
Figure 7.4

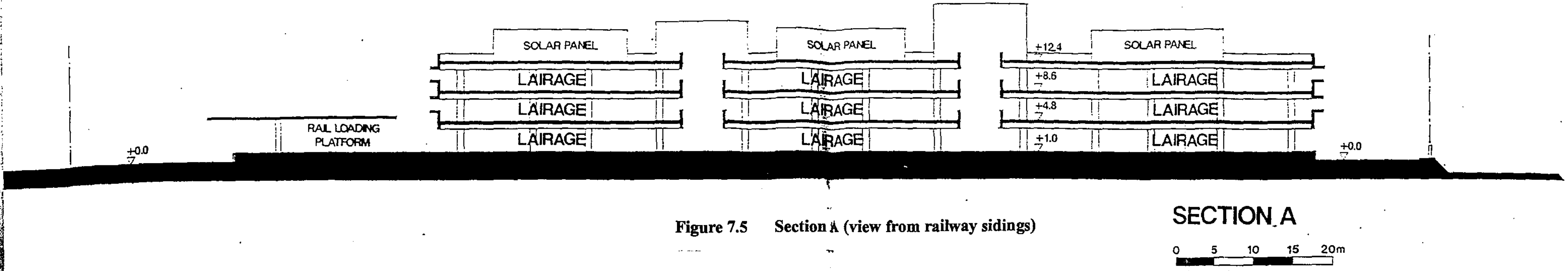


Figure 7.5 Section A (view from railway sidings)

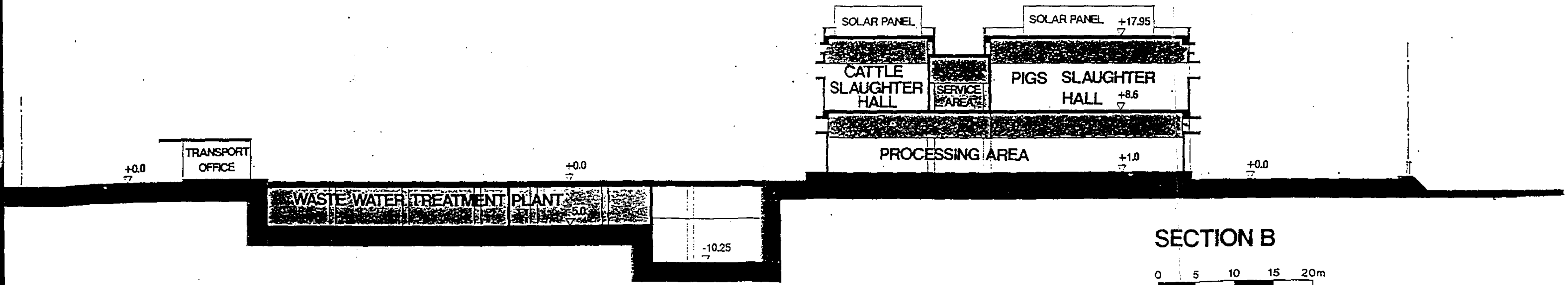


Figure 7.6 Section B (view from south)

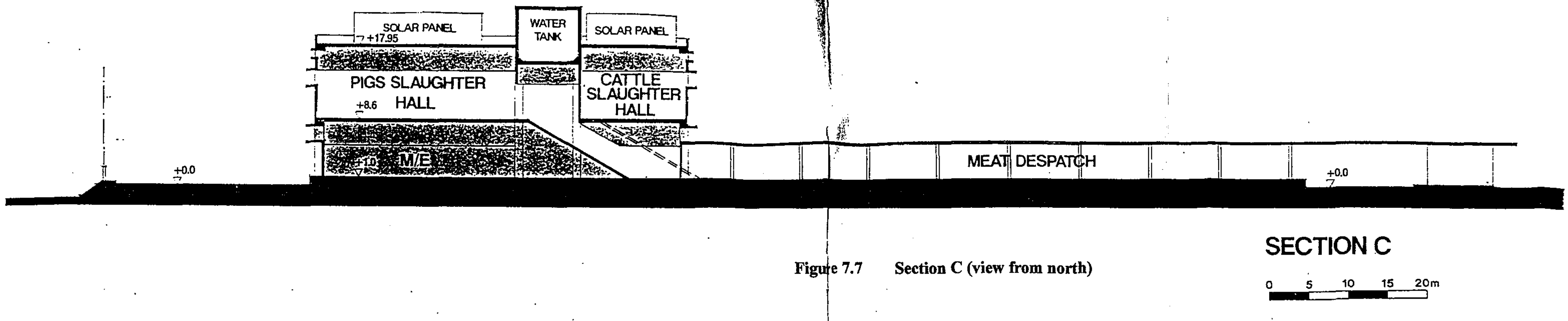
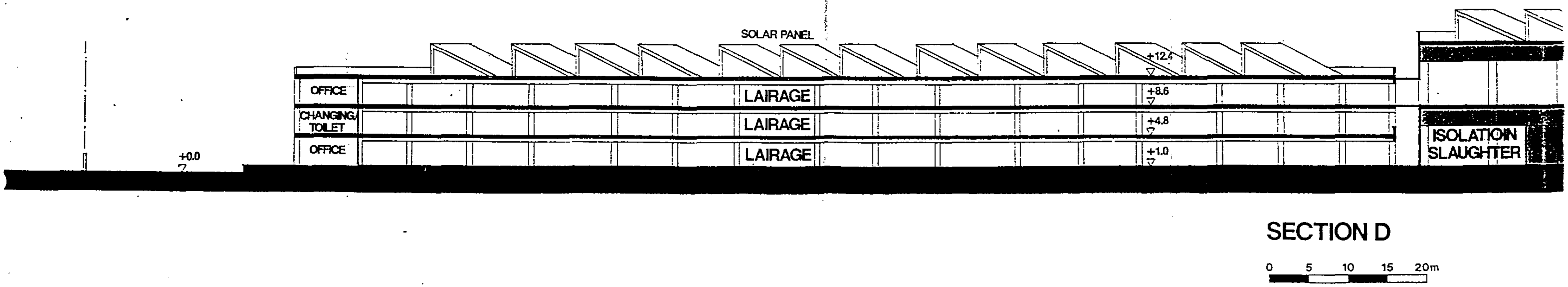


Figure 7.7 Section C (view from north)



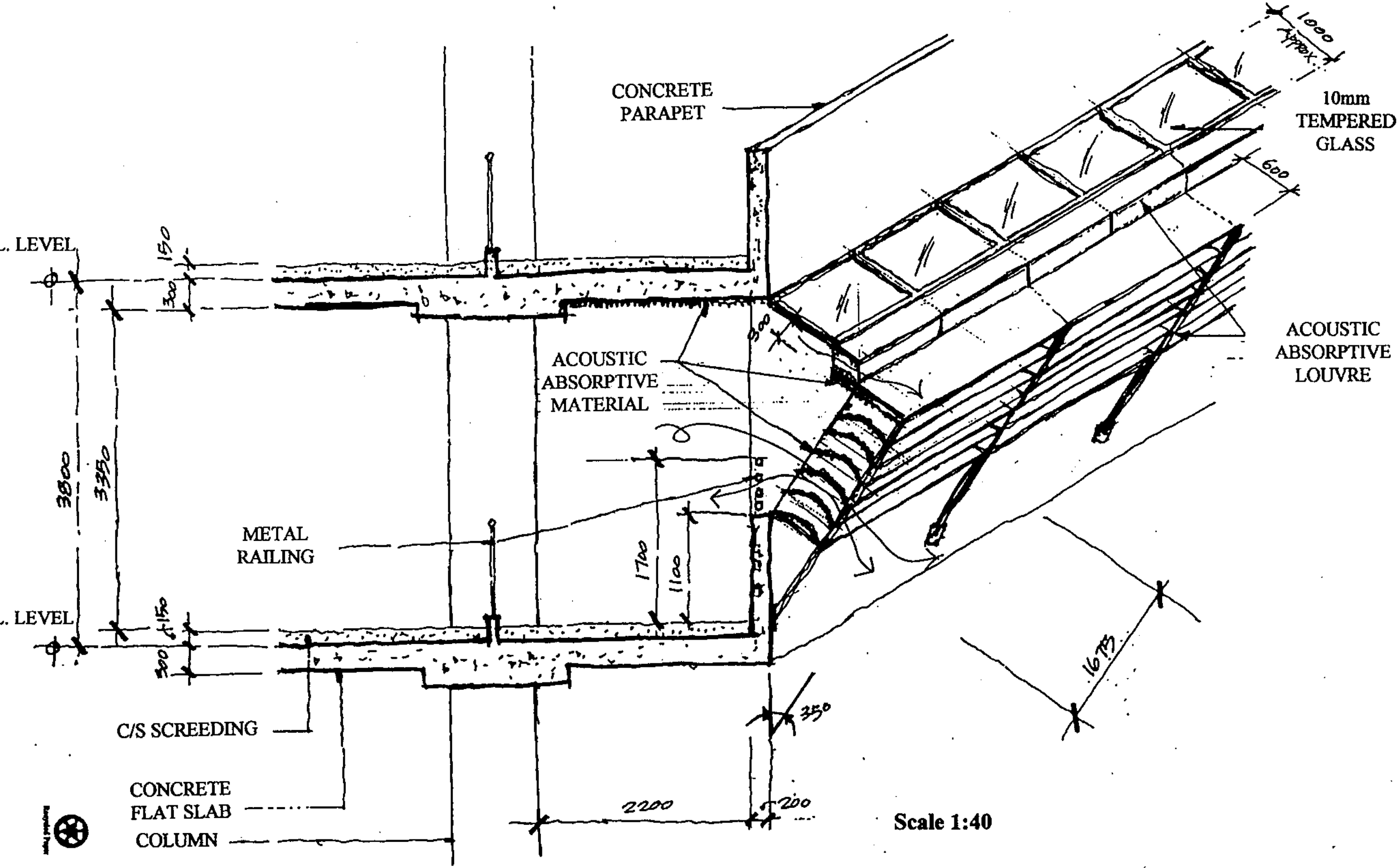
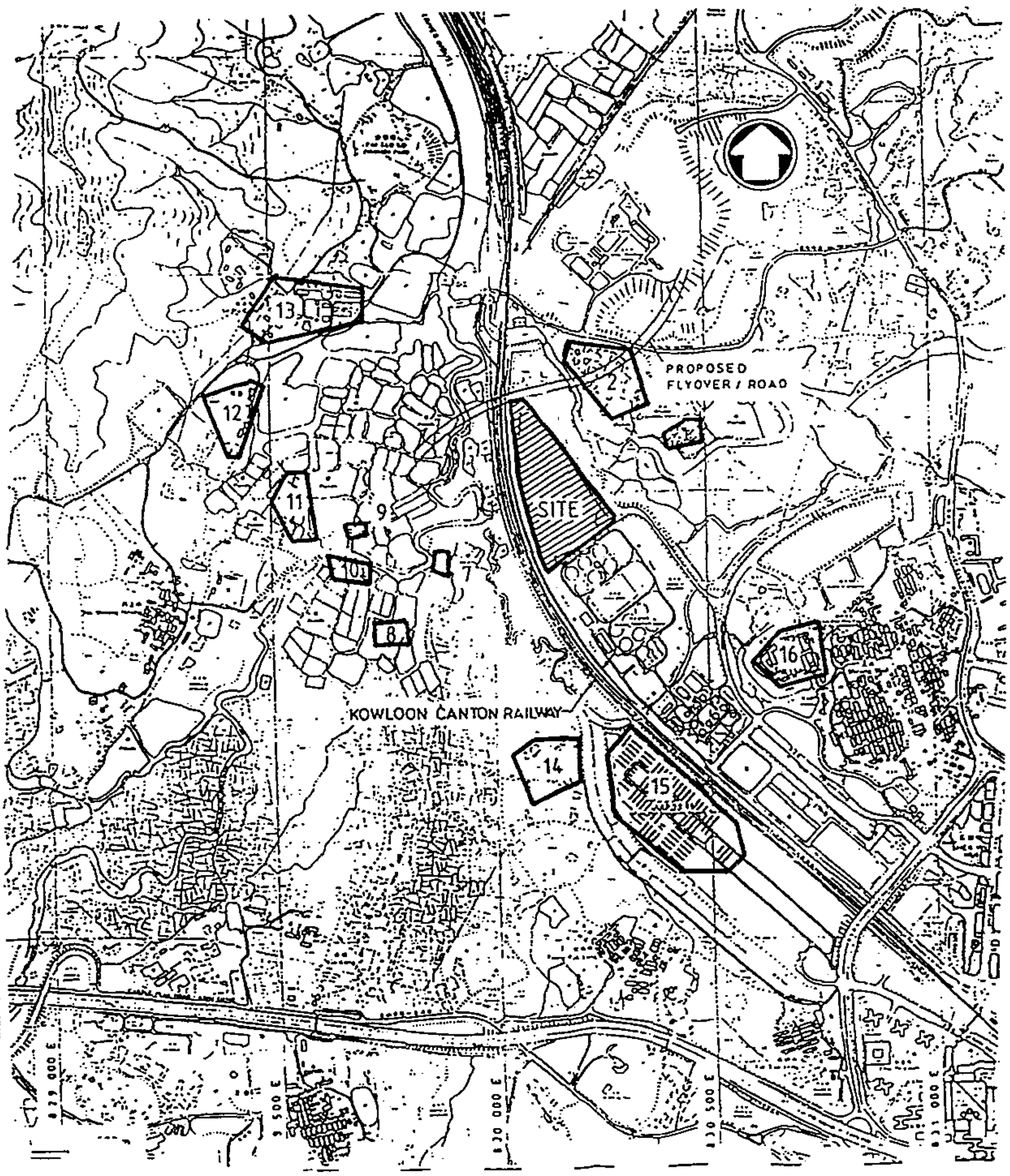


Figure 7.7:1 Section Through Lairage Wall (showing acoustic arrangements)



Legend:

8	Noise Sensitive Receivers

NSR locations

Figure 7.8

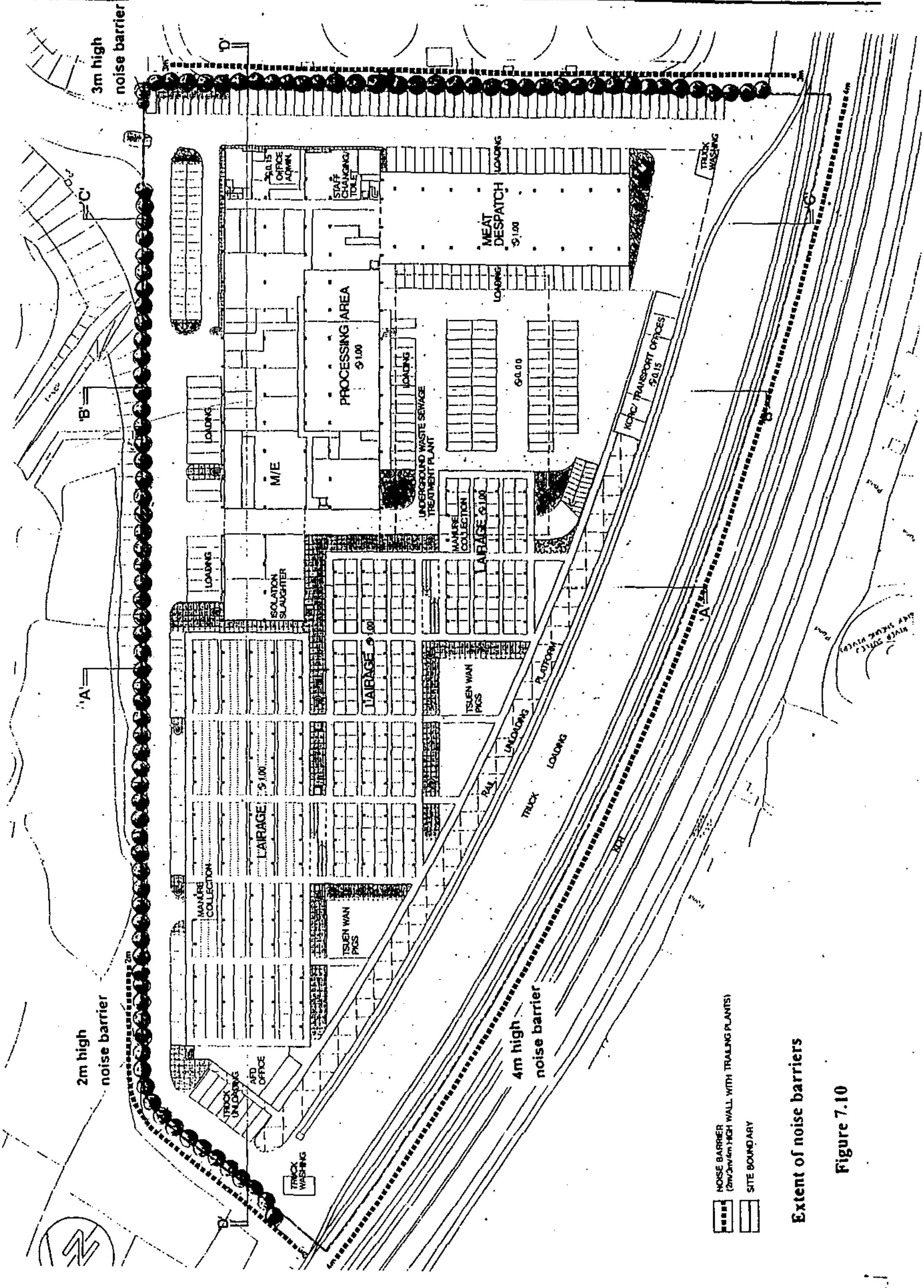
Project : Sheung Shui Slaughter House
Title : Breakdown of the Daily Activities

Period	Time	OPERATION AREAS													
		pig stunning area	pig waiting lairage	pig holding lairage	pig & cattle slaughter hall	cattle stunning	meat despatch area	By-product plant		pig & cattle unloading area	Deodorisation Plant				
								F	R		unloading area roof fans	lairage scrubbers	condemned meat area scrubbers	by-products plant scrubbers	
														F	R
Nighttime	2300-0000											✓			
	0000-0100											✓			
	0100-0200		✓									✓			
	0200-0300	✓	✓		✓	✓		✓	✓			✓		✓	✓
	0300-0400	✓	✓		✓	✓		✓	✓			✓		✓	✓
	0400-0500	✓	✓		✓	✓	✓	✓	✓			✓		✓	✓
	0500-0600	✓	✓		✓	✓	✓	✓	✓			✓		✓	✓
	0600-0700	✓	✓		✓	✓	✓	✓	✓			✓		✓	✓
Daytime	0700-0800	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	0800-0900	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	0900-1000	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	1000-1100	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
	1100-1200	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
	1200-1300		✓	✓				✓		✓	✓	✓	✓	✓	
	1300-1400		✓	✓				✓		✓	✓	✓	✓	✓	
	1400-1500		✓	✓				✓		✓	✓	✓	✓	✓	
	1500-1600		✓	✓						✓	✓	✓			
	1600-1700		✓	✓						✓	✓	✓			
	1700-1800									✓	✓	✓			
	1800-1900									✓	✓	✓			
Evening	1900-2000									✓	✓	✓			
	2000-2100											✓			
	2100-2200											✓			
	2200-2300											✓			

Legend
F Full-Scale BPP
R Reduced -Scale BPP

Note: The above table is extracted from Figure 11.1 of the *Final Report* Ref T355/04 Rev 02 prepared by Mott MacDonald

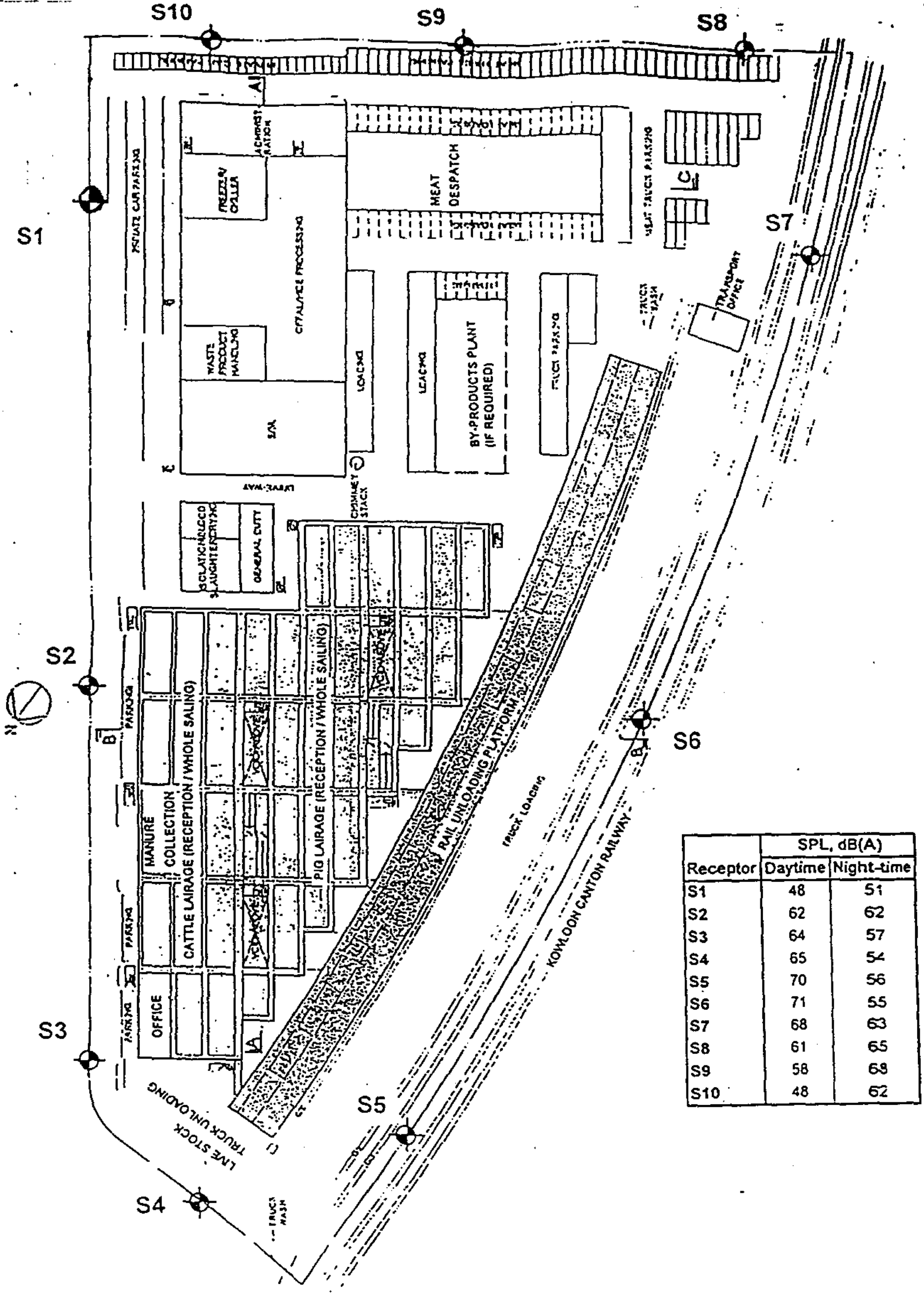
Figure 7.9 : Breakdown of the daily activities within the slaughter house



Extent of noise barriers

Figure 7.10

Recycled Paper



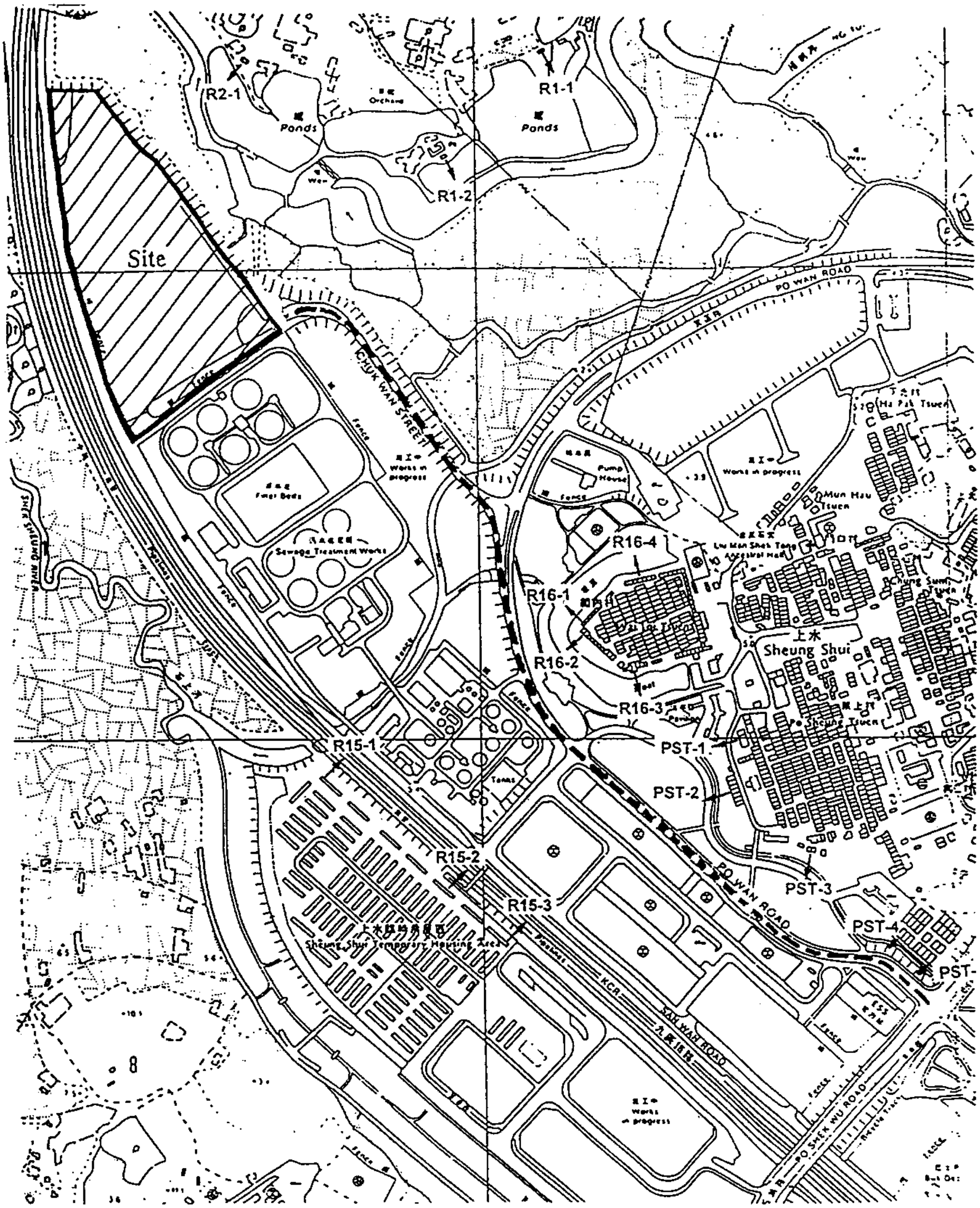
Receptor	SPL, dB(A) Daytime	Night-time
S1	48	51
S2	62	62
S3	64	57
S4	65	54
S5	70	56
S6	71	55
S7	68	63
S8	61	65
S9	58	68
S10	48	62

Legend

Noise receptor at site boundary

Predicted noise levels at site boundary
(daytime & night-time)

 Figure 7.11



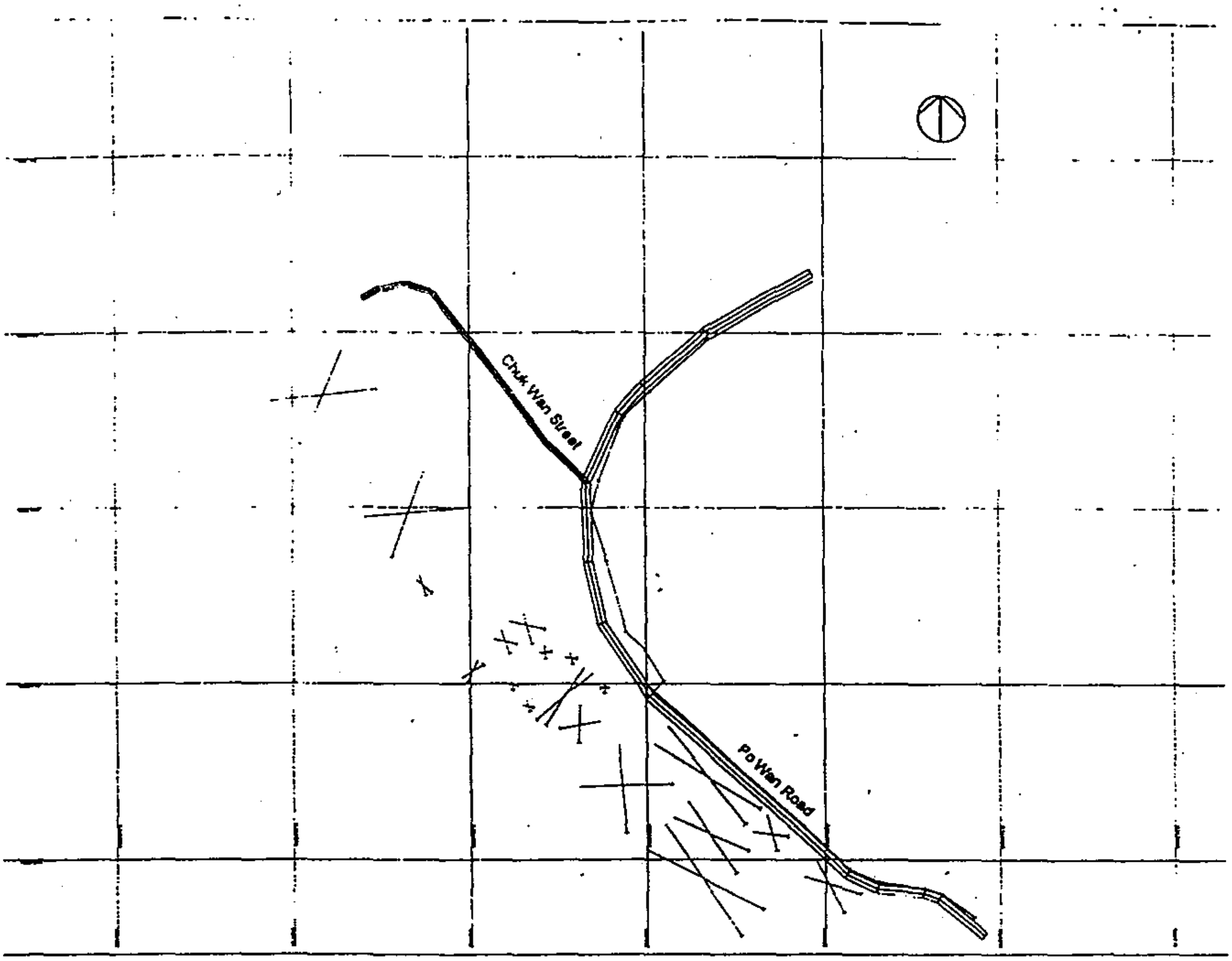
LEGEND :

— — — Study area of off-site transportation noise

R1-1 ←— Noise sensitive receiver

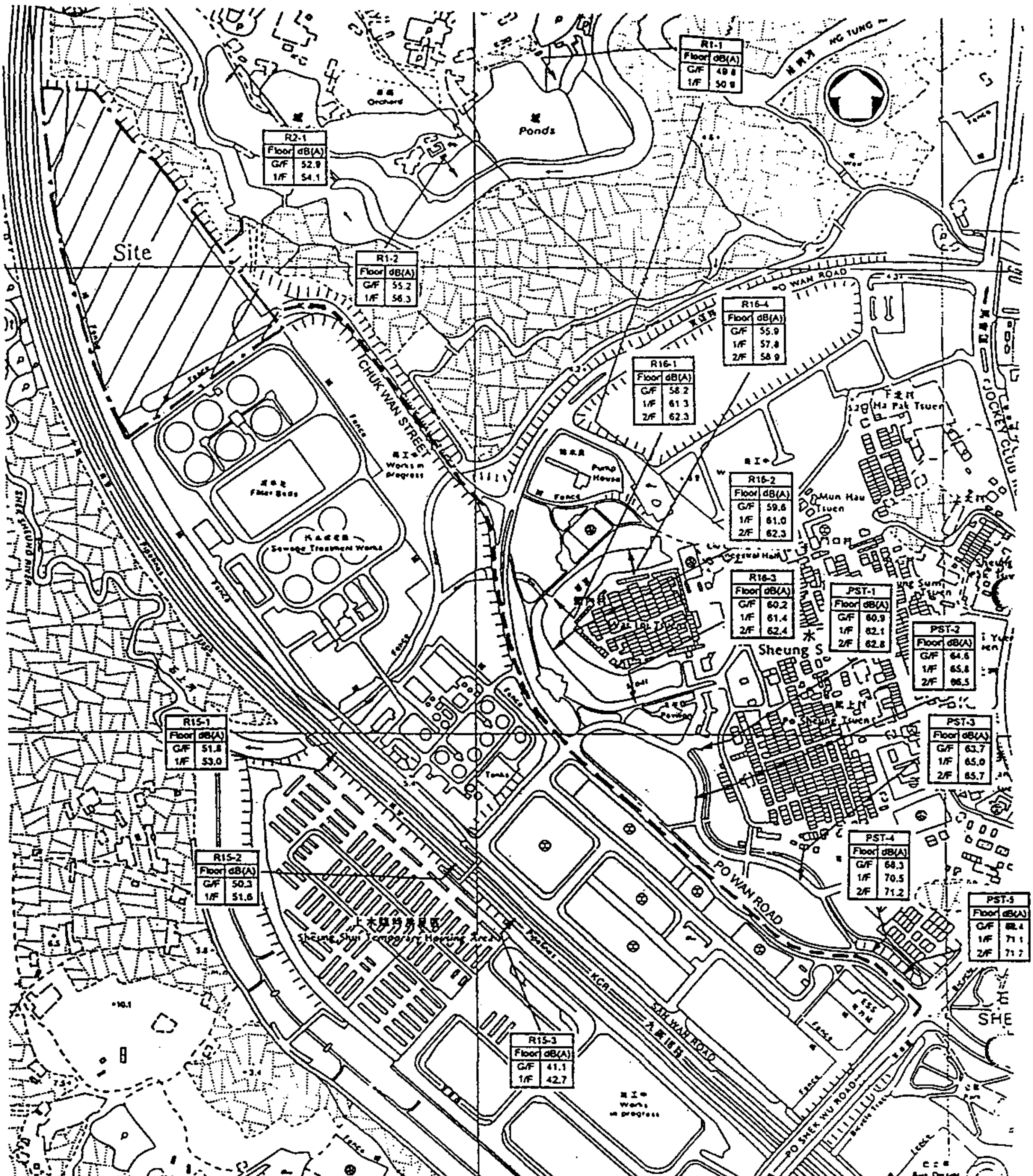
Study area of off-site transportation noise

Figure 7.12



Computer plot of road scheme
(off site transportation noise)

Figure 7.13

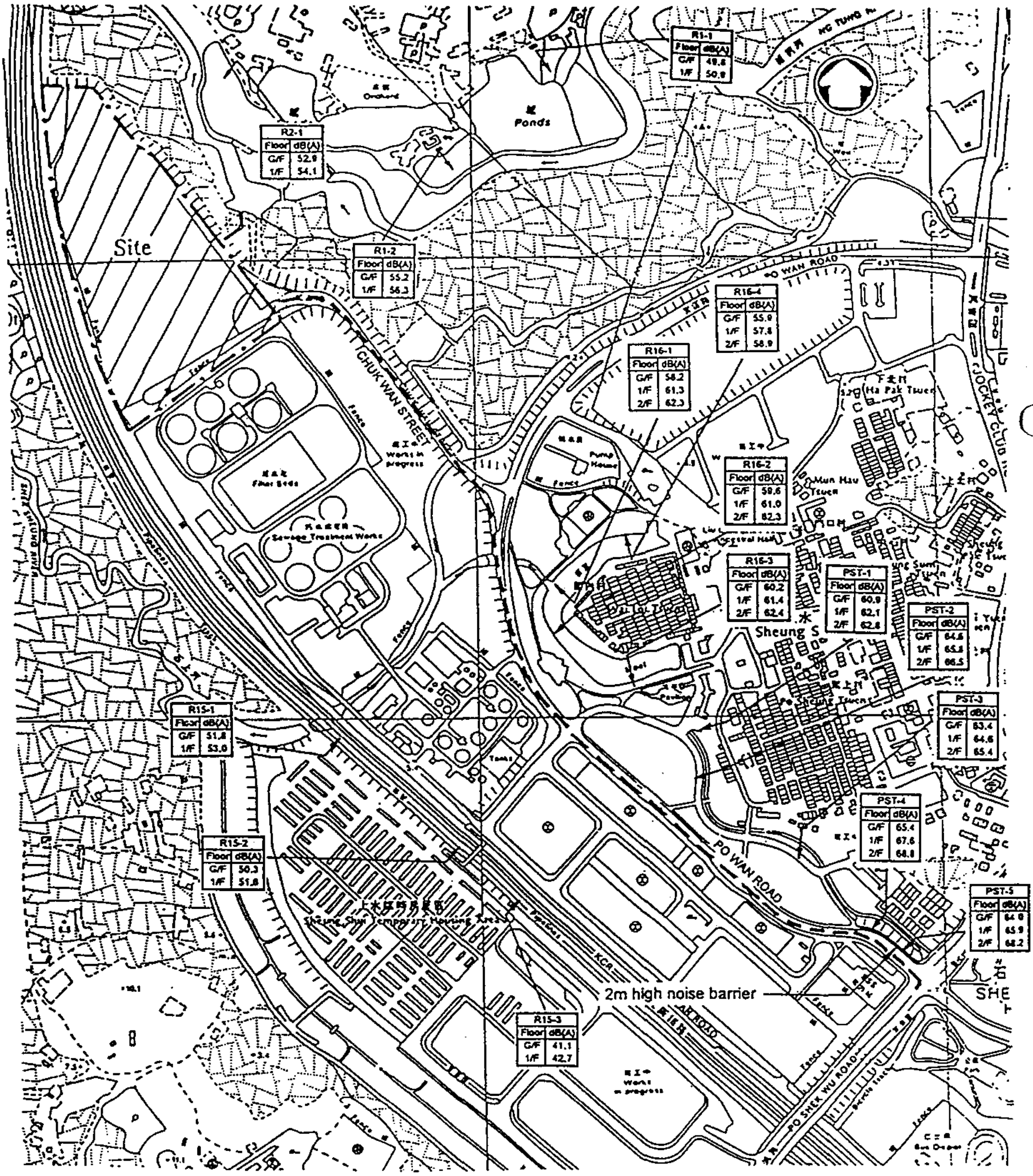


LEGEND :

— — — — Study area of off-site transportation noise

Predicted off-site traffic noise levels at NSRs
(without mitigation)

