HONG KONG GOVERNMENT
DRAINAGE SERVICES DEPARTMENT

Agreement No. CE 28/93
CENTRAL, WESTERN & WAN CHAI WEST SEWERAGE

REVISED FINAL ENVIRONMENTAL IMPACT ASSESSMENT

April 1997

MAUNSELL CONSULTANTS ASIA LTD
in association with
ATKINS HASWELL

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PREPARED BY :

CONSULTANTS IN
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FOR :

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ACRONYMS

ANL	Acceptable Noise Level
APCO	Air Pollution Control Ordinance
AQO	Air Quality Objective
ASR	Area Sensitivity Rating
CNP	Construction Noise Permit
CNL	Corrected Noise Level
CW3	Central Western and Wan Chai West Sewerage
FEIA	Final Environmental Impact Assessment
EPD	Environmental Protection Department
EQO	Environmental Quality Objective
FDM	Fugitive Dust Model
HKPSG	Hong Kong Planning Standards and Guidelines
NCO	Noise Control Ordinance
NSR	Noise Sensitive Receiver
ou	Odour Unit
PME	Powered Mechanical Equipment
RSP	Respirable Suspended Particulates
SSDS	Strategic Sewage Disposal Scheme
SR	Sensitive Receiver
SWL	Sound Power Level
TM	Technical Memorandum
TSP	Total Suspended Particulates
WPCO	Water Pollution Control Ordinance
WCZ	Water Control Zone
WRII	Wan Chai Reclamation Phase II

1 INTRODUCTION

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1.1 BACKGROUND

A study for the Central, Western, and Wan Chai West Sewerage Master Plan was completed in 1993. It recommended the construction of a new sewerage system to relieve existing overloaded sewers and to cater for future development of the metropolitan area, including the Central and Wan Chai Reclamation.

In May 1994, Maunsell Consultants Asia Limited were appointed by the Drainage Services Department to undertake a design and construction assignment to implement sewerage improvements in the Central, Western and Wan Chai West area.

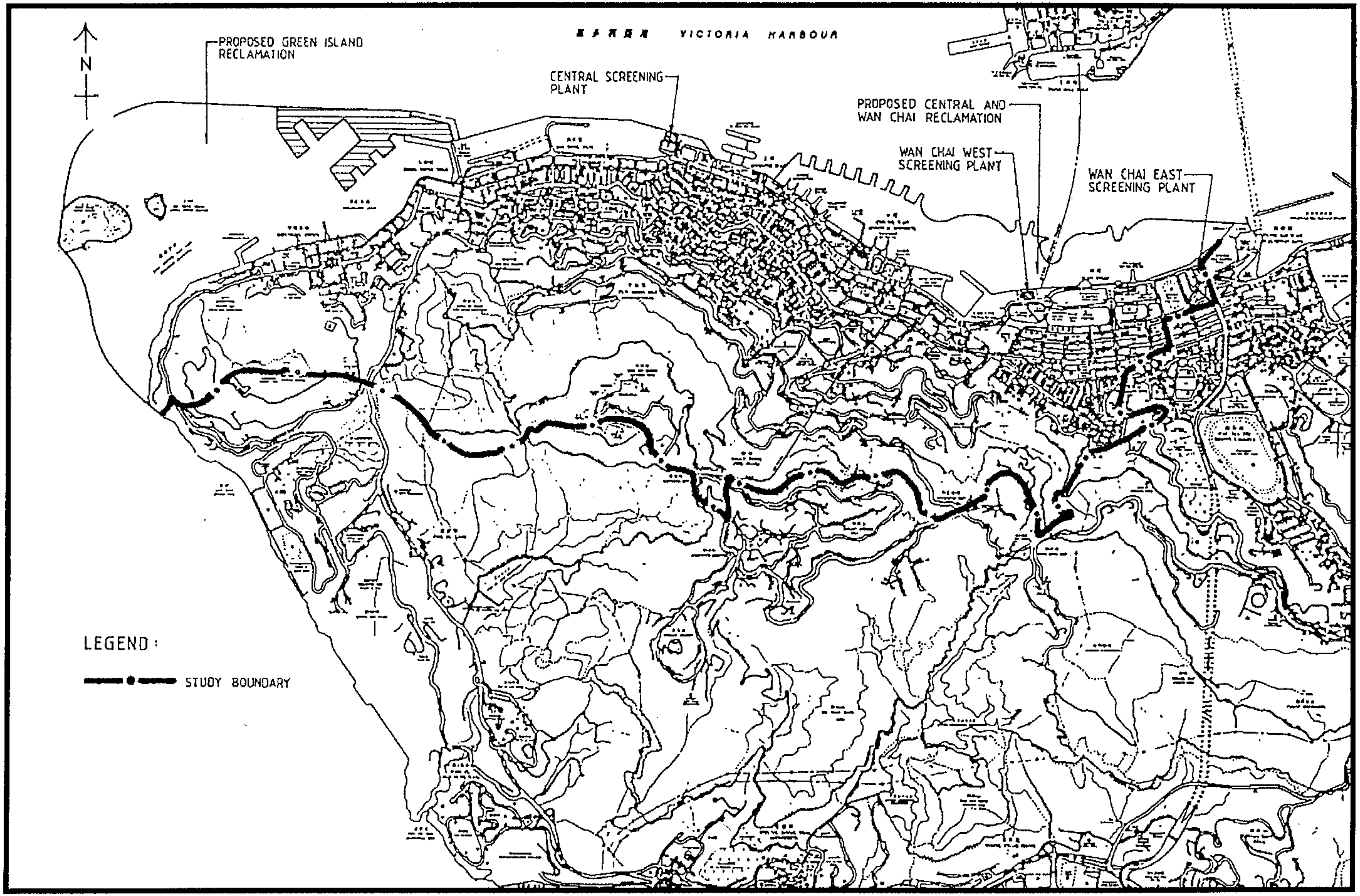
1.2 PROJECT DESCRIPTION

The study area [Figure 1.1] includes the western part of Wan Chai District, together with the urban area to the west including Central District, Sheung Wan, Sai Ying Pun, and Kennedy Town. It also includes Victoria Peak, Mid-Levels, Mount Kellett, Mt Gough and Mount Davis. The major works in the project consist of:

- Construction of two trunk sewers: Central and Wan Chai East trunk sewers which will involve the construction of:
  - 3.5 km of trunk sewer with hydraulic diameters between 1050 mm to 1800 mm to collect and transfer flow from Western and Central districts to Central Screening Plant, and
  - 2.3 km of trunk sewer with hydraulic diameters between 1200 mm to 1800 mm to collect and transfer of flow to Wan Chai East Screening Plant.
- Construction of approximately 31.2 km of interceptor and reticulation sewers and installation of about 1540 numbers of manholes in the study area to connect to the above trunk sewers. Depending on locations, the diameters of the pipelines will be between 225 mm and 1650 mm;
- Construction of a new pumping station at the existing Central Screening Plant;
- Construction of a new pumping station and an extension to the existing screening plant facilities at Wan Chai East Screening Plant.

Overall key plan of proposed works from Western to Central and Central to Wan Chai are summarised in Figures A-1 and A-2 respectively in Appendix A.

Once Stage III/IV of the Strategic Sewage Disposal Scheme (SSDS) is implemented, flows will be diverted from the existing Wan Chai West Screening Plant to the extended Wan Chai East Screening Plant facilities for screening and degritting prior to discharge to the SSDS, deep



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STUDY AREA
FIGURE 1.1

tunnel system. The Wan Chai West Screening Plant will then be decommissioned. The design capacity of the existing Wan Chai East Outfall will not be exceeded under the project.

1.3 OBJECTIVES

The objectives of this Final Environmental Impact Assessment Report (FEIA) are to:

- Identify and assess environmental impacts resulting from construction activities of the scheme;
- Examine in greater detail the environmental impacts associated with the operation of permanent facilities such as screening plants and pumping stations;
- Identify sensitive receivers (SRs) and propose mitigation measures in order to reduce environmental impacts upon SRs to levels which will comply with environmental performance standards;
- Recommend environmental monitoring programmes as necessary to determine baseline conditions and to demonstrate compliance with environmental quality objectives (EQOs);
- Recommend a programme of environmental auditing for the scheme.

It should be recognised that the environmental assessment contained in this Report has been undertaken using data and information correct at the time of production. As the design process proceeds and implementation of the project progresses, changes in the nature, scale and effect of environmental impacts may occur.

1.4 SCOPE

Impacts have been assessed in terms of the negative effect on existing or planned SRs in the vicinity of construction and operation sites. They include:

- Construction Impacts:
  - noise impacts on identified noise sensitive receivers (NSRs) caused by construction equipment
  - dust emission caused by construction activities
  - qualitative cumulative dust impact from relevant projects in the study area
  - impact of discharging construction wastewater
  - handling and disposal of excavated spoil including contaminated soil

- Operational Impacts
  - odour emissions from pumping stations and screening plants
  - noise from two pumping stations and screening plants
  - marine water quality impact due to effluent discharge

Also included in the FEIA are recommendations for mitigation measures designed to minimise any impacts and to ensure compliance with environmentally acceptable standards. Monitoring and audit programmes to determine baseline conditions, extent of impacts and compliance with EQOs are also considered.

2 CONSTRUCTION AND OPERATIONAL ACTIVITIES

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2.1 CONSTRUCTION ACTIVITIES

2.1.1 Introduction

Construction activities will generally involve excavation of working shafts, manholes, tunnels, and trenches for the sewers and deep excavation for the new pumping stations. Details are summarised in the following paragraphs.

2.1.2 Trunk Sewers

It is anticipated that the trunk sewer will be constructed by a combination of conventional open trench excavation methods and either tunnelling or pipejacking methods. The construction method selected will be influenced by the depth and diameter of sewer, the alignment and other physical constraints such as geotechnical conditions and traffic constraints. A final decision has still to be made on whether tunnelling or pipejacking methods are adopted and on the type of construction plant used for these methods. The locations of working shafts, in particular, have yet to be confirmed since they are so dependant on the actual construction method adopted. It is therefore only possible at this stage of the design process to examine a range of options for their locations.

Tunnel Excavation: The tunnel excavation will be initially supported by a precast concrete segmental lining employing a wedge system, incorporating a water proof seal between adjacent segments. On completion of the tunnel excavation, an in-situ concrete lining will be installed.

Pipejacking: This is very similar to the tunnelling method but more frequent construction shafts are required, although these are utilised for a shorter time. Ground support is provided by concrete pipes instead of a segmental lining. Excavation methods are very similar.

Open-cut Excavation: This will involve the breaking up of the existing carriageways and paved surfaces with pneumatic plant, excavation of trenches using mechanical equipment, sheet piling or timbering, pumping of water from excavated trenches, removal of excavated spoil off-site by lorries for disposal or temporary stockpiling, laying of pipes into the trenches, and backfilling and reinstatement of the entire length of footpath/carriageway.

2.1.3 Shafts and Manholes

As noted in sub-section 2.1.2, the number of shafts will be influenced by the construction method. Pipejacking will require shafts every 100 to 200 m whereas tunnel options can cope with lengths in excess of 1 km.