Figure 7.14



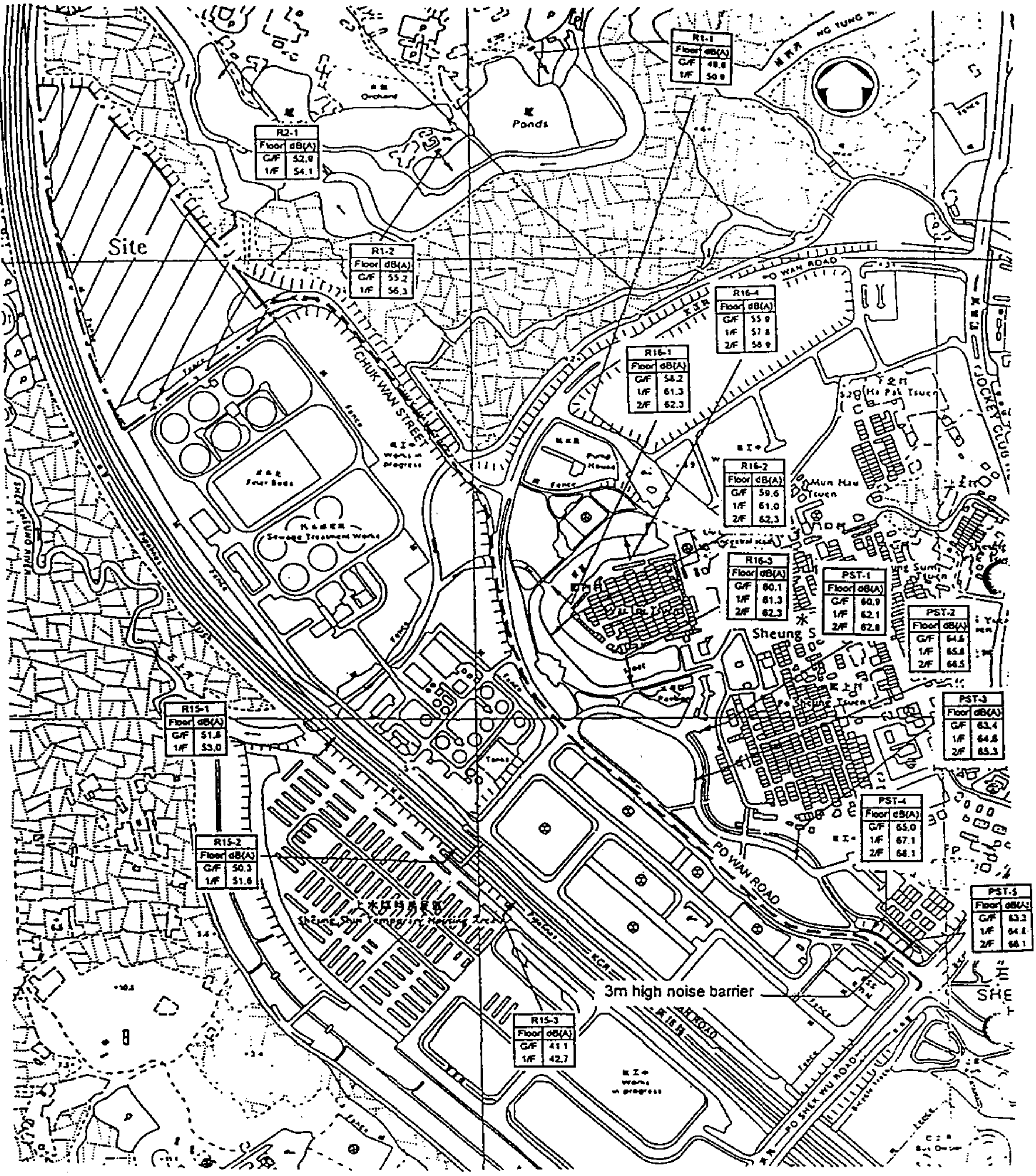
LEGEND :

— — — — Study area of off-site transportation noise

———— 2m high noise barrier

Predicted off-site traffic noise levels at NSRs
(with 2m high barrier)

Figure 7.15



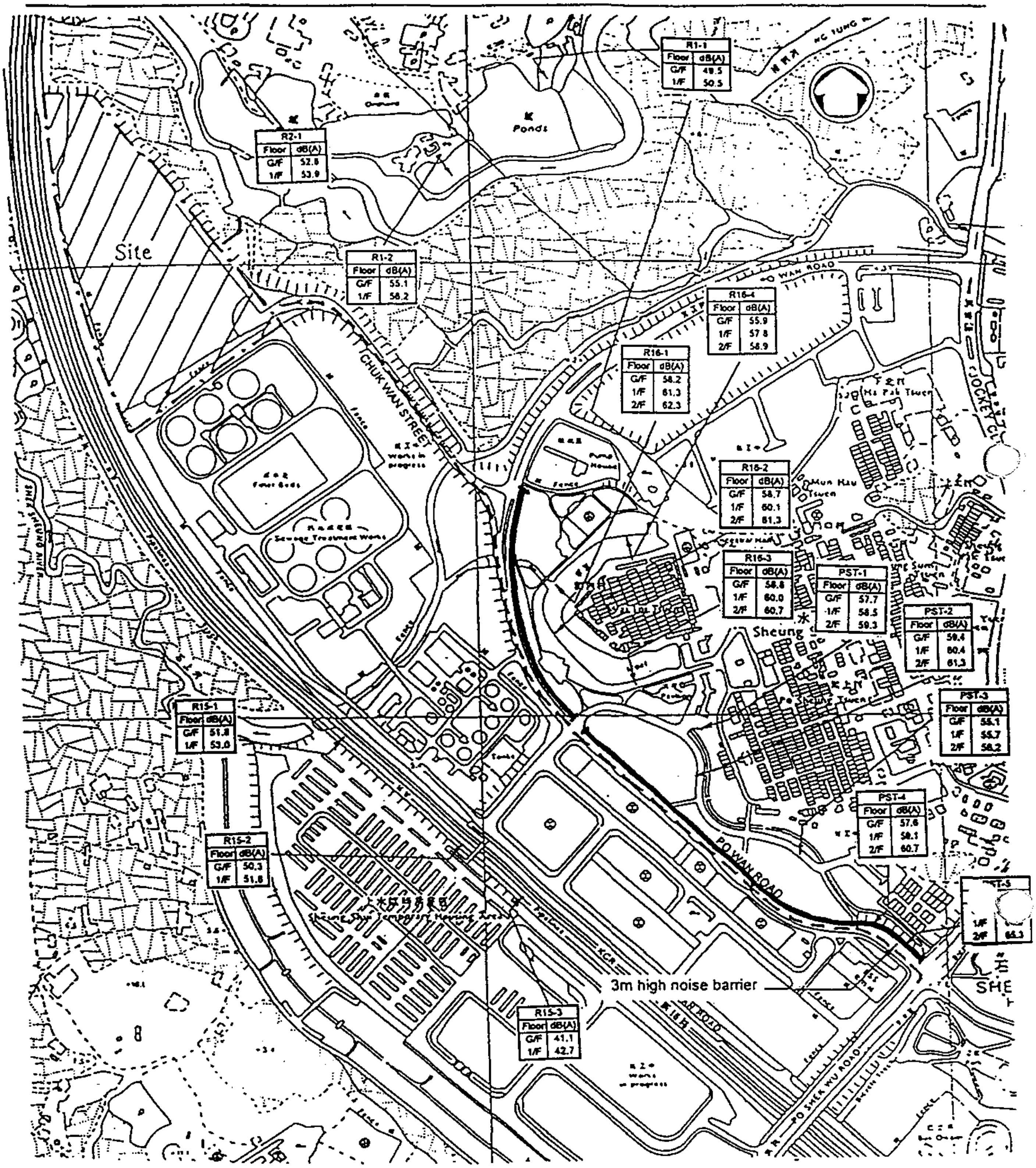
LEGEND :

— — — — Study area of off-site transportation noise

———— 3m high noise barrier

Predicted off-site traffic noise levels at NSRs
(with 3m high barrier)

Figure 7.16



LEGEND :

— — — — Study area of off-site transportation noise

———— 3m high noise barrier

Predicted off-site traffic noise levels at NSRs
(with approximately 700m long, 3m high barrier)

Figure 7.17

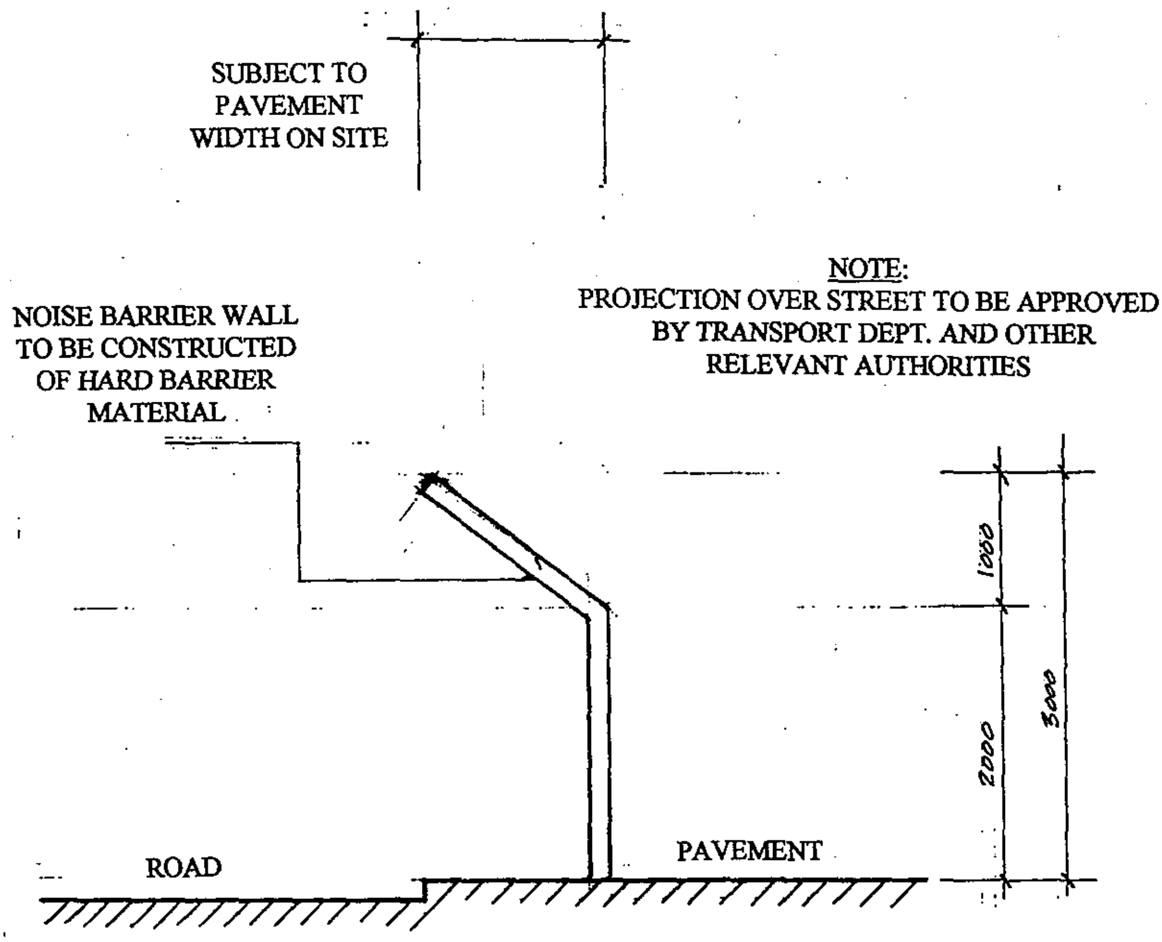
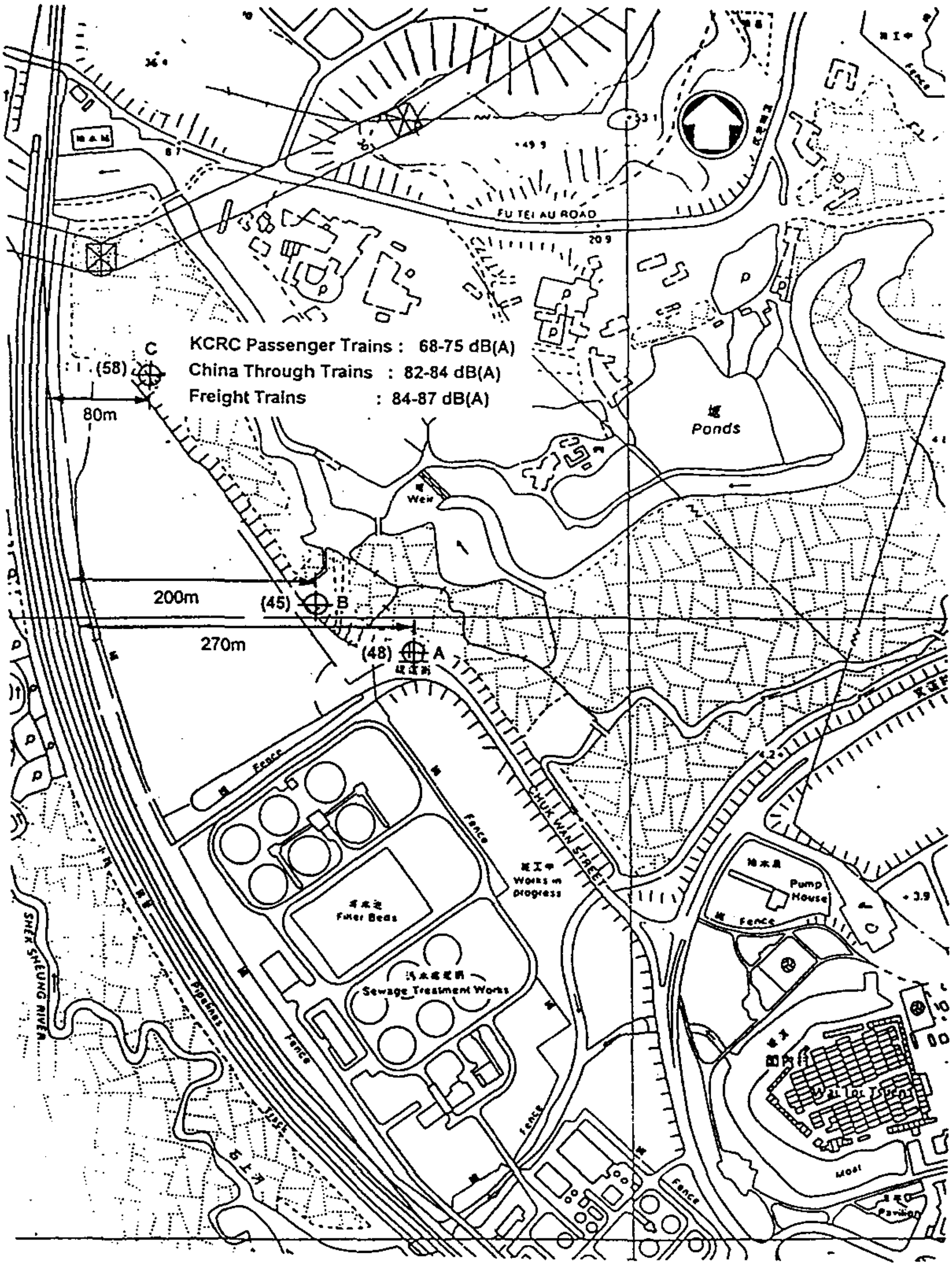


**Figure 7.17:1 Noise Barrier Wall Section
(with cantilever)**

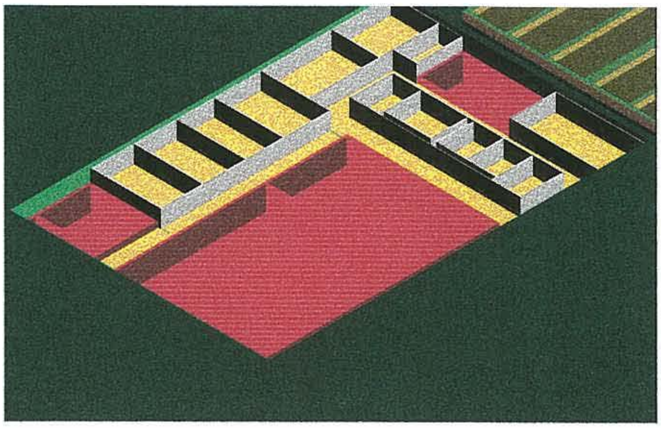


LEGEND :

(48) ⊕ Day-time background noise = 48dB(A) L_{90}

Location for train noise measurement

Figure 7.18



8. WASTEWATER DISPOSAL

8. WASTEWATER DISPOSAL

Key Issues

8.1 In this SEIA, account has been taken of current practices in Hong Kong. Key issues have been identified which relate to slaughterhouse operation and the ancillary facilities can be broadly subdivided as follows:

- identification of the sources and characteristics of wastewater;
- quantification of wastewater discharges in terms of flow rates and pollution loading;
- proposed effective and adequate wastewater treatment collection, transfer, treatment and disposal methods for treating the wastewater to an acceptable standards;
- identification of opportunities for the minimisation of wastewater arising from operation.

Sources and Characteristics of Wastewaters

8.2 It is essential to accurately identify, characterise, and quantify sources of effluent arising from slaughterhouse operations at an early stage. This will allow due consideration to be given to any special requirements which may need to be incorporated into the detailed design of the new facilities.

8.3 Sources of liquid wastes include:

- the slaughtering hall : including from killing, dressing, scalding and hair removal;
- cleaning;
- carcasses and paunch contents washing;
- the lairages;
- KCRC siding washing and runoff,
- meat despatch area washing and runoff;
- livestock and meat despatch lorries washing and runoff;
- by-products handling; and
- domestic facilities.

8.4 Process waters included in the following assessment comprise contributions from domestic sources, stormwater and runoff, livestock wastes in addition to those arising within the slaughter hall and ancillary facilities.

Domestic Effluent

8.5 Sources of domestic effluent include :

- toilet and shower facilities for the lorry drivers, animal and meat handlers, process work force, office workers, dealers and buyers.
- kitchen and restaurant facilities.

8.6 Estimations of the domestic contribution to the overall effluent were made using the methodology proposed in the Sewage Strategy Study (SSS), 1989. One of the fundamental assumptions of the SSS, 1989, was that effluent flow rates and pollution loads from people in employment should be divided between their place of work and home. However, for this specific case, an increase in water consumption on account of the amount of water used in the shower and washing facilities needs to be considered.

8.7 For the purposes of this preliminary assessment of effluent flows, it has been judged that, in addition to the 60 l/head/day assumed as the "employed contribution", an additional 100 l/head/day should be allowed for showering and ablutions, (Ref. Metcalf and Eddy, 1991, 3rd Edition).

8.8 Loadings from on-site canteen facilities also need to be included in the overall effluent budget. The Civil Engineering Design Memorandum Volume VI Sewerage and Drainage advises that a factor of 0.027 kg/BOD/day should be included in the overall calculations for every meal provided.

8.9 An estimated 1,500 staff and associated personnel will be employed at the slaughterhouse in various capacities on a daily basis, although not all at any one time. It has been assumed that all 1,500 employees will have at least one shower and will consume one meal per day at the slaughterhouse. Estimates of domestic effluent flow rates and pollutant loads have been made and the results given in Table 8.1.

Table 8.1 Domestic Contribution

Parameter	Unit Rate	Unit Flow/Unit load
Daily flow	0.06 + 0.10 m^3/d	240 m^3/d
SS Loading	0.034 kg/d	51 kg/d
BOD Loading domestic canteen	 0.034 kg/d 0.027 kg/d	 51 kg/d 40.5 kg/d
COD Loading	0.070 kg/d	105 kg/d
TKN Loading	0.0061 kg/d	9.2 kg/d
NH_3-N Loading	0.0040 kg/d	6.0 kg/d
TTM Loading	0.000065 kg/d	0.098 kg/d
Bacterial Count	4.92E11 Counts/no./day	7.4×10^{14} Counts/no./day

Runoff and Stormwater Drainage

8.10 For the purposes of this preliminary assessment, the sources of stormwater drainage were identified as follows:

- reception and car/lorry parking areas which could be used for the washing down lorries and trucks.
- parking areas and service yards where live animals could be held prior to transport to the lairage.

8.11 Runoff from the reception and vehicle parking areas connect to the foul sewage system and will need to comply with the standards set in the Technical Memorandum.

8.12 From discussions with the operators of Kennedy Town Abattoir, it has been assumed that the present practice of sending unwashed animal wagons back to China will be maintained at Sheung Shui. This potential pollution source has thus been discounted from the effluent budget.

8.13 Any washing down of vehicles or trucks (for example those carrying livestock or meat) should be confined to a separate vehicle washing area. This area should be provided with perimeter drains leading to the foul sewerage system rather than to the stormwater system. Sediment traps and gratings should be incorporated into the drainage design.

8.14 Runoff form the hardstandings, the temporary holding areas and any other uncovered area through which livestock pass, has been included in the overall calculations of wastes arising This was done on account of the fact that livestock could be kept in these areas for some time prior to being received at the lairages.

8.15 An estimate of 18 cu.m/day was incorporated into the overall daily effluent flow rate from the area between the Railway Sidings and the reception lairage to take account of hosing down of this area to maintain standards of cleanliness. However, no pollution loading was ascribed to this potential source as it was judged to be largely subjective.

Lairage

8.16 It is well recognised that the quality and quantity of effluent generated by animals held in lairage prior to slaughter will depend upon the amount of water and the type of diet provided for the animals. For these reasons various assumptions were made when estimating the pollution load from this source.

8.17 Following a literature search, it was concluded that the effluent flow and pollutant load factors proposed in the SSS 1989, would provide the best overall estimate of liquid waste arising from the lairage areas. Under the SSS's general classification the multiplication factors for pigs has been adopted as the reference point.

8.18 Despite the fact that the number of cattle to be held in lairage is relatively small compared to the number of pigs, the effluent generated by cattle in these areas will contribute to the overall budget. As previously mentioned, the quantification of effluent generation rates must be as accurate as possible, even at this preliminary stage, as this will have a direct impact on the size and type of effluent treatment plant proposed.

8.19 From the available literature, a relationship for relating effluent generation rates between cattle and other animal has been found. According to Steffen et al. 1990 in "A Guide to Water and Wastewater Management in the Red Meat Abattoir Industry", Water Research Commission Report No. TT 45/90, one "cattle unit" is equivalent to 2.5 pigs, 2 calves and 6 sheep/goats. Thus the number of "pig units" held in lairage will be 12,000 plus the

5,500 pig units derived from the 2,200 head of cattle. Since the peak periods of goat slaughtering are in winter and most of the time the goat pens are empty. Therefore, the 125 pig units derived from 300 goats will not be taken into account for estimation under normal slaughtering operation.

8.20 Using the most conservative (upper limit for lairage) figures, an estimate of the daily effluent flow rate and pollution load from this source is given in Table 8.2

Table 8.2 Effluent Flow Rate and Pollution Load from the Lairages

Parameter	Unit Rate	Unit Flow/Unit load
Daily flow	0.015 cu.m/d	263 cu.m/d
SS Loading	0.180 kg/d	3,150 kg/d
BOD Loading	0.077 kg/d	1,348 kg/d
COD Loading	0.200 kg/d	3,500 kg/d
TKN Loading	0.0230 kg/d	403 kg/d
NH_3N Loading	0.0120 kg/d	210 kg/d
Bacterial Count	6.00E12 Counts/no./day	1.05E17 Counts/no./day

Slaughter Hall and BPP

8.21 Effluent flow rates and pollution loads from the slaughter hall and by-products plant were calculated from the following sources:

- lairage;
- pig slaughtering area, slaughtering hall, viscera area, suckling pigs and goats slaughter area; and
- cattle slaughtering area, slaughtering hall, viscera area, stomach handling area.

8.22 The slaughterhouse processes and the by-products plant will generate the greatest pollution loads, with varying flows and strengths depending upon the processes undertaken at different times of the day.

8.23 When estimating the effluent budget for the slaughterhouse, the parameter which varies most significantly was the volume of water used in daily operations. In some countries, such as Brazil, the amount of water used pre head of cattle slaughtered is about 18 cu.m; whereas in South Africa where water is very much at a premium, the consumption per head of cattle is reduced to 1cu.m. Methods for estimating the volume of the effluent include the use of units per head of cattle, per tonne live weight killed as well as per tonne of carcass weight. The volume of effluent is critical when determining the concentration of pollutants in the waste stream and thus the level of treatment required to ensure compliance with the discharge consents.

8.24 The following sections outline three different methods used to estimate the effluent flows and loads. The first is a rapid assessment method, similar to that adopted for use in the Northern District Sewerage Master Plan, 1993. The basis for the following estimates relates to the tonnage per Live Weight Killed (LWK). Based on the design forecast the LWK/day at Sheung Shui will be (Loadings based on this method are shown in Table 8.3):-

5,000 x 95 (kg) (pigs) + 400 x 450 (kg) (cattle) = 655 tonne

Table 8.3: Flow Rates and Pollution Loads based on the Rapid Assessment Method

Parameter - Factor	Flow Rate/ Pollution Load
Flow (cu.m/d)- 10.0	6,550
COD (kg/day) - 12.0	7,860
BOD (kg/day) - 6.0	3,930
SS (kg/day) - 6.0	3,930
TKN (kg/day) - 0.7	458.5
NH_3N (kg/day) - 0.0	-
TTM (kg/day) - 0.0	-

8.25 It should be noted that the generic estimates outlined above do not take separate account of lairage requirements, reception areas for livestock, whether or not there is a by-products plant on-site, or the method of slaughtering. This method of estimating flows and loads was considered to be inappropriate for the present study. It should also be noted the Sewerage Master Plan (SMP) consultants used a different body weight for head of cattle and pigs and their assessment method was based on a "complex" slaughterhouse. This approach was adopted in the absence of any information available to them on the proposed plant at the time of their study.

8.26 It is generally agreed that abattoirs which include by-products plants are considered to be complex units. In a recent publication (Cowan JAC, Wat. Sci. Tech. Vol. 25, No 10 pp 137 -148) a method for estimating the pollution loads from complex abattoirs, in South Africa, was given. These complex abattoirs are similar in nature to the one proposed at Sheung Shui. The effluent flow and load factors were based on a cattle unit, as defined above, and translate as 400 actual head of cattle and 2,000 equivalent cattle units (5000 pigs) to be slaughtered daily. Estimates of wastewater flow rates and pollution loads are provided in Table 8.4. Although BOD is not defined in this method, there is a well established relationship between BOD : COD (Chemical Oxygen Demand) for red meat of approximately 1.0 : 1.5 which was adopted to estimate the BOD loading.

Table 8.4: Estimated Effluent Flow Rate and Pollution Load from SSSH

Parameter	Unit Rate	Flow Rate/ Pollution Load
Flow Rate	1.0 cu.m/d	2,400 cu.m/d
Total COD	6.6 kg/d	15,840 kg/d
Soluble COD	4.1 kg/d	9,840 kg/d
BOD	(66% of COD)	10,560 kg/d
SS	1.4 kg/d	3,360 kg/d
TDS	3.0 kg/d	7,200 kg/d
Protein	0.5 kg/d	1,200 kg/d

8.27 The third method proposed for estimating volumes of process water and the strength thereof, is based directly on operational experience, and relates to slaughterhouse operations similar to the one proposed at Sheung Shui.

8.28 To estimate the volume of process water used, the carcass weight of cattle (55% LWK) and pigs (73% LWK) must be derived. For daily operations at Sheung Shui this is calculated to be 99 tonnes for cattle (assuming 450 kg live weight) and 346 tonnes for pigs (assuming 95 kg live weight). For application in Hong Kong, it has been estimated that 9 cu.m of water is used per tonne carcass weight produced. Thus daily consumption of water is approximately 4,000 cu.m/ day with an additional 25% added for washing carcasses and paunch contents.

8.29 Using the established relationship that effluent discharge rates are approximately 90% of water consumption rates, for the 1996 design year an estimated 4,500 cu.m/ day of effluent is expected to be of the order of:

BOD	=	13,500 kg/day
COD	=	20,250 kg/day
SS	=	5,400 kg/day
N	=	1,575 kg/day

Summary

8.30 A summary of estimated flow rates and pollution loads has been complied on the basis of the foregoing assessments, as Table 8.5 below:

Table 8.5: Estimated Daily Effluent Flow Rates and Pollution Loads for Separate Waste Streams

Components	Q cu.m/d	SS kg/d	BOD kg/d	COD kg/d	TKN kg/d	NH3 kg/d	TTM kg/d	E.coli Count no./d
Process water	4,500	5,400	13,500	20,250	1,575	-	-	-
Domestic	240	51	92	105	9	6.0	0.1	7.4×10^{14}
Lairage	263	3,150	1,348	3,500	403	210	-	1.6E17
Holding Bay	18	--	--	--	--	--	--	--
Total	5,021	8,601	14,940	23,855	1,987	216	0.1	1.6E17

The estimated daily water usage is shown in Figure 8.1.

8.31 Comparison of the data generated within this section reveals the wide range of values which can be obtained using different assessment methodologies. Following detailed evaluation it was judged that for this assessment, the most appropriate method was to calculate effluent generation rates from individual activities as this method clearly identifies the major contributors to the effluent budget. Other minor contributors to the overall budget may include water from the by-products plant condensers (if used) and similar processes; however in terms of strength and volume these will be minor compared to those given in Table 8.5. Furthermore, by quantifying pollution loads for individual waste streams, it is thus possible to design a plant which will incorporate discrete pre-treatment components into the overall effluent treatment facilities, thereby achieving a cost effective disposal option.

8.32 Preliminary estimates included herein are intended only to be indicators of the potential effluent flows and loads which may arise through operation of the proposed facilities at Sheung Shui. Further refinement may be required at the detailed design stage.

8.33 On the basis of the above preliminary assessment on discharge flow rates and pollutant loadings, the wastewater characteristics are estimated as follows:

Daily Flow : *5,021 cu.m/day*
SS : *1,713 mg/l*
BOD_5 : *2,976 mg/l*
COD : *4,751 mg/l*
TKN : *396 mg/l*
TTM : *0.02 mg/l*

Discharge Location and Requirements

8.34 Effluent from the SSSH will be discharged into the SWHSTW. The effluent standards to be achieved, both in design and practice, will be those given in Table 8.6. These have been extracted from the Technical Memorandum on "Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Water", Table 2 "Standards for effluents discharged into foul sewers leading into Government sewage treatment plants with microbial treatment".

8.35 There is no public foul sewer available in the vicinity of the subject site as confirmed by the Drainage Services Department. Effluent from the slaughterhouse could be pumped via a rinsing main to the Inlet Chamber of the SWHSTW with an invert level at -0.1mPD.

Charge for Sewage Services

8.36 With effect from 1 April 1995, charges on all effluent discharges were introduced by the DSD. These charges were created for the funding of sewage services. (Appendix 8.1) The charges consist of a Sewage Charge (SC) and a TES.

8.37 The SC is at a prescribed rate of HK$1.20 per cubic metre of water supplied. The TES is calculated as multiplying the volume of water supplied by a specified unit rate which depends on the nature of trade or business. As the proposed SSSH is located within the Deep Bay Water Control Zone, the TES rate of HK$3.78 per cubic metre is applied for the trade of slaughtering. The charging schedule for the TES is provided in Table 8.7. Therefore, the charges (95-96 rate) for the trade of slaughtering is at HK$1.20 + HK$3.78 = HK$ 4.98 per cubic metre of water supplied.

8.38 In case an in-house wastewater treatment facility is provided and the effluent quality is proven to be equivalent to or better than the domestic discharges, i.e. COD content less than 500 mg/l, the slaughterhouse operator may apply for exemption from the TES.

Table 8.6: Standards for effluents discharged into foul sewers leading into Government sewage treatment plants
(All units in mg/L unless otherwise stated; all figures are upper limits unless otherwise indicated)

Determinand / Flow rate (m^3/day)	≤10	>10 and ≤100	>100 and ≤200	>200 and ≤400	>400 and ≤600	>600 and ≤800	>800 and ≤1000	>1000 and ≤1500	>1500 and ≤2000	>2000 and ≤3000	>3000 and ≤4000	>4000 and ≤5000	>5000 and ≤6000
pH (pH units)	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10	6-10
Temperature (°C)	43	43	43	43	43	43	43	43	43	43	43	43	43
Suspended solids	1200	1000	900	800	800	800	800	800	800	800	800	800	800
Settleable solids	100	100	100	100	100	100	100	100	100	100	100	100	100
BOD	1200	1000	900	800	800	800	800	800	800	800	800	800	800
COD	3000	2500	2200	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000
Oil & Grease	100	100	50	50	50	40	30	20	20	20	20	20	20
Iron	30	25	25	25	15	12.5	10	7.5	5	3.5	2.5	2	1.5
Boron	8	7	6	5	4	3	2.4	1.6	1.2	0.8	0.6	0.5	0.4
Barium	8	7	6	5	4	3	2.4	1.6	1.2	0.8	0.6	0.5	0.4
Mercury	0.2	0.15	0.1	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cadmium	0.2	0.15	0.1	0.1	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Copper	1.5	1	1	1	0.8	0.6	0.5	0.4	0.3	0.2	0.15	0.1	0.05
Nickel	4	3	3	2	1.5	1	1	0.8	0.7	0.7	0.6	0.6	0.6
Chromium	2	2	2	2	1	0.7	0.6	0.4	0.3	0.2	0.1	0.1	0.1
Zinc	5	5	4	3	1.5	1.5	1	0.8	0.7	0.7	0.6	0.6	0.6
Silver	4	3	3	2	1.5	1.5	1	0.8	0.7	0.7	0.6	0.6	0.6
Other toxic metals individually	2.5	2.2	2	1.5	1	0.7	0.6	0.4	0.3	0.2	0.15	0.12	0.1
Total toxic metals	10	10	8	7	3	2	2	1.6	1.4	1.2	1.2	1.2	1
Cyanide	2	2	2	1	0.7	0.5	0.4	0.27	0.2	0.13	0.1	0.08	0.06
Phenols	1	1	1	1	0.7	0.5	0.4	0.27	0.2	0.13	0.1	0.1	0.1
Sulphide	10	10	10	10	5	5	4	2	2	2	1	1	1
Sulphate	1000	1000	1000	1000	1000	1000	1000	900	800	600	600	600	600
Total nitrogen	200	200	200	200	200	200	200	100	100	100	100	100	100
Total phosphorus	50	50	50	50	50	50	50	25	25	25	25	25	25
Surfactants (total)	200	150	50	40	30	25	25	25	25	25	25	25	25

Table 8.7: Charging Schedule of Trade Effluent Surcharge

Trade, business or manufacture	Rate for premises located in a water control zone $/m^3	Rate for premises located outside a water control zone $/m^3
yarn sizing	3.78	10.67
washing new garments, excluding laundries	0.82	0.82
bleaching and dyeing of garments	0.64	0.64
bleaching and dyeing of knitted fabric	1.01	1.01
bleaching and dyeing of woven fabric	1.73	1.73
textile stencilling and printing	1.32	1.32
knit outerwear	1.01	1.01
wearing apparel other than knit outerwear	1.80	1.80
spinning cotton	0.34	0.34
laundries	0.60	0.60
soap and cleaning preparations, perfumes, cosmetics	3.78	16.05
medicines	3.78	4.98
paints, varnishes and lacquers	1.16	1.16
basic industrial chemicals	3.78	4.02
tanneries and leather finishing	2.56	2.56
pulp, paper and paperboard	4.09	4.09
soft drinks and carbonated waters industries	1.49	1.49
breweries and manufacture of malt liquor	3.29	3.29
distilling, rectifying and blending spirits	0.11	0.11
cocoa, chocolate and sugar confectionery	3.78	4.26
vermicelli, noodles, and similar farinaceous products	3.29	5.16
bakery products	3.29	5.16
grain mill products	5.98	9.54
vegetable oil peanut oil, peppermint oil and aniseed oil	3.78	19.55
canning, preserving & processing of fish & crustaceans	1.73	1.73
canning and preserving fruit and vegetables	3.63	3.63
dairy products	3.78	9.15
slaughtering, preparing and preserving meat	3.78	9.01
soy and other sauces	3.78	8.38
restaurants	3.78	9.12

Level of Treatment

8.39 Typical pollution loading of domestic discharges is listed below:-

BOD_5 :	250 mg/l
SS :	250 mg/l
COD :	500 mg/l
TKN :	50 mg/l

8.40 The required removal efficiencies of the pollutants for two treatment options are presented in Table 8.8.

Option 1 : To meet the required discharge limits (Table 8.6)
Option 2 : To be exempted from the TES

Table 8.8 Required Level of Treatment for the Two Options

	Required Removal Efficiency	
	Option 1	**Option 2**
BOD_5	73%	92%
SS	53%	85%
COD	58%	89%
TKN	75%	87%

High Strength and Low Strength Wastewater

8.41 Daily wastewater discharge pattern is shown in Figure 8.2. Wastewater which can meet the discharge requirements after primary treatment (screening and dissolved air flotation) is called low strength wastewater.

8.42 Following a preliminary assessment on wastewater generation and characterisation, it is estimated that approximately 26% of wastewater may be classified as low strength wastewater. However, a comprehensive survey for Hong Kong Abattoir is suggested to further investigate the stream separation by flow determination and wastewater analysis to verify this estimation if necessary. Low-strength wastewater sources and the estimated quantity is presented in Table 8.9.

Table 8.9: Low-strength Wastewater Source

	Source	Estimated Quantity (m^3)
i)	Sanitary sewage from toilets, lavatories, drinking fountains, showers, canteen, etc.	240
ii)	Meat despatch area	200
iii)	Petroleum-bearing wastewater from vehicles washing area, maintenance workshop, etc.	80
iv)	Discharges from odour control facilities	200
v)	Some rinsing water from slaughtering activities	600
	Total :	**1,320 (26%)**

Layout Design of the Plant

8.43 In view of site constraint, the area available for the wastewater treatment plant is very limited. Layout of the plant should be compact and easy to operate and maintain. Circular process tanks should be avoided to optimise land use. Locating the treatment facilities underground may be considered as a viable solution.

8.44 According to the Drainage Impact Assessment (DIA) report for the subject site (Appendix 8.2), it is recommended that the formation level is preferably not lower than 8.0mPD. If it is, the potential risk of plant flooding due to storm water runoff is very unlikely. Full standby electricity supply and pumping equipment should be provided to prevent the possible risk of plant flooding due to electrical or mechanical failure.

8.45 The major slaughtering activities will take place from 2:00 am to 8:00 am with over 80% of wastewater generated during this period. Moreover, 4 batches of high strength and hot (60°C) wastewater of about 200 cu.m from scalding tanks will be discharged at around 11:00 am. Adequate flow equalisation is required to balance the peaks so as not to overload the downstream treatment processes.

8.46 Separation of liquid and solids will be achieved through the incorporation of manure traps and gratings within the drainage systems designed for all areas inside and outside the plant. Solids will be collected in a container for off-site disposal.

8.47 All walls within the slaughterhouse will be required to achieve a high quality finish which will be flat, smooth and washable. Floors will be made of concrete and finished with an impact resistant non-slip material. Slopes on the floors will be in a negative direction towards the drainage system.

8.48 Furthermore, in order to provide facilities which are easy to clean, all working surfaces which could come into contact with edible material will be required to be formed from stainless steel. Working platforms and all heavy equipment will be required to be made from galvanised material. Wooden equipment and parts are to be avoided on account of the difficulty in cleaning such surfaces. Equipment should be designed to avoid angles and crevices as these tend to collect dirt and are difficult to clean.

8.49 Equipment and facilities for maintaining hygiene standards within the slaughter hall, and other areas of the plant, and for personal hygiene should be readily accessible and in close proximity to the areas where the main activities are taking place. Standard operating procedures will need to be established (for all personnel engaged on-site) prior to commencing operations at Sheung Shui, to attain high standards of hygiene for the plant itself while minimising the risk of contamination of the products produced.