Working shafts will provide temporary access to the tunnel during the trunk sewer construction as well as working areas for materials including excavated spoil and equipment handling. The tunnel spoil will be pumped to the surface at the access shafts and will be treated on-site by spoil removal and slurry cleaning plant prior to transportation to the designated sites for disposal. Tunnel lining segments will be delivered to the working shafts and transported along the tunnel to the face. Pipes for pipejacking will be delivered to the shaft.

A reception shaft is required at the end of each tunnel or pipejacking drive to remove the tunnelling/pipejacking machine. This is only used for a few days for machine removal and can therefore be temporarily decked over following its construction until the machine is close to the shaft. Both working and reception shafts can be used for more than one drive.

Manholes will be required at changes in direction of the sewer and to connect in flows from the existing sewer system. Wherever possible these will be located to coincide with working and reception shaft locations.

Shafts will be constructed using diaphragm walling or continuous piling methods. The base of each shaft will be grouted to control the vertical inflow of groundwater. In addition, the ground outside the shaft where the tunnel drive either commences or terminates will be grouted to enable work to be done in free air at the shaft and at the end of the drive. Shallower shafts may be constructed by sheet piling methods.

2.1.4 Pumping Stations and Screening Plants

Two deep centrifugal pumping stations will be constructed to replace the existing ones at the Wan Chai East and Central Screening Plants. The existing screening plant facilities will also be upgraded and although the degree of modification of each plant will be different depending upon site-specific requirements, the following similar construction work will take place:

- Diaphragm walling and bulk excavation for pumping stations;
- Pumping out excavation;
- Demolition of some existing structures;
- Delivery/stockpiling of reinforcement and other construction materials;
- Construction, erection and dismantling of concrete formwork;
- Piling of foundations for new structures.

2.1.5 Reticulation and Interceptor Sewers

A conventional open cut and cover trenching technique will be used for the construction of reticulation and interception sewers. A description of this method is presented in Section 2.1.2.

2.2 OPERATIONAL ACTIVITIES

Continued operation of both existing screening plants will be required. Existing and proposed facilities at the plants are summarised in Table 2.1.

Table 2.1 Existing and Proposed Facilities at Central and Wan Chai East Screening Plants

Site	Existing Facilities	New Installations
Wan Chai East	Screening Plant with: • Inlet pumping station • Coarse and fine screens • Pista grit traps	• New inlet pumping station • New coarse screening • Two Jeta grit traps • New fine screens • New plant building • New motor control centre • New substation • New administration offices
Central	Screening Plant with: • Inlet bar rack • Inlet screw pumping station • Coarse and fine screens • Pista grit traps	• New pumping station building with administration office • Motor control centre room • Transformer room • New inlet chamber with coarse screens • Associated channels

3 ENVIRONMENTAL STANDARDS, AND LEGISLATIVE CONTROL AND EXISTING CONDITIONS

3 ENVIRONMENTAL STANDARDS, LEGISLATIVE CONTROL AND EXISTING CONDITIONS

3.1 AIR QUALITY

3.1.1 Legislation and Guidelines

The Air Pollution Control Ordinance (APCO) provides power for controlling air pollutants from a variety of stationary sources (including fugitive dust emissions from construction sites) and motor vehicles. Air Quality Objectives (AQOs) for CO, NO_2, Total Suspended Particulates (TSP) and Respirable Suspended Particulates (RSP) in ambient air have been assigned. These are listed in Table 3.1.

Table 3.1 Hong Kong Air Quality Objectives

Parameter	Average Concentration μgm^{-3}			
	1-Hour	8-Hour	24-Hour$^{(i)}$	Annual
CO	30000	10000	-	-
NO_2	300	-	150	80
TSP	-	-	260	80
RSP	-	-	180	55

(i) Not to be exceeded more than once per year.

In addition to the above established legislative controls, it is generally accepted that an hourly average TSP concentration of 500 μgm^{-3} should not be exceeded at any location within the site. Such a control limit has no statutory basis but is particularly relevant to construction work and has been imposed on a number of construction projects in Hong Kong in the form of contract clauses.

The AQOs do not specify a maximum level for odour but control has been imposed previously at industrial sites through the inclusion of "maximum permissible odour levels at the site boundary" in contract documents. Typically, control levels of 2 odour units (ou) have been used for odorous installations in Hong Kong. This is equivalent to a dilution factor of 2, which means that the odour must not exceed a level twice that of its detection threshold, defined as that concentration which can be detected nasally by 50% of the members of an odour assessment panel.

3.1.2 Existing Air Quality Conditions

No site specific dust monitoring data is available. Air quality data from Environmental Protection Department's (EPD's) Central/Western monitoring station is selected as it is in close proximity to the working sites [Table 3.2].

These data have been extrapolated from histograms since no tabulated data were provided and therefore may not be totally accurate. However, in general terms it can be seen that annual TSP and RSP levels appear to have slightly improved in 1993, with little change to SO_2 and NO_2 levels. In 1992 both TSP and RSP levels exceeded their AQO. With the exception of SO_2 all daily readings have increased from the previous year, though AQOs have yet to be exceeded.

Table 3.2 Annual and Daily EPD Air Quality Statistics from Central/Western Monitoring Station

Year	Mean Annual Conc. (μgm^{-3})				Max. Daily Conc. (μgm^{-3})			
	SO_2	NO_2	TSP	RSP	SO_2	NO_2	TSP	RSP
1991	18	50	75	*60*	70	120	210	145
1992	23	50	*90*	*60*	138	120	150	146
1993	23	50	*82*	53	102	134	190	153

Note: Italics type denotes exceedance of AQO

Dust levels at the Wan Chai East site are difficult to predict because of its location in the urban environment and, in particular, construction activities constantly taking place in adjacent areas.

Baseline odour monitoring was undertaken by CES (Asia) Ltd in March 1995. Four sampling locations (between 100 and 150 m from the screening plant site boundaries), two for each screening plant, were selected. The monitoring results indicate that the ambient odour levels were all within the 2 ou limit.

3.2 NOISE

3.2.1 Legislation and Guidelines

Noise generated by industrial and related operations is controlled under the Noise Control Ordinance (NCO). The NCO also regulates noise from percussive piling, and from general construction activities during restricted evening (19:00-23:00) and night-time (23:00-07:00) hours, as well as all day during public holidays including Sundays.

The criteria for assessing the extent of noise impact depend on the appropriate area sensitivity rating (ASR) and the time period under consideration. The ASR is determined by the prevailing noise climate of the area in question. 'A' is classed as being unaffected by influencing factors (such as busy roads); 'B' is indirectly affected; and 'C' is directly affected.

<u>Construction Noise:</u> General construction noise during restricted evening and night-time hours, as well as public holidays including Sundays is governed by the Technical Memorandum (TM) on Noise from Construction Work other than Percussive Piling under the

NCO. The acceptable noise levels (ANLs) at the facade of NSRs must be complied with [Table 3.3]. A Construction Noise Permit (CNP) will also be required for working during these restricted periods.

A daytime (except holidays) construction noise limit is not specified in the NCO, nor in the Hong Kong Planning Standards and Guidelines (HKPSG). However, the Practice Note For Professional Persons (ProPECC DP 2/93) recommended $L_{Aeq\ 30\ min}$ limits of 75 dB(A) at dwellings, 70 dB(A)$L_{Aeq\ (30\ min)}$ for school and 65 dB(A)$L_{Aeq\ (30\ min)}$ during examinations. A CNP is not required for work carried out during this period.

Operational Noise: For the operational phase, ANLs [Table 3.3] for fixed noise sources are governed by the TM for the Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites. The HKPSG also recommends that in order to plan for a better environment, the level of intruding noise at the facade of the nearest NSR should be at least 5 dB(A) less than the appropriate ANL, or in the case of existing background noise being 5 dB(A) lower than the ANL, the intruding noise level should not be higher than background.

Table 3.3 Acceptable Noise Levels for Different Area Sensitivity Ratings

Time Period	ANLs (dB(A)) for Different ASRs(i)					
	Construction			Operation		
	A	B	C	A	B	C
Daytime: 07:00 - 19:00 (excluding holidays & Sundays)	75(ii)	75(ii)	75(ii)	60	65	70
Evening: 19:00 - 23:00 on all day 07:00 - 19:00 (on holidays & Sundays)	60	65	70	60	65	70
Night-time: 23:00 - 07:00 on all days	45	50	55	50	55	60

(i) $L_{Aeq\ (30\ min)}$, except construction noise during evening, night-time and holidays, which is $L_{Aeq\ (5\ min)}$.
(ii) Non-statutory requirement.

Piling Noise: Noise generated by percussive piling is similarly subject to control under the NCO by provisions described in the TM on Noise from Percussive Piling. The separate CNP required for piling includes restrictions on the hours during which piling can take place. The permitted hours of operation are presented in Table 3.4. These are based on the extent to which the Corrected Noise Level (CNL) at the NSRs exceeds the ANL.

It is an offence, under the Summary Offenses Ordinance (cap 228) to drive piles between the hours of 19:00 and 07:00 unless an exemption has been granted.

Table 3.4 Permitted Hours of Operation for Percussive Piling

Amount by Which Percussive Piling CNL Exceeds 85 dB(A)	Permitted Hours of Operation on Any Day Not Being A General Holiday
More than 10 dB(A)	08:00 - 09:00, 12:30 - 13:30 and 17:00 - 18:00
Between 1 dB(A) and 10 dB(A)	08:00 - 09:30, 12:30 - 14:00 and 16:30 - 18:00
No exceedance	07:00 - 19:00

3.2.2 Existing Noise Conditions

During October 1994, background noise monitoring was undertaken at six selected locations in Wan Chai, Central and Western districts [Figure 3.1]. Noise levels during daytime, evening and night-time were recorded on three separate occasions. Mean noise levels for each station are summarised in Table 3.5. Details of noise monitoring data are included in Appendix B.

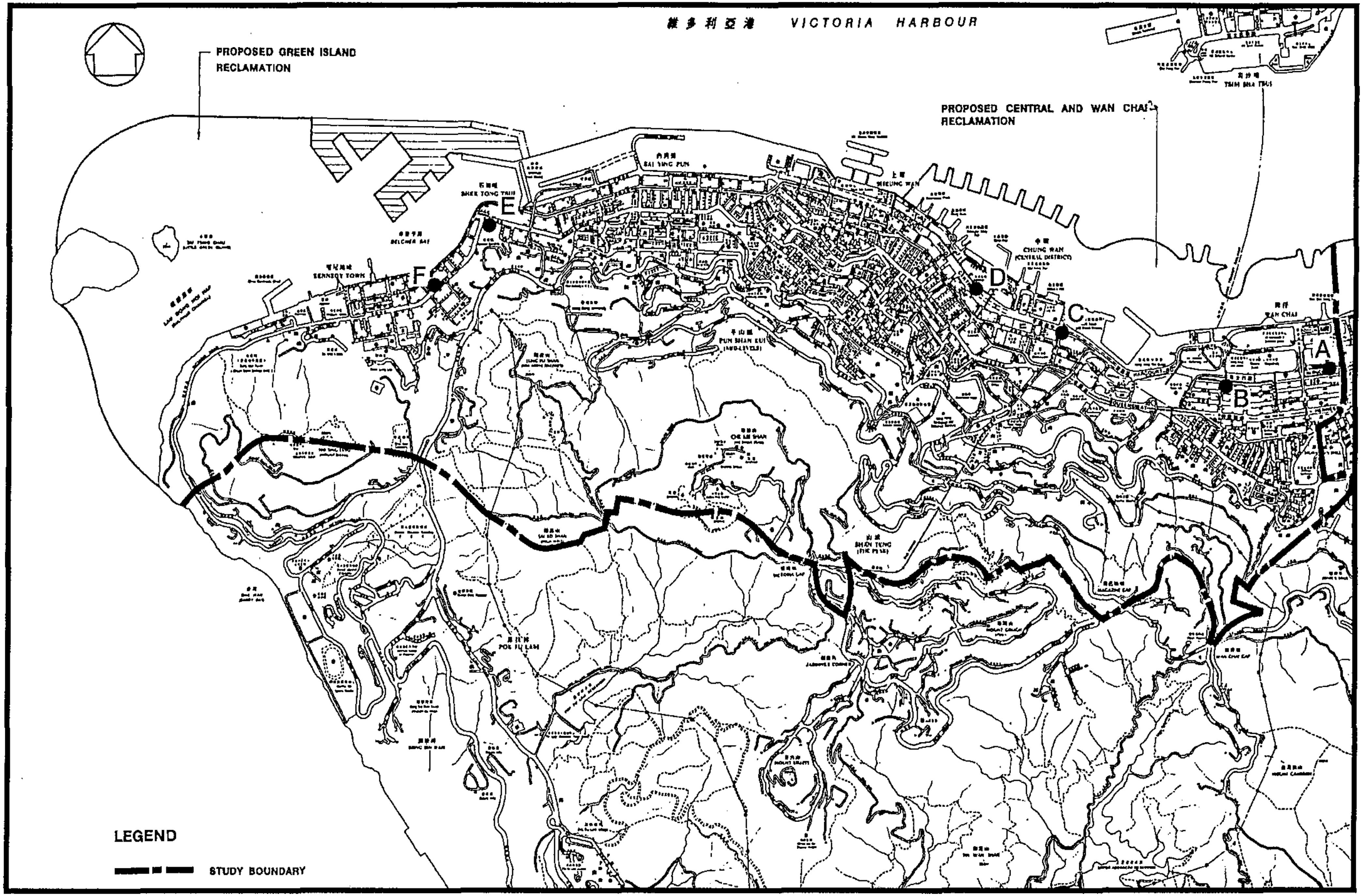
Table 3.5 Baseline Noise Monitoring Results

Location		Noise Level, dB(A)		
		Day $L_{Aeq\ (30\ min)}$	Evening $L_{Aeq\ (5\ min)}$	Night $L_{Aeq\ (5\ min)}$
Station A	Podium of Sun Hung Kai Centre facing Gloucester Road	74.7	74.8	74.3
Station B	Ground floor of Evergo House facing Gloucester Road	75.8	74.8	72.4
Station C	Footbridge over Harcourt Road by Hutchison House	76.7	74.5	73.9
Station D	Footbridge in front of Exchange Square facing Connaught Road Centre	81.6	75.7	72.7
Station E	Ground floor & in front of 570-572 Queen's Road West	76.0	76.3	72.3
Station F	Ground floor & in front of 23 Belcher's Street	77.4	78.8	71.2

Note: Station A,C & D measurements made in free field
Station B, E & F measurements include facade effect

The results indicate that the discrepancy of noise levels during daytime, evening and night-time in the study area is very small. Noise levels are constantly high and over 70 dB(A). They (except for daytime noise for Station A) exceeded their respective ANLs specified in the construction and operation TM respectively and limits in ProPECC DP 2/93.

Similarly, results were obtained at the monitoring stations of the Western Harbour Crossing during baseline monitoring between late 1993 and early 1994. Means of noise levels in the Sai Ying Pun area were constantly high during daytime, evening and night-time periods.



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BASELINE NOISE MONITORING STATIONS
FIGURE 3.1

3.3 WATER QUALITY

3.3.1 Legislation

The control of water quality in Hong Kong is mainly governed by the Water Pollution Control Ordinance (WPCO) which was enacted in 1980 and amended in 1990. This legislation enables the Government to declare Water Control Zones (WCZ) within which discharge of effluent is controlled through licenses, and to permit the establishment of WQOs for each zone or subzone.

A TM issued in 1990 under the WPCO is used as a guide for setting standards in licenses for effluent discharged to foul sewers, storm water drains, inland and coastal waters within WCZs. All discharges within gazetted WCZs, other than a discharge of domestic sewage into foul sewers, should comply with TM standards.

The study area is situated within the Victoria Harbour WCZ (Phase III), which was gazetted in April 1996. Any discharges within this zone are therefore subject to control through licences.

3.3.2 Existing Water Quality Conditions

Water quality in Victoria Harbour is poor due to discharges of industrial effluents and untreated wastewaters. The situation will continue until commissioning of new sewerage schemes.

3.4 SOLID WASTE

3.4.1 Legislation

Hong Kong currently has no criteria of its own for assessing land contamination. However, a standard approach has been developed in the Netherlands and this system is recognised by EPD.

The Dutch system provides reference values for soil at three levels A, B and C. The A value is the normal background level, the B value is set at the 'delimiting value for soil having the potential for causing adverse effects to human health or the environment and requiring further investigation' and the C value delimits 'heavy pollution and requirement for remedial action'. The Dutch criteria for judging the significance of soil contamination for selected relevant parameters are presented in Table 3.6. The Dutch B value has been previously adopted in local projects as the threshold level for remedial action, although consideration should be given to site-specific factors.

Table 3.6 Selected Dutch Values for Judging Significance of Soil Contamination

Parameter	Reference Values ($mg\ kg^{-1}$)		
	A	B	C
Total Petroleum Hydrocarbons (TPH)	100	1000	5000
Benzene	0.01	0.5	5
Toluene	0.05	3	30
Ethylbenzene	0.05	5	50
Xylenes (total)	0.05	5	50
1,1,1-Trichloroethane	0.1	5	50
Polycyclic Aromatic Hydrocarbons (PAH) (total)	1	20	200
Arsenic	20	30	50
Cadmium	1	5	20
Chromium	100	250	800
Copper	50	100	500
Lead	50	150	600
Tin	20	50	300
Mercury	0.5	2	10
Zinc	200	500	3000
Nickel	50	100	500

4 ENVIRONMENTAL IMPACTS DURING CONSTRUCTION PHASE

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4.1 AIR QUALITY

4.1.1 Identification of Impacts and Assessment Methodology

Vehicle and plant exhaust emissions are not expected to constitute a significant source of impact, in view of the existing high volumes of traffic in the Study Area and limited number of equipment to be used on the sites. The most important airborne pollutant arising from construction would be dust. At all work sites, dust could be caused by:

- Concrete breaking;
- Bulk excavation for shafts, trenches, or pumping stations;
- Material handling;
- Backfilling of shafts and/or open-cut trenches;
- Vehicle movements around dusty areas.

Considering the short duration of construction work along both trunk and reticulation/interception sewer alignments, dust emissions from these locations are expected to be minimal. Thus quantitative dust emission predictions, in terms of TSP concentrations (1-hour and 24-hour), were only undertaken for both Central and Wan Chai East Screening Plants, representing the most intensive construction activities.

The emission factor for general heavy construction operations was predicted by means of USEPA *Compilation of Air Pollutant Emission Factors* (AP-42) although the factor was considered to be a conservative estimate for this small construction site. Practical dust suppression measures with mitigation efficiency of 50 percent was assumed in the dust emission calculations. In addition, the modelling also assumed that the construction activities would be undertaken between 07:00 and 23:00, and 70 percent of the construction area would be working simultaneously at any one time.

TSP dispersions were modelled using AAQuIRE (Ambient Air Quality in Regional Environments) system developed by CES. AAQuIRE performs multiple runs of the USEPA approved Fugitive Dust Model (FDM) to assess potential impacts from the construction activities.

Sequential hourly data for wind speed, wind direction and surface observations from the Royal Observatory for the year 1992 were used for the assessment. Dispersion modelling was undertaken for 120 predefined separate meteorological categories. At each receptor grid point, the 1-hour average concentration for TSP was predicted for each of the categories. The concentration predictions for the 120 meteorological categories were then compared with each sequential hourly meteorological data set to produce time-sequenced hourly pollutant concentrations. These sequential hourly concentrations allowed realistic

1-hour and 24-hour averages to be generated at each receptor grid point, rather than relying on the simplistic 'worst-case' approach.

4.1.2 Assessment

4.1.2.1 Trunk Sewer Alignments

Trenchless Sections: Most of the construction for the trenchless sections will be undertaken underground. The surface work will only occur at the working shaft sites where concrete breaking and surface excavation of shafts will take place during the initial construction. These activities will be limited to very small areas up to 30 m^2 depending upon the location. Therefore, dust generation is considered to be insignificant and should fall within the environmental performance requirements. As excavation of the tunnels continues to be carried out underground, dust may be generated by activities related to the handling and transportation of construction materials. Only several truck loads per day are expected at any given shaft site. Dust emission due to such activities would be negligible. Therefore, it is not considered that dust emission at these construction sites will cause unacceptable impacts at the SRs. However, it is still recommended that dust suppression measures described in Section 6.1 should be adopted where practicable to minimise the impact.

Open Cut and Cover Sections: Dust will be emitted during construction as a result of the activities identified in Section 4.1.1. Emissions may be greater than those at the shaft sites. This is due to all the construction work being undertaken above surface along the trenches, and the temporary storage of excavated spoil along the sides of the trenches prior to transportation off-site for re-use or disposal. The degree of impact on SRs will depend upon dust generating activities at the time, distances to the SRs, and weather conditions. Considering the low intensity and small scale nature of the construction activities, and the high water contents of spoil, it is envisaged that on the whole, unacceptable dust impact due to the construction should not occur. The impact should also be temporary at each SR. Mitigation measures recommended in Section 6.1 should ensure compliance with AQOs.

4.1.2.2 Reticulation/Interception Sewer Alignments

Construction activities along sewer alignments will be similar to the open cut and cover sections. However, because only small diameter pipes are required, excavation and material handling will be on a smaller scale. In view of the low intensity of construction, it is not considered that dust will cause noticeable impact on the SRs. However, mitigation recommended in Section 6.1 should be adopted where possible to minimise the impact.

4.1.2.3 Screening Plants

The construction of new facilities at two screening plants will be on larger scale and for longer duration, lasting approximately one year. Detailed construction activities were described in Section 2.1.4. It was considered that the major dust impact would result from ground excavation, superstructure and traffic moving on unpaved site areas for the delivery and transport of materials.