8.50 It is recommended that the floor of the slaughter hall is hosed down during and at the end of each shift as this will assist in preventing the floor from becoming slippery, reduce the potential for the blockages of drains and will improve working conditions. The present practice of using hot water, without detergent, is also recommended.

8.51 To encourage high standards of personal hygiene it is recommended that facilities such as showers, toilets, and locker rooms are well equipped with adequate arrangements to accommodate the number of staff employed for each shift.

8.52 As a general rule, all waste traps should be cleaned at least once per day, and the solids collected in a container for onward disposal at landfill.

8.53 Water Supplies Department have advised that at least one days supply of potable water will need to be provided, in addition to a continuous supply of hot water during those periods when the slaughterhouse is operational. A header tank will be required with sufficient pressure to maintain supply. This tank will be enclosed for reasons of hygiene.

Proposed Wastewater Collection Systems

8.54 Stormwater will be collected and conveyed off-site via a drainage system which will include perimeter drains according to standard design practice.

8.55 The drainage system within the reception area, vehicle body washing area, and in any other areas where livestock may pass through, will require gratings of appropriate sizings and solid traps to prevent clogging, and should be connected to the foul sewerage system rather than the stormwater system. A canopy should be provided to protect against the ingress of rain.

8.56 Within the slaughter hall, gratings and traps to block any large items of solid waste will be incorporated into the design of the drainage system. Floors will be required to have a minimum (negative) slope towards the surface drains which will also have a negative gradient. The distance over which the effluent is conveyed prior to treatment should be short as practical to minimise the potential for blocked or choked drains.

8.57 Lairage areas should be provided with tile finish floors, and will also require drainage layouts which incorporate traps to separate the solid and liquid wastes for individual treatment. The collection system shall be designed to ensure the main drains are located outside the actual enclosures. Curbs shall also be provided around the pens to prevent the spread of manure beyond these closures. Manure traps will be mandatory if the holding pens are washed down, rather than adopting a dry muck out method.

8.58 While the suspect carcass area is most likely to be used for the slaughter of diseased animals when the main slaughter hall is not in operation, it is maintained that the purpose of an isolation unit is to contain and control liquid and solid wastes and treat them according to the potential impact they could have on public health. Therefore it is recommended that the drainage design permits total isolation of both the area and the drainage facilities so that, if required, wastes from this area can then be contained and treated separately.

Wastewater Treatment Processes

Organic Matter Removal

Dissolved Air Flotation

8.59 Dissolved Air Flotation (DAF) is widely used in slaughterhouse to pre-treat wastewater due to its high removal efficiencies for oil & grease (O&G) and SS with a much less liquid retention time compared with conventional grease trap and sedimentation tank. A DAF unit is currently operated at Kennedy Town Abattoir to pre-treat wastewater from by-products plant, scalding tank, pig dressing area and cattle dressing area.

8.60 SS or oil globules can be removed from wastewater stream by decreasing their net density with air bubbles. The particle/air agglomerate will then float to the surface. An effluent stream is saturated with air under pressure, on return to atmospheric pressure when mixed with the raw wastewater, air evolves from solution forming bubbles which become enmeshed in wastewater particle.

8.61 Typical pollutants' removal efficiencies for DAF with the addition of polyelectrolyte into wastewater stream for coagulation and flocculation enhancement are listed below:

BOD_5 :	55% (up to 70%)
SS :	75% (up to 90%)
COD :	35% (up to 50%)
O&G :	90% (up to 95%)

Since most of the nutrient , i.e. TKN and Total Phosphorus (TP), are in soluble forms, their removal efficiencies may be considered to be insignificant.

8.62 Based on the above removal efficiencies, using DAF only would not be adequate to pre-treat wastewater to meet the discharge requirements. Downstream treatment is required to further remove soluble organic matters and nutrient to an acceptable standard.

Biological Treatment

8.63 Biological treatment can be broadly classified as "aerobic" and "anaerobic" which aimed to coagulate and remove non-settleable colloidal solids and to stabilise organic matters. It is considered as the cost-effective treatment process to remove biodegradable matters and suspended solids in wastewater.

Aerobic Treatment

8.64 Conventional aerobic biological treatment systems, often classified as either suspended growth (e.g. activated sludge) or attached growth (trickling filters) systems, use a diverse culture of micro-organisms in the presence of oxygen to break down organic matter in wastewater, oxidising a portion and converting the remainder into biological solids. Non-biodegradable suspended contaminants are removed by physical entrapment and subsequent removal with the generated biomass.

8.65 Removal efficiencies for BOD_5, COD and SS are typically in the range of 80-99% for domestic sewage and could be higher for high strength industrial trade effluent.

Anaerobic Treatment

8.66 In anaerobic digestion process, organic material in mixtures of primary settled and biological sludge is converted biologically, under anaerobic conditions (in absence of oxygen), to a variety of end products including methane and carbon dioxide. This process is particular applicable for high strength industrial wastewater. Methane gas may be utilised for electricity generation and water heating.

8.67 Since the digestion process is extremely slow, liquid retention time is typically in the range of 30 to 60 days (about 1 day for aerobic treatment). Therefore, spatial requirement for anaerobic treatment is enormous.

Nitrogen Removal

Physical or Chemical Processes

8.68 There are some physical and chemical processes adopted for nitrogen removal such as air stripping, breakpoint chlorination and selective ion exchange. However, because of the associated high chemical cost and inconsistent performance, there application are very limited.

Biological Nutrient Removal

8.69 Biological (aerobic) treatment systems can be configured to remove nutrient nitrogen and/or phosphorus. Nitrogen removal is accomplished by modification of the conventional biological treatment system to incorporate the biochemical processes of nitrification and denitrification.

8.70 Nitrification is the oxidation of ammonia and organic nitrogen to nitrates. The process is mediated by the activity of a specialised class of bacteria that can be grown in conventional biological systems by extending the biological solids residence time resulting in more complete biodegradation of organic matter. Nitrogen removal is subsequently obtained by denitrification whereby the nitrate nitrogen is reduced to nitrogen gas.

Recommendation for Treatment Process

Organic Matter Removal

8.71 Aerobic and anaerobic biological treatment processes are described. There are three main reasons leading to conclude that anaerobic process is not suitable for this application(Aerobic biological treatment process is therefore recommended.):-

- Large spatial requirement; particularly relevant as site area is very limited in this case;
- Potential explosion/fire risk for methane gas handling; and
- Serious odour problems associated with anoxic process.

Nitrogen Removal

8.72 Physical and chemical nitrogen removal processes are usually adopted for small-scale application or as an ancillary facility installed at disposal end of treatment plant being in use when the nitrogen content exceeds the discharge limit occasionally. Large scale continuous application is very uncommon.

8.73 Biological nitrogen removal has widely been used as the most cost-effective technology. An example of large scale local application is the Shatin STP. As nitrification and denitrification processes can be readily incorporated into conventional (aerobic) biological treatment processes which is recommended above, the minimal increment in capital and recurrent costs makes it more attractive to be a total treatment solution for BOD_5, COD and total nitrogen removal.

Combined Organic Matter and Nitrogen Removal

8.74 Among all the available biological nitrogen removal processes, the following systems are selected for process evaluation.

- Conventional Activated Sludge (CAS) System
- Sequencing Batch Reactor (SBR)
- Rotating Biological Contactor (RBC)

Conventional Activated Sludge

8.75 CAS processes are commonly used for large STP such as the Shatin STP and SWHSTW and are capable of producing consistently good effluent quality. They have been widely used for biological nutrient removal with anaerobic/anoxic/aerobic operation for domestic sewage and slaughterhouse wastewater.

8.76 Care should be taken to achieve plug-flow conditions to avoid any solids separation problems such as foaming and bulking. This is particularly important with this slaughterhouse wastewater high in protein and O & G contents.

8.77 To ensure no solids carry-over especially during high flow conditions, over sizing of the secondary clarifier is normally adopted. Circular secondary clarifiers occupy more space as compared to rectangular tank configuration. This results in more spatial requirements than for sequencing batch reactors.

8.78 Solids must be carefully managed to ensure appropriate sludge wasting rates. During increases in hydraulic loading, process changes must be implemented quickly to ensure that sludge washout does not occur. Diffusers and blowers should be carefully selected to ensure minimum maintenance requirements.

8.79 The space-oriented operation offers less flexibility to accommodate variations in both organic and hydraulic loadings.

8.80 The multi-tank configuration requires more piping and associated maintenance works. In particular for biological nutrient removal, the aerobic to anoxic mixed liquor and return activated sludge facilities need to be appropriately manipulated to maintain consistent effluent quality.

8.81 No large equipment for activated sludge aeration tanks is required, but careful consideration should be given to the feasibility of installing the circular sludge scrapper of secondary clarifiers underground because this large moving piece of equipment requires regular check-up and maintenance.

8.82 For capacity expansion, it is necessary to expand both anaerobic/anoxic/aerobic reactor and secondary clarifiers. Downstream chemical processes can be added to achieve phosphorus removal, if necessary.

Sequencing Batch Reactor

8.83 SBRs have been widely used for large and small scale application handling both high and low strength industrial wastewater. This includes abattoir wastewater and domestic sewage, which can produce consistently good effluent quality.

8.84 Due to rapid advancement in microprocessing control technology, operating with alternating fill and draw sequences has been simplified, leading to the development of fully automated SBR plants. Since there are few moving parts (no mixed liquor recycle and return activated sludge line), the system requires minimal maintenance.

8.85 The SBR accomplishes three basic stages of biological wastewater treatment (primary sedimentation, carbonaceous oxidation and secondary clarification) in an single-tank leading to a more compact plant area compared with RBC (i.e. 10 - 30% less) and conventional activated sludge, and to a reduced capital and operation and maintenance costs (20 - 30%).

8.86 Intermittent operation inherently buffers variations in flow and load and creates plug-flow conditions to minimise the risk of foaming and bulking solids handling problems. The large all-in-one basin also provides a large surface area for secondary clarification. Solids carry over during high hydraulic loading is thus usually not a problem.

8.87 Easily expandable and upgraded, single basins can be arranged in parallel to handle increased flow requirements and time-oriented operation can be adjusted to incorporate biological nutrient removal without any plant modification. No large equipment required for SBRs leading to the ease of underground installation.

Rotating Biological Contactor

8.88 RBCs are widely used in Hong Kong for small scale domestic sewage treatment. Typically, these systems can produce effluent quality of BOD_5 20 mg/L and SS 30 mg/L.

8.89 Biological nutrient removal performance, in particular nitrification, is poor especially for handling high strength wastewater. Large scale applications can not be found easily.

8.90 High flows may lead to sloughing of the media, so deteriorating the effluent quality. Increased turbulence in the secondary clarifier may lead to solids carry over. A long start-up period (up to six months) is required for bacterial attached growth development. If maintenance problems arise due to shaft failure, media breakage and bearing failures, a long re-start-up time will follow.

8.91 Insect and odour problems often arise, particularly at the inlet if the system is over-loaded.

8.92 The RBC is relatively inflexible. Changes in the hydraulic and organic loadings can be accommodated to some extent by changes the volume of air supplied, and also the rotational velocity. This system can be expanded, but requires not only an expansion of biological tanks, but also the expansion of secondary tanks.

8.93 In general, the space requirement is larger than for conventional activated sludge processes and sequencing batch reactors. The RBC shaft is the largest piece of equipment. It may require a loading bay and crane for installation. A large opening will be required if the plant is to be underground.

Process Comparison

8.94 Comparison of the three biological treatment processes mentioned above is presented in Table 8.10.

Table 8.10: Comparison for 3 Different Biological Nitrogen Removal Processes

Parameters	CAS	SBR	RBC
1. Life cycle cost	M	M	M
2. Cost effectiveness	M	M	M
3. Reliability	M	M	L
4. Simplicity of operation	L	M	M
5. Ease of maintenance	L	M	M
6. Compactness of plant size	M	H	M
7. Performance	M	M	L
8. Ability to meet discharge requirement	H	H	M
9. Adaptability to change in influent quality	M	H	L
10. Adaptability to varying flow rate	M	H	L
11. Ease of construction	M	M	M
12. Adaptability to upgrading	L	M	L
13. Availability of major equipment	M	M	M
14. Post-installation service/chemical delivery	M	M	M
15. Personnel skill level	M	M	M
16. Energy utilisation	M	M	M
17. Residue production	M	M	M
18. Cost of residue disposal	M	M	M
19. Potential for effluent use/reuse	M	M	L
20. Significance of air/odour emission	M	M	M

H: HIGH (Desirable), M: MEDIUM, L: LOW (Not Desirable)

8.95 The SBR is considered as the most suitable biological nitrogen removal treatment process due to its high adaptability to varying loading, reliability in treatment performance, simplicity in plant operation and maintenance and compactness.

Scheme Options for Recommended Process

Aboveground Vs Underground Wastewater Treatment Plant

8.96 Due to site constraint, limited area could be allocated for the provision of wastewater treatment plant (WWTP). It is estimated that a total area of 6,000 square metres is required. Locating the WWTP entirely aboveground is considered not feasible. Multi-storey (partially underground) WWTP and completely underground WWTP are considered feasible. A comparison for multi-storey and completely underground WWTP is presented in Table 8.11.

Table 8.11 Comparison of Multi-Storey Vs Completely Underground WWTP

Multi-Storey (Partially Underground)	**Completely Underground**
Advantages • Lower construction cost • Solid handling facilities can be located aboveground for the ease of trucking away for disposal • Vehicular assess to underground plant may not be required	Advantages • Locating the optional BPP above the treatment plant is feasible • Odour generated is readily contained for mitigation • It facilitates the collection of all wastewater sources by gravity flow
Disadvantages • Possibility of locating the by-products plant above the treatment plant is restricted • Potential odour problem from solid handling facilities	Disadvantages • Higher construction cost • Possible difficulties in trucking away solid waste

8.97 In order not to restrict the possibility of locating the optional BPP above the treatment facilities, underground WWTP is therefore recommended for further consideration. However, it is not intended to eliminate the possibility of multi-storey WWTP which may be considered at a later stage.

Treatment Schemes

8.98 Two treatment schemes are considered.

Scheme 1 : Segregating high strength and low strength wastewater for separated treatment with effluent quality to meet the required discharge limits.

Scheme 2 : Combined stream for centralised treatment with effluent quality better than the typical domestic discharges.

8.99 Advantages of stream segregation for separated treatment are as follows:

- Hydraulic loading to the ancillary high strength wastewater treatment facilities could be significantly reduced.
- Overall capital cost, as well as the spatial requirement, of the WWTP could be reduced.

8.100 Disadvantages of separated treatment are as follows:

- Two drainage systems are required to collect high strength and low strength wastewater separately which would complicate the drainage design.
- Although the hydraulic loading is significantly reduced, its total pollution loading to the ancillary high strength wastewater treatment facilities could not be much reduced and so as the scale of the biological treatment facilities.

Scheme 1 : Separated Treatment

8.101 Low strength and high strength wastewaters are separately handled by the low strength wastewater treatment facilities (LSWTF) and high strength wastewater treatment facilities (HSWTF) respectively. LSWTF will consist of a fine screen and a dissolved air flotation unit. HSWTF will consist of a fine screen., a dissolved air flotation unit and a biological nitrogen removal system. Wastewater after treatment will mix together in an effluent holding tank prior to be diverted to the SWHSTW. Effluent quality will meet the discharge requirement for foul sewer disposal.

8.102 Sludge from the DAF units and the biological treatment system will be dewatered by a recessed plate filter press and then mixed together with screenings from the fine screens for proper landfill disposal. Schematic diagram and layout plan of the Scheme 1 separated treatment are shown in Figure 8.3 and 8.4 respectively. An estimated area of 61m x 90m will be required for the whole wastewater treatment facilities.

Scheme 2 : Combined Treatment

8.103 The system is basically similar to the HSWTF of scheme 1. It consists of a fine screening, dissolved air flotation and biological nitrogen removal processes. Treated effluent will be piped to the SWHSTW. Effluent quality will be attained at a pollution level equivalent to or better than domestic discharges. Similarly, sludge from the dissolved air flotation units and the biological treatment system will be dewatered by a recessed plate filter press and then mixed together with screenings from the fine screens for proper landfill disposal.

8.104 Schematic diagram and layout plan of the Scheme 2 separated treatment are shown in Figure 8.5 and 8.6 respectively. An estimated area of 63m x 100m will be required for the whole wastewater treatment facilities.

Cost Analysis

Capital Cost

8.105 Estimated electrical and mechanical capital costs for the two schemes are presented in Table 8.12.

Table 8.12 Comparison of Electrical & Mechanical Cost for the Two Schemes

	Scheme 1 (HK$M)	Scheme 2 (HK$M)
1. Screen c/w compactor	1.5	1.2
2. DAF c/w flocculator	7.0	6.5
3. Pumps	1.0	0.8
4. Air blowers	5.0	8.5
5. Air diffusers	1.5	2.5
6. Decanting facilities	1.2	1.8
7. Sludge handling/dewatering facilities	5.0	7.2
8. Mixing devices	0.5	0.8
9. Plant monitoring, electrical and control systems	5.0	6.5
10. De-odourisation facilities	7.0	8.0
11. Contingency	2.3	4.2
Total :	**37.0**	**48.0**

8.106 Civil construction costs for Schemes 1 and 2 (completely underground layout) are estimated to be HK$40.0M and HK$50.0M respectively.

Recurrent Cost

8.107 Estimated daily plant recurrent costs for the two schemes are presented in Table 8.13.

Table 8.13: Comparison of Recurrent Cost for the Two Schemes

	Scheme 1 (HK$/day)	Scheme 2 (HK$/day)
1. Electricity cost (including ventilation & de-odourisation)	17,000	19,000
2. Chemical cost (including de-odourisation)	13,000	14,500
3. Labour cost (assume 6 technicians will be required)	3,000	3,000
4. Maintenance cost (assume 10% of equipment cost)	10,200	13,200
5. Sludge disposal cost (assume 4 trucks per day at a rate of HK$2,000/truck)	8,000	8,000
6. Landfill disposal cost (assume HK$ 100 per tonne at full cost recovery) (see s. 8.113)	3,100	3,800
Total :	**54,300**	**61,500**

8.108 Annual expenditures on trade effluent disposal for the two schemes are calculated as follows:

Scheme 1
Annual plant recurrent cost + trade effluent tariff (SC + TES)
= HK$54,300/day*364day/yr + 5,021cu.m/day*HK$(1.2+3.78)*364day/yr
= HK$19.77M + HK$9.10M
= HK$28.87M

Scheme 2
Annual plant recurrent cost + trade effluent tariff (SC only)
= HK$61,500/day*364day/yr + 5,021cu.m/day*HK$1.2*364day/yr
= HK$22.39M + HK$2.19M
= HK$24.58M

It is assumed 364 days per year for slaughterhouse operation.

8.109 Summary of the capital and annual recurrent costs for the two schemes is presented in Table 8.14.

Table 8.14: Summary of Capital and Annual Recurrent Costs for the Two Schemes

	Scheme 1 (HK$M)	**Scheme 2 (HK$M)**
Capital Cost	77	98
Annual Recurrent Cost	28.87	24.58

8.110 Although the capital cost for the scheme 2 is higher (21M overall), the saving in recurrent cost (4.29M per annum) is substantial and is therefore recommended.

Solid Waste Generation

8.111 Assuming that 75% SS removal by the DAF unit, amount of sludge generated from the flotation process is calculated as follows:

Sludge generation :	0.75*8,601 kgSS/day
(For both Scheme	= 6,450.8 kg/day (100% dryness)
1 & Scheme 2)	= 21,503 kg/day (30% dryness)
	or 21.5 tonnes/day

8.112 Assuming that 55% BOD removal by the dissolved air flotation unit and 0.5kg sludge generated per kgBOD removal by the biological treatment process, amount of sludge generated from the biological process is calculated as follows:

Sludge generation:(0.45×2.976–0.8) kgBOD/m^3*5,021 m^3/day*0.5 kg sludge kgBOD

(For Scheme 1)	= 1353.7 kg/day (100% dryness) = 4512.2 kg/day (30% dryness) or 4.5 tonnes/day
Sludge generation : (For Scheme 2)	(1-0.55)*0.5*14,940 kgBOD/day = 3,361.5 kg/day (100% dryness) = 11,205 kg/day (30% dryness) or 11.2 tonnes/day

8.113 The sludge from the flotation and biological processes will then be mixed with screenings (an estimate of 3-5 tonnes/day) collected from the fine screen. A total amount of 30-40 tonnes/day solid waste will be generated from the wastewater treatment plant (approximately, 31 tonnes/day for Scheme 1 and 38 tonnes for Scheme 2). The solid waste will need to be trucked away for proper landfill disposal.

Pilot Plant

8.114 A small scale pilot plant is recommended to be installed in one of the Hong Kong Abattoirs to assess treatability options for detailed design of the proposed wastewater treatment plant at SSSH. As the design parameters of a biological treatment system may vary for different characteristics of wastewater (from abattoir to abattoir), different operating procedures and different management practices may apply. The pilot plant would collect design and operating data so that the treatment facilities and capabilities can be more accurately tailored during the design phase to meet local requirements.

Plant Design and Operation

8.115 ProPECC PN5/93 and "Guidelines for the Design of Small Sewage Treatment Plants" should be referred to during the design stage of the wastewater treatment facilities.

The slaughterhouse operator is required to obtain a discharge licence under the WPCO before the discharge commences.

8.116 A new regulation (currently in drafting stage) on the Operation and Maintenance of Wastewater Treatment Facilities is scheduled to be enacted by 1996. The new regulation would require registered operators to undertake the operation and maintenance of the wastewater treatment plant.

Reduction of Water Usage

8.117 Water used in meatworks represent an operating cost when it enters the works as potable water, and again when it leaves the works as polluted effluent for treatment. The total cost depends on the charges of incoming water, treatment costs and the amount of water used. There are several areas in meatworks where water usage can be reduced.

Cleaning of yards

8.118 Closer supervision of dry-cleaning and washing could reduce overall water consumption.

Pre-slaughter wash (beef)

8.119 Cattle washing facilities must be available in holding yards, and foot or belly sprays may be provided in lead-up races to the knocking box. The amount of water used depends on the system installed. Whatever the system, water sprays or hoses can be left to run continuously or they can be turned off when not in use. It is a waste of water to run wash sprays when there are no cattle to wash.

8.120 If spray nozzles become blocked, and floor sprays often do, the flow of water is restricted and the sprays are weak. This may appear to be saving water, but weak sprays are not doing an adequate job and the water is wasted. Instead of manually-operated wash sprays, the water could be controlled by timer solenoids. If the time of the wash is set for optimum wash results, water wastage through over-washing can be avoided.

Viscera Table

8.121 The purpose of the viscera table wash is to clean off visible fat, protein, and manure, and to leave a sanitary surface. This wash should consist of cold water sprays at the discharge end of the table to clean off blood, manure, tissues and other fluids. At the opposite end of the table, there should be water sprays at 82°C to clean off fat and to sanitise the surface of the table. The hot water sprays should be followed by cold water sprays to cool the metal surfaces.

8.122 Each set of sprays must work efficiently if satisfactory results are to be achieved. If a cold water spray is blocked, or misaligned, or if the pressure is not sufficient, blood may be left on the table and this will be backed onto the table surface by the hot water spray. Correctly aligned, high pressure sprays will achieve satisfactory results on the viscera table, with reasonable water flow rates. The water flow should be adjusted to a rate where adequate cleaning is achieved.

8.123 Water wastage can also be avoided if the water sprays are controlled by the movement of the table. When the table is stopped, there is no need for wash water, and the sprays should be turned off automatically.

Carcass wash

8.124 The way in which sides and carcasses are washed varies between works and must account for some of the large differences found in the amounts of water used. The operators should be trained to wash a side or carcass until it is clean and not to waste water by washing for an unnecessarily long time.

8.125 In an automatic wash cabinet, the sprays may be left on permanently, or they may be switched on/off, by switches operated by the skid or roller, when a side or carcass is in position. In one wash cabinet for beef sides, about 60 litters of water per carcass were used when the sprays were switched on and off automatically. In the same cabinet, 200 litters per carcass were used when the sprays were allowed to run continuously. One important objective of the wash is to remove bone dust. As most of the bone dust is on the side of the carcass where the backbone is split, there are opportunities for saving water by concentrating the wash in this area.

Tripe wash

8.126 Water is often used in chutes to assist the movement of tripe from the slaughter floor to the tripe room, and large quantities are used in the tripe room to wash manure out of the tripe. The amount of water used to assist transport of tripe should be restricted to a thin film over the chutes. This will provide adequate lubrication for the tripe to slide down the chute. The chutes should have a sufficient degree of fall and no sharp corners, so that tripe can move smoothly.

8.127 In the conventional method of emptying paunches, water is sprayed into the paunch while the contents are emptied. Dry dumping the paunch contents will save water. The paunch is then transferred to a second tank for washing. Although water is still used to clean the paunch after dry dumping, the water used to sluice out the contents is saved.

Harsher washer

8.128 The amount of water used in a hasher washer depends on its design and operation. In most slaughterhouse, there is potential for reducing the amount of water used in the hasher washer.

Cleaning

8.129 Cleaning represents such a large proportion of the water usage in a works that there must be potential here for reducing overall water consumption. When cleaning is inadequate, re-cleaning is required. To avoid this situation, cleaning is often over zealous, and wasteful procedures are used to ensure that a satisfactory end result is achieved. This approach to cleaning may result in excess water being used. Cleaners should be closely supervised to control water use. Untrained and unsupervised cleaners use more detergent and sanitiser than recommended by the manufacturers, in the belief that the more detergent used, the better the result. In the same way, they are likely to use more water than is required for an efficient cleaning job.

8.130 As part of the supervision of cleaning staff, there must be a documented cleaning procedure. This will eliminate any doubt about how an area or piece of equipment should be cleaned, and thereby control the amount of water used. The programme should specify when dry cleaning methods apply. Dry cleaning should be the first step in the general clean-up, and can also be used for cleaning during smoke hosing, but there are benefits in reduced water usage, improved recovery of fats and protein for rendering, and improved quality of effluent.

8.131 When water is used for cleaning, floor grates and drains must be so designed that build-up of solid material around the grate does not prevent water escaping to the drain. If drains are blocked, water and waste material cannot flow, and this may encourage people to use excess water to force the material down the drain.

Possibilities for recycling water

8.132 Non-potable water is permitted for certain restricted uses. These uses include washdown of stockyards, in hasher washers, and in vapour condensers on inedible renderers. In some cases, non-potable water may also be used for cattle showers, providing that the final shower is with potable water. In these areas, water which has been used through the works could be recycled as non-potable water.

8.133 In conclusion, there are three main ways to approach water usage:

- Proper supervision: Avoid water wastage through carelessness and poor housekeeping, e.g. hosing unnecessarily, taps left running unnecessarily, and faulty valves.
- Effective design: Take care to design and construct equipment which is effective and which limits water use.
- Regular monitoring: Keep a check on water consumption by the use of meters.

Energy Conservation

8.134 Hot and warm water generation in slaughterhouse represents a significant operating cost. It is estimated that a daily consumption of about 30,000 litres of hot (82°C) water and 100,000 litres of warm (45°C) water in the SSSH for sterilisation and cleaning. Besides to reduce hot and warm water consumption by effective water management, a significant cost saving could be achieved by using solar heating system to pre-heat water to about 60°C. Potential application of solar heating system is described in Section 12.

8.135 As electricity consumption accounts for significant portion of operating cost for wastewater treatment plant, energy conservation measures will be incorporated in design of total water management plan at SSSH.

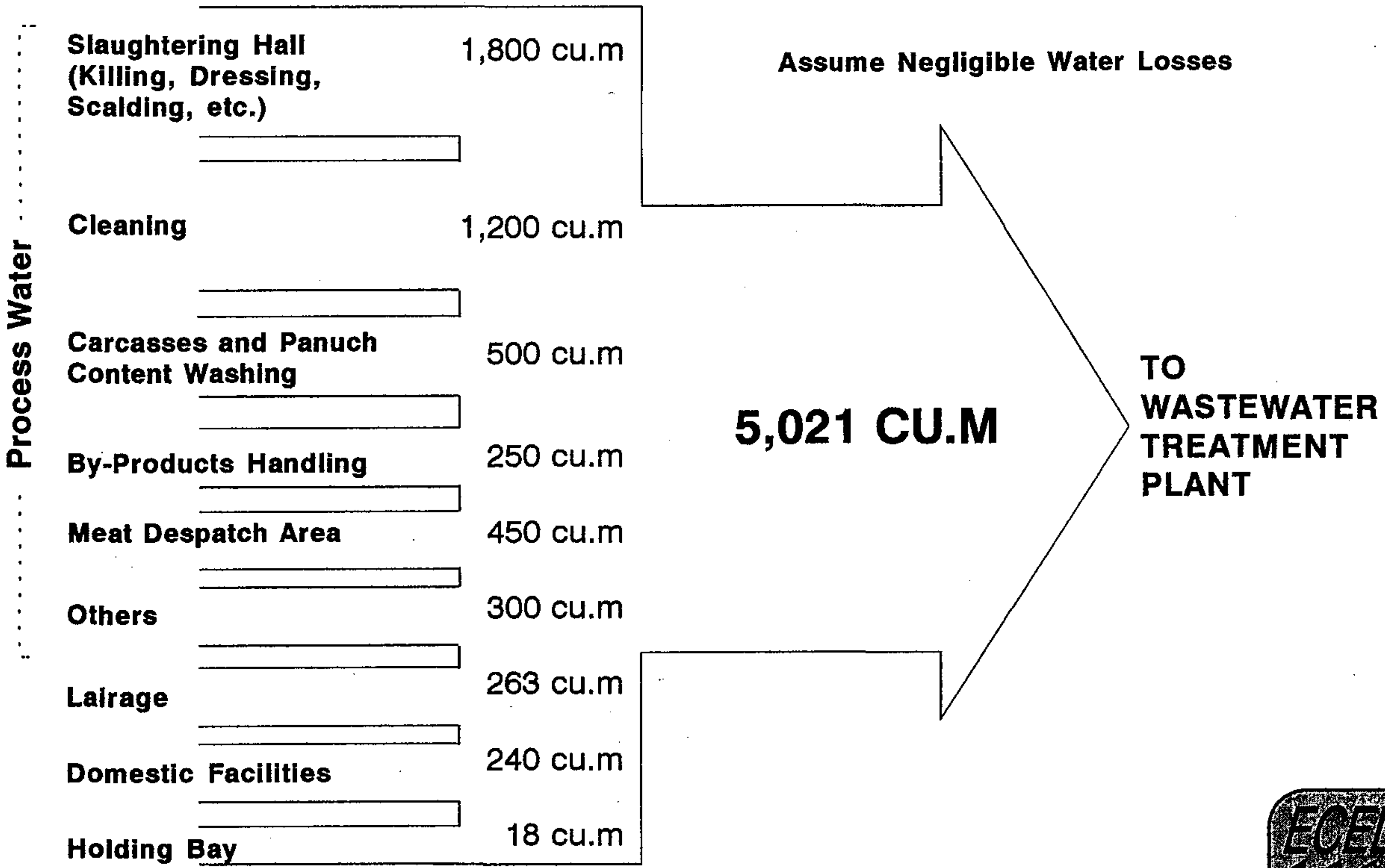


Figure 8.1 : Estimated Daily Water Usage

Feasibility Study of Sheung Shui Slaughter House
Daily Wastewater Discharge Pattern

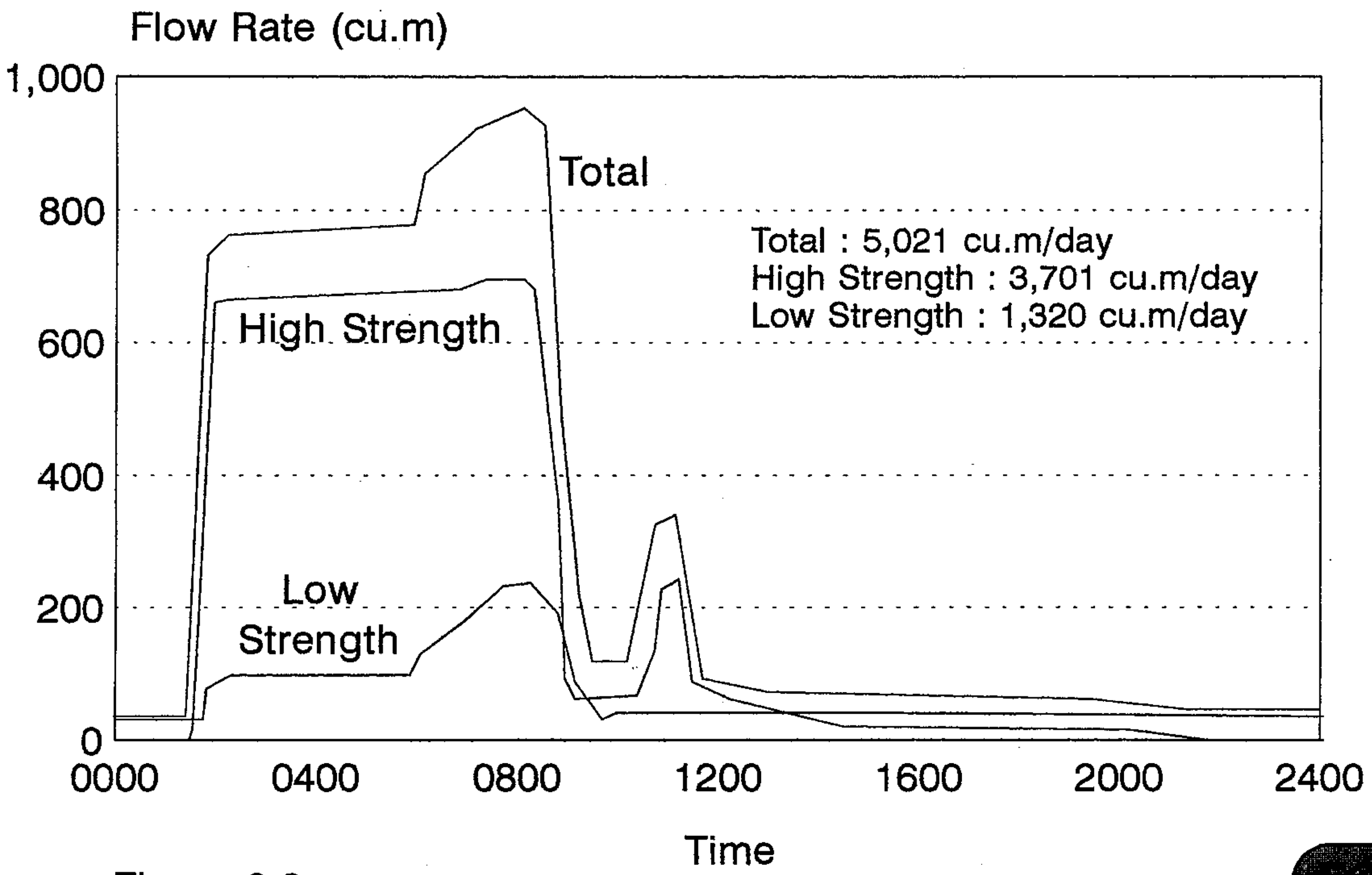


Figure 8.2

Scheme 1 : Segregating High & Low Strength Wastewater for Separated Treatment

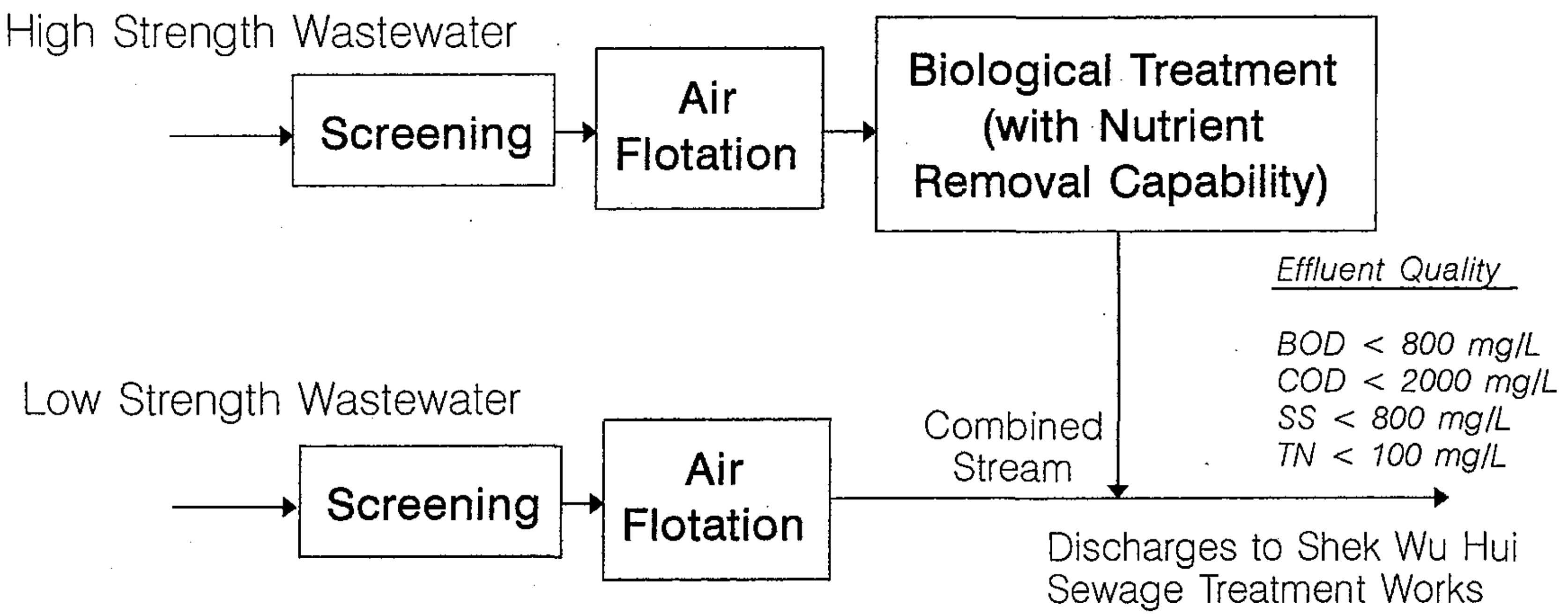


Figure 8.3 Schematic Diagram of Scheme 1

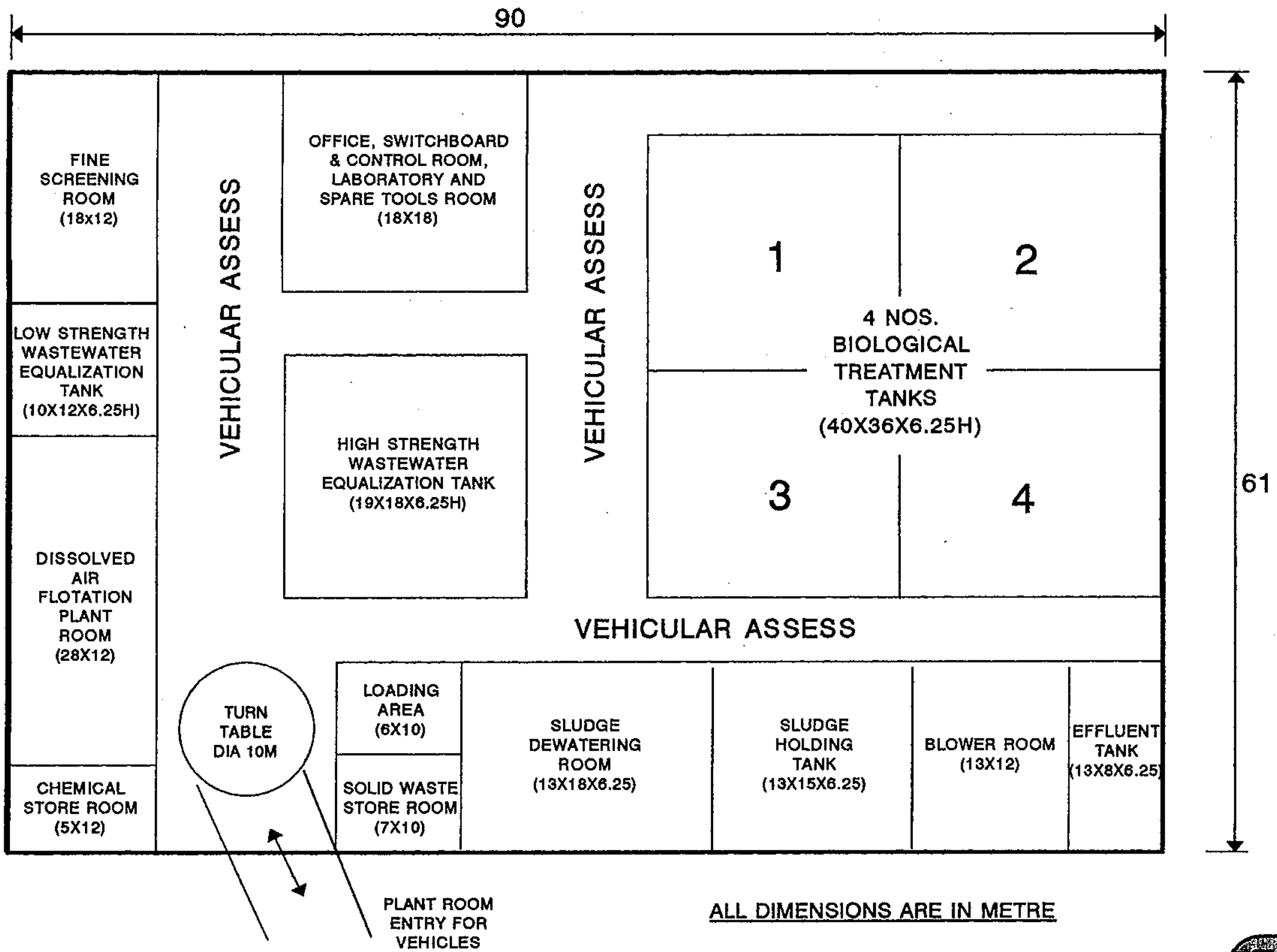


FIGURE 8.4 LAYOUT PLAN OF UNDERGROUND WWTP FOR SCHEME 1
SEPARATED TREATMENT FOR HIGH & LOW STRENGTH WASTEWATER

Feasibility Study of Sheung Shui Slaughterhouse

Scheme 2 : Combined Stream for Biological Treatment

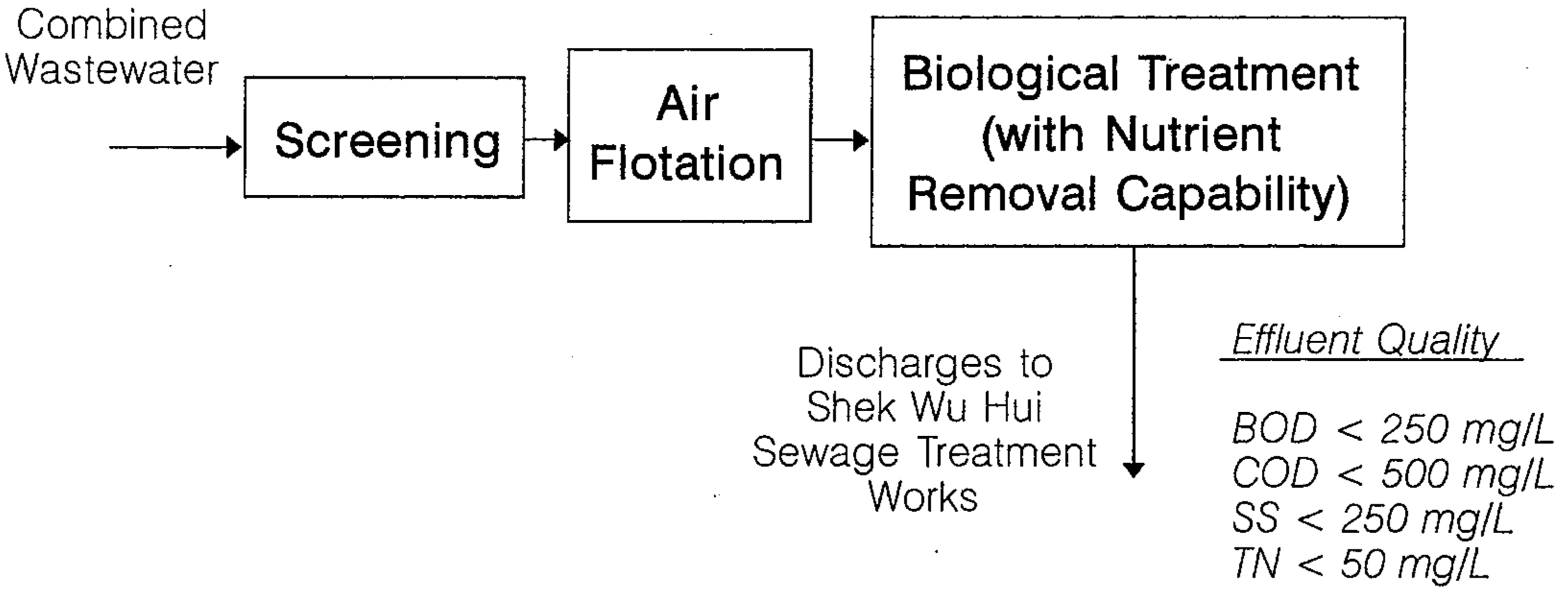


Figure 8.5 Schematic Diagram of Scheme 2

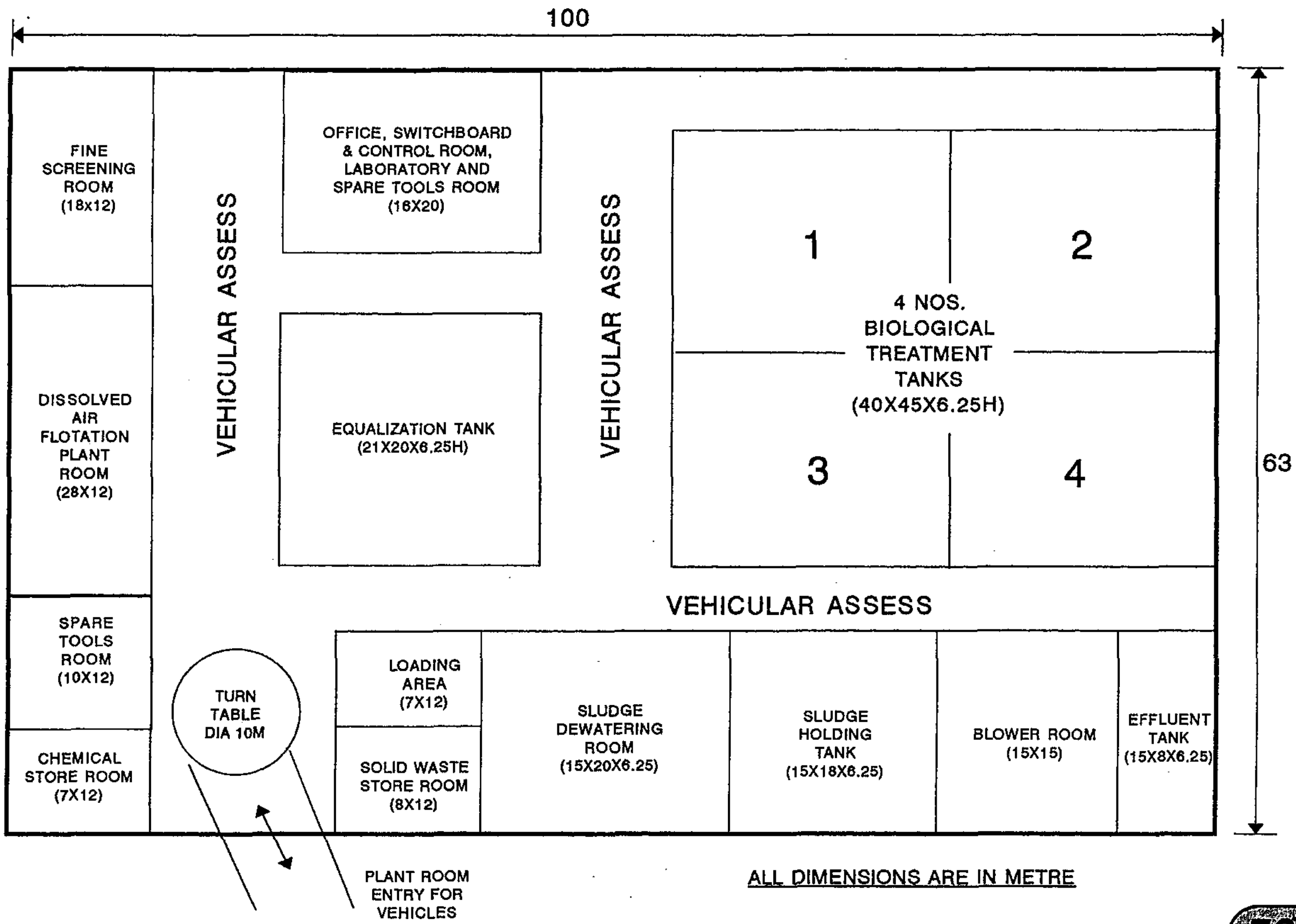


FIGURE 8.6 LAYOUT PLAN OF UNDERGROUND WWTP FOR SCHEME 2
COMBINED STREAM FOR BIOLOGICAL TREATMENT

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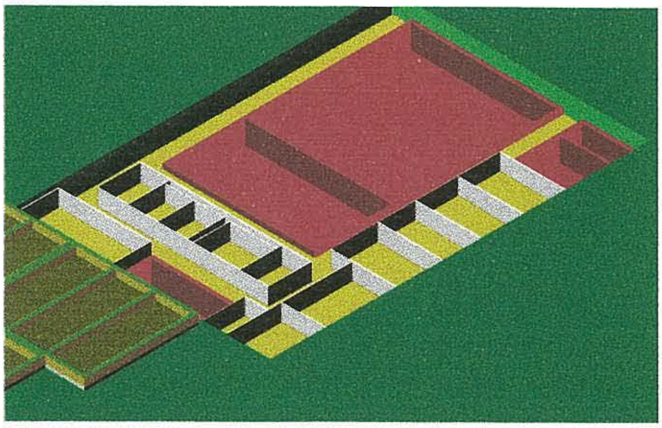


9. WASTE MANAGEMENT RECYCLING & DISPOSAL

9. WASTE MANAGEMENT, RECYCLING AND DISPOSAL

Sources of Solid Waste

9.1 In order to minimise the impact of solid wastes generated in the operation of the proposed slaughterhouse the following issues will be addressed:

- Ensure efficient, operator safe collection, storage and disposal of solid wastes;
- Avoid solid waste contamination of products, by-products, working surfaces and wastewater; and
- Maximise potential recycling of solid wastes.

9.2 Solid wastes generated from the operation of the proposed slaughterhouse have been identified and estimates of their respective quantities and disposal options are given in Table 9.1. This table does not include by-product solids which will be sold and therefore do not require disposal i.e. cattle heads, hides, hooves, tails, horns.

Table 9.1: Solid Wastes and quantities

Waste Type	Quantity (tonnes/day)	Moisture Content	Point of On-Site Storage
coagulated blood*	12.0	75% (70%)	1. blood coagulation room ($200m^2$)
paunch contents, discarded offal**	10.2	75%	2. refuse collection room ($40m^2$)
manure, discarded fodder, straw**	3.8	70%	
hair & bristles**	5.2	55%	3. bristles refuse collection room (40 m^2)
condemned meats & offal**	3.6	----	4. condemned meat freeze/chill room (80 m^2)
dewatered sludge***	30-40	35%	wastewater treatment plant
Office wastes	0.03	<10%	5. administration building
food remnants, tins, bottles, etc.	0.056	55%	

Note: Coagulated blood and condemned meat and offal will be eliminated by the installation of a full-scale BPP.

* Based on the calculation = (90% weight after coagulation, 90% weight after dewatering) = 13.6T/day x 0.9 x 0.9 = 11.02 T/day

** Based on the current estimation of the existing abattoirs at Kennedy Town, Cheung Sha Wan, and Yuen Long

*** Based on the calculation in Section 8.

Collection and Transportation

9.3 Collection and transportation of solid waste will be by road haulage. Safe and secure transfer of solid waste is a priority. The system provided by the contractor will have to ensure safety and security is implemented and maintained. The following are proposed.

- fully enclosed transit skips for collection and storage of waste on-site
- trained personnel will exclusively deal with collection and transfer of wastes
- minimum handling - efficient transfer equipment such as skip handler, conveyor belts, etc.
- spillages: suitable cleaning equipment, conveniently located in the loading bays.

Wastes generated by slaughterhouse operations

Blood

9.4 Sufficient quantities of blood will be produced from the pig, suckling pig, cattle and goat slaughtering areas and lesser quantities from the pig and cattle viscera handling areas and roaster pig offal cleaning room. Blood will be generated throughout the hours between 0200 and 1200 and will be collected in blood tanks and transported via blood transport facilities to the blood coagulation room. Efficient use of the collection and transfer equipment should aim to minimise the spillage of blood and therefore avoid washwater contamination.

Blood will be transferred to the blood coagulation room for rendering. The continuous blood coagulation processes including coagulation, centrifugation and belt press ensure a coagulum of 25% dry solids' contents which meets with EPD's recommendation prior to disposal to the designated landfill site.

By-products; Paunch Contents & Hairs and Bristles

9.5 By-products will also be generated throughout the slaughter hours between 0200 and 1200. The paunch contents will be generated from the pig (porkers and roasters) viscera areas and cattle handling viscera areas. The paunch contents which contain high moisture content and high suspended solids will then be directed to an enclosed isolated room where a dehydration process will separate liquid from solid. Separated solids will be loaded into collection facilities while the separated liquids will be directed to the wastewater treatment plant.

9.6 Hair and bristles collected from the pig, suckling pig, cattle and goat slaughtering areas located on (L2) and passed to the bristles storage room (L1) for storage prior to disposal.

Condemned meat & offal

9.7 At any point throughout the slaughterhouse facility condemned meat and whole animal carcasses will be removed from those areas and directed to the condemned product collection room on the level 1. Condemned meat will also be generated in smaller quantity form the AFD Veterinary and health inspector's laboratories

9.8 Discarded offal collected from pig and cattle viscera handling area, and roaster pig offal cleaning room, are also passed to manure collection room (L1) for storage prior to disposal to the designated landfill site.

Lairage wastes

9.9 Manure, discarded fodder and bedding from pig and cattle wholesaling, holding, waiting lairages, and isolation rooms, and goat pens, located on all floors (L1 - L3) are collected by two methods:-

- Dry cleaning: solids collected and transported to enclosed refuse room on level 1 for storage prior to disposal
- Wet cleaning: solid and liquids separated, solids pass to enclosed refuse room on level 1 for storage prior to disposal

9.10 All lairages will be cleaned regularly and manure will be directed to the two manure storage rooms situated at opposite ends of the lairage block of the slaughterhouse. lairages on the level 2 will be connected to the storage rooms via manure chutes. Straw bedding will only be provided in the cattle lairages.

Wastewater solids

9.11 Fine screenings will be placed at appropriate openings to drainage network. Scum, O & G from grease traps, organic solids, hairs and bristles, etc. will be removed frequently to maintain efficiency of screens and prevent contamination of wastewater. The total quantity of wastes collected from screening will be around 10 tonnes/days

Sludge

9.12 The quantity of sludge produced depends mainly on the amount of Total Suspended Solids (TSS) and BOD_5 removed. As performance efficiency in terms of their removal increases, sludge quantity generally increases. The sludge generated from a WWTP, which will cater to meet or exceed the Technical Memorandum (TM) standard, will be estimated as 30 tonnes/day. If the other option of biological treatment to a level without TES will be considered, the sludge produced in this scheme is estimated to be 40 tonnes/day.

Office Wastes

9.13 Substantial amounts of waste can be generated from office operations; common office wastes include paper and paper products, cardboard, metal, wood, and organic materials such as food wastes. Paper accounts for the bulk of the waste from offices; studies have shown that each individual office worker generates between 200g and 700g of paper per day. Most office waste is not hazardous, although some office products may contain hazardous constituents. Common waste materials from office operations are listed in Table 9.2.

Table 9.2: Common Wastes Generated from Office Operations

Activity	Waste
General	Paper (various grades), cardboard, laser jet printer toner cartridges, photocopying toner cartridges, printer ribbons, type-writer ribbons, pens, pencils
Mailroom and loading dock	Junk mail, envelopes, packaging waste (cardboard, plastic, shrink-wrap, metal bands, polystyrene "peanuts," bubble-wrap, pallets)
Employees' personal consumption	Newspapers, food, aluminium cans, glass and plastic beverage container, paper and polystyrene cups, paper bags, fast-food packaging
Maintenance	Chemical cleaning products, empty containers, rags or paper towels, light bulbs
Miscellaneous	Surplus or broken equipment, file folders, disposable pens, pencils, paper clips, staples
Miscellaneous (hazardous wastes)	Batteries, correction fluids formulated with solvents (e.g., White Out), cleaning chemicals, mercury ballasts from fluorescent lights

Waste Management

9.14 In fact, the most cost-effective waste reduction techniques are simple and relatively inexpensive changes in production procedures of slaughterhouse. Available techniques include: improving current operation and maintenance procedures; changing the materials used in production; and employing more efficient and more cost-effective-equipment.

Improving current operation and maintenance procedures

9.15 For slaughterhouse business, the first step in instituting improved operations geared to pollution prevention is to examine the current production process for ways to improve its efficiency. A comprehensive set of good operating practices will lead to wastes prevention.

9.16 Waste segregation is one way to prevent mixing of hazardous wastes with non hazardous wastes, to store materials in compatible groups and to isolate liquid wastes (e.g. waste water) from solid wastes (sludge and condemned meat etc.). In SSSH, it is useful for the future operator to institute facility management, such as the maintenance of equipment history cards on equipment location, characteristics, and maintenance, the keeping of a master preventive maintenance schedule for regulating maintenance work and repair history of the slaughterhouse processing equipment and wastewater treatment plant etc.

Changing the materials used in production

9.17 The operator of new slaughterhouse should have an objective to change hazardous materials used in either a product formulation or a production process into a less hazardous or non hazardous materials. A less hazardous material used in the production process of slaughterhouse will generally reduce the amount of hazardous waste produced and, in turn, reduce the cost of capital equipment needed to meet environmental regulatory limits.

9.18 Examples of using synthetic enamel points in daily marking will not be recommended, because they contain heavy metals. It will not be environmentally friendly that the operator will use new paint based on water solvents.

Employing more efficient and more cost-effective equipment

9.19 Waste generation may be reduced by installing more efficient equipment or by modifying existing equipment to take advantage of better production techniques. Not only can new or updated equipment process materials more efficiently, it produces less wastes. Also, by reducing the number of rejected or off-specification products, high-efficiency systems reduce the amount of material that must be discarded.

9.20 In the analysis, waste reduction is not an environmental issue, but a competitive one. Innovative business management methods are also a critical part of any waste reduction effort. Technology alone will not reduce waste - it must be coupled with significant employee involvement. Therefore, good management teams and co-operative employee will facilitate waste recovery techniques which can help eliminate waste disposal Costs, reduce raw material costs, and possibly income from a saleable waste.

Management options for the wastes generated by slaughterhouse operations

9.21 An evaluation of wastes generated by slaughterhouse daily operation is assessed to be about 12 tonnes of coagulated blood, 3.6 tonnes of condemned meat and offal, 10.2 tonnes of paunch contents, 5.2 tonnes of hair and bristles, and 3.8 tonnes of manure and bedding fodder (See Table 9.2a). Since the quantities of individual types of lairage wastes and coagulated blood are so high, odour and wastewater emissions are tremendous loading entering the nearby environment. As a result, the reduction of slaughterhouse operational waste is a significant goal in a pollution prevention programme. In slaughterhouse operation, the first step in waste management is a detailed assessment of all waste production. This includes the review of production records to determine a realistic mass balance accounting of all animal wastes and operational wastes during slaughtering of animals. This includes not only the number of animals in slaughterhouse, but also an accounting of on-site disposal services and on-site recycling and reclamation efforts.

9.22 In dealing with the animal wastes, the operators should plan for the segregation of wastes by type to allow for sorting and recovery. To obtain the highest market value, recyclable materials should be source-separated, that is collected in separate containers and free of any contaminants. For example, the coagulated blood will be put into a container which will then be directly collected for transportation. The paunch contents, discarded offal, discarded fodder, hair and bristles refuse should be contained in an enclosed vessels prior to disposal. The manure should be segregated from the rest of animal wastes and placed in other containers. Condemned meat should be stored in condemned meat refrigeration room with odour control technologies.

9.23 The source reduction analyses the wastestreams of the slaughtering line and lairage facility to identify any opportunities for source reduction and recycling. Some of the coagulated blood will probably be sold to the nearby markets including Sheung Shui, Yuen Long and Fanling. This will need some further market research closer to the commissioning date of the SSSH to find exact suppliers, and hence the market, for the coagulated blood.

9.24 Apart from selling the coagulated blood, the blood must be processed prior to disposal to landfill in order to reduce the water content. A continuous process will be used to process the coagulated blood, so as to generate an increase in dry solids content to 25%, to meet the EPD's requirement. Condemned meat and offal will be placed in the fully enclosed standard size transit skips during transportation. Odour mitigative measures, such as the installation of ozonizers, will be recommended for eliminating odour nuisance. The condemned meat and offal is to be disposed of at the proposed CIF, in accordance with EPD's requirement.

9.25 Paunch contents may require drying. Mechanical dehydration generally only achieves a dry solids contents of >20%, however, the use of strongly dehydrated machines, such as screw presses, can achieve a dry solids content of >35%.

9.26 Other animals wastes, such as discarded offal, hairs and bristles will be transported by the contractor to the landfill for disposal. There will be no significant off-site environmental impact from transportation of wastes from SSSH to the NENT landfill because: wastes will be containerised and moved in enclosed vans, therefore creating no odour nuisance; the number of vehicles going to the landfill will be small, therefore having minimal effect on noise levels and air quality.

9.27 All the above management options for the wastes generated by slaughter house operations are considered under the scenario of the absence of a full-scale BPP at SSSH. If the CIF cannot tie in with the development of the SSSH, interim measures should be adopted so as to address the problems of condemned meat and offal: either the existence of a full-scale BPP or disposal to landfill. In the case of a full-scale BPP, the coagulated blood will be processed through a continuous rendering process plant while the condemned meat and offal will be processed in batch cooker for the assurance of disinfection. Then, the blood, condemned meat and offal will be recovered for animal feed supplement. In this case, the odour control technologies for the by product plants need to be addressed in order to minimise the odour nuisance. In the case of a reduced-scale BPP, the coagulated blood only will be processed.

9.28 If the construction of CIF is indefinitely delayed and there is no full-scale BPP, the condemned meat and offal will be disposed of at landfill. However, this may have some hygienic considerations if the condemned meat and offal have been infected by an epidemic. This problem should be carefully addressed in the detailed design stage.

Table 9.2a: Summary of disposal points for solid wastes

Waste Type	**Quantity (tonnes/day)**	**Disposal Points**
coagulated blood	12.0	full or reduced scale BPP/ landfill
paunch contents, and discarded offal	10.2	landfill
manure, discarded fodder, straw	3.8	composting or landfill
hair & bristles	5.2	landfill
condemned meats & offal	3.6	full-scale BPP/ incineration/ landfill
dewatered sludge	30-40	direct land application/ landfill
Office waste	0.03	landfill
food remnants, tins, bottles, etc.	0.056	landfill

Sludge Management

9.29 In this analysis, four alternative sludge management options were considered:

- Direct land application
- Composting with the give-away of the finished products
- Incineration with the disposal of ash to landfill
- Land disposal in a dedicated landfill or a refuse landfill

Direct Land Application

9.30 In direct land application, treated sludge is hauled to a site in a liquid or dewatered state and injected into, or spread and incorporated into the soil. The nutrient-rich organic matter in the sludge provides a food source for microbiological organisms and earthworms, which provide nutrients for crop uptake and benefit soil structure. The beneficial reuse of treated trade effluent to increase crop production which also reduces the potential pollution from the use of chemical fertilisers. The organic material in the sludge also increases the soil's ability to store water and hence acts as a soil conditioner.

9.31 The treated sludge is hauled to some organic farms or possibly agricultural land operated by the AFD for direct land application. The detailed scheme of direct land application to some local organic farms will be pending on further pilot study on application of treated sludge from an existing slaughterhouse. Should direct land application still leave an excess quantity of sludge, then disposal to landfill would be considered.

Composting

9.32 Composting is an aerobic decomposition process, usually out in open piles. It is assumed that composting is by the static aerated pile method with wood chips or similar materials used as the bulking agent. No credit is given for the sale of the compost, which is often the case. The dewatered sludge feed of about 20% to 30% solid will be produced. The finished compost will be useful for plantation purpose.

9.33 Since EPD provides a free composting service to livestock farmers in control area (EPD, 1994), sludge composting at Government composting centre at Sha Ling should be investigated.

Incineration

9.34 Incineration may be considered as one of the management options. The incineration of sludge at SSSH will not be considered as it generates environmental nuisances. At present, there is no incineration facility for sludge. The proposed CIF, located in Tuen Mun, New Territories, is expected to commence operation in mid-1997. The proposed CIF will cater for special wastes, consisting of clinical wastes, animal carcasses (including animal by-products), and security wastes. The CIF is expected to have a total daily waste throughput of up to 40 tonnes/day by 2012. Therefore, there will be no room for slaughterhouse sludge handling.

Land Disposal

9.35 There are currently three strategic landfills in Hong Kong, West New Territories (WNT), South East New Territories (SENT), and North East New Territories (NENT). All these landfills are capable of accepting the slaughterhouses solid waste, however, NENT is the closest, being located to the west of Wong Mau Hang Shan. In the case of landfilling, the sludge is deposited in a dedicated landfill (NENT in this case). The sludge at 30% solids which meets with EPD's recommendation, is transported to landfill. In this case, the sludge assists in the anaerobic decomposition of the solid waste and may be considered a beneficial addition to the landfill. Four trucks will be suggested for the transport of sludge to landfill for disposal if the management option is to be considered.

9.36 The management option of sludge handling associated with operating slaughterhouse is a function of level of wastewater treatment, plant size, location, and transportation.

There are opportunities for sludge recycling and demand-side management. Therefore it is highly recommendable to have sludge for direct land application subject to pilot study of the application of slaughterhouse sludge generated from an existing slaughterhouse. Around 30 - 40 tonnes of dewatered sludge will be disposed to landfill. The current charge for the disposal of sludge by private contractor is HK $2000/truck, i.e. about $8000/day assuming 10 tonnes/truck.

Waste Management in Office Operations

9.37 Office wastes are amenable to a range of relatively simple prevention and recycling techniques. Waste prevention and recycling in the office typically does not involve a large capital investment, engineering changes to production lines, or extensive staff training.

9.38 Source reduction or waste prevention refers to efforts given to reduce the quantity and the toxicity of the materials and products used and then discarded from any operation in slaughterhouse. Therefore, SSSH should focus attention on targeting procurement with a view to reduce the toxicity or amount of a product or package destined to become waste, and to avoid the purchase of toxic materials eliminates the transportation, storage, use and disposal of these materials. Common source reduction procurement practices are listed below:-

- Requiring full utilisation of materials;
- Using more durable goods;
- Minimising unnecessary packaging;
- Eliminating the use of disposable or single-use items;
- Material substitution for toxic material reduction;
- purchasing energy - or water-efficient products; and
- purchasing long-shelf-life items.

9.39 In office operations, recycling recovers materials destined for disposal and converts them into useful products. Recycling benefits are well documented; the most obvious benefit is the conservation of natural resources. Recycling can also be financially beneficial. Some recycling facilities will pay for recycled materials such as aluminium, while others will accept the materials but pay nothing for them or charge a fee to collect and process the recycled materials. If enough material is diverted from the wastestream by recycling, less material would be sent to the landfill which may also translate into savings from reduced disposal fee. Moreover, the slaughterhouse operator may act as an environmentally friendly consumers by purchasing and using products made with recovered materials, from acoustical tile to wastebaskets, are available for purchase. An entire office can be supplied with everything from wallboard made with recycled newspaper to carpet made from recycled plastic bottles.

9.40 It may be helpful to establish a company-wide procurement policy stating a preference for reusable, refillable, and less toxic products, as well as those with recycled content. Therefore, reducing the amount of waste that requires disposal should be a priority for every operation in SSSH facility, including the office. Waste preservation and targeting purchasing practices play an important role in reducing the volume of products and packages that become waste waiting for disposal. Then, recycling and recovery of valuable resources for reuse should be considered as environmentally friendly approaches.

Chemicals

9.41 The potential sources of chemical usage during the operation of the proposed slaughterhouse have been identified and are listed below in Table 9.3; the various chemicals listed also include materials which are categorised as Dangerous goods according to the Dangerous Goods Ordinance (CAP. 295). The chemicals are sodium hydroxide and sodium hypochlorite. In order to minimise the potential impact of chemical usage i.e. excessive use and accidental spillage, the main aim of the contractor should be to minimise usage in all areas and maintain efficient packaging and storage.

Table 9.3: Chemical Usage

Chemical	Origin	Pattern of Generation	Quantity
Ammonia/ Refrigerant R507	Cold Room Chill Room Walk-in-Freezers	Continuous Usage	Not available (normally handled by the supplier)
Residues of oil & lubricants	E&M Facility	Continuous Usage	4 gallons/ annum
Synthetic Enamel Paints	Wholesale / Waiting Lairage	Daily Marking Wastewater Scalding Tank	12 gallons/ annum
Oxidising Bleach (Active ingredient; Calcium	All Lairages	Cleaning - Every 3 months Wastewater	16 gallons/ annum
Disinfectant agents Medical Waste (incl. glassware)	Veterinary Laboratory & Inspector's Laboratory	Daily Cleaning Work Surfaces Occasional Usage	minor quantity
Sodium Hydroxide & Sodium Hypochlorite	Wet Scrubbers	Continuous usage	2 tonnes/ day 1 tonne/ day
Paraffin wax based rat baits; Chloralose, Thallium Sulphate, Crimidine, etc.	Condemned Meat Lairage (Pest Control)	Minimal Usage	Not available (handled by pest control contractor)
Neutralising agents	All lairages	Odour control Daily use	N/A

Recycled Paper

Recycling/Reduction Chemical Usage

9.42 In connection with the usage of refrigerants, non-CFC refrigerants should be used. There are other refrigerants, including butane and propane, on the market which are inherently less polluting to our environment. With regard to the current usage of refrigerant R507, a refrigerant leak detection system will be installed to allow rapid detection of minor leaks and thereby undue losses may be prevented. Losses will be further avoided by sufficient refrigerant circuit maintenance with particular attention to joints, seals, etc. of the equipment. Refrigerant will be recovered and recycled also during servicing and maintenance of refrigerant equipment.

9.43 Disinfectants, bleaches, paints will be utilised at relatively high concentrations to minimise quantities handled and stored. The concentrations will be diluted sufficiently as to have an negligible effect on the wastewater treatment system. A high standard of hygiene in the condemned meat area will be maintained e.g. coverage of condemned meat, etc. will avoid excess use of rodent poison and all openings to this area will be blocked with mesh or suitable covering and regularly inspected for signs of contamination. Storage all rodent poisons will be locked in a clearly defined storage facility.

9.44 Maximum use of refillable containers will be maintained in order to minimise waste generated from disposal of these chemical containers e.g. polyethylene drums for Sodium Hypochlorite and Sodium hydroxide storage. Final disposal of drums/containers may be pierced or crushed prior to disposal to minimise impact upon final disposal site.

Chemical Handling and Disposal

9.45 All chemicals in use will be stored, packaged and handled in strict accordance with specifications outlined in the "Dangerous Goods Ordinance (Cap. 295)". The proper management of chemical waste is outlined under the "Waste Disposal Ordinance (Cap. 354)". Adherence to these specifications will ensure minimum impact upon the environment and personnel staff due to accidental chemical spillage, container leakage or unsatisfactory chemical waste disposal.

Storage and Packaging

9.46 Chemicals used routinely will be stored in a specified area which is clearly labelled, well-ventilated with an impermeable floor covering. Partition walls will be provided to ensure segregation of different categories of chemicals if required.

9.47 Sodium Hydroxide and Sodium Hypochlorite however will be stored and handled away from all other activities including the general chemical storage area e.g. located on the roof and should be maintained by specified trained personnel.

9.48 All containers will be clearly labelled with the appropriate symbol e.g. flammable, toxic, irritant, etc. All personnel will be instructed to the meaning of the chemical labelling provided on containers.

9.49 Routine inspections of chemical containers (particularly after transportation) for damage, leakage, corrosion, operational closing mechanism, etc. will reduce wastage and ensure safe handling. An up to date inventory of all chemicals will also be maintained.

9.50 Specific personnel will be given training / instruction in the safe handling and transport of chemicals to avoid accidental spillages. However equipment to combat potential spillages will be provided in readily accessible locations i.e. fire extinguishers, empty storage drums, absorbent materials, cleaning materials, hand-operated pump, etc. Sufficient provision of safety and protective equipment for handling chemicals; gloves, goggles and protective clothing will also be conveniently located.

Chemical Waste Disposal

9.51 The future management of the SSSH, will be required to register with the Environmental Protection Department as a Waste Producer under the Waste Disposal (Chemical Waste)(General) Regulation (CWR). The management must be responsible for complying with the regulatory requirement specified therein before engaging in activities that produce chemical wastes.

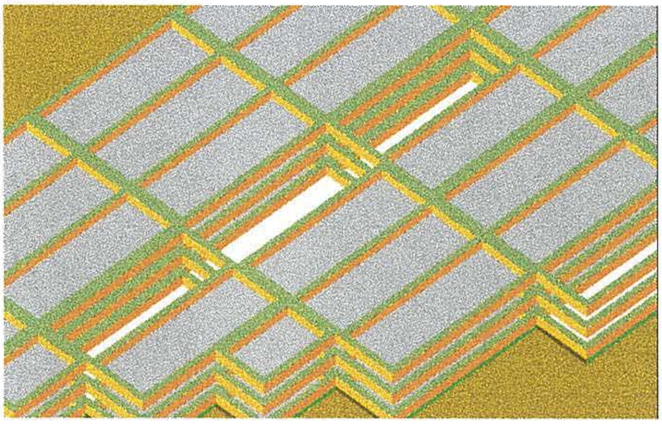
9.52 The chemicals requiring routine disposal will generate mainly from the veterinary and inspector's laboratory. These wastes will be properly contained and labelled and stored in a safe manner prior to collection and disposal.

9.53 The SSSH management will arrange a qualified and responsible licensed Waste Collector to collect and transport their chemical waste arisings to a licensed Waste Disposal site for treatment and disposal. The Chemical Waste Treatment Centre at Tsing Yi is a licensed waste collector and disposal site which would ideally take care of the SSSH chemical waste arisings. Collection or disposal of chemical waste without a licence is an offence liable to prosecution, as is any breach of licence terms and conditions.

9.54 SSSH management will follow the requirements for Waste Producers stipulated in the CWR and in the Code of Practise on the Packaging, Labelling and Storage of Chemical Wastes

9.55 Licensed waste collectors have to submit monthly returns of all trip ticket transactions to the EPD for monitoring and record purpose.

9.56 Only licensed waste collectors should transport chemical wastes to the licensed treatment/ disposal facilities.



10. IMPACT ON LAND USE

10. IMPACTS ON LAND USE

Current Surrounding Environment

10.1 Operations described in Section 2 will not impinge upon the study area as described in Section 3.

10.2 The wastewater generated from the slaughtering activities will contain high concentrations of inorganic matter (in terms of biochemical demand), nutrients, and O & Gs. Different wastewater management options will leave different impacts on the SWHSTW. If the wastewater is to be treated in a full scale wastewater treatment plant, then there will have to be an extra loading to the SWHSTW. If the slaughter house wastewater is to be treated up to TM standard or to be a standard equivalent to domestic discharge, there will have to be a strong implication on the upgrading and / or expansion of SWHSTW in the future.

Future Environment

10.3 It is necessary for the assessment of operation phase impacts to include consideration phase impacts and to give consideration to future proposed land uses.

10.4 The proposed future land uses include the following:

- flood balancing reservoir
- sewage treatment plant;
- river channelling
- Tsung Pak Long (Village)
- Tai Tau Leng (Village)
- Government/ Institution/ Community Use Area
- bus depot
- Sheung Shui Tsuen (Village)
- general green belt
- miscellaneous undermined areas; and
- ponds and agricultural land uses.

10.5 Upon the request of the Drainage Services Department, the Town Planning Board will consider rezoning the "Other Specified Use (Helipad)" site and portion of the "Industrial" site to the south-east of the proposed SSSH to "Other Specified Use (Sewage Treatment Plant)" on the draft Fanling/Sheung Shui Outline Zoning Plan. This will then tie in with the likely expansion of the Shek Wu Hui Sewage Treatment Works.

10.6 The proposal for locating the slaughter house in a remote location away from residential blocks is appreciated. With mitigation measures, the slaughter house operations will have minimal environmental impacts on the surrounding sensitive receivers, such as Tsung Pak Long (Village), Tai Tau Leng (Village) and Sheung Shui Tsuen (Village).

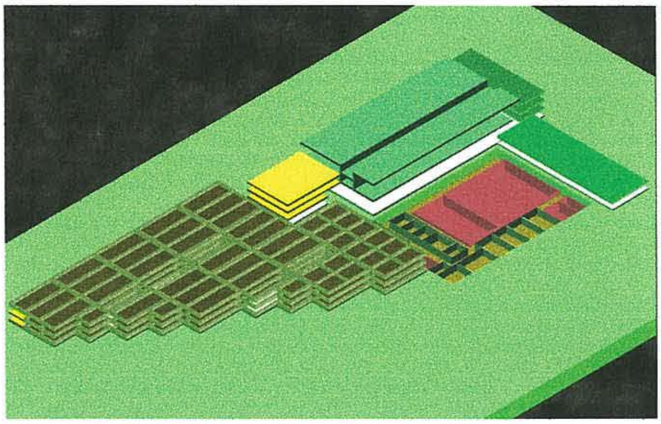
10.7 A buffer zone surrounding the site will be recommended through planning/ regulation to prevent any further incompatible development for intensive urban uses nearby and to minimise any potential conflict between the nearest residents and the SSSH. Therefore, the establishment of a general "Green Belt" should be considered which could include the co-existence of the present land use (i.e. ponds and agricultural land) and also the STW.