Predicted maximum 1-hour and 24-hour average TSP concentrations at 1.5 metres above local ground level in the proximity of the pumping stations are shown in Figures 4.1 to 4.4. The dust level contours in the figures indicate that dust impacts are mainly confined to the areas close to the construction sites. At Central Screening Plant, TSP of 1-hour and 24-hour average at the closest SRs of Sheung Wan Fire Station) are 200 μgm^{-3} and 70 μgm^{-3} respectively [Figures 4.1 and 4.2]. Similarly, at the Wan Chai East Screening Plant, TSP of 1-hour and 24-hour average are 300 μgm^{-3} and 140 μgm^{-3} respectively at the closest air SRs of the Royal Society for the Prevention of Cruelty to Animals, Hong Kong [Figures 4.3 and 4.4]. They are all within the 1-hour average guideline of 500 μgm^{-3} and the 24-hour average AQO of 260 μgm^{-3}. However, due to the close proximity to the SRs, mitigation measures recommended in Section 6.1 should still be adopted.

4.1.2.4 Cumulative Impact Assessment

It is understood that this project may interface with a number of other projects within the study area. Cumulative dust impact on SRs may therefore occur. Due to the uncertainty of construction programmes of other projects, it is impossible to undertake quantitative cumulative dust impact. However, as mentioned above, dust impact due to this project will be minimal and can be easily controlled within the acceptable levels. In addition, the control of dust impacts from other projects are beyond the responsibility of this contractor. Thus it is considered more appropriate and practical to minimise dust emission from this project by enforcing mitigation measures on the contractor, thereby reducing overall negative impacts on the air quality. It is recommended that a similar approach should also be adopted by the contractors of other projects to protect the overall ambient air quality.

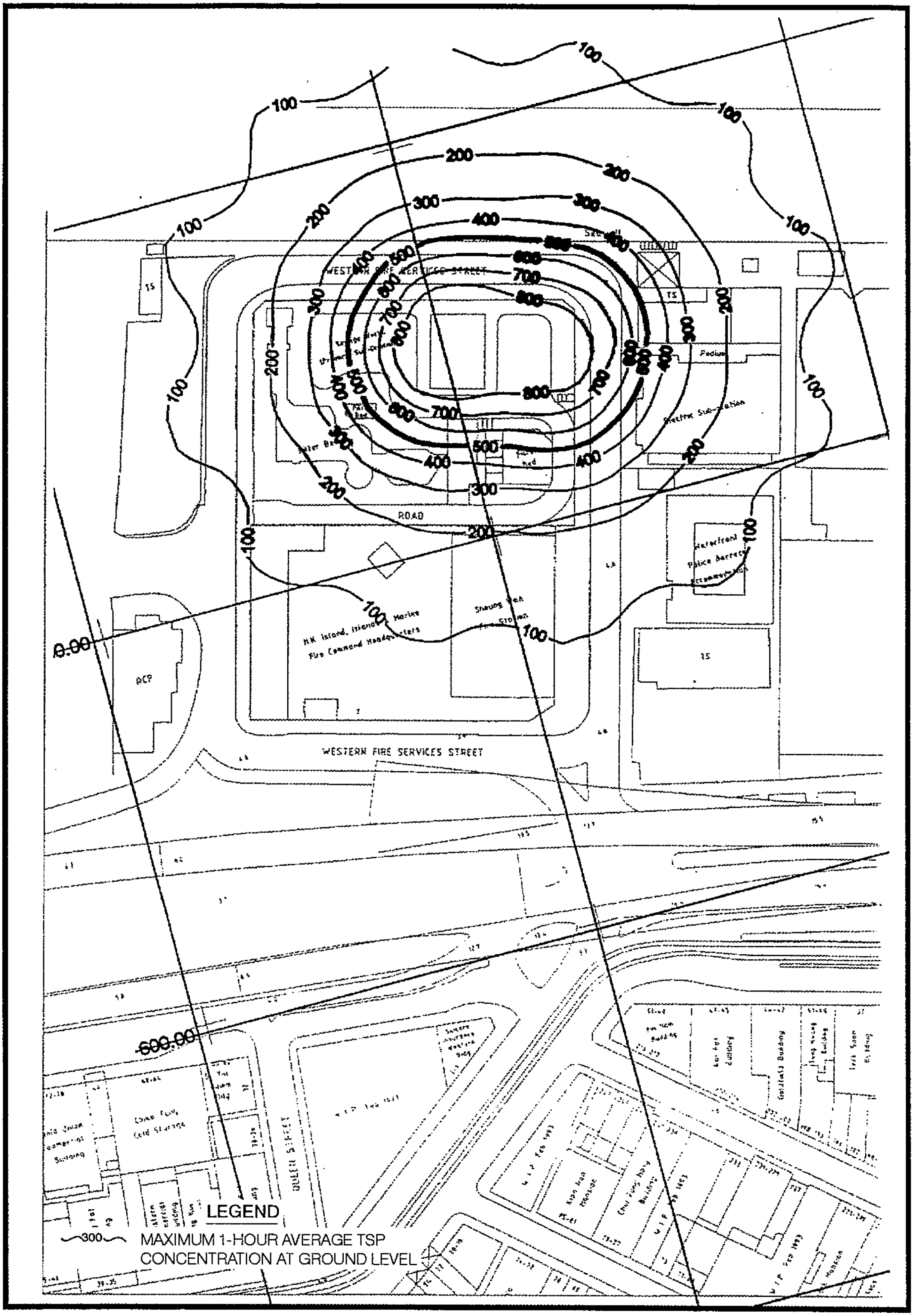
4.2 NOISE

4.2.1 Identification of Impacts and Methodology

It is likely that noise from construction activities will be a source of nuisance for residents and workers in close proximity to working areas. The main source will be powered mechanical equipment (PME) used for concrete breaking, excavation and material handling. The purpose of the construction noise impact prediction is to identify the extent to which NSRs will be affected by the construction of the proposed trunk sewer alignments, pumping stations at Central and Wan Chai East Screening Plants and reticulation/interception sewers.

Potential noise impacts are assessed in accordance with the criteria and methodology given in the TM of NCO and British Standard 5228, Part 1:1984, 'Noise Control on Construction and Open Sites'. Additionally, the following assumptions have been made with regard to the noise assessment for the construction of trunk sewers, in order to calculate noise impacts under the worst scenario:

- Distances between NSRs and the sewer alignment are measured as the minimum distance between the two locations, and these distances are made from the ground level of the NSR to the ground level of the nearest part of the sewer alignment. This is the case for both proposed 'open cut' sections and also 'no dig' sections;



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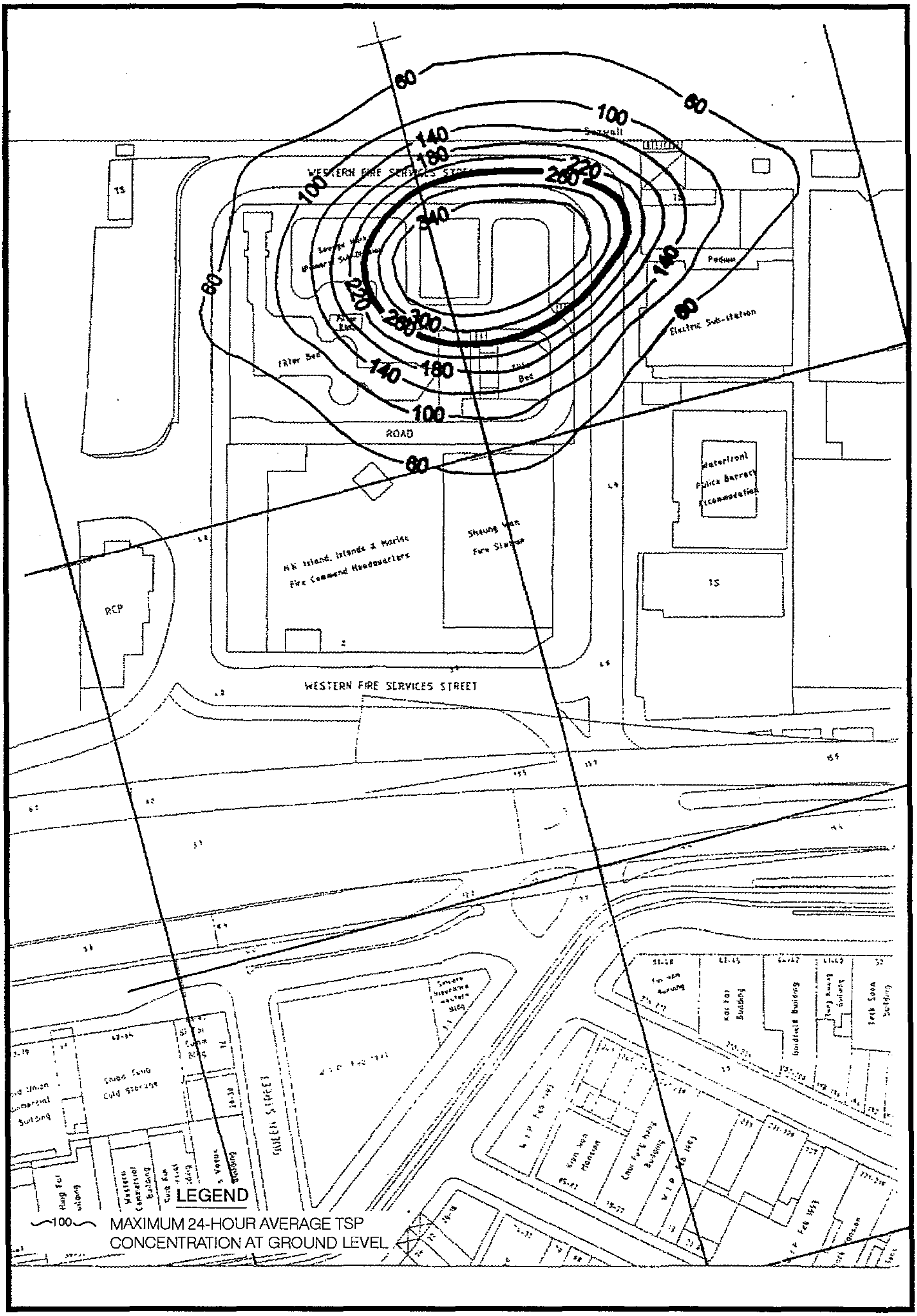
1-HOUR TSP CONCENTRATIONS AT CENTRAL SCREENING PLANT

FIGURE 4.1



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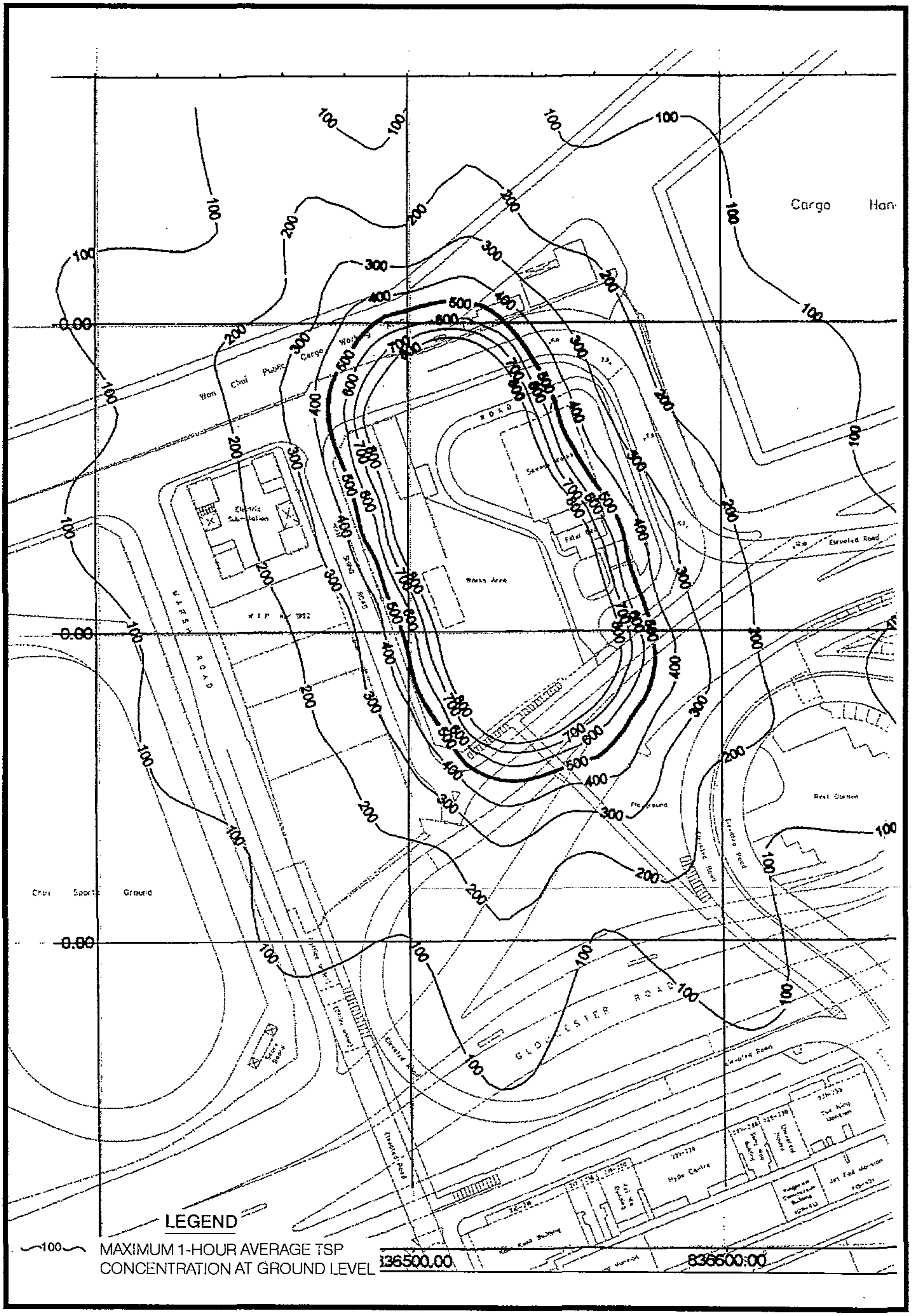
24-HOUR TSP CONCENTRATIONS AT CENTRAL SCREENING PLANT
FIGURE 4.2



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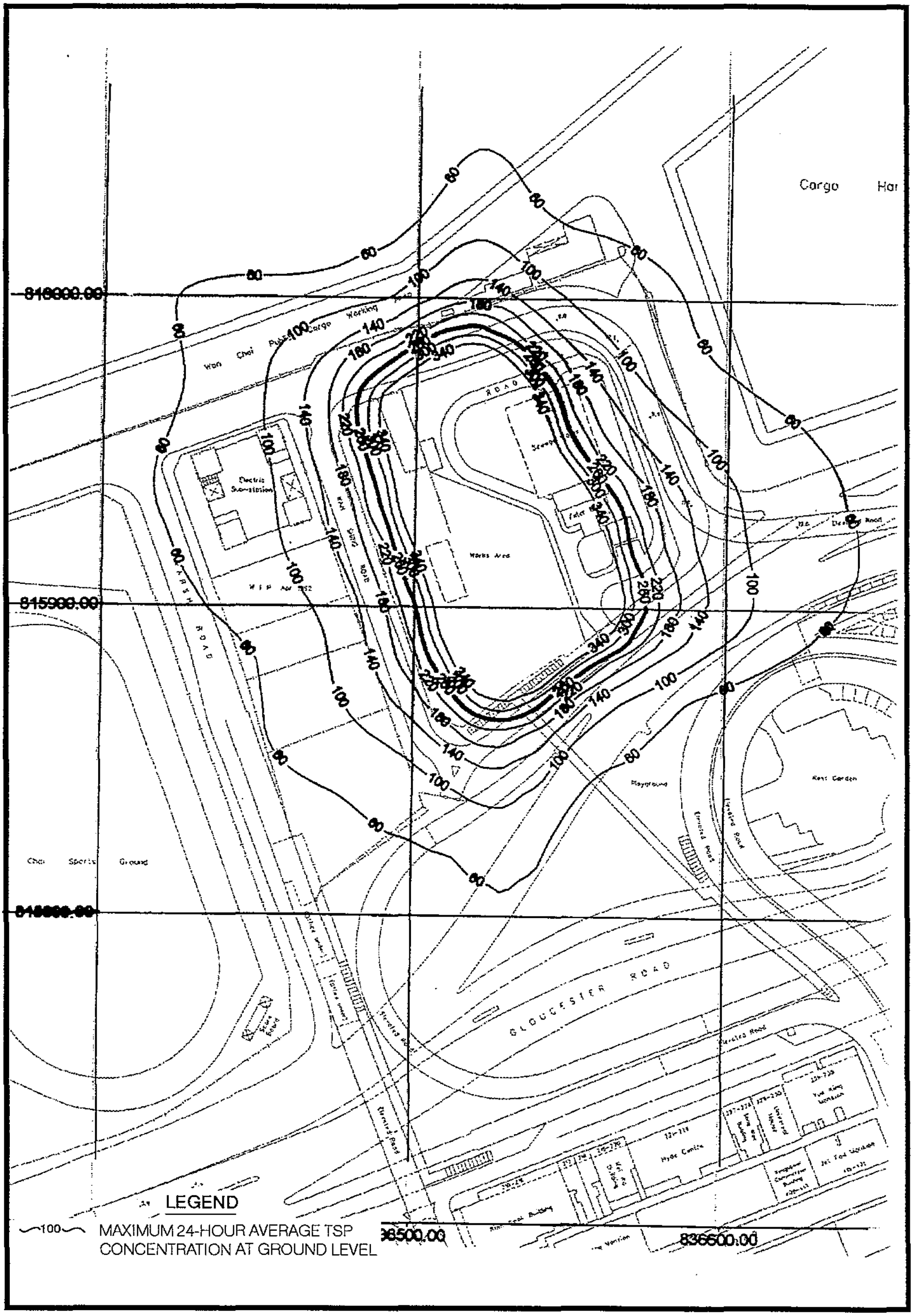
1-HOUR TSP CONCENTRATIONS AT WAN CHAI EAST SCREENING PLANT

FIGURE 4.3



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24-HOUR TSP CONCENTRATIONS AT WAN CHAI EAST SCREENING PLANT
FIGURE 4.4

- Some working shaft and manhole sites are yet to be finalised, thus every part of the 'no dig' section, unless otherwise indicated, is considered as a potential shaft site. Thus this worst case assumption allows the shaft site locations to be altered without worsening the predicted noise impacts at NSRs;

- Only those NSRs within direct line of sight of the construction site are considered as they represent the worst case scenario;

- It is assumed that each item of equipment identified for each type of construction may be used at any time. However, the piling impact for trunk sewers is assessed separately because it would not overlap with the rest of construction activities;

- For the purpose of this assessment it has been assumed that all PME will be used constantly (100% on times assumed).

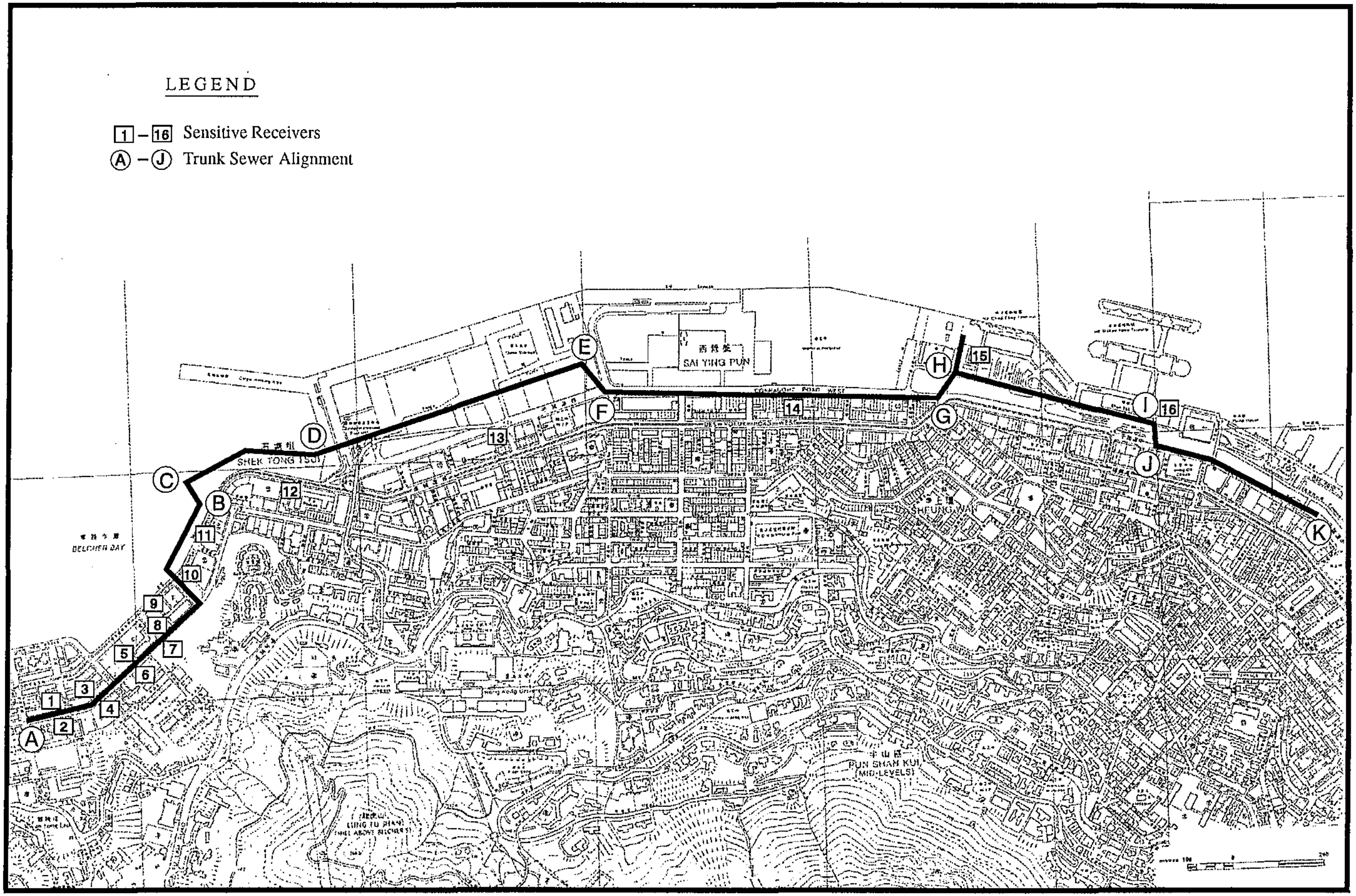
According to the proposed construction programme, it is unlikely that major noisy activities (i.e concrete breaking, excavation and piling) for the construction of trunk sewer and pumping stations will overlap at both screening plants. Thus noise assessment for the existing screening plants does not consider the cumulative impact.