The buffer distance between the SSSH and the nearest sensitive receiver depends on the BPP option employed. The buffer distance relates to the odour units received at the SRs, since the recommended limit of 5 OU should not be exceeded at any of the SRs. In the case of a full-scale BPP, according to the odour modelling in Chapter 6, there is exceedance at SRs 2 and 7 and therefore the buffer zone extends beyond these 2 SRs. There is no exceedance, however, with the scenario of a full scale BPP with 5 stacks, with an emitting height of 40m. In theory, therefore, a buffer zone would not be required, although it would be recommended to restrict any development (i.e. establish a "Green Belt") to outside a 150m, distance from the site boundary (i.e. from SR2 to SSSH). In the case of a reduced scale BPP, again there is no exceedance at any of the SRs and any condemned meat and offal will be immediately containerised and removed from the site in enclosed vans.

The site itself is in a relatively large open space with the advantage of any buildings in the vicinity being of low-rise. For the two scenarios with no exceedance, these factors combined with the minimal odour impact from the SSSH, with its environmental protection measures will mean that the present "Green Belt" surrounding the site will be more than sufficient to prevent any odour nuisance.

10.8 As the slaughter house is to be located in low-lying ground, the development of flood balancing reservoirs and river channelling will probably be favourable. This is to ensure that there will also be no potential adverse implications to the slaughter house as a result of flooding.

10.9 All future developments must not impinge on the green belts and full consideration must be given to development impacts on SSSH operations. The ultimate effectiveness of the buffer area (including the STW) therefore rests with the Town Planning Board to keep the Green Belt intact.



11. VISUAL IMPACT

11. VISUAL IMPACTS

Visual Sensitive Receivers

11.1 Residents of the low-rise village houses will be the most sensitive receivers of visual impact. This is a result of the proximity of the slaughterhouse and the relative mass of the building in comparison with the small-scale units of the village settlements and surrounding farmland.

11.2 Residents of high-rise blocks in the northern area of Sheung Shui will also be able to see the proposed slaughterhouse. However, such development is relatively distant from the Site and the individual structure of the slaughterhouse, when viewed alongside the sewage treatment works and industrial estate, is unlikely to be less visually intrusive to these sensitive receivers.

11.3 Passengers of trains travelling between Sheung Shui and Lo Wu KCR stations will pass closest to the slaughterhouse. Due to the speed of the train the visual impact will be transitory and the proposed building will tend to be seen as a component of the existing development of sewage treatment works, temporary housing areas, and urban/industrial estate fringe alongside the railway corridor to the south.

Mitigation Measures

11.4 Planning and landscape design will need to be incorporated into the site boundary, with particular reference to areas visible to village housing. Provision of mounding and structural planting at the construction phase will provide a basis for further landscape design. This should aim to join all other areas of vegetation.

11.5 Opportunities to introduce peripheral landscape screen-planting will be identified to screen village housing. The predominantly low-lying surrounding landscape will mean that the proposed plant will have a high level of visibility from the adjacent farms and villages emphasising the need for landscape screen planting to the periphery of the site as shown in Figure 11.1. The additional areas that would be planted would be an approximately 150m long screening for Fu Tei Au village to the north-east of the site and also approximately 450m to the south-east of the site, screening Wai Loc Tsuen as shown in Figure 11.2. The exact areas to be landscaped will be laid down in the detailed design at a later stage.

Extensive screenings around the boundary of the site and particularly along the KCR siding will help to link together other areas of boundary structure and reduce the visual impact of more distant views from the northern areas of Sheung Shui. A combination of retaining walls and earth bunds with structural planting will provide aesthetically pleasing barriers between areas of different activity e.g. truck washing bay area and meat dispatch loading bays.

Boundary screenings will be planted along the north-east and eastern edges of the site along with the north-eastern boundary. Perimeter planting will also be carried out along the KCR siding.

11.6 The use of trees and shrubs should be maximised to soften the visual impact of outdoor areas such as car parks. Fast-growing semi-native and ornamental trees and shrubs will be used extensively outdoor in all possible areas to provide an aesthetically pleasing environment for personnel.

11.7 As the slaughterhouse is designed as a low-rise building, the visual impact will most affect the more immediate sensitive receivers. Incorporating the use of colour schemes and material finishes associated with the surrounding environment and structures, to the final building design should assist in reducing the visual impact of the slaughterhouse. Tile finish would provide large areas of flat colour and simple maintenance. Co-ordination of colour schemes and material usage will be required for the range of buildings within the site.

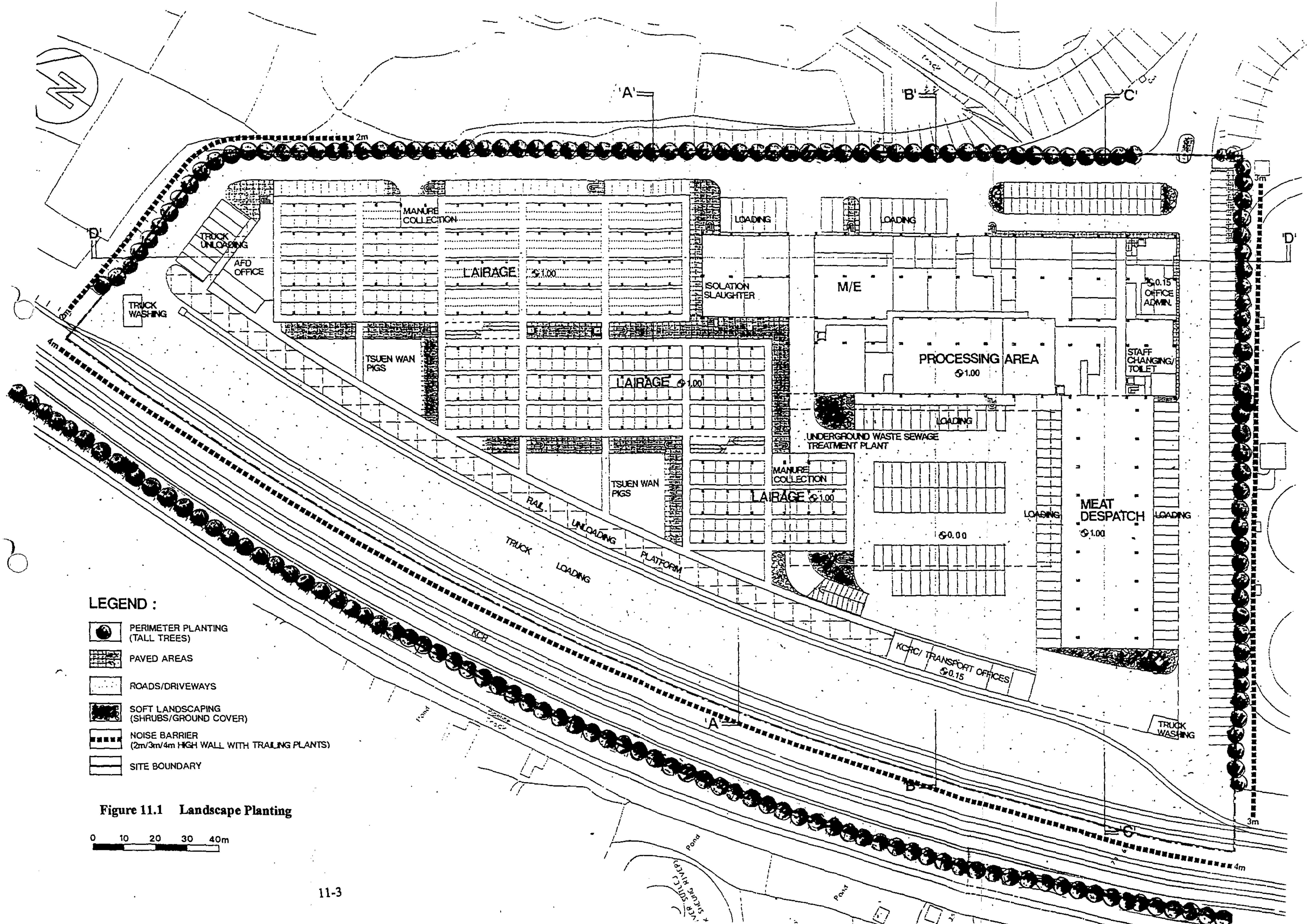


Figure 11.1 Landscape Planting

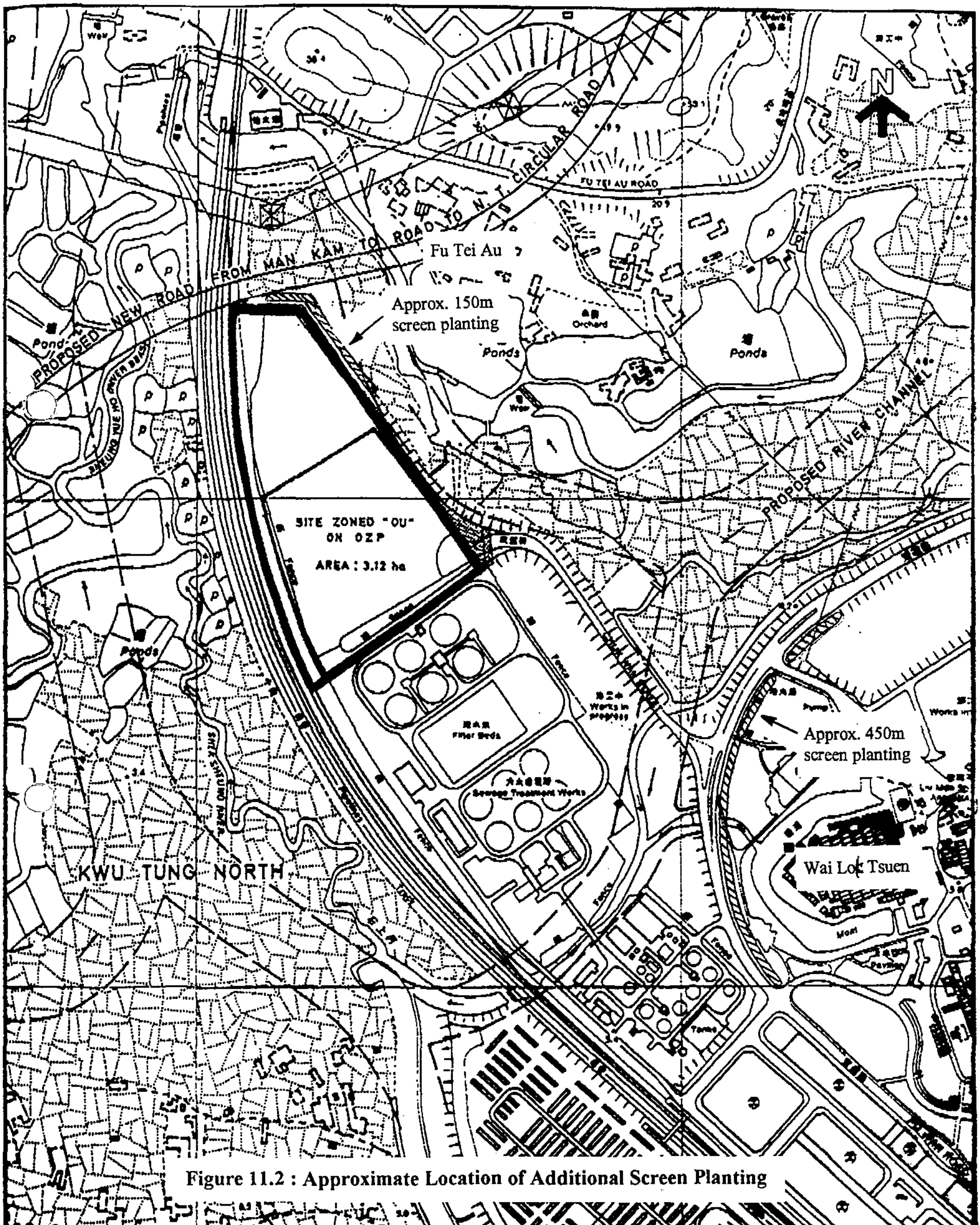
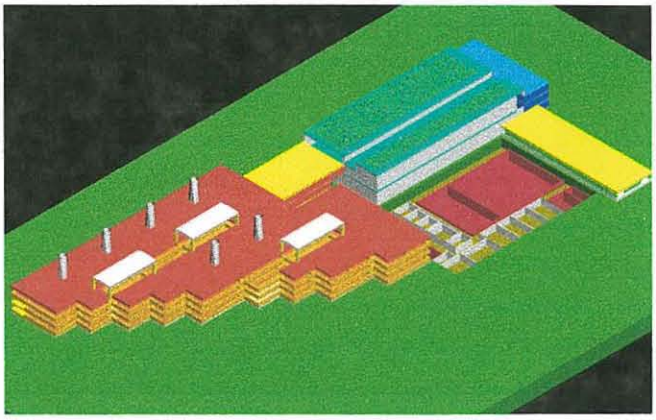


Figure 11.2 : Approximate Location of Additional Screen Planting



12. ENVIRONMENTAL MANAGEMENT SYSTEM

CONSTRUCTION PHASE

INTRODUCTION

12.1 The construction phase EMS aims to minimise any environmental effects arising from construction activities, and ensure that the construction of the slaughterhouse is managed in an environmentally responsible and friendly manner.

12.2 This construction phase EMS takes the form of an environmental management manual for the *Resident Engineer* and the contractors. The major focus of the EMS is the environmental effects mitigation, and monitoring & auditing requirements.

12.3 The major concern during the construction phase is the minimisation of the nature and extent of environmental effects which could arise during the construction of the slaughterhouse. The EMS developed here is dependent on the contractor implementing the operational controls and adhering to the quality performance limits set out herein.

12.4 The inclusion of contract clauses and operation requirements to control noise, air and water quality should be incorporated in the tender & contract documents specifying the requirements of the operator during construction activities.

ENVIRONMENTAL POLICY

12.5 The Environmental Policy of the SSSH will be a public commitment to the protection of the environment within, and external to, the slaughterhouse.

12.6 The EMS covers all areas of the construction of the slaughterhouse, and will be implemented at all levels. The core of the environmental constructions is the following Environmental Policy Statement:-

- *Minimisation of pollution and effluent discharges:* We will minimise the release of any pollutant or effluent that may cause environmental damage to the air, water or earth.
- *The sustainable use of natural resources:* We will make sustainable use of renewable natural resources such as water and forests. We will conserve non-renewable resources through efficient use and careful planning.
- *Reduction and disposal of waste:* We will minimise waste, especially hazardous waste, and whenever possible recycle materials. We will dispose of all waste in a safe and responsible manner.
- *Wise use of energy:* We will use environmentally safe and sustainable energy sources to meet our needs, and invest in improved energy efficiency technologies where available. Energy efficient management practices will be developed.
- *Risk reduction:* We will minimise the environmental, health and safety risks to our employees and the communities in which we operate by employing safe technologies and operating procedures, and by being constantly prepared for emergencies.
- *Environmental commitment:* We will commit management resources to implement this management system. All employees will be made aware of their individual responsibilities for acting in accordance with the company's environmental policy.
- *Good neighbour:* The company will seek to be a good neighbour, improve the aesthetic appearance of the site, develop a system for handling complaints and make every effort to provide an efficient and friendly channel of communication.
- *Assessment and annual audit:* We will conduct and make public an annual self-evaluation of our progress in implementing these principles and in complying with all applicable laws and regulations. We will work towards the timely creation of independent environmental audit procedures to which we will adhere.

ORGANISATION AND PERSONNEL

Responsibility, Authority and Resources

12.7 Responsibility of contractors should be defined and documented. The *Resident Engineer* must ensure the following:-

- sufficient resources are provided by the contractors for implementation of the EMS;
- any environmental problems are identified and recorded;
- solutions to any environmental problems are developed through designated channels;
- the implementation of solutions is verified;
- activities are controlled until correction; and
- emergency procedures are developed by the contractors.

Verification Resources and Personnel

12.8 The construction organisational flowchart is shown in Figure 12.2. The *Resident Engineer* should act as the link between the Client, the EPD and the Contractor(s).

Resident Engineer

12.9 A senior manager, hereafter referred to as the "*Resident Engineer*", to oversee the implementation of the construction phase EMS shall be appointed. The person should be sufficiently senior to effect change, with good managerial skills and an interest in environmental affairs. The individual is likely to have extensive construction management experience in addition to the educational qualifications. See also Paragraph 12.118 for the auditing skills required.

12.10 The job description of the *Resident Engineer* is likely to include, in addition to t "standard" Engineering duties, the following:-

- to supervise and authorise environmental audits on the construction of the slaughterhouse;
- to ensure that environmental standards set for contractors are maintained and improved;
- to ensure contractors are aware of the environmental requirements; and
- to maintain records relating to the contractors' environmental performance.

12.11 The *Resident Engineer* will receive reports from individual contractors, and ensure that contractors are acting according to SSSH environmental policy.

Training

12.12 The *Resident Engineer* will ensure that the contractors educate all their on and off-site staff. An explanation of the EMS should be the centrepiece of any training programme.

12.13 The contractors should be made aware of the contractual and legal requirements during construction, and of what is expected from the *Resident Engineer* with regards monitoring assistance and mitigation implementation.

12.14 In addition, procedures should be developed and maintained by the contractors to ensure that their staff, at all levels, are aware of:-

- the importance of compliance with the environmental policy;
- the significant environmental effects, actual or potential, of their work activities;
- their roles and responsibilities in achieving compliance; and
- the potential consequences of departure from specified operating procedures.

Communications

12.15 The *Resident Engineer* will be responsible for all communications with interested parties. Co-ordination of communications both internally and externally will be required. All reports, such as breaches of the TAT levels, and audits, should be signed off by the *Resident Engineer*. The chain of communications is shown in Figure 12.2.

Contractors

12.16 The Client, and *Resident Engineer*, must ensure that all contractors are aware of the relevant EMS requirements and provisions. This may include information leaflets (depending on the environmental commitment of the contractors used).

12.17 Suggested Contract clauses are listed in the SEIA Appendices, and should be used to ensure the contractors' operations are in accordance with the construction phase EMS.

12.18 The *Resident Engineer* must appoint an Environmental Team to conduct all monitoring and mitigation requirements. The team should report directly to the *Resident Engineer*.

12.19 Each contractor has permission to work within the periods of 0700 to 1900, provided that works under contract do not exceed quality performance limits as set out below.

12.20 The contractor has the duty to monitor the environmental effects, and to take remedial measures where the quality performance limits have been breached. If so instructed by the *Resident Engineer*, the contractor shall take appropriate remedial action. If the contractor fails to remedy the breach within reasonable time, the *Resident Engineer* has the duty to suspend the works, or any part of the works, without compensating the contractor.

REGISTER OF REGULATIONS

12.21 The regulations and requirements listed in "Register of Regulations" for Slaughter House Operations in section 12.152 - 12.202 also apply during the construction phase of the development. In addition, those regulations specifically applying to the construction phase are:-

Air quality

12.22 *Road Traffic (Construction and Maintenance of Vehicles) Regulations*
Specifies smoke levels for in-service vehicles.

Noise pollution

12.23 *Noise Control Ordinance*
Controls noise from commercial activities including ventilation noise. The ordinance is enacted through three Technical Memoranda and two sets of Regulations.

12.24 *Road Traffic (Construction & Maintenance of Vehicles) Ordinance*
Prohibits the use of motor vehicles without silencers or with a modified or defective silencer.

12.25 *Technical Memorandum on Noise from Construction Work other than Percussive Piling (TM1)*
Prescribes maximum noise levels for all construction activities that include powered mechanical equipment other than those required for percussive piling. Basic Noise Levels (BNLs) (Table 12.1) are set out according to an area's sensitivity rating (ASR) (Table 12.2). The definition of ASR A will apply to the study area, and there will be no effect from Influencing Factors (IF) in this area.

Table 12.1: BNLs for Construction Noise Other than Percussive Piling (dB(A))

Time period	A	B	C
All days during the evenings (1900 to 2300 hours)	60	65	70
General holidays (including Sundays) during day and evening (0700 to 2300 hours)	60	65	70
All days during night (2300 to 0700 hours)	45	50	55

Table 12.2: Areas Containing NSRs

Type of Area Containing NSR	Degree to which NSR is affected by IF: Not Affected	Indirectly Affected	Directly Affected
Rural area, including country parks or village type developments	A	B	B
Low density residential area consisting of low-rise or isolated high-rise developments	A	B	C
Urban area	B	C	C
Area other than those above	B	B	C

12.26 *Technical Memorandum on Noise from Percussive Piling (TM2)*
Regulations for the control of percussive piling include restrictions on piling times and the procurement of a Construction Noise Permit (CNP) issued by the EPD. The permitted hours of operation (Table 12.3) are determined by the amount by which the Calculated Noise Level (CNL) exceeds the Acceptable Noise Level (ANL) (Table 12.4).

Table 12.3: Permitted Hours of Operation for Percussive Piling

Amount by which CNL exceeds ANL	Permitted hours of operation
More than 10 dB(A)	0800 - 0900, 1230 - 1330 and 1700 - 1800
Between 1 & 10 dB(A)	0800 - 0930, 1200 - 1400 and 1630 - 1800
No exceedance	0700 - 1900

Table 12.4: ANLs for Percussive Piling

NSR Type	ANL (dB(A))
NSR (or part of NSR) with no windows or other openings	100
NSR with central air conditioning system	90
NSR with windows or other openings but without central air conditioning system	85

12.27 *Noise Control (Hand Held Percussive Breakers) Regulations*
Requires hand held percussive breakers to comply with specified noise emission standards and to be fitted with noise emission labels when in use.

12.28 *Noise Control (Air Compressors) Ordinance*
Requires hand and portable air compressors to comply with specified noise emission standards and to be fitted with noise emission labels when in use.

REGISTER OF INTERESTED PARTIES

Nearby Residents

12.29 Residents near the SSSH development reside in low-rise village houses, and relatively distant high-rise blocks to the north. Sensitive Receivers have been identified and consist of groupings north-west, south-west, south-east and north of the study site. The Sensitive Receivers include Noise Sensitive Receivers, and Air Sensitive Receivers, see Annex 12.2.

Workforce and Contractors

12.30 During construction activities, the workforce will consist primarily of contracted parties. Contractors will greatly affect the success or otherwise of the construction phase EMS. Their interest in environmental issues will relate to any environmental policy the individu contractors operate, and to any cost implications of compliance with the slaughterhouse's environmental policy.

Environmental Interest Groups

12.31 The initial construction activities will serve as a barometer of the environmental commitment of the slaughterhouse operators. Good working relations with these groups is important, and central to good media and public relationships.

12.32 During the construction stage the *Resident Engineer* should ensure communication with the Groups is maintained, and tours of the site showing all the mitigation measures adopted and constructed would be advantageous.

The General Public

12.33 Potentially less well informed than the other interested parties, the general public has enormous power to affect environmental change. As mentioned above, the construction activities will give a good introduction to management concern for the environment. In order to obtain and maintain good working relations, the *Resident Engineer* must ensure that communication is maximised. Regular press releases detailing audit findings and the implementation of the EMS would assist in this respect. Media invitations to tour the new slaughterhouse construction may also enable the general public to be better informed about the slaughterhouse's raison d'être.

Government Regulators

12.34 The government regulators have direct powers over construction activities.

ENVIRONMENTAL EFFECTS EVALUATION

12.35 The Environmental Effects Evaluation is an examination, assessment and compilation of all direct, indirect, beneficial and adverse impingement of the environment from the construction phase of the slaughterhouse development.

Environmental Effects

12.36 The environmental effects of the construction phase of the slaughterhouse can be summarised as follows:-

Table 12.5: Summary of Construction Phase Environmental Effects

Air Quality • emissions from on- and off-site vehicles and on-site generators • dust pollution from construction and excavation work
Noise Pollution • emanating from construction vehicles • relating to excavation and piling works • general on-site construction noise
Wastewater Quality • rainfall surface run-off • run-off from construction, maintenance and cleaning activities • sewage waste from temporary facilities • domestic wastewaters • storage and use of any chemicals including solvents and oils
Waste Management, Recycling and Disposal • landfill from construction of underground sewage treatment works • disposal of materials & equipment wrappings • slurry/grouting wastes

Environmental Effects Evaluation

12.37 The use of light diesel with low sulphur content will minimise the environmental impact of the on- and off-site vehicles and on-site generators. There should be no major dust pollution problem from the construction and excavation activities, so long as the contractors carry out that work according to the mitigation measures laid down in this EMS, and according to their contractual requirements.

12.38 The ambient noise in the locality is expected to increase considerably due to the slaughterhouse construction. However, the noise is limited to daylight hours, and the contractor must operate within the contractual obligations minimising noise pollution.

The environmental effects of the construction activities are not expected to cause nuisance.

12.39 Site run-off will include a high concentration of suspended solids, particularly after heavy rainfall, and in water derived from dust-suppression equipment and monitoring. Routine maintenance, repair work, and cleaning activities will generate potential accidental discharges. The *Resident Engineer* must ensure the mitigation measures detailed in the following Chapter are applied. No significant effect from other wastewaters is predicted, as no waste water is anticipated to be discharged from the premises into nearby water bodies. There should be minimal impact from the stored chemicals and solvents, in the unlikely event of an accident, the spillage response plan detailed in the Annex 12.3 should be followed.

12.40 The construction wastes, if recycled where possible, will have minimal environmental effects. The major source of the wastes will be landfill from construction of t' underground wastewater treatment plant.

ENVIRONMENTAL OBJECTIVES AND TARGETS

12.41 The identification of Trigger, Action and Target (TAT) Levels for the respective Environmental Effects will be calculated with the aim of indicating any potentially deteriorating environmental quality and allowing a proactive response to be taken.

Trigger, Action, Target Levels

Trigger Levels

12.42 A reference level 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 investigations and possibly remedial action if appropriate.

Action Levels

12.43 These levels indicate that environmental deterioration is significant and that urgent corrective action is required.

Target Levels

12.44 The maximum permissible level which will achieve compliance with the appropriate regulatory and other standards. Achievement of this level is undesirable and may lead to the cessation of activities. Compliance monitoring schedules will be devised so that remedial action is taken to prevent this level being attained. The Target Level should, under no circumstances, be considered as the desired level.

Air Quality

12.45 The environmental effects arising from construction activities are summarised above. The quality performance limits detailed in Table 12.6, are designed to help ensure that these environmental effects are minimised.

12.46 The air quality performance limits are based on the air quality objectives and the background baseline monitoring data at Lo Wu Camp (with reference to Mott MacDonald's report, 1995). The Trigger Level is based on the baseline monitoring data marked up by 30%. The Target Level is based on the EPD's air quality objectives, and the Action Level is the average of the Trigger and Target Levels. For 1-hr TSP levels, baseline data should be obtained approximately 1 month before construction commences to obtain Trigger and Action levels.

Table 12.6: Construction Air Quality - Quality Performance Limits

Limit breached	24-hr TSP Levels	1-hr TSP Levels
Trigger Level	105 μg/m^3	Baseline data + 30 %
Action Level	185 μg/m^3	Avg. of Trigger & Target Levels
Target Level	260 μg/m^3	500 μg/m^3

Noise Pollution

12.47 The environmental objectives and targets for noise, for the construction phase, are summarised in Table 12.7. These quality performance limits are based both on a complaints system, and an internal monitoring programme.

Table 12.7: Construction Noise Pollution - Quality Performance Limits

Limit breached	Complaint Received	Normal Weekdays (0700 - 1900)
Trigger Level	One documented noise complaint from the public.	-
Action Level	Two or more documented noise complaints within a two week period.	-
Target Level	-	75 dB(A)

12.48 During restricted hours Construction Noise Permits (CNPs) are required for the use of powered mechanical equipment for construction purposes. Conditions, if any, stipulated in the CNPs must be followed.

Wastewater Quality

12.49 The environmental objectives and targets for wastewaters, for the construction phase, are summarised in Table 12.8. These quality performance limits will form the basis of the environmental programme and operational controls outlined below.

Table 12.8: Construction Wastewaters - Quality Performance Limits

Limit breached	Water quality
Trigger Level	Down-stream SS > 20% above the same-day upstream levels
Action Level	Down-stream SS > 30% above the same-day upstream levels
Target Level	Down-stream SS levels persistently (3 or more consecutive samples) > 30% above the same-day up-stream levels

ENVIRONMENTAL MANAGEMENT PROGRAMME

12.50 The environmental programme for the construction phase of the slaughterhouse development will consist of construction environmental effect mitigation measures, controls and monitoring.

Air Quality

12.51 The environmental effects of construction activities will be controlled by the adoption of mitigation measures. The mitigation measures for the achievement of air targets can be summarised as follows:-

Table 12.9: Summary of Construction Air Pollution Mitigation Measures

Mitigation Measures
Pave or Gravel all roads at the start of works
Water any unpaved areas
Utilise wheel washing equipment
Cover all exposed ground & stockpiles
Cover all earth-moving lorry loads

Noise Pollution

12.52 The following mitigation measures are recommended to ensure that the TAT Levels, as detailed in "Environmental Objectives and Targets", are not violated:-

Table 12.10: Summary of Construction Noise Pollution Mitigation Measures

Mitigation Measures
Schedule activities to avoid parallel operation of noisy equipment
Use well-maintained/silenced equipment
Minimise transportation movements
Utilise acoustic panels

Wastewater Quality

12.53 The following mitigation measures detailed in Table 12.11 are recommended to ensure that the TAT Levels, as detailed in "Environmental Objectives and Targets", are not violated.

12.54 All the wastewaters generated during construction activities should be treated either on-site (i.e. septic tank and soakaway pit for domestic usage, and oil interceptor for equipment cleaning, or the provision of packaged wastewater treatment plant) or off-site (i.e. trucking away wastewaters to approved sewage treatment facilities). No untreated wastewater is anticipated to be discharged from the premises into nearby water bodies.

Table 12.11: Summary of Construction Wastewaters Mitigation Measures

Mitigation Measures
Incorporate drainage management plan
Implement spill action plan (see Annex 12.3)
Install oil interceptor and sediment trap at the effluent end
Create a management plan for equipment cleaning and maintenance
Ensure adequate planning for temporary sewage services
Ensure correct chemical handling, storage and disposal

Waste Management, Recycling and Disposal

12.55 Apart from excavation landfill, there will not be significant quantities of solid wastes from construction activities. The major area of concern will be the treatment of the excavated land associated with the wastewater treatment works. Mitigation measures may include:-

Table 12.12: Summary of Construction Waste Management, Recycling and Disposal Mitigation Measures

Mitigation Measures
Recycling and reuse of waste wood from construction
Management programmes for disposal of earth and other waste, these should be suitable for disposal to public dump
Safe storage of construction material
Safe collection and disposal of chemical waste by licensed operator

Visual Impacts

12.56 Mitigation measures include the planting of trees and bund construction. The low-rise design of the slaughterhouse will ensure that the construction activities will not cause major and negative visual impacts.

Environmental Management Documentation

12.57 Procedures to control and manage all documents include the following:-

- management must ensure the documents are readily identifiable, with clear reference to air, noise, water, solids, and hazards. The *Resident Engineer* must ensure references are clear;
- periodic review and revision of all documentation requirements by the Environmental Committee must take place to ensure applicability;

- availability of relevant documents and manuals at all appropriate locations within the slaughterhouse must be checked by the *Resident Engineer*; and
- removal of obsolete documentation must be prompt and regular. *The Resident Engineer* must approve in writing before any removal of documentation.

12.58 All documents shall be dated (with dates of any revisions), readily identifiable, and properly maintained. The *Resident Engineer* shall be responsible for any modifications of the manuals or any other documentation. Those documents suitable for external perusal shall be made available by the authorisation of the *Resident Engineer*.

12.59 Sample documentation for the monitoring of noise, air and water quality are detailed in Annex 12.5.

CONSTRUCTION MONITORING & CONTROLS

12.60 The monitoring teams to conduct dust, noise and water monitoring should be properly trained and report directly to the *Resident Engineer*.

12.61 Field staff are required to record observations and events of the concerned site and the vicinity, with date, time, site identification, filter number, and name of operator, etc. Field staff requirements are listed above.

12.62 Custody Transfer documents should be used to ensure that a complete chain of custody exists from the point of sampling through the analysis to final disposal. At each point in the chain one individual is identified as responsible for the sample, until the custody transfer document is signed by another individual, who then assumes responsibility. In this way the integrity of the samples can be ensured.

Verification, Measurement and Testing

12.63 Ongoing environmental effects monitoring should be conducted on the following basis:-

- in response to any complaints received from the public;
- to routinely monitor that the works are in accordance with the environmental objectives; and
- for the environmental auditing activities.

Air Quality

12.64 To measure the mass concentration of TSP in ambient air the standard high volume sampling method, as set out in the Title 40 of the Code of Federal Regulations, Chapter 1 (Part 50), Appendix B, will be followed.

12.65 High Volume Samplers (HVS) will be in compliance with the specification requirements EPD listed in Table 12.13.

12.66 The direct reading dust meter capable of achieving a comparable result as the HVS may be used for the 1-hr sampling. The instrument should be calibrated against primary standard regularly.

12.67 Two high volume air samplers with appropriate calibration kits should be provided for the baseline monitoring, regular impact monitoring, and ad hoc monitoring for the 24-hr and 1-hr measurement of the identified monitoring stations.

12.68 The HVS should be equipped with electronic mass flow controller and be calibrated against traceable standard at regular interval. All the equipment, calibration kit, filter papers, etc. should be clearly labelled.

Table 12.13: HVS Specification Requirements

Specification of High Volume Sampler for TSP Monitoring
m^3 / min (20-60 SCFM) adjustable flow range
Equipped with timing/ control device with +/- 5 minutes accuracy for 24 hours operation
Installed with elapsed time meter with +/- 2 minutes accuracy for 24 hours operation
Capable of providing minimum exposed area of 406 cm^2 (63in^2)
Flow Control Accuracy : +/- 2.5% deviation over 24-hr sampling period
Equipped with shelter to protect the filter and sampler
Incorporated with an electronic mass flow rate controlled or other equivalent devices
Equipped with a flow recorder for continuous monitoring
Provided with peaked roof inlet
Incorporated with manometer
Able to hold and seal the filter paper to the sampler housing at horizontal position
Easy to change filter
Capable of operating continuously for 24-hour period

12.69 When positioning the samplers, the following points should be noted:-

- a horizontal platform with appropriate supporting to secure the samplers against gusty wind should be provided;
- no two samplers should be placed less than 2 meters apart;
- distance between the sampler and the obstacles, such as buildings, must be at least twice the height of the obstacle protruding above the samplers;
- requirements are: a minimum of 2 meters of separation from walls, parapets, and penthouses is required for rooftop samplers; and a minimum of 2 meters of separation from any supporting structure (measured horizontally);
- no furnace or incinerator flues should be nearby;
- there must be unrestricted airflow around the sampler;
- there must be more than 20 meters from the dripline to the sampler;
- any wire fence or gate to protect the sampler should not cause any obstruction during monitoring; and
- accessibility and the ready availability of electricity.

12.70 Initial calibration of dust monitoring equipment should be conducted upon installation and thereafter in a bi-month interval.

12.71 Transfer standards should be traceable to the internationally recognised primary standard and be calibrated annually. The calibration data should be properly documented for future reference. All the data should be converted into standard temperature and pressure condition.

12.72 All relevant data including temperature, pressure, weather conditions, elapsed-time meter reading for the start and stop of the sampler, identification and weight of the filter paper, and other special phenomena and work progress of the concerned site etc., should be recorded down in the field in details. Sample data sheets are attached in Annex 12.5.

12.73 One form per sampling occasion should be used for recording. Flow-rate of the sampler before and after the sampling exercise with the filter in position should be verified to be constant and be recorded down in the data sheet. All the data/record should be kept for an additional 6-month period after the completion of construction.

12.74 A clean laboratory, with constant temperature and humidity, equipped with necessary measuring and conditioning instruments to handle the dust samples collected should be available for sample analysis and equipment calibration/maintenance.

12.75 Filter paper of size 8" x 10" should be labelled before sampling. It should be a clean filter paper with no pin hole, and should be conditioned in a humidity controlled chamber for over 24-hr and be pre-weighed before use for the sampling.

12.76 After the sampling, the filter paper loaded with dust should be kept in a clean and tight sealed plastic bag. The filter paper is then returned to the laboratory for reconditioning in the humidity controlled chamber followed by accurate weighing by an electronic balance with readout down too 0.1 mg. The balance should be calibrated against traceable standard regularly.

12.77 Additional conditioned and weighed filter papers should be ready for immediate action whenever necessary. All the collected samples should be kept in a good condition for 3 years before disposal.

Monitoring Requirements

12.78 The schedule for regular impact monitoring for each of the monitoring stations for the next 2 months should be included in the monthly report. The monitoring location chosen by the *Resident Engineer* should reflect the prevailing wind direction (from the South South-East) and the construction programme (yet to be finalised). The *Resident Engineer* should refer to Paragraph 12.69 when finalising the monitoring position. Baseline monitoring may be carried out at the same locations as odour assessment as shown in Figure 12.4, at the site boundary provided that the locations are accessible and have a source of electricity nearby.

12.79 Baseline monitoring should be carried out in all of the identified monitoring stations for at least two consecutive weeks prior to the commissioning of the construction work according to the following frequency:-

- daily for 24-hr sampling, and
- at least 3 times per day for 1-hr sampling (taken while the highest dust impact is expected).

12.80 For reference, a set of baseline monitoring data is available in Section 3 of the SEIA Report.

12.81 In regular impact monitoring, the sampling frequency of at least once for every six-day should be strictly observed in all of the monitoring stations for 24-hr monitoring. For the

1-hr monitoring, 3 times for every 6-day at the highest dust impact occasion should be observed.

12.82 Specific time to start and stop the 24-hr TSP monitoring should be clearly defined for each location and be strictly followed by the contractors.

12.83 In case of non-compliance with the air quality criteria, more frequent monitoring exercise as specified in the Action Plan, detailed in Table 12.15, should be conducted within 24 hours. This additional monitoring should be continued until the excessive dust emission or the deterioration in air quality problem is rectified.

Noise Pollution

12.84 Baseline monitoring will be carried out daily in all of the identified monitoring stations for at least two consecutive weeks prior to the commissioning of the construction work. The monitoring locations, shown in Annex 12.2, correspond with NSR 7 and NSR 2. The recommended location is 841 670 N: 830 280 E, and 841 370 N: 829 890 E. The *Resident Engineer* should finalise the exact location in consultation with the EPD, corresponding to the receiver's name or number of the building.

The SR's 2 and 7 have been chosen since they are in closest proximity to the site and SR 2 is a residential group of village houses. The exact location will be determined at a later stage according to the layout of the houses at the start of construction, but approximately at the co-ordinates stated above.

12.85 Noise monitoring will be required and shall be carried out by the Contractor during the construction period with the following objectives:-

- to monitor noise quality to ensure that the quality performance limits are not exceeded at the NSRs; and
- to provide data to determine the effectiveness of any mitigation measures which may be required for the construction activities.

12.86 The noise monitoring shall be conducted at the identified designated monitoring stations. The assessment point shall be at a position 1m from the exterior of the building facade but may be at another point considered to be appropriate by the EPD.

12.87 The measurement and monitoring period shall be appropriate to ensure that the noise measured is truly representative of the construction activities. It is recommended that the monitoring frequency should not be less than three times a week for measured noise levels. Monitoring locations are shown in Annex 12.2. The Construction Noise Pollution Action Plan is given in Table 12.16.

12.88 The sound level meters to be used by the Contractor shall comply with Type 1 specifications given in International Electrical Commission (IEC) publications 651:1979 and 804:1985. The calibration equipment to be used on site shall comply with IEC 942, Type 1 specifications.