It is likely that diaphragm walling would be used for the building foundation in Central Screening Plant. The final decision has yet to be made on the type of piling to be used for locations of the shafts/manholes. Thus piling impacts are only considered for 'open cut' trunk sewer alignments and Wan Chai East Screening Plant. Other impacts will be addressed at a subsequent reporting stage when construction methods are finalised.

4.2.2 Sensitive Receivers

Potential NSRs were identified along the trunk sewer alignment and adjacent to the screening plants only if they were within direct line of sight of the proposed construction sites. Locations of NSRs are presented in Figures 4.5 and 4.6 and a list of NSRs is provided in Table 4.1.

In addition, the Royal Society for the Prevention of Cruelty to Animals, Hong Kong was identified as an NSR for piling activities for Wan Chai East Screening Plant. This is in accordance with the TM on Noise From Percussive Piling.



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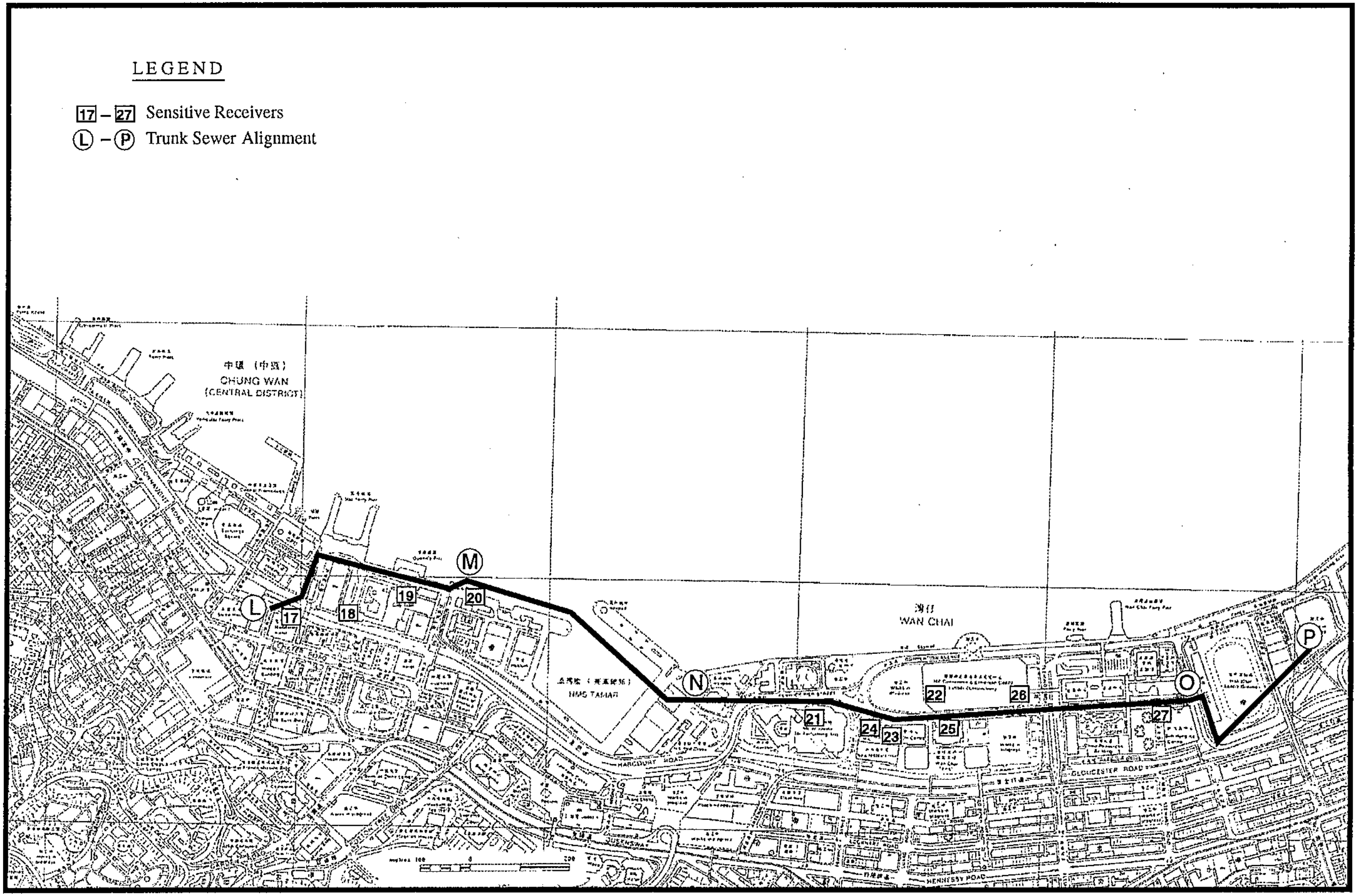
NOISE SENSITIVE RECEIVER LOCATIONS FROM CENTRAL TO WESTERN

FIGURE 4.5



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NOISE SENSITIVE RECEIVER LOCATIONS FROM CENTRAL TO WAN CHAI

FIGURE 4.6

Table 4.1 Noise Sensitive Receivers

Alignment Section	Identification	Noise Sensitive Receiver
A-B	1	Nos. 71-111 (west side Belcher's Street)
	2	Nos. 46-86 (east side Belcher's Street)
	3	Nos 37-61 (west side Belcher's Street)
	4	Nos. 26-42 (east side Belcher's Street)
	5	Nos. 15-35 (west side Belcher's Street)
	6	Nos. 16-26 (east side Belcher's Street)
	7	Welfare Centre (opp. Holland Street)
	8	7-11 Belcher's Street
	9	Sai Chung Street (west)
	10	Sai Chung Street (east), Belcher Court
	11	Buildings west of Kennedy Town Praya (eg Chester Court)
CE	12	Buildings south of Kennedy Town Praya (eg Nos. 430-458)
	13	Buildings south of Connaught Road West (eg Nos 168-187)
F-H	14	Buildings south of Connaught Road West (eg Nos. 1-158)
	15	Fire Station
H-J	16	Shun Tak Centre (Victoria Hotel)
L-M	17	Mandarin Hotel
	18	Municipal Library
	19	City Hall
M-N	20	Blake Block, HMS Tamar
N-O	21	HK Academy for Performing Arts
	22	Grand Hyatt Hotel
	23	YMCA, Harbour Road
	24	HK Arts Centre
	25	District Court, Harbour Road
	26	New World Harbour View Hotel
	27	Residential Block A, Harbour Road

4.2.3 Assessment

4.2.3.1 Trunk Sewers

Noise from General Construction Activities: As mentioned in Section 2.1.2, the final decision has still to be made as to where tunnelling and pipejacking methods will be adopted, on the type of construction plant used for these methods and the locations of working shafts. Thus noise impacts have been calculated in some instances for general areas rather than specific building facades. This has particularly been the case in areas with a high concentration of domestic premises. For some sections, noise impacts caused by both 'open cut' and 'no dig' construction methods have been examined.

Lists of proposed construction plant and their relevant sound power levels (SWL) are presented in Tables 4.2 and 4.3.

Table 4.2 Details of Equipment Used for Open Cut Construction Method

Equipment	No. of Pieces	SWL Per Piece dB(A)	SWL of All Pieces dB(A)
Dewatering pump, petrol	1	100	100
Air compressor, super silenced	1	100	100
Pneumatic breaker, hand held, silenced	1	110	110
Excavator	1	112	112
Lorry	1	112	112
Compactors, vibrating	1	105	105
Total SWL			117 dB(A)

Table 4.3 Details of Equipment Used for No Dig Construction Method

Equipment	No. of Pieces	SWL Per Piece dB(A)	SWL of all Pieces dB(A)
Generator, s.s., enclosed	1	95	95
Hydraulic jacking unit	1	65	65
Slurry pump, submersible	1	85	85
Slurry pump, electric	1	88	88
Lorry	1	112	112
Total SWL			112 dB(A)

Based upon this information, construction noise impacts on the NSRs are summarised in Tables 4.4 and 4.5. Noise contours with indications of likely noise impacts on NSRs are presented in Figures 4.7 and 4.8. General conclusions are as follows:

- The 'no dig' option would be more favourable than the 'open cut', because the former generates less noise in the order of approximately 5 dB(A), based upon the selected equipment list. It should be noted that noise arising from the 'no dig' method would mainly be caused by the lorries used for the collection and delivery of construction materials. Without the lorries in operation, SWL could be reduced by up to 16 dB(A). In practice, lorries would only operate 25% of time. This would effectively result in a noise level decrease of approximately 6 dB(A). Thus the degree of noise reduction by using 'no dig' method would often be greater than 5 dB(A). The 'no dig' method should be adopted where practical;