12.89 Other measuring and analytical instrumentation used shall be of a comparable professional quality. Microphones giving a free-field response shall be used for noise monitoring. Wherever necessary, the equipment shall be protected against moisture and other weather elements. If long-term monitoring is considered to be necessary, the equipment shall be protected in a weather-proof case and a microphone unit suitable for outdoor use shall be used. The equipment shall be used in accordance with manufacturer's instructions.

12.90 The noise monitoring equipment is required to be calibrated annually by an accredited calibration laboratory for compliance with the appropriate parts of IEC publications 651 and 804 (and any other relevant national standard). On site calibration requires that before and after each set of noise measurements, the accuracy of the sound level meter shall be checked using the calibrator in accordance with the guidelines given by the equipment manufacturer to ensure that no significant drift of greater than 0.5 dB in the calibration results.

12.91 The noise monitoring shall be carried out with reference to the Technical Memorandum the Assessment of Noise from Construction Work other than Percussive Piling, Hong Kong Government.

12.92 The noise parameter shall be the A-weighted equivalent continuous sound pressure level (L_{eq}) with an integrating sound level meter using the "fast" response mode. Noise measurements shall be taken over a 30-minute period outside restricted hours and a 5-minute period within restricted hours.

12.93 Noise measurements shall not be taken in the presence of mist, fog or rain or with wind at a steady speed exceeding 5 m/s, or gusts exceeding 10 m/s. Measurements shall not be made outside the conditions as recommended by the equipment manufacturers. Nor shall they be taken when extraneous noise sources (other than Influencing Factors) are apparent at the assessment point. If this cannot be practically avoided, a suitable correction shall be made of such sources in the assessment procedure.

12.94 A record shall be kept by the Contractor of the measured noise results. In recording the results, the following information relating to the monitoring shall be presented:-

- site name;
- the area of the source or activity under investigation;
- the date and time period over which the monitoring was undertaken;
- details of the assessment point, including its location, distance from the construction activity being monitored, description of noise screen or intervening topography, height above ground level and distance from any reflecting surface;
- weather conditions, including wind speed and direction, rain, mist and fog;
- details of equipment used, including the manufacturer, model/type, serial number and date of last full calibration by an accredited laboratory;
- equipment settings;
- calibration levels before and after measurements;
- presence of Influencing Factors, if any;
- the name of the *Resident Engineer* conducting monitoring; and
- any other information likely to be appropriate (e.g. presence of extraneous noise sources during the monitoring period, activities at the site not representative).

Wastewater Quality

12.95 To ensure that the neighbouring water courses are not adversely affected by the construction activities, monitoring of Suspended Solids (SS) is to be carried out. Due to the highly polluted nature of the river system (and the extreme variations in that pollution, see Table 12.14), and the zero level of wastewater discharges from site, effluent indicative parameters (e.g. BOD, COD, SS, oil & grease, MLSS, and TNK) need not be monitored. The monitoring of SS will ensure that there is not excessive impact from site run-off.

Table 12.14: EPD Monitoring Results for the River Indus (1993)

Parameter	IN1	IN2	IN3
Dissolved Oxygen (mg/L)	2.1 (0.7 - 4.1)	1.5 (0.4 - 3.3)	1.9 (0.9 - 3.8)
Biochemical Oxygen Demand (mg/L)	12 (7 - 21)	8 (5 -26)	20 (9 - 52)
SS Suspended Solids (mg/L)	27 (9 - 140)	21 (4 - 80)	23 (8 - 83)
pH Value	7.0 (6.6 - 7.4)	6.9 (6.3 - 7.2)	7.1 (6.5 - 7.2)

Notes: 1. data presented are annual medians of monthly samples
2. those figures in brackets are the ranges

12.96 Monitoring should be undertaken once every six days at the Designated Monitoring Stations (exact locations of the monitoring points shall be determined by the *Resident Engineer* according to accessibility and progress of the river training programme):-

- approximately 100 metres up-stream from construction activities; and
- approximately 100 metres down-stream from the construction site.

Results from monitoring will be compared and if there is any increase in the downstream levels, this will indicate that this is due to the SSSH. This ensures that the results are not affected by rain, flooding or discharges from livestock farms etc.

12.97 During the course of construction activities, the monitoring should be undertaken on working days at a time when the highest runoff impact is expected. Two samples or suspended solid measurements shall be taken at a depth of 1 metre at each Monitoring Station.

12.98 A transparent PVC or glass cylinder (with a capacity of no less than 2 Litres) which can be effectively sealed with cups at both ends should be used for sampling. The sampler shall have a positive latching system to keep it open and prevent premature closure until released (at a depth of 1 metre). The samples shall be stored at 4^0C during delivery to laboratory and before commencement of the analysis. The laboratory analysis should be carried out in accordance with Method 2540D of the Standard Methods for the Examination of Water and Wastewater (ALPHA, AWWA, WPCF, 17th edition 1989)."

Waste Management, Recycling and Disposal

12.99 Checks on the disposal of solid wastes and recycling will be undertaken as part of the Environmental Management Audit provisions listed below.

Visual Impacts

12.100 The *Resident Engineer* should ensure, by occasionally viewing the construction activities from a distance, that the appearance of the site is not negative. The *Resident Engineer* should ensure that any trees planted are well looked after, that there are not large quantities of rubbish left lying around the site, and that any hoarding or bund construction is well maintained and clean.

Non-Compliance and Corrective Action

12.101 The responsibility and authority for initiating investigation and corrective action in the event of non-compliance are defined below. Procedures for such investigation and corrective action are detailed in the respective action plans.

Air Quality

12.102 Should air quality deteriorate due to the construction activities, and if quality performance limits, as detailed in Table 12.6, are reached; the following actions should be implemented.

Table 12.15: Construction Air Quality Action Plan

Limit Breached		Engineer's Action	Contractors' Action
Trigger Level	exceeded for one sample	- repeat measurement - notify all contractor	- identify source
	exceeded consecutive samples	- notify all contractors - repeat measurement	- identify source - apply mitigation measures
Action Level	exceeded for one sample	- repeat measurement - notify all contractors	- identify source - apply mitigation measures
	exceeded consecutive samples	- impose daily monitoring - notify contractor & EPD - request additional mitigation proposals from Contractor	- identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action
Target Level	exceeded for one sample	- impose daily monitoring - notify contractors & EPD - request additional mitigation proposals from contractor - provide investigation report & forward to EPD	- identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action
	exceeded consecutive samples	- continue daily monitoring - notify contractors & EPD - require additional mitigation proposals immediately - reschedule operations if necessary - render investigation report & forward to EPD	- identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action - render investigation report - reschedule operations as required by Engineer

Noise Pollution

12.103 The construction noise pollution action plan is detailed in Table 12.16. Should the noise pollution levels deteriorate due to construction activities breaching the noise quality performance limits detailed in Table 12.7, the following actions should be taken.

Table 12.16: Construction Noise Pollution Action Plan

Limit Breached		Engineer's Action	Contractors' Action
Trigger Level		- notify all contractors of breach - reply to letter of complaint	- take measurement - identify source - apply mitigation measures
Action Level		- impose daily monitoring - notify all contractors - request additional mitigation proposals - reply to letters of complaint	- take measurement - identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action
Target Level	limit exceeded for one sample	- impose daily monitoring - notify EPD & all contractors - request additional mitigation proposals - review investigation report & forward to EPD	- repeat measurement - identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action
	limit exceeded for consecutive samples	- continue imposing daily monitoring - notify EPD & all contractors - require additional mitigation proposals immediately - review investigation report & forward to EPD - reschedule operations if required	- identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action - render investigation report - reschedule operations as required by Engineer

Wastewater Quality

12.104 The Construction wastewaters action plan is detailed in Table 12.17. If any of the quality performance limits, listed in Table 12.8, are exceeded, the following actions should be taken by the contractors and the *Resident Engineer*.

Table 12.17: Construction Wastewaters Action Plan

Limit Breached	Engineer's Action	Contractors' Action
Trigger Level	- notify all contractors of breach	- take measurement - identify source - apply mitigation measures
Action Level	- impose daily monitoring - notify all contractors - request additional mitigation proposals	- take measurement - identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action
Target Level	- continue daily monitoring - notify EPD & all contractors - request additional mitigation proposals - review investigation report & forward to EPD - reschedule operations if required	- identify source - review operations - submit mitigation proposals to Engineer - implement remedial action - notify Engineer of action - reschedule operations as required by Engineer

ENVIRONMENTAL MANAGEMENT RECORDS

12.105 A system of records will be maintained in order to demonstrate compliance with the requirements of the EMS and to record the extent to which planned environmental objectives and targets have been met. The main areas requiring record systems are:-

- register of regulations - as detailed above;
- environmental effects register - the register should be based on the SEIA report and the summary in "Environmental Effects Evaluation" of the EMS;
- progress to meet targets and objectives - these records should summarise the results of any audits and management reviews, signed off by the *Resident Engineer*;
- audit and review reports - as presented to the Board of Directors and EPD;
- failure to comply with policy and corrective action - managed by the *Resident Engineer*, these records must be available for management and EPD review when requested;
- non-compliances and corrective action - as above;
- incidents, accidents and follow-up;
- complaints and follow-up - to be managed solely by the *Resident Engineer*;
- supplier and sub-contractor information - to be prepared for review by the *Resident Engineer*;
- inspection and maintenance reports - furnished by the individual contractors, with copies forwarded to the *Resident Engineer*; and
- monitoring, test and validity data - to be managed by the respective contractors, with copies forwarded to the *Resident Engineer*.

12.106 Procedures will be further established by the *Resident Engineer* to ensure the availability of records, both within and external to the slaughterhouse. The *Resident Engineer* should be responsible for overseeing the maintenance of the records and record procedures in all departments and work areas

ENVIRONMENTAL MANAGEMENT AUDITS AND REVIEWS

12.107 The Environmental Management Audits (EMA) will be carried out in order to determine whether or not construction activities conform to the environmental management programme, procedures and controls, and whether or not the EMS is fulfilling the SSSH environmental policy. The audit programme is established for these purposes.

Audit Programme

12.108 The Audit Programme deals with the following points:-

- the specific areas to be audited;
- the frequency of audit of each activity/area; and
- the responsibility for auditing each activity/area.

Areas to be Audited

12.109 The specific effects to be audited during the construction phase are noise pollution, air quality, water use & discharge, disposal of solid wastes, visual appearance of the site, and emissions to air. The specific areas and activities to be audited include the organisational structures, administrative and operational procedures, and work areas, operations and processes.

Frequency of Audits

12.110 The audits should take place monthly, and every quarter. The reports should be forwarded to the EPD no later than 10 working days after the auditing period (unless agreed otherwise).

Audit Responsibility

12.111 The *Resident Engineer* will act as independent auditor. Full responsibility and authority should be afforded the *Resident Engineer* to enable him or her to carry out an effective and independent audit.

12.112 Personnel requirements will be small, in addition to the *Resident Engineer*, temporary assistance from suitably qualified technicians will be required. These assistants, known as the Audit Team should be provided by the contractors. See the Management Structure for construction at Figure 12.2.

Audit Protocols and Procedures

12.113 Audit protocols and procedures shall deal with the following:-

- documentation, reports and records;
- environmental performance;
- personnel requirements;

- methodologies for conducting the audits; and
- procedures for reporting audit findings.

Documentation, Reports and Records

12.114 The documentation requirements involve the preparation and reporting of monthly and quarterly audits.

12.115 The results and findings of each monthly audit shall include at least the following:-

a) a short executive summary;
b) basic project information including a synopsis of the construction organisation, programme and management structure, and the work undertaken during the month;
c) drawings showing the project area, any environmental sensitive receivers and the locations of the monitoring and control stations;
d) a brief summary of EMA requirements including:-
    - all monitoring parameters;
    - environmental quality performance limits;
    - action plans in the event of non-compliance;
    - mitigation measure employed; and
    - environmental requirements in contract documents.
e) advice on the status of mitigation measures;
f) monitoring results (printed and on diskette) together with the following information:-
    - monitoring methodology;
    - equipment used and calibration details;
    - parameters monitored;
    - monitoring locations; and
    - monitoring date, time, frequently, and duration;
g) graphical plots of trends of monitored parameters over the past four reporting periods for representative monitoring stations annotated against the following:-
    - major activities being carried out on site during the period;
    - weather conditions during the period; and
    - any other factors which might affect the monitoring results.
h) advice on the solids and wastewaters management;
i) a summary of non-compliance of the environmental quality performance limits;
j) a review of the reasons for, and the implications of, non-compliance and any follow-up procedures relating to earlier non-compliance;
k) a summary record of all complaints received (written or verbal) for each media, including locations and nature of complaints, liaison and consultation undertaken, actions and follow-up procedures taken and summary of complaints;
l) a forecast of the works programme, impact predictions and monitoring schedule for the next three months; and
m) comments, recommendations and conclusions for the month.

12.116 The Quarterly EMA summary report should generally be around 5 pages and contain, as a minimum, the following information:-

a) a short executive summary;
b) basic project information including a synopsis of the project organisation, programme, contacts of key management, and a synopsis of work undertaken during the quarter;
c) drawings showing the project area, any environmental sensitive receivers and the locations of the monitoring and control stations;
d) a brief summary of EMA requirements including:
    - monitoring parameters;
    - environmental quality performance limits; and
    - mitigation measures.
e) advice on the status of environmental protection and pollution control measures, as recommended in the SEIA, summarised in the updated implementation schedule;
f) graphical plots of the trends of monitored parameters over the past 4 months (the last month of the previous quarter and present quarter) for representative monitoring stations annotated against;
    - the major activities being carried out on the site during the period;
    - weather conditions during the period; and
    - any other factors which might affect the monitoring results;
g) a summary of non-compliance with environmental quality performance limits;
h) a brief review of the reasons for and the implications of non-compliance, including a review of pollution sources and working procedure;
i) a summary of the action plans in the event of non-compliance and any follow-up procedures related to earlier non-compliance;
j) a summary of all complaints received (written or verbal) for each media, liaison and consultation undertaken, actions and follow up procedures taken;
k) comments, recommendations and conclusions for the quarter; and
l) proponents' contacts and any hot-line telephone number for the public to make enquiries.

Environmental Performance

12.117 An evaluation of the environmental performance of the construction activities is required. The study will include noise, air, solid waste and water. General achievements in relation to the environmental policy, and environmental objectives, should be assessed.

Personnel Requirements

12.118 The *Resident Engineer* must be sufficiently independent of the activities audited so they can make an objective and impartial judgement. The *Resident Engineer* should have sufficient expertise in relevant disciplines, and be supported by specialists where required.

12.119 The *Resident Engineer* should be responsible for the overall audit programme, assisted by an audit team. The team will not need detailed specialist knowledge during the construction phase, however a broad knowledge of environmental processes and effects is preferred.

12.120 Refer to Paragraph 12.112 for details of the reporting channel and the audit team composition.

Audit Methodologies

12.121 The audit methodologies for the construction phase should follow the guidelines detailed in "Construction Monitoring and Controls".

Environmental Management Review

12.122 The *Resident Engineer* shall review the EMS in addition to reviewing the monthly and quarterly EMA reports, to ensure its continuing suitability and effectiveness. The review shall address the possible need for changes to the policy and objectives in light of a changes in the construction programme.

12.123 Issues to be considered by the *Resident Engineer* include:-

- implementations of recommendations from audit reports;
- suitability of policy;
- suitability of environmental targets and objectives; and
- revision of environmental management programme, manual and other documentation.

12.124 The main aim of the review is to assess the effectiveness of the EMS. Reviews should be regular, and modifications made whenever necessary to ensure its continued relevance to the slaughterhouse operations.

OPERATIONAL PHASE

INTRODUCTION

12.125 The Environmental Management System (EMS) (Figure 12.1) for SSSH aims to be a natural extension of the slaughterhouse's management system. Working in harmony with SSSH employees, this EMS will form the centrepiece of the "green" operations of the slaughterhouse.

12.126 This EMS will be the platform from which a "home-grown" EMS will be developed. As such it lays out the essential elements of an EMS, and includes all elements known before the detailed design is finalised (from the SEIA study, and observations of the Kennedy Town Abattoir). There should be updates to the EMS once the development is finalised, and once operations commence.

12.127 Revised Environmental Objectives and Targets will be a natural progression once operations commence. This issue is discussed further in the sub-chapter "Environmental Management Reviews". On-going development and improved environmental performance is essential for the successful operation of the slaughterhouse EMS.

ENVIRONMENTAL POLICY

12.128 The Environmental Policy of the SSSH will be a public commitment to the protection of the environment within, and external to, the slaughterhouse. The company recognises that environmental concern and protection are an integral part of its business strategy.

12.129 The EMS covers all areas of the slaughterhouse operations, and will be implemented at all levels of management. Environmental objectives will be set and made publicly available through publication of a promotional pamphlet distributed through the "*Green Manager*".

12.130 The slaughterhouse will seek to reduce its impacts on the environment through the implementation of a coordinated EMS. The company is committed to the continual improvement of the system, having as the core of its environmental operation the following Environmental Policy Statement:-

- *Minimisation of pollution and effluent discharges:* We will minimise the release of any pollutant or effluent that may cause environmental damage to the air, water or earth.
- *The sustainable use of natural resources:* We will make sustainable use of renewable natural resources such as water and forests. We will conserve non-renewable resources through efficient use and careful planning.
- *Reduction and disposal of waste:* We will minimise waste, especially hazardous waste, and whenever possible recycle materials. We will dispose of all waste in a safe and responsible manner.
- *Wise use of energy:* We will use environmentally safe and sustainable energy sources to meet our needs, and invest in improved energy efficiency technologies where available. Energy efficient management practices will be developed.
- *Risk reduction:* We will minimise the environmental, health and safety risks to our employees and the communities in which we operate by employing safe technologies and operating procedures, and by being constantly prepared for emergencies.
- *Environmental commitment:* We will commit management resources to implement this management system. All employees will be made aware of their individual responsibilities for acting in accordance with the company's environmental policy.
- *Good neighbour:* The company will seek to be a good neighbour, improve the aesthetic appearance of the site, develop a system for handling complaints and make every effort to provide an efficient and friendly channel of communication.
- *Assessment and annual audit:* We will conduct and make public an annual self-evaluation of our progress in implementing these principles and in complying with all applicable laws and regulations. We will work towards the timely creation of independent environmental audit procedures to which we will adhere.

ORGANISATION & PERSONNEL

Responsibility, Authority and Resources

12.131 The predicted organisational chart is shown in Figure 12.3.

12.132 The appointment of a management representative, hereafter referred to as the *"Green Manager"*, with the authority and responsibility of ensuring the requirements of the standard are implemented and maintained is essential.

12.133 The *Green Manager* should report directly to the board, to ensure independence and effectiveness. Support of an Environmental Committee is advised to ensure that the environmental communications reach all levels of the workforce. The *Green Manager* should have sufficient authority to ensure the following:-

- initiate action to ensure compliance with environmental policy;
- identify and record any environmental problems;
- initiate, recommend or provide solutions to those problems;
- verify the implementation of such solutions;
- control further activities until any environmental deficiency has been corrected; and
- act in emergency situations.

12.134 The Environmental Committee, chaired by the *Green Manager*, should ensure the *Green Manager* receives the necessary support from all levels in the workforce, and that sufficient resources and personnel are provided for the implementation of the EMS.

Verification Resources and Personnel

12.135 In-house verification procedures, as detailed in Operational Controls, must be supported by adequate resources and personnel. The *Green Manager* should designate selected personnel to routinely and simply assess odour levels, wastewater influent and effluent quality, and noise pollution. Further personnel requirements are discussed below.

Green Manager

12.136 A senior manager to oversee the implementation of the EMS shall be appointed. See Figure 12.3 for the suggested management structure for operations. The person should be sufficiently senior in the company to effect change (middle to senior manager status), with good managerial skills and an interest in environmental affairs. The individual is likely to have a science-based degree, and substantial industrial experience. See Annex 12.1 for a brief guide for the future *Green Manager*.

12.137 The job description of the *Green Manager* is likely to include the following:-

- carry out environmental audits on the slaughterhouse operations;
- ensure that environmental standards are maintained and improved;
- provide specialist advice to line management;

- supervise and manage technical staff;
- ensure mitigation technologies are operating effectively and efficiently;
- educate staff on the need for environmental protection;
- communicate SSSH environmental awareness to interested parties (see Register of Interested Parties);
- advise the company on the implementation of better environmental policies;
- maintain records relating to the company's environmental performance;
- setting up of Environmental Management Manuals;
- chair the Environmental Committee; and
- report back to board members.

12.138 The *Green Manager* will be assisted by a number of specialized technicians responsible for the operation and monitoring of the sewage treatment works. In addition to their wastewater treatment function, the technicians will be responsible for the implementation of the environmental programme mitigating and controlling noise and air environmental effects. For the human monitoring of odour, a monitoring team should be regularly rotated by the *Green Manager* to ensure the results of monitoring are not biased.

Environmental Committee

12.139 Employee participation is vital for the success of the EMS. The Environmental Committee team should be rotated to maintain the flow of fresh ideas and introduce new perspectives and considerations. The team would be responsible for strengthening the ongoing health and safety and EMS initiatives.

12.140 The Environmental Committee should consist of members of the general workforce in addition to members from each of the major departments, including:-

- the Department of Production;
- the Department of Maintenance;
- the Department of Finance; and
- the Department of General Affairs.

12.141 The Environmental Committee should also be responsible for the communication of all environmental issues relevant to management and line workers. The Committee should act as a link between employee awareness and action, and the slaughterhouse's environmental policy.

Environmental Action Teams

12.142 Environmental Action Teams should be set up and led by one or more members of the Environmental Committee to examine, in depth, a particular part of the slaughterhouse's activities. These might include office procedures and paper usage, solid waste management, training, educational visits, or any other part of the internal functions of the slaughterhouse.

12.143 The Action Teams would meet once a fortnight to consolidate progress made on particular issues. The staff time required will be very minor, however it can be of use to the management, ensuring that the operations are efficient, and that staff are being proactive in their work.

Training

12.144 A training and induction programme will be developed for all levels of management. This training will be ongoing, and essential to the successful implementation of the EMS. New employees will be inducted by existing employees, or members of the Environmental Committee.

12.145 The training should move from the general to the specific (ie starting with global environmental problems and ending with practical employee-initiated solutions). The programme should cover:-

- global environmental issues;
- the legislative framework in Hong Kong and the UK;
- the impact of the slaughterhouse on the environment;
- SSSH environmental policy, and EMS action taken;
- impact of individual departments and actions to be taken; and
- individual actions to be taken.

12.146 Additional training will be required for the rotating staff assigned to monitor the odour generated by the slaughterhouse. This training must ensure that each person monitoring the odour is aware of the programme, measurement and recording programme.

12.147 In addition to the training measures, procedures should be developed and maintained to ensure that SSSH employees, at all levels, are aware of:-

- the importance of compliance with the environmental policy;
- the significant environmental effects, actual or potential, of their work activities;
- their roles and responsibilities in achieving compliance; and
- the potential consequences of departure from specified operating procedures.

12.148 Such procedures include specific training in the induction process, informational posters displayed intermittently around the workplace, and educational meetings organised by the Environmental Committee and the *Green Manager*.

Communications

12.149 On a rotational basis, staff should be responsible for educational visits from schools or interested parties. Educational tours would ultimately be managed by the *Green Manager*. The benefits of such tours are twofold: the SSSH staff focus their attention on environmental issues relating to the slaughterhouse, and the "students" will gain an insight into the environmental achievements of the slaughterhouse.

12.150 The *Green Manager* will be responsible for all communications with interested parties. Coordination of communications both internally and externally will be required, and essential to ensure the slaughterhouse remains at the forefront of environmental awareness. Communications with other *Green Managers* from different industries, in Hong Kong and overseas, will form an important part of the environmental "benchmarking" of operations.

Contractors

12.151 SSSH must ensure that all contractors are aware of the relevant EMS requirements and provisions. This may include training with SSSH employees, or information leaflets (depending on the environmental commitment of the contractors used). The slaughterhouse management should require contractors use clean delivery trucks, and well maintained vehicles at all times.

REGISTER OF REGULATIONS

Slaughterhouse Operations

12.152 The operations of the slaughterhouse are governed by a number of guidelines, bylaws, and licensing conditions. Requirements of these conditions include suitable siting and design, and humane and hygienic operations.

12.153 *Hong Kong Planning Standards and Guidelines*
Chapter 9 sets out guidelines for the siting of abattoir facilities, including distances from sensitive land uses.

12.154 *Public Health & Municipal Services Ordinance: Slaughterhouses (Regional Council) Bylaws 1991*
Provides for the licensing and control of slaughterhouses other than public slaughterhouses in the Regional Council area.

12.155 *Slaughterhouses Licensing Conditions*
Details the operational design requirements necessary for the permission to operate as a slaughterhouse.

12.156 *Public Health (Animal and Birds) Regulations - Chapter 139*
Sets out requirements for the prevention of the introduction of infectious disease.

12.157 *Prevention of Cruelty to Animals Ordinance (Cap. 169)*
Sets out operational requirements to ensure that animals are not subjected to cruelty.

12.158 *Codes of Practice and Guidelines*
Notes issued by the Hong Kong Government Department of Agriculture & Fisheries including:-

- guidelines for the transportation, handling, and care of pigs; and
- codes of practice for the welfare of animals - specifically cattle.

Air Quality

12.159 Control of dust, odour, and other emissions are required in Hong Kong. EMS will comply with the following air quality requirements:-

12.160 *Hong Kong Planning Standards and Guidelines*
Sets out the principal framework for planning against air pollution and a summary of common pollution sources and sensitive uses.

12.161 *Air Pollution Control Ordinance (Cap. 311)*
Provides for the control of air pollution from stationary sources and motor vehicles.

12.162 *Air Pollution Control Technical Memorandum*
Specifies principles, methods, standards, and guidelines for assessing air pollution from stationary polluting sources.

12.163 *Air Pollution Control (Fuel Restriction) Regulations 1990*
Prohibits the use of liquid fuels with a sulphur content of more than 0.5% by weight and with a viscosity of more than 6 centistokes at 40 degrees Celsius, or of solid fuels with a sulphur content of more than 1% by weight.

12.164 *Air Pollution Control (Vehicle Design Standards) (Emission) Regulations 1991*
Specifies emission standards for vehicle engines.

12.165 *Air Control Zone Statement of Air Quality Objectives*
Provides statutory air quality objectives for all 10 declared Air Control Zones in the Territory. The objectives are listed in Table 12.18.

Table 12.18: Hong Kong Air Quality Objectives (Concentration in μg/m³) (i)

Pollutant (i)	**1 hr** (ii)	**8 hrs** (iii)	**24 hrs** (iii)	**3 mths** (iv)	**1 yr** (iv)
Sulphur Dioxide	800		350		80
Total suspended particulates (v)	500		260		80
Respirable suspended particulates (vi)			180		55
Nitrogen dioxide	300		150		80
Carbon monoxide	3,000	10,000			
Photochemical oxidants (vii)	240				
Lead				1.5	

Notes:
(i) measured at 25 degrees Celsius and 1 atmosphere
(ii) not to be exceeded more than three times per year
(iii) not to be exceeded more than once per year
(iv) arithmetic means
(v) TSP 1-hr guideline level has no exceedance allowance
(vi) suspended particulates in air with a nominal aerodynamic diameter of 10 micrometres and smaller
(vii) photochemical oxidants are determined by measurement of ozone only.

12.166 *Air Pollution Control (Furnaces, Ovens & Chimneys) (Installation & Alteration) Regulations*
Requires the submission of plans for the installation and alteration of furnaces, ovens, and chimneys. This is to ensure appropriate designs.

12.167 *Air Pollution Control (Specified Processes) Regulations*
Provides for the licensing of new, specified processes and registration of existing ones.

12.168 *Air Pollution Control (Dust and Grit Emissions) Regulations*
Stipulates the emission standards, procedures, and requirements for assessing particulate emissions from stationary combustion sources.

12.169 *Air Pollution Control (Smoke) Regulations*
Restricts emissions of dark smoke from stationary combustion sources.

12.170 *Road Traffic Ordinance (Cap.374)*
Regulates road traffic, vehicles, and users of roads and related matters. This includes provisions which limit pollution from vehicles.

12.171 *Public Health and Municipal Services Ordinance (Cap. 132)*
Makes provision for urban services and public health.

12.172 *Ozone Layer Protection Ordinance*
Effects Hong Kong's international obligations under the 1985 Vienna Convention, the 1987 Montreal Protocol, and any amendments thereof to control the manufacturing and the import and export of any ozone depleting substances.

12.173 *Ozone Layer Protection (Controlled Refrigerants) Regulation*
Requires the conservation of controlled refrigerants used in large scale installations and motor vehicles.

12.174 *EPD criteria*
In odour impact assessment, any odour prediction at a receptor equal to or exceeding 5 odour units, based on a prediction averaging time of 5 seconds, shall be considered as an indication of odour nuisance to the receptors. For odour monitoring, 2 odour units at the receptors shall be the criteria for odour nuisance.

Noise Pollution

12.175 Control of transportation and operational noise is required in Hong Kong. The EMS will be carried out in accordance with the following noise pollution requirements:-

12.176 *Noise Control Ordinance*
Controls noise from commercial activities including ventilation noise. The ordinance is enacted through three Technical Memoranda and two sets of Regulations.

12.177 *Hong Kong Planning Standards and Guidelines*
Sets out the Government's overall policy objectives for noise control, the principal framework for planning against noise, a summary of noise emitters, and noise sensitive and noise tolerant uses.

12.178 *Technical Memorandum for the Assessment of Noise from Places other than Domestic Premises, Public Places, or Construction Sites (TM3)*

Outlines procedures to be adopted for the measurement and assessment of noise emanating from industrial premises. Different ANLs are applied during the day, evening, and night, as detailed in Table 12.19.

Table 12.19: Acceptable Noise Levels for Commercial Activities in the Study Location

Time	ANL (dB(A))
day (0700 to 1900)	60
evening (1900 to 2300)	60
night (2300 to 0700)	50

Wastewater Quality

12.179 Control of water pollution is required in Hong Kong. The introduction of the sewage treatment charges has made it economically and legally essential to use water and dispose of wastewater accordingly. The EMS will take account of the following water pollution requirements:-

12.180 *Hong Kong Planning Standards and Guidelines*
Sets out the overall objectives and principal framework for preventing water pollution and gives a summary of potentially polluting and sensitive uses.

12.181 *Waste Disposal Ordinance (Cap. 354)*
Provides for the licensing of collection services and disposal facilities for all types of waste, including the control of the discharge or deposit of livestock waste in designated control areas. Also requires the production of a comprehensive plan for the collection and disposal of wastes.

12.182 *Water Pollution Control Ordinance (Cap. 358)*
Provides for the designation of control zones within which discharges of effluent into waters or into a foul sewer must be licensed.

12.183 *Technical Memorandum Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*
Sets the limits that make effluents acceptable into foul sewers, storm water drains, inland and coastal waters. The limits control the physical, chemical, and microbial quality of effluents.

12.184 *Sewage Services Ordinance*
Provides for the imposition of sewage charges (SCs) and trade effluent surcharges (TESs) and other related matters.

12.185 *Sewage Services (Trade Effluent Surcharge) Regulation*
Sets out rates for the sewage tariff, TES, and water quality requirements.

12.186 *Technical Memorandum on the Procedures and Methods for Sampling and Analysis of Trade Effluents for the Trade Effluent Surcharge Scheme*
Sets out the procedures and methods to be adopted for sampling, analysis, approval of laboratories, presentation of results, and any other matters relating to the establishment of specific effluent characteristics.

12.187 *Waste Disposal (Livestock Waste) Regulations*
Sets out the precautionary measures in handling livestock waste to guard against dangers to public health or risks of pollution. The River Indus was declared a Livestock Waste Control Area in 1989.

12.188 *Building Ordinance (Cap. 123)*
Allows the Building Authority to require adequate waste treatment facilities in any new building. Provides for control over the design of refuse chutes within buildings, private drainage works, and oil storage facilities.

12.189 *Technical Memorandum on Standards for Effluents Discharged into Drainage and Sewerage Systems, Inland and Coastal Waters*
Table 2 will be adopted for the wastewater management.

12.190 *Control on the Operation and Maintenance of Wastewater Treatment Facilities (made under WPCO)*
This regulation is currently in the drafting stage and is scheduled to be enacted by 1996. Upon enactment, it will become a mandatory requirement that only persons registered under the regulation operate and maintain wastewater treatment plants. Failing to comply with the regulation would be an offense liable to prosecution.

12.191 The maximum allowable hydraulic, organic, and TKN (Total Kjeldahl Nitrogen) loadings need to be determined by the Drainage Services Department (DSD).

Waste Management, Recycling and Disposal

12.192 Waste management planning and control is required in Hong Kong. The EMS will be in accordance with the following:-

12.193 *Hong Kong Planning Standards and Guidelines*
Sets out the Government's overall objectives for waste management planning, the principal framework for waste management, and a summary of waste reception/transfer facilities and uses with special requirements for waste disposal.

12.194 *Slaughterhouse (Hygiene) Regulations*, 1977, Part IV
Details the hygienic practices expected of a slaughterhouse in Section 47.

12.195 *Slaughterhouses (Urban Council) Bylaws*, 1992, Part VII
Outlines the requirements for the disposal of carcasses, condemned meat & offal and waste matter of animal food.

12.196 *Abattoirs (Urban Council) Bylaws*, 1992, Part IV
Requirements for the marking and transporting of slaughtered food/animals.

12.197 *Slaughterhouses (Regional Council) Bylaws*, 1992, Part VII,
Outlines the requirements for the disposal of carcasses, condemned meat & offal, and waste matter of animal food.

Chemical and Hazardous Materials Controls

12.198 *Waste Disposal (Chemical Waste) (General) Regulation*
Provides for control on all aspects of chemical waste disposal including; storage, collection, transport, treatment, and final disposal. It is an offense to indiscriminately discharge chemical waste into sewers.

12.199 *Dangerous Goods Ordinance; Category 2, 4 & 5 (Town Gas, Bleaching Powder & Paint)*
Defines dangerous goods by category and controls storage and transportation thereof.

12.200 *Code of Practice on the Packaging, Labelling and Storage of Chemical Wastes*

12.201 *Pesticides Ordinance*
(Registered low toxicity pesticides)

12.202 *Public Health and Municipal Services Ordinance (Cap. 132)*
Provides for the discharge of hazardous material to sewers.

REGISTER OF INTERESTED PARTIES

Nearby Residents

12.203 Residents near the SSSH development reside in low-rise village houses, and relatively distant high-rise blocks to the north. Sensitive Receivers have been identified and consist of groupings north-west, south-west, south-east and north of the study site. The Sensitive Receivers include Noise Sensitive Receivers, and Air Sensitive, see Annex 12.2.

Workforce

12.204 There will be approximately 1500 employees responsible for the slaughterhouse operations. The environmental concerns of this group will include not only the external environmental effects, but also any environmental effects impinging on the work environment.

Customers/Dealers

12.205 Concerned customers will require that the operations are conducted in an environmentally friendly manner, however their main concern will revolve around the quality, freshness and cleanliness of operations. There should be proper interface and support from the resident *Green Manager* and the dealers.

Environmental Interest Groups

12.206 The major concerns of Environmental Interest Groups will most likely be related to the operational side of the slaughterhouse. Good working relations are preferred with these groups, as they can have a major influence on public and ultimately Government opinions. Information is set out in "*Environmental Effects Evaluation, Communications*", and "*Organisation and Personnel, Communications*".

12.207 The *Green Manager* will be responsible for communications with these Groups. Communication can be developed through the following:-

- dissemination of information pamphlets;
- publication of environmental audit and review results;
- meetings with green groups, setting out the actions taken by management and the environmental mitigation measures taken; and/or
- invitations to attend tours of slaughterhouse operations.

The General Public

12.208 Potentially less well informed than the other interested parties, the general public has enormous power to affect environmental change. In order to obtain and maintain good working relations, the *Green Manager* must ensure that communication is maximised. Regular press releases detailing audit findings and the implementation of the EMS would assist in this respect. Media invitations to tour the slaughterhouse may also enable the general public to be better informed about the slaughterhouse's raison d'etre, and its environmental foundations.

Government Regulators

12.209 The government regulators have direct powers over slaughterhouse operations. The Environmental Protection Department (EPD) have set out requirements and expectations which must be followed for slaughterhouse operations.

ENVIRONMENTAL EFFECTS EVALUATION

Communications

12.210 To ensure a proactive approach is taken, the *Green Manager* should ensure there is sufficient liaison with the interested parties. If there are any complaints received from the relevant interested parties (both internal and external) should be handled by the *Green Manager*.

12.211 The *Green Manager* should respond to any correspondence received within two working days. If a complaint is received, relevant monitoring records should be consulted to substantiate the justification for the complaint. Letters shall be kept on file, along with response. Inclusion in the Environmental Audit Reports should be accompanied by details of any follow up action taken.

12.212 Where complaints are part of the Environmental Action Plan, for air quality and noise pollution, the *Green Manager* shall ensure that the appropriate action is taken in response to any complaints.

Environmental Effects Evaluation

12.213 The Environmental Effects Evaluation is an examination, assessment and compilation of all direct, indirect, beneficial and adverse impingements of the environment from the operational phase of the slaughterhouse development.

Environmental Effects

12.214 The Environmental Effects of the operational phase of the slaughterhouse discussed in the SEIA can be summarised as follows:-

Table 12.20: Summary of Operational Phase Environmental Effects

Resource Usage • use of fuels and other natural resources
Air Quality • odours from the animal unloading area and lairages • odours from the slaughter block • odours from the wastewater treatment plant • odours from the BPP (full- or reduced-scale) • pollutants from fuel combustion and chemical leakages

Recycled Paper

Table 12.20: Summary of Operational Phase Environmental Effects (Continued)

Noise Pollution • animal noise, emanating from the unloading bay, lairages, and stunning area • mechanical noise principally from the ventilation systems and odour treatment technologies • operational noises from slaughter process and operators (including human activities in the meat dispatch area and wholesale lairages) • transportation noise from both trains and lorries
Wastewater Quality • effluent discharge from wastewater treatment plant
Waste Management, Recycling and Disposal • manure and discarded fodder • paunch contents, condemned meat & offal, and slaughter screenings • cattle heads, hides, hooves, tails and horns (sold) • wastewater plant sludge • administration block materials: including paper, plastics, metals, glass and foodstuffs

Environmental Effects Evaluation

12.215 Impacts on the air quality will arise from different sites of the slaughterhouse. Without mitigation, the odours will have significant impact on the surrounding area. Mitigation measures must be implemented if the operations are to be environmentally sound. Chemical leakages, if any, will not have a significant impact on the environment as a clean-up action plan will be prepared and carried out, should such leakage occur (see s. 9.41 - 9.50).

12.216 Animal noise will impact significantly on the environment. As a result, mitigation measures must be proposed to minimise the impact. Mechanical and operational noise will not significantly affect the surrounding environment, and with the construction of an acoustic chamber and silencer these noises will be minor. Traffic noise has an off-site impact on the sensitive receivers, and has the potential to cause nuisance to the nearby residents. Construction of noise barriers is recommended.

12.217 The slaughterhouse has the potential to use large quantities of water, resulting in large water bills, and potential waste of a valuable natural resource. Effluent discharges are potentially high in nutrients and oil and grease, however effluent discharged from the wastewater treatment plant will be treated to satisfactory levels to meet treatment objectives. There should be no adverse impact on the environment provided the treatment plant is operating satisfactorily.

12.218 The slaughterhouse will generate significant quantities of solid wastes. Management options must be developed and maintained to ensure that wastes are segregated by type, reducing the impact on landfill, and maximising recycling opportunities.

ENVIRONMENTAL OBJECTIVES AND TARGETS

12.219 Environmental objectives and targets have been, an will continue to be, developed with consideration to the financial, operational and business requirements. The identification of Target, Trigger and Action (TAT) Levels for the respective environmental effects will be calculated with the aim of indicating any potentially deteriorating environmental quality and allowing a proactive response to be taken.

12.220 The TAT Levels take account of the background pollution levels and the likely effectiveness of mitigation measures.

Trigger, Action, Target Levels

Trigger Levels

12.221 A reference level 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 investigations and possibly remedial action if appropriate.

Action Levels

12.222 These levels indicate that environmental deterioration is significant and that urgent corrective action is required.

Target Levels

12.223 The maximum permissible level which will achieve compliance with the appropriate regulatory and other standards. Achievement of this level is undesirable and may lead to the cessation of activities. Compliance monitoring schedules will be devised so that remedial action is taken to prevent this level being attained. The Target Level should, under no circumstances, be considered as the desired level.

Resource Management

12.224 Clean energy options will ensure the progressive reduction of environmentally detrimental emissions and discharges. Energy efficiency will be another environmental objective of operations. Options will be examined to determine how this is best achieved, and will include the application of a solar energy system.

12.225 The major energy source employed in SSSH will be town gas. Electricity will be used for lights and operation of appliances. Light diesel fuel with low sulphur content will be used only as the back-up energy source (mainly on the occasion of the failure of the town gas supply).

12.226 The solar energy system will supply the auxiliary thermal source to the hot water supply is recommended as a clean energy option. The direct and diffuse solar radiation will be converted into thermal energy through solar panels with highly efficient selective absorptive surfaces. Water circulation through solar panels will absorb heat. The heated water will be stored for immediate or delayed use.

Air Quality

12.227 The quality performance limits for the air assessment applying to the operational phase of the slaughterhouse developments are listed in Table 12.21. The Trigger and Action Levels are representative only, enabling the odour panel to efficiently monitor the odour levels (see the following chapter).

Table 12.21: Operational Phase Air Quality - Quality Performance Limits

Limit breached	Complaint Received	Odour Level
Trigger Level	One documented odour complaint from the public.	-
Action Level	Two or more documented odour complaints within a two week period.	-
Target Level	-	Strong odour, coupled with a measurement of 2 OU from dynamic olfactormeter at site boundary.

Noise Pollution

12.228 The environmental objectives and targets for noise, for the operational phase, are summarised in Table 12.22. Long term monitoring is not required. Once the slaughterhouse is operating at full capacity, the *Green Manager* should continue monitoring for a period not less than 6 months. If the quality performance limits are not systematically and regularly breached, then the *Green Manager* should advise the board and the EPD that monitoring is no longer to be carried out.

12.229 Should letters of complaint be received after this date, the *Green Manager* should investigate possible reasons for the letter of complaint (such as changes in operations).

Table 12.22: Operational Phase Noise Pollution - Quality Performance Limits

Limit breached	Complaint Received	Day & evening (0700 - 2300)	Night (2300 - 0700)
Trigger Level	One documented noise complaint from the public.	-	-
Action Level	Two or more documented noise complaints within a two week period.	-	-
Target Level	-	60 dB(A)	50 dB(A)

Wastewater Quality

12.230 The environmental quality performance limits for wastewaters are listed in Table 12.23 below. These limits form the basis of the Environmental Programme outlined below. The Operational Controls will be based on the following quality performance limits. The quality performance limits are based on the adoption of the combined treatment of wastewaters to domestic standards (without paying TES) as discussed in Section 8 of the SEIA.

Table 12.23: Operational Phase Wastewaters - Quality Performance Limits

Test	Trigger Level	Action Level	Target Level
BOD_5 (mg/L)	200	225	250
SS (mg/L)	200	225	250
TKN (mg/L)	40	45	50
COD (mg/L)	400	450	500

Waste Management, Recycling and Disposal

12.231 The maiden objectives for Waste Management, Recycling and Disposal are to set up the organisational framework necessary to run recycling schemes, and to manage wastes and waste disposal. No targets will be set at this stage, however it is envisaged that once the slaughterhouse is fully operational there will be scope to set target levels for the maximisation of recyclables, and the minimisation of waste.

ENVIRONMENTAL MANAGEMENT PROGRAMME

12.232 The following environmental programme is the means of achieving SSSH's environmental objectives. A number of possible mitigation measures required to control the environmental effects are listed.

Resource Management

12.233 A number of clean energy management options are detailed in the SEIA. Town gas, which will have low sulphur content, will be employed. Electricity will be used for lights and operation of appliances. Diesel fuel with low sulphur content is suggested as the back-up energy source.

12.234 A solar thermal system has been considered as an auxiliary energy source. A solar energy heating system will be a reliable and effective means for pre-heating the water used in the slaughterhouse. The utilization of solar energy is one of the most environmentally friendly options, ensuring the slaughterhouse operations are sustainable.

12.235 Further clean energy management options (such as low-energy lighting, use of timers and management programmes) should be further developed over time in line with the commitment to continual environmental development and improvement.

Mitigation Programme

12.236 Mitigation measures form part of the environmental programme for the slaughterhouse operations. The mitigation measures listed below are necessary for the achievement of the environmental objectives and targets. Further measures may be occasionally required in abnormal or emergency operating conditions, as detailed in Operational Controls.

Air Quality

12.237 The mitigation measures proposed in the SEIA to control the air quality around the slaughterhouse can be summarised in Table 12.24 below. The measures are a combination of environmental technologies, and on-site management programmes.

12.238 Responsibility for achievement of environmental objectives and targets rests ultimately with the *Green Manager* and the Environmental Committee, however, each department and work area is responsible for ensuring the slaughterhouse's environmental policy is adhered to, and that any improvements to the EMS be suggested to the Committee and Manager.

Table 12.24: Summary of Operational Air Pollution Mitigation Measures

Odour Type/Air Quality	Mitigation measures
Lairage and animal unloading odours	- air will be drawn through scrubbers to abate emissions - odour neutralizing sprays - adequate ventilation provisions - management programme to ensure adequate cleaning and sterilization of areas
Slaughter-rooms and wastewater treatment plant odours	- air will be drawn through ozone treatment, followed by secondary treatment in scrubbers - enclosure of areas - rooms will be under negative pressure to prevent odour leakage - management programmes to ensure adequate cleaning and sterilization of areas
Air quality	- utilization of clean fuels - minimisation of transportation - a well maintained vehicle fleet

Noise Pollution

12.239 Measures to ensure that the environmental objective of minimal noise pollution are detailed in the SEIA, and can be summarised as follows in Table 12.25:-

Table 12.25: Summary of Operational Noise Pollution Mitigation Measures

Noise Source	Mitigation Measures
Animals	- partial enclosure of lairage
Mechanics	- construction of an acoustic chamber
Operations	- on-site management programmes
Transportation	- construction of noise barriers - optimisation & control of transport routing

Wastewaters

12.240 Measures to ensure the achievement of the objective of acceptable wastewater quality can be summarised as follows in Table 12.26:-

Table 12.26: Summary of Operational Wastewater Mitigation Measures

Wastewater issues	Mitigation Measures
Water usage	- Adoption of water minimisation procedures
Drainage	- Proper maintenance of drainage systems
Effluent quality	- Adoption of completely automatic technology to treat wastewaters to the Government effluent discharge standard.

Waste Management, Recycling and Disposal

12.241 The Environmental Programme to ensure that the objectives of minimising solid wastes, maximising recycling opportunities, and managing waste disposal are detailed in the SEIA. The measures can be summarised as follows in Table 12.27:-

Table 12.27: Summary of Operational Waste Management, Recycling and Disposal Mitigation Measures

Waste Management Issues	Mitigation Measures
Waste Management	- By-product wastes will be collected in clearly marked, closeable containers - On-site management programmes will be adopted to ensure proper handling and disposal procedures
Recycling	- Recycling of office and canteen waste where possible
Disposal	- Wastewater plant sludge and scum arising from treatment will be de-watered before disposal.

12.242 Measures to be included as part of the environmental management programme should include the following guidelines for green operations:-

Table 12.28: Additional Guidelines for Green Operations in Administration Block

Administration Block Area	**Environmental Issue**
The Office	- ensure air-conditioning is properly maintained - place photocopiers away from work situations - limit smoking to specific places and times - avoid using disposable cups in the office - provide filtered water drinking taps - provide re-usable purpose designed internal main envelopes - fully use paper before discarding - recycle paper
Washrooms	- use recycled & unbleached lavatory paper & hand towels - avoid using powerful bleaches or detergents in cleaning - avoid the use of synthetic fresheners - ensure automatic flush toilets do not use excess amounts of water
The Canteen	- avoid using disposable cups, plates, chopsticks and cutlery - use recycled & unbleached hand towels & serviettes - use the minimum recommended quantity of cleaning fluids - do not use detergents containing phosphates or chlorine - serve more vegetarian food, wholefoods, and fresh foods - avoid serving over-processed food

ENVIRONMENTAL MANAGEMENT MANUAL

Manual

12.243 EMMs will be developed, with work instructions for all activities which have environmental effects related to SSSH employees. Procedures for verification of compliance and corrective work procedures will also be outlined. The manual will summarise the recommended environmental mitigation measures and give guidelines for the environmental monitoring and audits.

12.244 The manuals which will need to be produced can be summarised as follows. They should be developed over the first year of operations, with the first to be produced the manuals for the department of maintenance, followed by those for the department of production.

12.245 The manuals should be developed by the *Green Manager*, with assistance from the Environmental Committee, and Environmental Action Teams developed specifically for the Environmental Management Manual (EMM) development.

Table 12.29: Environmental Management Manual Production

Department	Manuals to be Produced
Departments of Production	- division of pigs - division of cattle
Department of Maintenance	- air technologies - wastewater treatment plant
Department of General Affairs	- general EMM (based on above manuals)

12.246 The Manual is the top level of documentation necessary for the EMS. It states what the slaughterhouse intends to do to meet the requirements imposed by the organisation. It is the permanent reference to the implementation and maintenance of the EMS.

12.247 The EMMs will take various forms, and should be developed by the *Green Manager* in conjunction with the various departments. A "top-down" approach to their development will not result in satisfactory manuals. The *Green Manager* must work with the respective departments and teams to ensure the Manuals are functional. The timeframe for their development will therefore depend on the experience of the departments, and any operational problems they may have experienced or predicted.

12.248 The manuals must be sufficiently detailed to be used by the system auditor to verify that the EMS exists, and is effective and purposeful. The manuals shall:-

- collate the environmental policy, objectives and targets, and programme;

- document the key roles and responsibilities; and
- provide direction to related documentation and describe other aspects of the management system, see below.

12.249 The manual shall cover abnormal operating conditions and incidents. Emergency plans shall, where necessary, contain relevant environmental information and instructions. Provisional operating manuals for the air and water treatment technologies are detailed in Appendix 12.1. Upon finalisation of technology specifications these manual will be updated and tailored for insertion in a stand-alone EMM.

Documentation

12.250 Environmental management records will be kept and made available within the organisation and to interested parties. The EMS must be operationally successful at all levels of management, minimising any potentially bureaucratic requirements. The records will be kept with reference to the EMM requirements (see Environmental Management Records, for full requirements).

12.251 Procedures to control and manage all documents include the following:-

- management must ensure the documents are readily identifiable, with clear reference to air, noise, water, solids, and hazards. The *Green Manager* must ensure references are clear;
- periodic review and revision of all documentation requirements by the Environmental Committee must take place to ensure applicability;
- availability of relevant documents and manuals at all appropriate locations within the slaughterhouse must be checked by the *Green Manager*; and
- removal of obsolete documentation must be prompt and regular. *The Green Manager* must approve in writing before any removal of documentation.

12.252 All documents shall be dated (with dates of any revisions), readily identifiable, and properly maintained. The *Green Manager* shall be responsible for any modifications of the manuals or any other documentation. Those documents suitable for external perusal shall be made available by the authorisation of the *Green Manager*.

12.253 Sample documentation for the monitoring of noise, air and water quality are detailed in Annex 12.5.

OPERATIONAL CONTROL

Control

12.254 The significant environmental effects are listed in the previous chapter. SSSH shall plan such activities affecting the environment to ensure that they are carried out under controlled conditions. Particular attention must be paid to the following:

- documented work procedures and work instructions defining the manner of conducting the activity must be prepared;
- contractors and agents must supply procedures and work instructions for approval in order to show compliances with the SSSH environmental policy;
- monitoring and control of operations; and
- criteria for performance.

Verification, Measurement and Testing

12.255 Verification that the slaughterhouse operations are complying with the organisation's environmental objectives and targets will be required. This will take the form of a monitoring programme, or operational controls, to determine the magnitude of any environmental effects.

12.256 Environmental effects monitoring should be conducted on a routine and ad hoc basis:-

- in response to any complaints received from the public;
- in response to any irregularities reported by on-site personnel;
- to routinely verify that the works are in accordance with the environmental objectives; and
- for the environmental auditing activities.

Air Quality

12.257 The monitoring programme should involve all areas of the plant, including odours arising from the lairage and animal unloading areas, the wastewater treatment plant, and the processing operations. Odour may be detected, and thus monitored, by the human nose and/or by an instrument that measures an indicator chemical. Sensitivity to odours is quite variable within the human population, but the sensitivity is often much greater than an instrument. A somewhat more controlled odour measurement can be done by taking a sample and using a selected panel of people. This option is expensive.

12.258 Chemical composition of complex odourous mixtures, such as those from the slaughterhouse, varies with many factors. For example, manure odours depend upon type of feed, sickness, and season; sewage depends upon operation and incoming composition; rendering odours depend upon the raw material composition and freshness; blood odour depends upon the staleness, etc. Also, composition is difficult to relate to odour level because of the interactions between the chemicals. Thus, instrumental odour analysis of a small number of indicator chemicals cannot indicate odour levels very reliably.

12.259 Given the above limitations, a monitoring program may best be a combination of human and instrument analyses. The portable chemical meter should be used as a gross indicator only.

12.260 The members of the Environmental Committee should designate selected personnel to routinely and simply assess the odour level for rough order of magnitude and quality. This should be done along the border of the site at a time (or times) of day when emissions are routinely found to be the highest. These times are predicted to be as follows:-

- lairage: 0500;
- BPP/Coagulation Room: 0800;
- wastewater treatment plant: 0800; and
- unloading area: afternoon.

12.261 Assessment should be done daily by the human observers following the outline in Figure 12.4, and Annex 12.5. Weekly instrument analysis will be required, unless there are complaints received, when daily monitoring should be undertaken for a period of one week after each complaint. Record keeping is essential with a simple quantitative scale.

12.262 Rooms should also be routinely checked for odour levels (particularly the by-products room for fugitive emissions, if a by-products plant is included, because of the potentially high intensity of such odours). Employees should be encouraged to report for investigation any odours they think excessive.

12.263 Instrument analyses should ideally be simple to do and on-site (ie no involved sample collection and delivery to laboratory), portable in nature, and provide reliable, verifiable, data. Portability is important because of the size of the site, the need for spot investigation of odour sources, and potential measurements required at ASRs.

12.264 Indicator chemicals to be measured must be representative of the odour sources as detailed in Section 6 of the SEIA. The recommended indicator chemicals for the major odour sources are described below:-

- the major source of odour requiring detection is the pig manure because of the amount of source emission, and the open nature of the unloading area. Ammonia is recommended as the indicator chemical for odours from animal manure. Detection of ammonia emissions from livestock buildings is fairly common due to concerns about the large release of ammonia to the atmosphere which causes eutrophication;
- a secondary source requiring detection would be the wastewater treatment plant. Even though it is enclosed with odour control, the source is significant with potential for higher odour generation if there are any operational irregularities. Hydrogen sulfide is commonly used as the indicator as it is the greatest contributor to odour from wastewater treatment plants;
- the slaughter block sources are minor because of their low emission and enclosure with odour treatment. Thus, detection of an indicator chemical would be considered advantageous, but not required; and

- if a by-products plant is included, monitoring could be by hydrogen sulfide. Note that rendering produces hydrogen sulfide, methanethiol and butanal in greatest amounts.

12.265 Whereas routine monitoring at the ASRs does not appear warranted, yearly visits to them to administer a questionnaire would provide a database on verification. The commissioning stage would be very important in gathering data and experience with the odour emissions, odour control equipment, and monitoring equipment. Measurement of odour at the ASRs via panel odour unit determination is suggested during the commissioning stage for data and initial verification of control.

Noise Pollution

12.266 Noise monitoring will be required and shall be managed by the *Green Manager* with the following objectives:-

- to monitor noise quality to ensure that the target noise levels are not exceeded at the NSR's 2 and 7 shown in Annex 12.2, Figures A and B; and
- to provide data to determine the effectiveness of any mitigation measures.

12.267 The assessment point shall be at a position 1m from the exterior of the building facade but may be at other points considered by the EPD to be appropriate.

12.268 The sound level meters to be used by the Contractor shall comply with Type 1 specifications given in International Electrical Commission (IEC) publications 651:1979 and 804:1985. The calibration equipment to be used on site shall comply with IEC 942, Type 1 specifications.

12.269 Other measuring and analytical instrumentation used shall be of a comparable professional quality. Microphones giving a free-field response shall be used for noise monitoring. Wherever necessary, the equipment shall be protected against moisture and other weather elements. Once the results of the initial Environmental Audits are known, the *Green Manager* will be able to determine if continued instrumental monitoring is required. If long-term monitoring is considered to be necessary, the equipment shall be protected in a weather-proof case and a microphone unit suitable for outdoor use shall be used. The equipment shall be used in accordance with manufacturer's instructions. If the noise problem is not major, then the monitoring frequency and requirements can be lessened.

12.270 The noise monitoring equipment is required to be calibrated annually by an accredited calibration laboratory for compliance with the appropriate parts of IEC publications 651 and 804 (and any other relevant national standard). On site calibration requires that before and after each set of noise measurements, the accuracy of the sound level meter shall be checked using the calibrator in accordance with the guidelines given by the equipment manufacturer to ensure that no significant drift of greater than 0.5 dB in the calibration results.

12.271 The measurement and monitoring period shall be appropriate to ensure that the noise measured is truly representative of the slaughterhouse operations. Monitoring sould continue for a period of not less than 6 months of full capacity operations (final monitoring period will be determined by the Green Manager, and will be contingent on the monitoring results obtained). It is recommended that the monitoring frequency should not be less than once a week for measured noise levels within the trigger level and appropriate actions to be taken to reduce the offending noise sources in the event that measured noise levels exceed the target level. The Operations Noise Pollution Action Plan is given in Table 12.31.

12.272 The noise parameter shall be the A-weighted equivalent continuous sound pressure level (L_{eq}) with an integrating sound level meter using the "fast" response mode. Noise measurements shall be taken over a 30-minute period outside restricted hours and a 5-minute period within restricted hours.

12.273 Noise measurements shall not be made in the presence of mist, fog or rain or with wind at a steady speed exceeding 5 m/s, or gusts exceeding 10 m/s. Measurements shall not be made outside the conditions as recommended by the equipment manufacturers. Nor shall they be taken when extraneous noise sources (other than Influencing Factors) are apparent at the assessment point. If this cannot be practically avoided, a suitable correction shall be made of such sources in the assessment procedure.

12.274 A record shall be kept by the *Green Manager* of the measured noise results. In recording the results, the following information relating to the monitoring shall be documented:-

- site name;
- the area of the source or activity under investigation;
- the date and time period during which the monitoring was undertaken;
- details of the assessment point, including its location, distance from the construction activity being monitored, description of noise screen or intervening topography, height above ground level and distance from any reflecting surface;
- weather conditions, including wind speed and direction;
- details of equipment used, including the manufacturer, model/type, serial number and date of last full calibration by an accredited laboratory;
- equipment settings;
- calibration levels before and after measurements;
- presence of Influencing Factors, if any;
- the name of the engineer conducting monitoring; and
- any other information likely to be appropriate (e.g. presence of extraneous noise sources during the monitoring period, activities at the site not representative).

Wastewaters

12.275 To ensure that effluent discharges are achieving the set standards and expected efficiencies, ongoing monitoring of effluent indicative parameters (eg BOD, COD, SS, oil & grease, MLSS, TKN and possibly dissolved oxygen in aeration tanks) is required, as shown in the wastewater quality management system, Annex 12.6. Routine analyses are also required to fine-tune the performance. The *Green Manager* should have daily checks on COD, and weekly checks on the other parameters so as to ensure the compliance of wastewater treatment up to the regulatory standards.

Waste Management, Recycling and Disposal

12.276 Baseline monitoring of the solid wastes and recycling schemes will form part of the environmental audit i.e. quantitive (by weight) analysis of the point of disposal of solid wastes at the start of commissioning. The initial objectives of establishing recycling schemes, and ensuring satisfactory disposal of solid wastes will be relatively easy to audit (the programmes either exist, of have been delayed). Once established, the waste management system can be monitored, by analysing the amount of waste which is recycled, re-used or sent to landfill.

Non-Compliance and Corrective Action

12.277 The responsibility and authority for initiating investigation and corrective action in the event of non-compliance will be defined in relation to the following Trigger, Action and Target Levels.

Air Quality

12.278 The mitigation measures summarised above should ensure that the Target Levels, as detailed in Table 12.21, are not reached. If the quality performance limits are reached, the following action plan should be implemented by slaughterhouse management:-

Table 12.30: Operations Air Quality Action Plan

Limit breached	**Action required**
Trigger Level	- monitoring team to identify potential sources and causes for the particular complaint - monitoring team to ensure mitigation measures are being applied - *Green Manager* to reply to letter of complaint
Action Level	- monitoring team to identify source - increase monitoring frequency - *Green Manager* to ensure mitigation measures and/or technologies are effective - *Green Manager* and monitoring team to ensure any additional mitigation measures are immediately applied - *Green Manager* to formulate revised programme to reduce odours and submit to EPD - *Green Manager* to reply to letters of complaint
Target Level	- *Green Manager* to notify EPD immediately - *Green Manager* to immediately apply mitigation measures - *Green Manager* to provide investigation report & forward to EPD - monitoring team to conduct odour sampling and use olfactometer to determine whether 2 OU is achieved at the site boundary - *Green Manager*, with approval from board of directors, to reschedule operations and/or technologies if required - *Green Manager* to reply to letters of complaint

Noise Pollution

12.279 The mitigation measures summarised above should ensure that the quality performance limits, as detailed in Table 12.22, are not reached. Due to the nature of the limits, both written complaints, and internal noise monitoring can cause a breach of the quality performance limits. If the quality performance limits are reached, the following action plan should be implemented:-

Table 12.31: Operations Noise Pollution Action Plan

Limit Breached		**Action Required**
Trigger Level		- monitoring team to identify source - monitoring team to repeat measurement - monitoring team to apply necessary mitigation measures - *Green Manager* to reply to letter of complaint (if received)
Action Level		- monitoring team to identify source - monitoring team to repeat measurement - *Green Manager* to review operations - *Green Manager* to formulate additional mitigation measures - *Green Manager* to implement remedial action - *Green Manager* to reply to letter of complaint (if received) - *Green Manager* to submit investigation report & forward to EPD (report should include a revised programme to reduce noise) - *Green Manager* to reply to letters of complaint
Target Level	limit exceeded for one sample	- monitoring team to identify source - *Green Manager* to impose daily monitoring - *Green Manager* to review operations - *Green Manager* to develop additional mitigation measures - *Green Manager* to implement remedial action - *Green Manager* provide investigation report, & forward to EPD (report should include a revised programme to reduce noise)
	limit exceeded for consecutive samples	- *Green Manager* to identify source - monitoring team to continue daily monitoring - *Green Manager* to notify EPD immediately - *Green Manager* to review operations - *Green Manager* to implement remedial action - *Green Manager* to provide investigation report & forward to EPD - *Green Manager*, with approval from board of directors, to reschedule operations as required - *Green Manager* to reply to letters of complaint

Wastewater Quality

12.280 The mitigation measures summarised above should ensure that the quality performance limits, as detailed in Table 12.23, are not reached. If the limits are reached, the following action plan should be implemented:-

Table 12.32: Operations Wastewater Quality Action Plan

Limit Breached		**Action Required**
Trigger Level	exceeded for one sample	- plant operators to identify reasons - plant operators to repeat measurement
	exceeded consecutive samples	- plant operators to identify reasons - plant operators to repeat measurement - plant operators to adjust treatment processes as required
Action Level	exceeded for one sample	- plant operators to identify reasons - plant operators to repeat measurement - plant operators to adjust treatment processes as required
	exceeded consecutive samples	- plant operators to identify reasons - plant operators to repeat measurement - plant operators to review operations with *Green Manager* - *Green Manager* to formulate additional mitigation measures - *Green Manager* to implement remedial action - *Green Manager* to submit investigation report & forward to EPD (report should include a revised programme to reduce noise)
Target Level	exceeded for one sample	- plant operators to identify reasons - *Green Manager* to impose more frequent monitoring - *Green Manager* to review slaughtering operations - *Green Manager* to develop additional mitigation measures - *Green Manager* to implement remedial action - *Green Manager* to provide investigation report, & forward to EPD (report should include a revised programme to reduce noise)
	exceeded consecutive samples	- plant operators to identify reasons - plant operators to continue frequent monitoring - *Green Manager* to notify EPD immediately - *Green Manager* to review operations and/or technologies - *Green Manager* to implement remedial action immediately - *Green Manager* to provide investigation report & forward to EPD - *Green Manager*, with approval from board of directors, to reschedule operations as required

ENVIRONMENTAL MANAGEMENT RECORDS

12.281 A system of records will be maintained in order to demonstrate compliance with the requirements of the EMS and to record the extent to which planned environmental objectives and targets have been met. The main areas requiring record systems are:-

- register of regulations - the initial register will be taken from "Environmental Regulations";
- environmental effects register - the register should be based on the SEIA report and the summary "Environmental Effects Evaluation" of the EMS;
- progress to meet targets and objectives - these records should summarise the results of any audits and management reviews, signed off by the *Green Manager*;
- audit and review reports - as presented to the Board of Directors and EPD;
- training records - should be managed, by department and individually, for every employee of the slaughterhouse;
- failure to comply with policy and corrective action - managed by the *Green Manager*, these records must be available for management and EPD review when requested;
- non-compliances and corrective action - as above;
- incidents, accidents and follow-up;
- complaints and follow-up - to be managed solely by the *Green Manager*;
- supplier and sub-contractor information - to be prepared for review by the *Green Manager*;
- inspection and maintenance reports - furnished by the individual departments, records shall be kept at each department, with copies forwarded to the *Green Manager*; and
- monitoring, test and validity data - to be managed by the respective departments, with copies forwarded to the *Green Manager*.

12.282 Procedures will be further established by the *Green Manager* to ensure the availability of records, both within and external to the slaughterhouse. The *Green Manager* should be responsible for overseeing the maintenance of the records and record procedures in all departments and work areas. Refer also to the EMM procedures laid out below.

12.283 The aim is to keep the records to a minimum, but of a sufficiency to indicate slaughterhouse operation's compliance with the EMS.

ENVIRONMENTAL MANAGEMENT AUDITS AND REVIEWS

12.284 The Environmental Management Audits (EMA) will determine whether SSSH's activities conform to the management programme and whether or not the EMS is fulfilling the slaughterhouse's environmental policy. The audit programme is established for this purpose.

Audit Programme

12.285 The Audit Programme deals with the following points:-

- the specific areas to be audited;
- the frequency of audit of each activity/area; and
- the responsibility for auditing each activity/area.

Areas to be Audited

12.286 The specific effects to be audited during the construction phase are noise pollution, air quality, water use & discharge, disposal of solid wastes, and visual appearance of the site. The specific areas and activities to be audited include the organisational structures, administrative and operational procedures, and work areas, operations and processes.

Frequency of Audits

12.287 The frequency of these audits will depend upon the success of the ongoing mitigation, the monitoring results, and any complaints from the public. Until the success of the installed and managed mitigation measures is known, more frequent audits are recommended. It is recommended they be undertaken on a quarterly basis.

12.288 Once the slaughterhouse operations are shown to be effectively mitigating the pollutions, it is recommended that the audits take place on an annual basis, forming part of the slaughterhouse's financial reporting and "self-check" procedures. An annual focus on the EMS will ensure its applicability and effectiveness for slaughterhouse operations.

Audit Responsibility

12.289 Managed by the *Green Manager*, the audits will collect and evaluate the effectiveness of the System and its implementation. Relying on employee input, and analysis of ongoing monitoring results, the audit will focus management on the overall management system.

12.290 Audits for each activity area, such as slaughter, waste removal, lairage management etc, should be evaluated on a rotational basis. The *Green Manager* should maintain a year planner which clearly illustrates when each area is to be audited. Each area will know well in advance the time of the next audit, allowing line management to undertake any self-assessments prior to the "independent" internal audit.

12.291 Personnel requirements will be small. In addition to the *Green Manager*, temporary assistance from suitably qualified technicians will be required. Support from the Environmental Committee will be required, ensuring that the individual members do not audit areas within their departments.

Audit Protocols and Procedures

12.292 Audit protocols and procedures shall deal with the following:-

- documentation, reports and records;
- environmental performance;
- personnel requirements;
- methodologies for conducting the audits; and
- procedures for reporting audit findings.

Documentation, Reports and Records

12.293 The documentation requirements involve the preparation and reporting of quarterly audits. These audits should become annual once the slaughterhouse operations have been proven to have environmental effects within the SEIA requirements.

12.294 The Quarterly EM&A summary report should be approximately 5 pages in length and contain, as a minimum, the following information:-

a) a short executive summary;
b) basic project information including a synopsis of the project organisation, programme, contacts of key management, and a synopsis of work undertaken during the quarter;
c) drawings showing the project area, any environmental sensitive receivers and the locations of the monitoring and control stations;
d) a brief summary of EM&A requirements including:
    - monitoring parameters;
    - environmental quality performance limits; and
    - mitigation measures.
e) advice on the status of environmental protection and pollution control measures, as recommended in the SEIA, summarised in the updated implementation schedule;
f) graphical plots of the trends of monitored parameters over the past 4 months (the last month of the previous quarter and present quarter) for representative monitoring stations annotated against;
    - the major activities being carried out on the site during the period;
    - weather conditions during the period; and
    - any other factors which might affect the monitoring results;
g) a summary of noncompliance with environmental quality performance limits;
h) a brief review of the reasons for and the implications of non-compliance, including a review of pollution sources and working procedure;
i) a summary of the action plans in the event of non-compliance and any follow-up procedures related to earlier non-compliance;

j) a summary of all complaints received (written or verbal) for each media, liaison and consultation undertaken, actions and follow up procedures taken;
k) comments, recommendations and conclusions for the quarter; and
l) proponents' contacts and any hot-line telephone number for the public to make enquiries.

12.295 The yearly audit results should be similar in format, however are likely to be more comprehensive in scope and information. The results should be published in the annual accounts.

Environmental Performance

12.296 An evaluation of the environmental performance of the operation activities is required. The study will include noise, air, solids and water. General achievements in relation to the environmental policy, and environmental objectives, should be assessed.

Personnel Requirements

12.297 Personnel carrying out the audits must be sufficiently independent of the activities they audit to make an objective and impartial judgement. They should have sufficient expertise in relevant disciplines, and be supported by specialists where required.

12.298 The team assisting the *Green Manager* may need specialist knowledge due to the complex nature of the environmental effects. The *Green Manager* should determine if a broad knowledge of environmental processes and effects is sufficient.

Audit Methodologies

12.299 The audit methodologies for the construction phase should follow the guidelines detailed in Operational Control particularly the section "Verification, Measurement and Testing".

Environmental Management Reviews

12.300 SSSH management shall review the EMS adopted to ensure its continuing suitability and effectiveness. The review shall address the possible need for changes to the policy and objectives in light of the changing operating circumstances and the commitment to continued improvement.

12.301 It is recommended that the review of the EMS be ongoing throughout the year. The EMS should be included as an agenda item in the regular meetings in which management reviews and discusses business issues. Regular liaison between the Environmental Committee and the Board of Directors (through the *Green Manager*) should be encouraged. Issues which should be part of the annual review process include:-

- implementation of recommendations from audit reports;
- suitability of policy;

- suitability of environmental targets and objectives; and
- revision of environmental management programme, manual and other documentation.

12.302 The main aim of the review is to assess the effectiveness of the EMS. Reviews should be regular, and modifications made whenever necessary to ensure its continued relevance to the slaughterhouse operations.

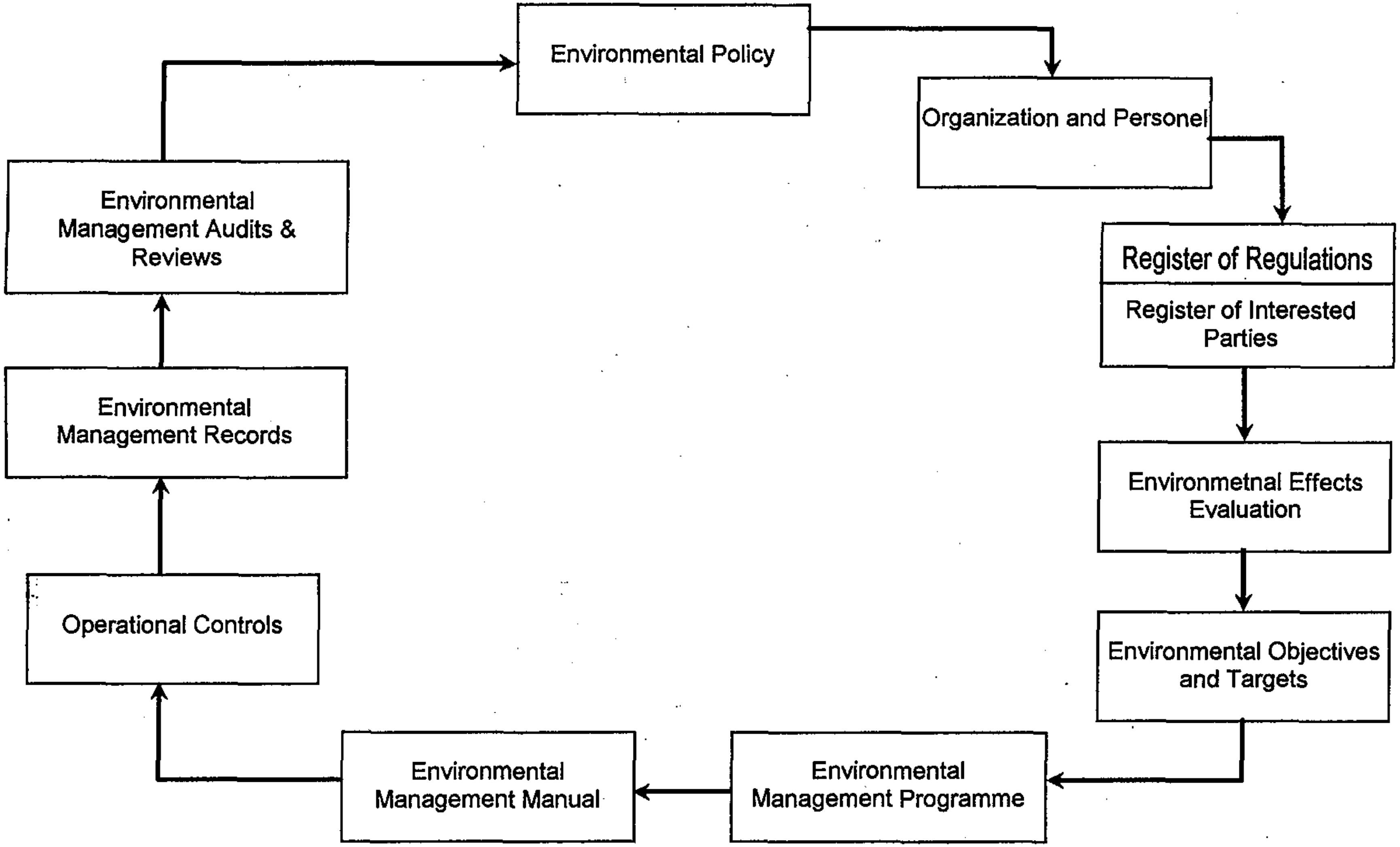


Figure 12.1 Schematic diagram of the stages in the implementation of the Sheung Shui Slaughter House environmental management system