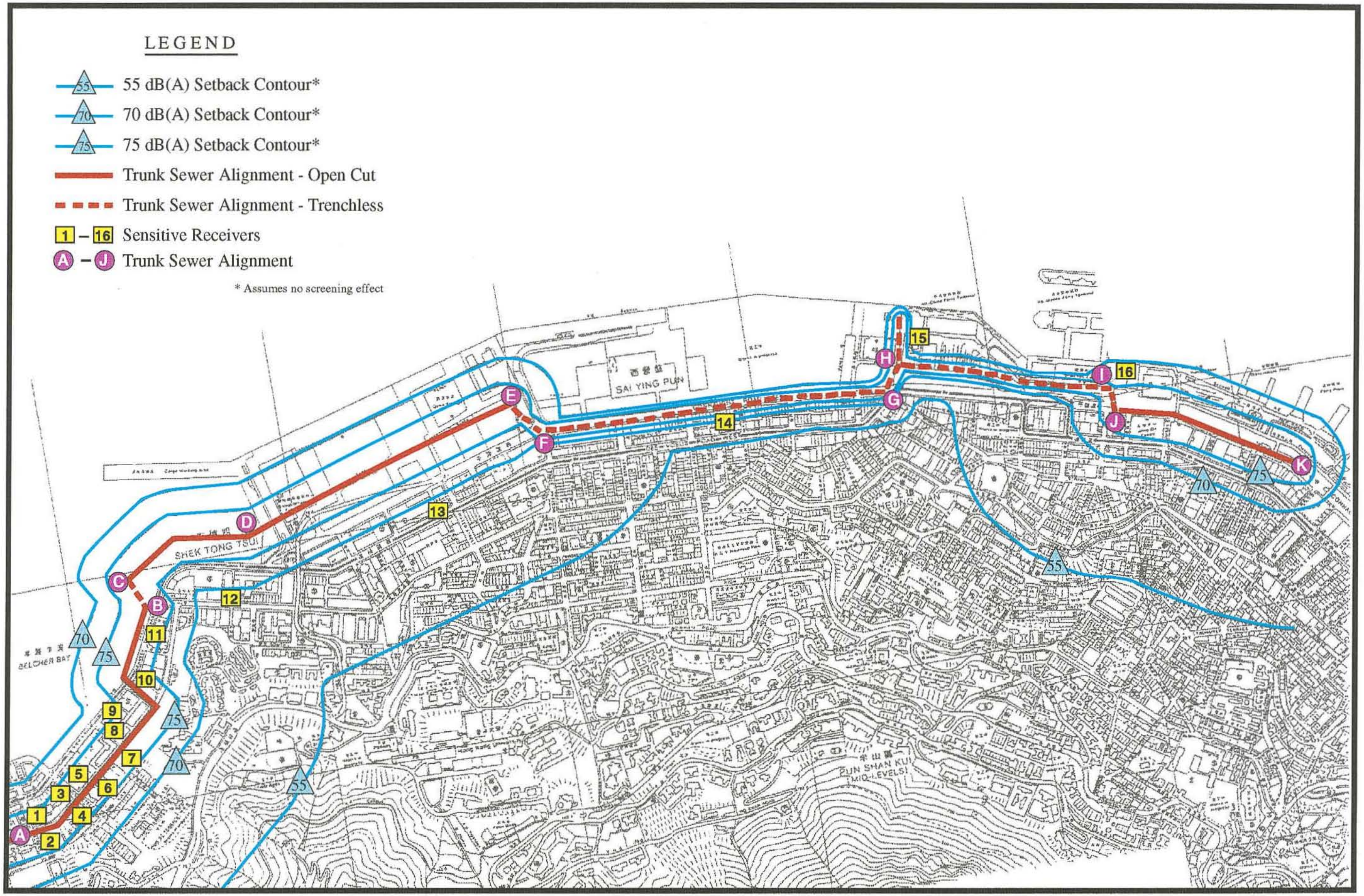
- Severe impacts on the NSRs along sewer alignment section A to B will be inevitable during construction, although mitigation measures recommended in Section 6.2 will minimise the effects. NSRs at some locations may experience noise impact of at least 10 dB(A) above background levels;

- Except for alignment section A to B, construction impacts at the remainder of the sites should be mitigated to acceptable levels, even at those locations where high levels of construction noise impacts have been predicted. For instance:

  - At the HK Academy for Performing Arts (NSR 22), the very high construction noise of 101 dB(A) is directly related to the assumed shaft location (some 2 m away). Thus location of the shaft away from the site as far as practical should be considered to minimise the impact.

  - At the Mandarin Hotel (NSR 18), high construction noise of up to 89 dB(A) will be caused by 'open cut' construction. Thus if the quieter 'no dig' method is used a reduction of noise level of 10 dB(A) could be achieved. Adoption of other measures can further reduce the impact. The mitigation can include: restricting working hours to daytime and evening only; restricting concurrent plant usage, particularly avoiding the evening use of lorries; locating shaft sites as far from the hotel as possible. By so doing, substantial noise reduction could be achieved. A similar approach should be adopted for hotel NSRs (eg. NSRs 23, 24 and 27).

  - Along sewer sections J to O, high construction noise levels are predicted at locations in close proximity to the proposed alignments. They include commercial buildings (Section J-L), government offices (NSRs 20 & 26) and public libraries (NSR 19). If construction work is carried out during evening (in particular) and night-time hours when there are no nearby NSRs present, the impact would be minimal. In addition, it would also relieve the traffic congestion problem in line with the recommendation of the Traffic Management Working Group Paper 1/94. The paper suggested that due to traffic congestion considerations, daytime working should be prohibited in certain areas:



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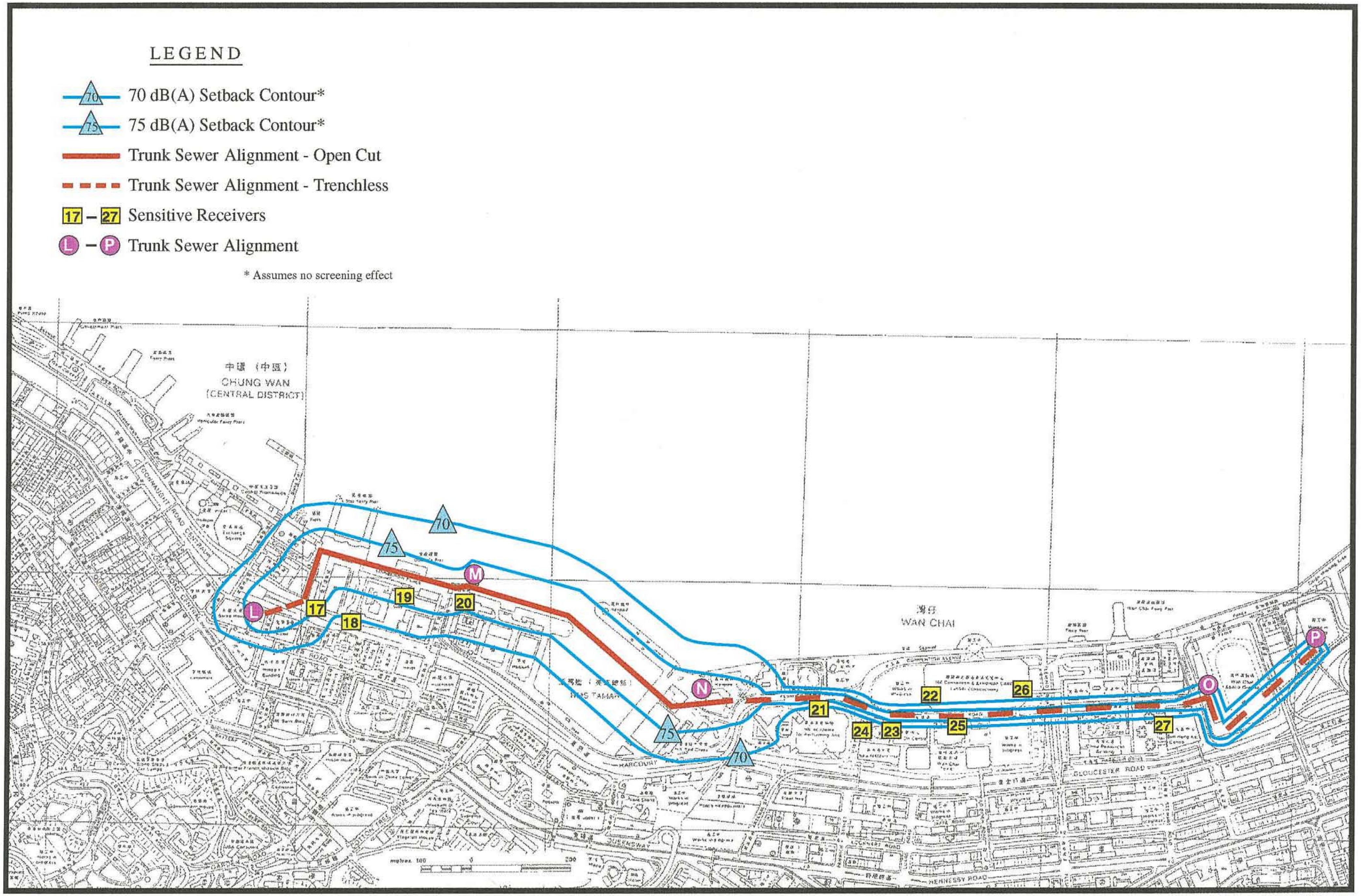
PREDICTED NOISE CONTOURS FOR TRUNK SEWERS FROM CENTRAL TO WESTERN

FIGURE 4.7



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PREDICTED NOISE CONTOURS FOR TRUNK SEWERS FROM CENTRAL TO WAN CHAI

FIGURE 4.8

Table 4.4 Predicted Noise Levels at NSRs for Western to Central Trunk Sewers

Alignment Section	Identification	Noise Sensitive Receiver (NSR)	Nearest Distance of NSR to Alignment (m)	Construction Noise Level dB(A)		Comments
				No Dig	Open Cut	
A-B	1	Nos. 71-111 (west side Belcher's Street)	10	N/A	92	The noise levels predicted from open cut construction techniques are extremely high, exceeding recommended daytime, evening and night-time levels by up to 27, 32 and 47 dB(A) respectively. In view of the high noise impact, considerable mitigation will be required to bring noise down. It is strongly recommended that effectively silenced equipment and acoustic enclosure should be employed where practicable. If necessary, manual equipment may have to be adopted. Moreover, construction work should be restricted to limited hours and night time work should not be undertaken. It has been proposed that construction works will be undertaken in discrete lengths of approximately 50 m. This will have the effect of limiting the number of NSRs exposed to construction noise at any one time.
	2	Nos. 46-86 (east side Belcher's Street)	3-4		100-103	
	3	Nos 37-61(west side Belcher's Street)	4		100	
	4	Nos. 26-42 (east side Belcher's Street)	10		92	
	5	Nos. 15-35(west side Belcher's Street)	4-5		98-100	
	6	Nos. 16-26 (east side Belcher's Street)	8-9		93-94	
	7	Welfare Centre (opp. Holland Street)	6		96	
	8	7-11 Belcher's Street	5		98	
	9	Sai Chung Street (west)	4		100	
	10	Sai Chung Street (east), Belcher Court	15		89	
	11	Buildings west of Kennedy Town Praya (eg Chester Court)	30		83	
B-C	N/A	None	NA	N/A	N/A	N/A
C-E	12	Buildings south of Kennedy Town Praya (eg Nos. 430-458)	86	N/A	73	Open Cut: Exceeds evening and night-time limits by up to 3 and 18 dB(A) respectively. Mitigation necessary for evening and night-time work.
	13	Buildings south of Connaught Road West (eg Nos 168-187)	90	71	N/A	No Dig: Night time construction would cause exceedance of the statutory noise limits by up to 46 dB(A) and should therefore be avoided. Impacts would be directly related to shaft location.