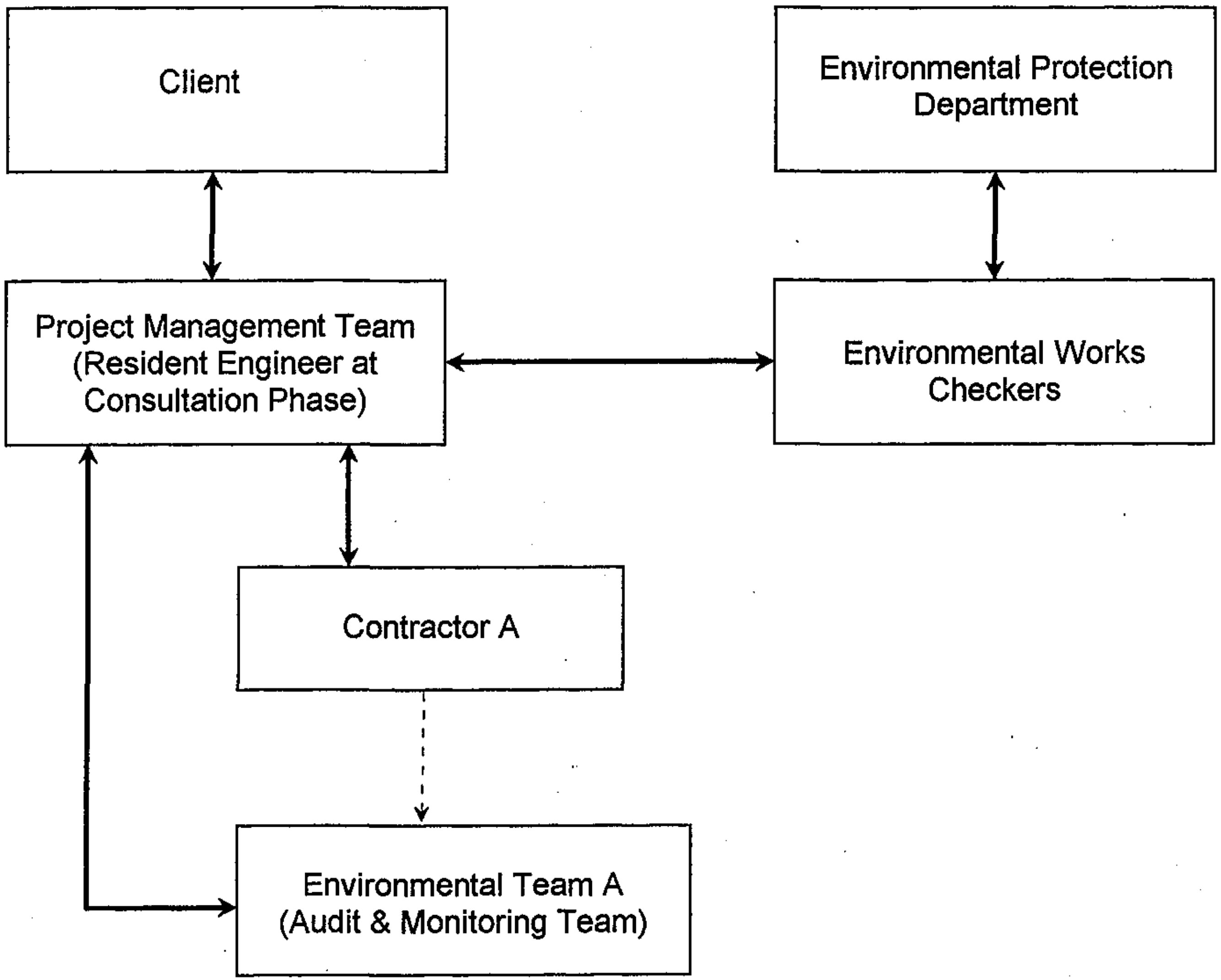


Figure 12.2 Construction Organization

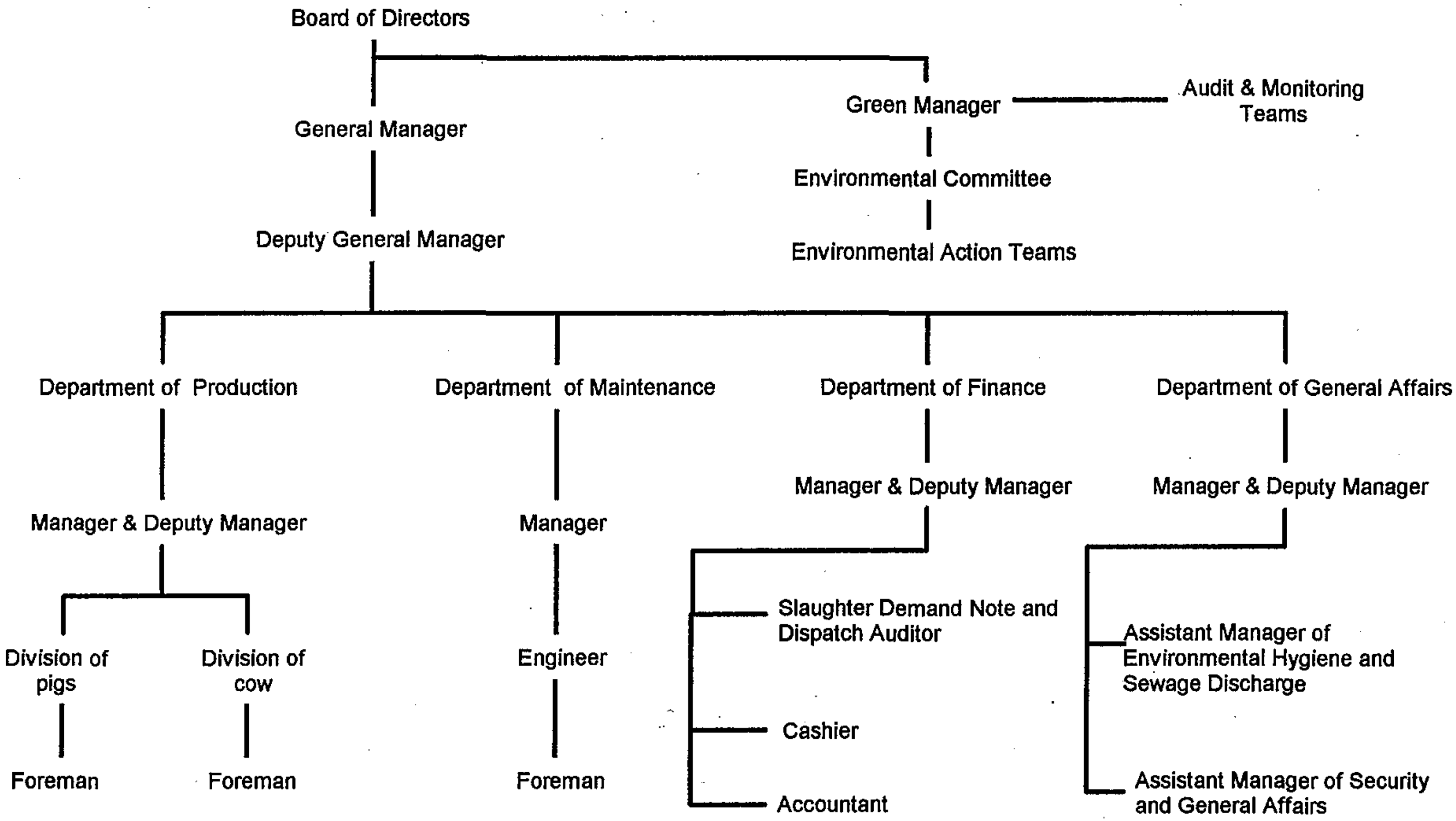


Figure 12.3 Operations Organization

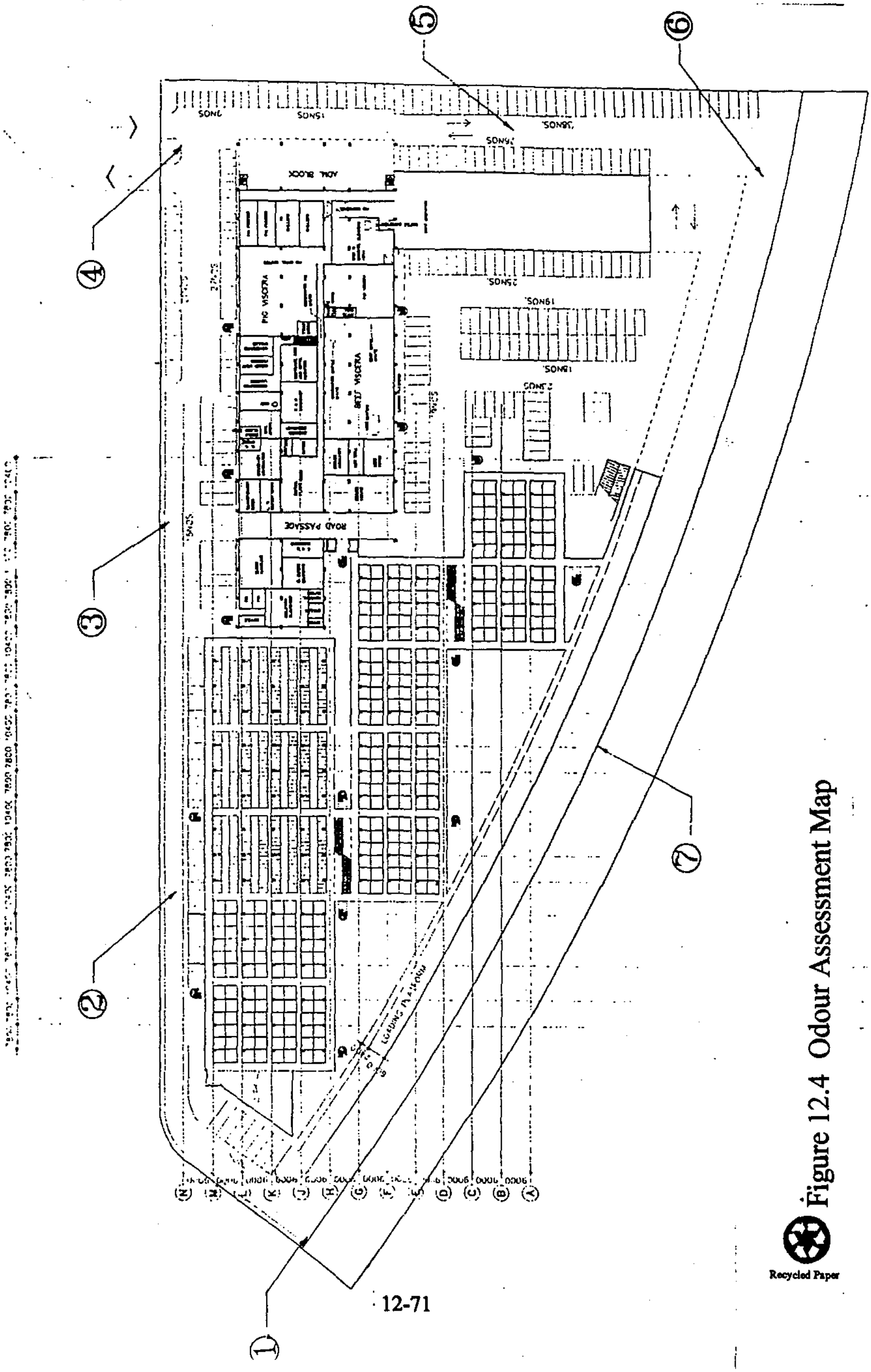


Figure 12.4 Odour Assessment Map

Recycled Paper

ANNEX 12.1

Green Management Outlines

Outlines for the future Green Manager of the SSSH

A1.1 The *Green Manager* has responsibility of implementing an Environmental Management System. The three key elements in the system are the audit, the policy and the plan. The EMS is not a passive defense, but an active contribution to the slaughterhouse's corporate strategy.

A1.2 Information is the key to success for any EMS. Internal records are crucial, and they should be routinely captured and analysed. The *Green Manager* must anticipate change, staying abreast of new products, legislation, technologies and issues. External information systems to achieve this information include conferences, magazine subscription, benchmarking and training. The Manager must liais with conservation groups, other organisations and statutory bodies.

A1.3 All information obtained by the *Green Manager* should be widely disseminated throughout the company to create interest and produce new ideas. Central to this dissemination is the Environmental Committee and Environmental Action Groups.

A1.4 This EMS is not the final, "set in concrete" document to be utilised, it provides the framework and foundation for future system developments.

Ideal qualities & qualifications in Green Manager

A1.5 The following lists some qualities and qualifications which would be found in the ideal candidate for position of *Green Manager*:-

- qualified with a degree, or equivalent, in Environmental Management;
- one to two years' experience as *Green Manager*, working to develop environmental management manuals, with environmental monitoring and auditing experience;
- five to ten years' industrial experience, preferably in a slaughterhouse or similar operation; and
- experience in public relations, communications, and committee management.

ANNEX 12.2

Figure A Noise - Designated Monitoring Station (1)

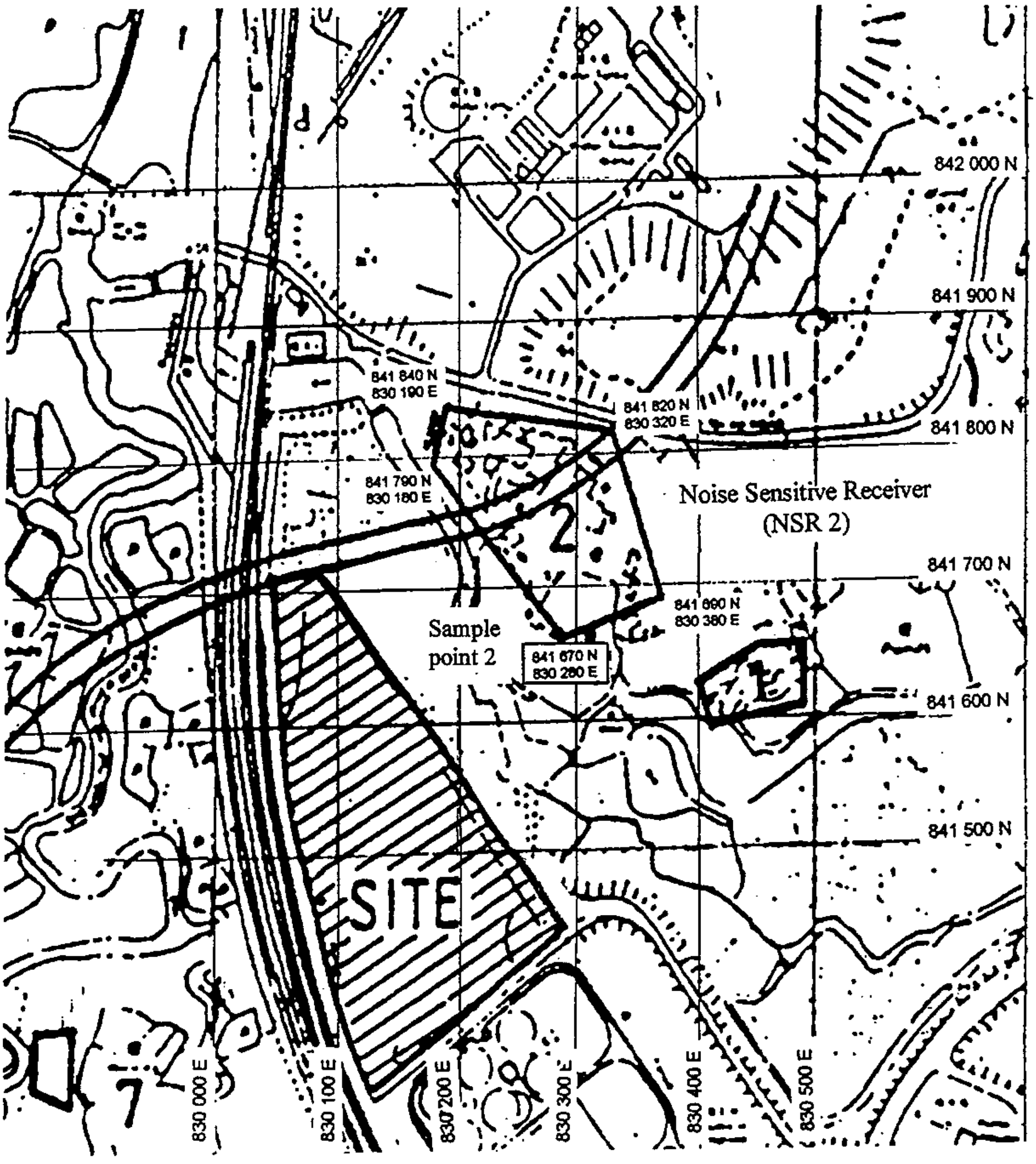
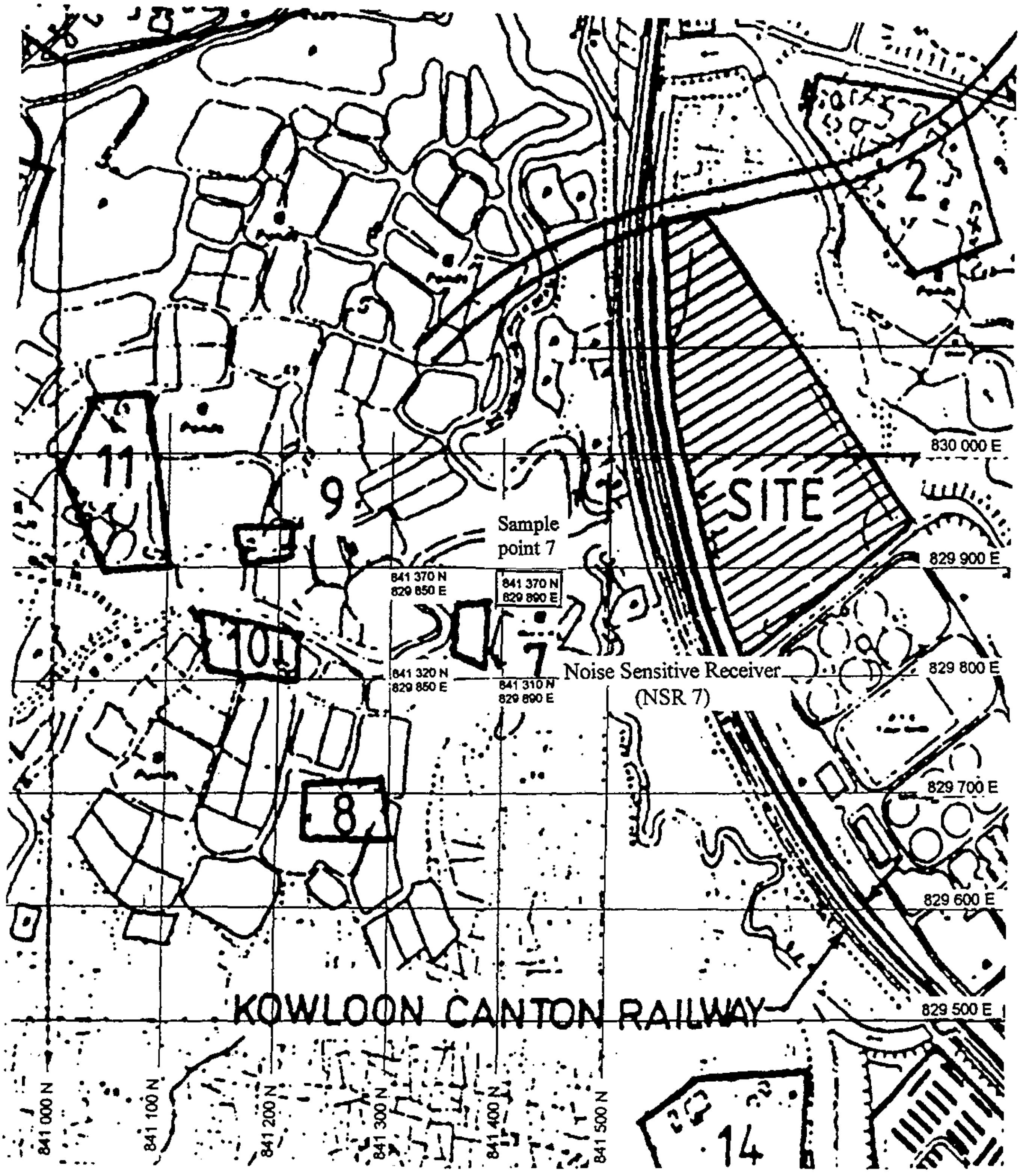


Figure B Noise - Designated Monitoring Station (2)



ANNEX 12.3

Spillage Response Plan

A3.1 A spillage response plan can be included once an accurate inventory of likely chemicals and hazardous substances is known. Until then, the following can be included as an appendix:-

A3.2 There should be a spillage response action plan to control any substance held which cannot enter the general environmental through storm water or sewage systems should a spill occur. The response should follow the plan listed below:-

- proceed immediately to scene of spillage;
- assess what has been spilled and if anyone is injured;
- see that any injured are treated;
- determine extent of spillage and contamination risks;
- call maintenance staff to scene with:
  - any necessary protective clothing;
  - dry sorb sand bags if risk of further contamination;
  - dry sorb for chemical soak up;
  - shovel for removal of contaminated dry sorb;
  - bin for collection of dry sorb;
- write report on incident, detailing leak, measures taken, any pollution, and future preventative measures; and
- report to EPD.

A3.3 The minimum equipment required for a spillage response plan is as follows:-

- 3 mops and buckets;
- 3 squeegees;
- roll of barrier tape;
- pedestal type barriers;
- 3 air respirators;
- 50 kg of dry sorb or equivalent;
- 3 pairs chemical resistant gum boots;
- 3 pairs chemical resistant gloves;
- 3 eye goggles;
- bolt cutters;
- 3 full length overalls;
- 6 dry sorb filled sand bags;
- shovel; and
- rubbish bin for contaminated dry sorb."

ANNEX 12.4

Glossary

- **environment** - the surroundings, and conditions of operation (from within the workplace to the global system)
- **environmental effect** - the impingement upon the *environment* (direct and indirect, beneficial and adverse)
- **environmental effects evaluation** - evaluation of the significance of the *environmental effects* (documented)
- **environmental effects register** - a list of the significant *environmental effects* (known and suspected)
- **environmental management** - aspects of the overall management function regarding *environmental policy*
- **environmental management audit** - systematic evaluation to determine whether the EMS and environmental performance comply with planned arrangements, and whether system is suitable
- **environmental management manual** - documentation describing the procedures for implementing the organisation's environmental programme
- **environmental management programme** - description of the means of achieving *environmental objectives* and *targets*
- **environmental management review** - formal evaluation by management of the status and adequacy of systems and procedures
- **environmental management system** - the organizational structure, responsibilities, practices, procedures, processes and resources for implementing *environmental management*
- **environmental objectives** - goals set to be achieved (quantifiable wherever possible)
- **environmental policy** - public statement of intentions and principles of action, giving rise to *environmental objectives* and *targets*
- **environmental targets** - detailed performance requirements which need to be met in order to achieve *environmental objectives*
- **interested parties** - include local residents, investors, insurers, workforce, customers, consumers, environmental interest groups, general public, and the regulatory bodies
- **organisation** - any organised body or establishment
- **verification activities** - all inspection, test and monitoring work related to *environmental management*

ANNEX 12.5

Air Quality Monitoring - Total Suspended Particulates

Location					
Filter ID					
Start of sampling	Date				
	Time				
	Counter				
Completion of Sampling	Date				
	Time				
	Counter				
Calibrated flow rate (cfm)					
Weight gain of filter (g)					
TSP (micrograms/m3)					
Weather conditions					
during sampling period					
Rainfall amount					
Wind strength					
Wind direction					
Temperature					
Date filter installed					
Installed by					
Meter reading					
Date filter removed					
Removed by					
Date to lab					

Remarks:

Odour monitoring sheet

Period of monitoring ______________________

Locations	Time		Daily Odour Levels and Weather														Weekly Instrument			
			Day 1		Day 2		Day 3		Day 4		Day 5		Day 6		Day 7		NH_3	H_2S	NH_3	H_2S
Border Locations *																				
1	0500	1500																		
2	0500	1500																		
3	0500	1500																		
4	0500	1500																		
5	0500	1500																		
6	0500	1500																		
7	0500	1500																		
Pig lairage																				
G/F	0500																			
1/F	0500																			
2/F	0500																			
Rooms																				
WWTP	0800																			
Blood Coag	0800																			
BPP	0800																			
Collection		1500																		
Wind	0500	1500																		
Weather	0500	1500																		

*** Border Locations (see Figure 10.1)**

1	North - near truck wash
2	East - road, middle of lairage
3	East - road, slaughterblock, drivethrough
4	East - guard house area
5	South - across from meat despatch
6	West - near transport office
7	West - middle of truck loading area

Odour levels

A	barely detectable
B	light
C	medium
D	strong

Wind direction

N	north
S	south
E	east
W	west

Weather condition

C	Clear
W	Windy
M	Misty
R	Rainy

Signatures/Authorisation

Staff ______________________

Engineer ______________________

Green Manager ______________________

Instrument calibration date ______________________

NOISE MONITORING REPORT		
Location		DATE:
Weather: Wind Strength: Wind Direction: Temperature: Cloud Cover: Other (e.g. rain, fog) Sea State (e.g. calm, choppy)		
Recording Position:		
Equipment: NB, Sound Level Meter Calibrated Before and After Use		
Measurement Time and Period:	Start	
	Finish	
Recorded Level LAeq (5 minutes) dB		
Factors influencing Recorded Noise Level (if any) :		
Construction Activity Noticeable during measurement period:		
Recommendations/ Conclusions		
Report prepared by: Signature:		

ANNEX 12.6 WASTEWATER QUALITY MANAGEMENT SYSTEM

1. Analytical Programme

Routine analyses are required for monitoring process performance. An analytical programme is provided in Table A.

Table A : ICEAS Plant - Sample Analysis Programme

Analysis	Sample	Mon.	Tues.	Wed.	Thurs.	Fri.
COD	In/Out	x		x		x
BOD	In/Out	x				x
SS	In/Out	x		x		x
O & G	In/Out	x		x		x
TKN	In/Out					x
NH_3-N	In/Out					x
MLSS (BWL)	Basin					x
MLVSS (BWL)	Basin					x
Determination						
Flow		x		x		x
COD Load		x		x		x
BOD Load		x				x
DO Profile		x		x		x
pH		x	x	x	x	x
Temperature		x	x	x	x	x
SVI						x
SOUR						x
Sludge Wasting Vol.		x		x		x
Sludge Age		x		x		x

Note: 1. The frequency of analysis can be reduced after the plant has stabilised.

2. For details of methods of analysis of wastewater and sludges, operators should consult: "Standard Methods for the Examination of Water and Wastewater, Alpha-AWWA-WPCF, 1980.

2. Purpose

The analytical data is important for the following purposes:

- monitoring of plant performance
- assessment of operational conditions
- fine tuning of performance.

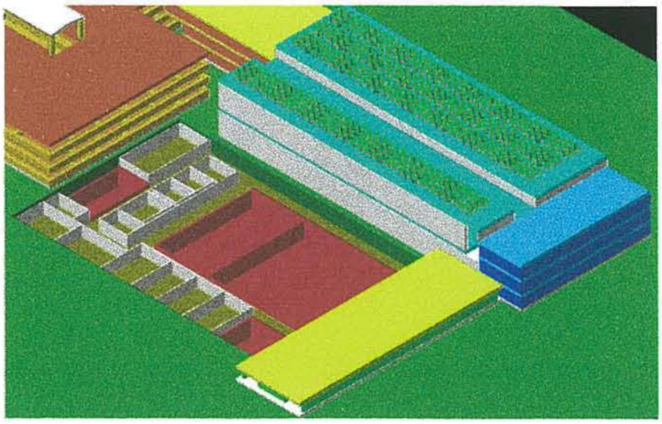
3. Sampling

Influent

A total composite sample (1 litre) comprising a number of grab samples is required. Influent samples should be taken of flow prior to entering the wastewater treatment plant and kept under cold storage until analysis.

Effluent

A composite sample (1 litre) comprising grab samples taken from the effluent tank.



13. CONCLUSIONS AND RECOMMENDATIONS

13. CONCLUSIONS AND RECOMMENDATIONS

13.1 The environmental impacts resulting from construction and operation of SSSH have been detailed in this SEIA. The study has recommended an approach to the architectural design and the proposed operation of the future slaughterhouse. Mitigation measures have been proposed in order to minimise environmental effects and to comply with applicable Governmental legislation and EPD guidelines.

13.2 The main conclusions and recommendations of the study, specifically for impacts on Air, Noise, Water, Solid Waste, Land Use and Visual Implications are detailed below and mitigation measures are summarized in Table 13.3 and 13.4.

Air Pollution

13.3 The odour levels generated from the various sources in SSSH range from 100 to 400,000 Odour Units. The odours are comprised of easily degradable natural organic compounds.

13.4 Incineration is not suitable in any of the applications of the slaughterhouse, except in the case of a full scale BPP process exhaust (if there is full-scale BPP) because it is expensive and only used for very high intensity odours. Biofilters require large areas and are heavy for roof-top installations. Activated carbon filters are not very suitable as local humidity reduces effectiveness substantially and they are expensive to maintain.

13.5 Effective mitigation measures identified are odour neutraliser agents (chemical and/or biological), wet scrubbers and ozone units. These may be used in combination with one another. The general approach for odour removal is to employ neutralising agents, in areas where animals are not present, to reduce odour at the source, and scrubbers and/or ozone to treat collected air.

13.6 In the open areas of KCR/ lorry unloading, transit pens, etc., the neutralising spray will be used frequently to achieve 90% odour reduction. In the lairage, a combination of neutralising spray and wet scrubbers will be used. The neutralising spray will be used less frequently as an odour depressant to achieve and maintain a 50% odour reduction and the wet scrubbers can achieve 95% reduction in emissions on their own, together they will achieve a total overall reduction of 97.5%.
There will be negligible odour impact from livestock vehicles off-site as pigs will be cleaned with water and the trucks will be washed before departure from the site.

13.7 For some confined areas, like the blood coagulation room, by-products collection area, by-products plant chill room, manure pump room, manure collection rooms, pig bristle chute room and the BPP room (if it is built), ozone will be used to abate odours and micro-organisms. Ozone has been shown to have a very high odour destruction efficiency depending upon the amount used and the contact retention time. The room exhaust air will be treated by scrubbers to achieve a high efficiency throughout the day since ozone is often used intermittently. This combination will result in removal efficiency of 95%, (Table 6.17).

13.8 The odour level from the wastewater treatment plant can be easily handled by a wet scrubber achieving 95% removal of hydrogen sulphide.

13.9 If a full-scale BPP is built, the odour treatment of the process exhaust must be extreme because the rendering process produces intense odours of up to 400,000 odour units. In this case, the incinerators are best suited to a high odour level and low air flowrate. It is recommended to have an incinerator for 99% removal of most odorous gases. From the BPP, the air will finally be carried through the ventilation system and passed through scrubbers, which have an odour removal efficiency of 95%. The combination of the exhaust incineration and scrubber processes should in theory result in 99.95% removal efficiency, however the accepted removal efficiency is 99.5%.

It will be desirable to employ ozone deodorization systems to ensure in-situ removal of odorous gases. Two ways of ozone deodorization will be performed in parallel at the same time, i.e., ozone aeration from ceiling (Figure 6.8d) and ozonised water for washing floors (Figure 6.8c). In principle, the ozonised air from the ozone generator will be pumped out (showering) through PVC pipes installed on the ceiling. The ozone is continually injected to achieve in-situ oxidation of odorous gases generated from rendering processes. Furthermore, ozonised air from the ozone generator will be mixed with water from the water tap by the mixing valve, and ozonised water is flushing out on the floor through PVC pipes installed on the floor. This ozonised water will also satisfactorily remove the odorous contaminants with simultaneous disinfection effects.

Conclusion

As it can be seen from the evidence supplied in Chapter 6, slaughterhouse operations will have an odour impact on local sensitive receivers. In Tables 6.7 - 6.12 odour impacts on the surrounding environment are clearly set out, the expected Odour Units must comply with the 5 OU impact limit. In this case it is our recommendation that a full-scale BPP would exceed this limit, this is unless five 40 m stacks were added to disperse the odour or the Government purchased the land containing the impacted sensitive receivers. A reduced-scale BPP at the SSSH would comply with the 5 OU stipulation if mitigation methods were applied. The client departments decided that only a reduced scale BPP (in the form of a blood coagulation plant to deal with waste blood) will be built. The condemned carcasses and coagulated blood will be sent to the Centralised Incineration Facility (CIF) for incineration and to landfill for disposal respectively.

Noise Impacts

13.10 SSSH construction and operational activities have significant noise impacts. Assessments were based on noise impacts at existing Kennedy Town Abattoir. Main problem areas include meat dispatch area, pig waiting lairage, unloading area noise and deodorization plant equipment.

13.11 Mitigation measures are recommended for these areas. Fans should be encased with silencers and scrubbers fitted on ventilation units. Vents should be acoustically treated with silencers and acoustic louvres installed.

13.12 It is recommended that the unloading area, which emanates significant noise levels from the livestock and trains, be screened by the proposed 2m to 4m high noise barriers, located within the site boundary.

13.13 Lairages which are characterized by high noise levels will be enclosed to different degrees with openings acoustically treated to reduce plant noise. Acoustic silencers will be fitted to air-intake sides and discharge sides of fans. All wall openings at holding lairage will be acoustically treated with 50% free area acoustic louvres for noise attenuation.

13.14 Noise barriers should have an impervious skin of material with no gaps and completely sealed joints. It is recommended that barriers have an absorptive surface to increase noise reduction efficiency. Table 7.14 "Recommended Noise Mitigation Measures" details areas/ activities and associated mitigation measures for operations throughout the slaughterhouse.

13.15 The Road Traffic Noise Assessment details noise levels emanated at roads located within the Study Area. Calculations of noise levels indicate that mitigation measures will reduce noise impacts to within the EPD guideline limit. The erection of a 700m long, 3m high noise barrier has been investigated and with this measure, facade noise levels would be reduced to 52-65 dB(A). The barrier is the most practical noise mitigation measure for road traffic and offers the greatest noise reduction

13.16 Train Noise Assessment indicates that with the erection of the proposed 2m to 4m high noise barriers, the Total Noise Levels from trains at the NSRs will be within the noise criteria.

Wastewater Disposal

13.17 Proper water pollution mitigation measures and monitoring program are recommended during construction phase to prevent discharge of sub-standard effluent from the premises.

13.18 Sources and characteristics of wastewater are identified. The estimated daily flow and pollution loading of wastewater are listed below:

Daily Flow :	5,021 cu.m/day
SS :	1,713 mg/l
BOD :	2,976 mg/l
COD :	4,751 mg/l
TKN :	396 mg/l
TTM :	0.02 mg/l

13.19 Wastewater generated from slaughtering operation and related activities will be treated by an underground wastewater treatment plant prior to be discharged to the SWHSTW. Treated effluent will achieve the domestic discharge quality such that the plant operator may apply for exemption from the Trade Effluent Surcharge.

13.20 An effective and extensive wastewater collection system is proposed. Separated drainage system for storm water and wastewater will be provided.

13.21 Two treatment options (combined treatment and separated treatment) and different treatment processes are evaluated. It is recommended that high strength and low strength wastewaters are combined for treatment. The treatment processes involve grease trap, screening, dissolved air flotation, flow equalization and biological nutrient removal.

13.22 Preliminary design parameters of the wastewater treatment plant are shown in Table 13.1. Other discharge requirements will be in accordance with Table 1 and Table 2, of the Technical Memorandum (Table 8.6).

Table 13.1: Preliminary Design Parameters of the Wastewater Treatment Plant

	Influent Characteristics (mg/l)	Recommended Effluent Quality (mg/l)	Removal Efficiency
SS	1,713	<250	>85%
BOD	2,976	<250	>92%
COD	4,751	<500	>89%
TKN	396	<50	>87%

13.23 Proper water saving measures are recommended to reduce the total water consumption.

Waste Management, Recycling and Disposal

13.24 Solid waste generation at SSSH will be significant. The majority of solid waste is generated as animal by-products/ wastes. Coagulated blood and paunch contents & offal are generated in the largest quantities, 12.0 and 10.2 tonnes/ day respectively.

13.25 Options for dealing with generated solid wastes are greatly influenced by the BPP option. With a full scale BPP, condemned meat and offal and coagulated blood will be processed. With the reduced scale BPP, coagulated blood, only would be processed, leaving the condemned meat and offal either to be disposed of in landfill or at the CIF. The full scale BPP option, therefore solves the problems of these wastes but must utilise extensive mitigation measures in order to reduce the intense odour that it will produce.

13.26 Significant quantities of sludge will be generated from the wastewater treatment plant. The recommended method of sludge disposal is trucking away to landfill. Options for trucking away stabilized sludge to organic farms should also be considered in terms of feasibility.

13.27 Chemical usage and disposal is an additional waste at SSSH. All chemicals are to be stored, packaged and handled in strict accordance with the Dangerous Goods Ordinance and other applicable legislation. SSSH must register as a Chemical Waste producer. Collection and disposal must be carried out by a licensed operator under the Waste Disposal (Chemical Waste) (General) Regulation.

Impacts on Land Use

13.28 Impact assessments for odour and water quality have indicated that land use implications will not be significant. With associated mitigation measures, the operations of the SSSH will have a residual impact on the SRs which will be within the Government regulations and EPD recommended limits.

13.29 A buffer zone is recommended for the area surrounding the SSSH which will include the SWHSTW. This area should be established as Green Belt to prevent any further urban development in the vicinity, as recommended in the Hong Kong Planning Standards and Guidelines. The exact buffer distance depends on the BPP option chosen. No buffer zone, in theory is needed with a reduced scale BPP or a full scale BPP, with 5 stacks, as none of the SR's exceed the 5 OU recommendation. The present "Green Belt" is recommended to be retained. In the case of the single stack, full scale BPP, a buffer zone extending beyond SR2 would be necessary.

13.30 Assessment of generated wastewater from SSSH indicates the need for either increased loading at the existing SWHSTW or the provision of on-site treatment facilities.

Visual Impacts

13.31 Construction and operation of SSSH will have visual impact comparable to the adjacent SWHSTW.

13.32 SRs include residents of low-rise village houses located in proximity to the Study Area as well as residents of high-rise buildings in North Sheung Shui.

13.33 Screen planting, as part of a planned landscaping system is recommended to mitigate visual impacts of SSSH during construction and operation. Covered walkways and hoardings erected during the construction phase are recommended. Other landscaping includes the planting of trees and shrubs around the border of the slaughterhouse.

Table 13.2 Preliminary Cost Estimation on Environmental Engineering Aspect

1. Odour

1.1	Unloading area - proposed train & lorry spray system, transit pens portable sprayers	0.6M
1.2	Sprinkler system for neutralising agent and odour monitoring system	6.0M
1.3	Lairage deodorization facilities - proposed multi-stage wet scrubbers	25.0M
1.4	Wastewater treatment plant deodorization facilities - proposed multi-stage wet scrubber	8.0M
1.5	Slaughter hall rooms i.e. blood coagulation room, by-products loading/unloading area, cold room	3.0M
	Sub-total :	**42.6M**

2. Wastewater Treatment

2.1	Provision of a wastewater treatment plant capable of treating slaughterhouse's wastewater to meet the discharge requirement for disposal at the Shek Wu Hui Sewage Treatment Works. Treatment processes include screening, air flotation, biological treatment with nutrient removal capability & sludge dewatering.	40.0M (E&M) 50.0M (Civil)
	Sub-total :	**90.0M**

3. Noise

3.1	Provision of mitigation measures for noise impact (silencer, boundary noise barriers and acoustic treatment).	10.0M
3.2	Off-site 700m long noise barrier wall	15.0M
3.3	Lairage Acoustic Louvre	12.5M
	Sub-total :	**37.5M**

4. Solid Waste

4.1	Provision of fully enclosed transit vehicles for transportation of by-products (condemned meat, animal cascasses and blood coagulum) to CIF and landfill.	2.0M
	Sub-total :	**2.0M**

5. Solar System

5.1	Provision of solar hot water system.	28.0M
	Sub-total :	**28.0M**

TOTAL ESTIMATE : HK$ 200.1M

Table 13.3 Summary of Environmental Concerns and Recommended Mitigation Measures for the Construction Phase

Environmental Consideration	Potential Environmental Impact	Recommended Mitigation Measures
Construction Phase		
Air	Fugitive dust Gaseous emissions	Paving/gravelling and regular watering, cleaning and maintenance of vehicles and equipment. Few vehicles and no temporary generators.
Noise	Piling, equipment, and machinery noise	Silencers on equipment, no parallel activities, use of portable sound barriers, route planning, no temporary generators.
Water	Contamination of surrounding watercourse	No untreated run-off, re-use for dust suppression, sediment and grease traps, spillage clean-up action plan, impervious ground for chemical use.
Waste	Solid and chemical waste disposal	Separation and recycling, chemical wastes handled and disposed of appropriately.
Visual Impact	Unsightly	Decorated hoardings and covered walkways, ordered site, early landscape planting.

Table 13.4 Summary of Environmental Concerns and Recommended Mitigation Measures for the Operation Phase

Environmental Consideration	Potential Environmental Impact	Recommended Mitigation Measures
Operation Phase		
Air	Emissions	
	On-site Odour	State of the art odour reducing technologies i.e. odour neutralising agent, wet scrubbers, ozone; high stack dispersion; negative pressure in buildings so no leakage; pigs from China cleaned on arrival.
	Off-site Odour	Livestock and trucks washed before transit to Tsuen Wan, containerised waste to landfill.
Noise	Animals and plant activity	Acoustically treated panels and silencers in the lairage.
	Traffic noise	Sound barrier (700m long, 3m high) along Po Wan Road, re-surface road.
	Meat dispatch area, train noise	Sound barriers erected along the north, west and south-east of site boundary.
Water	Contaminated effluent discharge	Specifically designed, fully automatic, underground wastewater treatment plant, reduce and re-use practise, effective internal drainage network
Waste	Solid and chemical waste disposal	Separation and recycling, chemical wastes handled and disposed of appropriately, by-product plant to reduce/recycle, sludge used as soil conditioner on farmland, minimum wastes to landfill.
Impact on Land Use	Incompatibility with other land uses	Present surrounding land use (agriculture and ponds) maintained through "buffer zone", no drainage impact
Visual Impact	Unsightly	Landscaping and site periphery planting, additional screen planting, sensitive colour schemes and choice of building materials.