Table 4.4 Predicted Noise Levels at NSRs for Western to Central Trunk Sewers (Cont'd)

Alignment Section	Identification	Noise Sensitive Receiver (NSR)	Nearest Distance of NSR to Alignment (m)	Construction Noise Level dB(A)		Comments
				No Dig	Open Cut	
E-F	N/A	None	N/A	N/A	N/A	N/A
F-H	14	Buildings south of Connaught Road West (eg Nos. 1-158)	9	88	N/A	Exceedance of the daytime, evening and night time levels by about 13, 18 dB(A) and 33 dB(A) respectively, Substantial mitigation is required for daytime and evening work, and night-time work may not be possible.
	15	Fire Station	25*	79	N/A	
H-J	16	Victoria Hotel, Shun Tak Centre	15*	84	N/A	Exceeds daytime, evening and night-time limits by 9, 14 and 29 dB(A) respectively. The degree of noise impact is directly related to the shaft location. Thus the shaft should be located as far from the hotel as possible.
J-L	N/A	None	N/A	N/A	N/A	Surrounded by commercial and office buildings. Evening (in particular) and night time work would therefore be possible in this area.

* *Distance to proposed nearest shaft site*

Table 4.5 Predicted Noise Levels at NSRs for Central to Wan Chai East Trunk Sewers

Alignment Section	Identification	Noise Sensitive Receiver (NSR)	Nearest Distance of NSR to Alignment (m)	Construction Noise Level at NSR dB(A)		Comments
				No Dig	Open Cut	
L-M	17	Mandarin Hotel	25*/15(i)	79	89	'No dig' method would cause considerable less noise impact, at least 9 dB(A). Thus this option would be favoured here. Work site should be located as far from the hotel as possible to minimise the impact further.
	18	Municipal Library	85	N/A	73	Mitigation may be required if daytime and evening work is carried out. Night-time work may be favoured because there are no NSRs during these periods.
	19	City Hall	22		85	
M-N	20	Blake Block	11	N/A	91	Considerable noise impact is predicted, though the status of these British Forces barracks is uncertain after 1997 and may prove not to be an issue.
N-O	21	HK Academy for Performing Arts	2	101	N/A	Considerably exceeds daytime and evening limits and will require substantial mitigation. Noise impact is directly related to shaft location. Thus all shaft should be placed as far from site as possible. Night-time work would be favoured due to the absence of NSRs during this period.
	22	Grand Hyatt Hotel	15	84	N/A	Mitigation measures would be required for all time periods. However, night-time work should not be carried out in close proximity to NSRs (23, 24, 27 and 28). At NSR 26, night-time work would be favoured due to the absence of NSRs during this period.
	23	YMCA	15*	84		
	24	HK Arts Centre	37*	76		
	25	District Court	10	87		
	26	New World Harbour View Hotel	12	86		
	27	Residential Block, Harbour Road	20*	81		

(i) *25 m is distance of NSRs from nearest potential shaft site*
15 m is the nearest distance of NSR to open cut alignment
* *Distance to specific proposed shaft site*

"Prior to the opening of the Western Harbour Crossing, no major excavation will be permitted east of Cotton Tree Drive which will affect the capacity of Gloucester Road except the Rehabilitation of Hennessy Road Project.

No day-time excavation will be allowed in the area bounded by Cotton Tree Drive in the east, Hill Road Flyover in the west and Bonham Road or Hollywood Road or Queen's Road Central in the south without provision of the same number of traffic lanes.

Only one lane closure at a time across the east-west movement will be allowed in the area west of Hill Road Flyover."

High construction noise is also predicted at Blake Block (NSR 21). However, the status of these British Forces barracks is uncertain after 1997 and they may be relocated. If so, construction noise should not be an issue.

It should be noted that the above predicted noise levels are based on the best estimates of likely equipment to be used on the construction sites. In reality, noise levels/impact on NSRs will be subject to changes depending upon the construction methods, numbers and types of equipment to be used concurrently by a contractor. The assessment assumed that all plant will operate concurrently. However, in practice it is likely that only a few plant items would be used concurrently. Thus the actual noise impact on NSRs would be less than predicted.

Noise from Sheet Piling: A SWL of 129 dB(A) has been assumed for the sheet piling. The resultant noise levels at NSRs are presented in Table 4.6.

The TM on Noise from Percussive Piling provides an ANL of 85 dB(A) for NSRs with windows or other openings, but without central air conditioning systems. Assuming this as a worst case situation then it can be seen from Table 4.6 that the 85 dB(A) ANL will be exceeded by more than 10 dB(A) along all of the A to B section of the trunk sewer alignment. Under these circumstances the TM states that piling work may only be undertaken between 08:00 to 09:00, 12:30 to 13:30 and 17:00 to 18:00.

Along sections L to M and M to N of the trunk sewer alignment the ANL of 85 dB(A) will also be exceeded, by greater than 10 dB(A). Again, the TM states that piling should only be undertaken between 08:00 - 09:00, 12:30 - 13:30 and 17:00 - 18:00. It should be noted that piling may not be required between Smithfield and Sai Cheung Street since the underlying strata for excavation is rock.

Along section C to E of the trunk sewer alignment no exceedance of 85 dB(A) is predicted to occur. In this case according to the TM, piling will be permitted between 07:00 - 19:00.

Table 4.6 Predicted Piling Noise Levels at NSRs

Alignment Section	Identification	Noise Sensitive Receiver	Distance of NSR to Alignment (m)	Resulting Noise Levels at NSRs dB(A)
A-B	1	Nos. 71-111 (west side Belcher's Street)	10	104
	2	Nos. 46-86 (east side Belcher's Street)	3-4	112-115
	3	Nos 37-61(west side Belcher's Street)	4	112
	4	Nos. 26-42 (east side Belcher's Street)	10	104
	5	Nos. 15-35(west side Belcher's Street)	4-5	110-112
	6	Nos. 16-26 (east side Belcher's Street)	8-9	105-106
	7	Welfare Centre (opp. Holland Street)	6	108
	8	7-11 Belcher's Street	5	110
	9	Sai Chung Street (west)	4	112
	10	Sai Chung Street(east), Belcher Court	15	101
	11	Buildings west of Kennedy Town Praya (eg Chester Court)	30	95
C-E	12	Buildings south of Kennedy Town Praya (eg Nos. 430-458)	86	85
	13	Buildings south of Connaught Road West (eg Nos 168-187)	90	85
F-H	14	Buildings south of Connaught Road West (eg Nos. 1- 158)	N/A	N/A
	15	Fire Station		
H-K	16	Victoria Hotel, Shun Tak Centre		
L-M	17	Mandarin Hotel	15	101
	18	Municipal Library	85	85
	19	City Hall	22	97
M-N	20	Blake Block	11	103
N-O	21	HK Academy for Performing Arts	N/A	N/A
	22	Grand Hyatt Hotel		
	23	YMCA		
	24	HK Arts Centre		
	25	District Court		
	26	New World Harbour View Hotel		
	27	Residential Block, Harbour Road		

4.2.3.2 Screening Plants and Pumping Stations

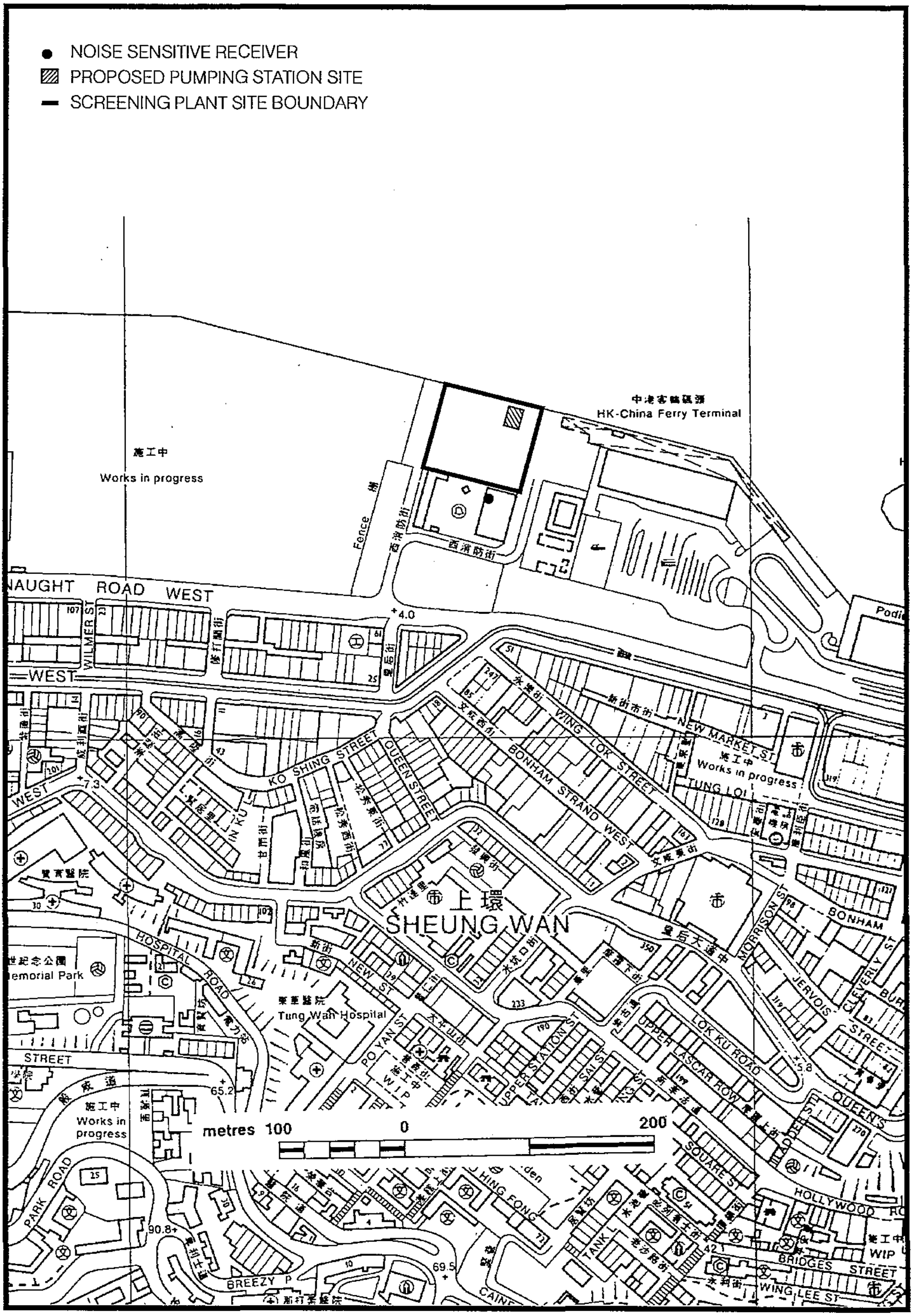
At present, it is intended that construction of new pumping stations will take place over daytime and evening periods, between 07:00 - 23:00 hours.

Central: The site is currently enclosed by a concrete wall, some 3 m in height. The Hong Kong Electric Co. Central substation is located some 30 m from the eastern boundary of the site. To the southeast of the site, there is a fire station, located approximately 35 m from the proposed pumping station. This represents the closest NSR [Figure 4.9].

Because of the influence of traffic noise from busy Connaught Road, an ASR of "C" has been assigned to this site. The resulting construction noise at this NSR is predicted to be 87 dB(A), which would exceed the daytime limit of 75 dB(A) and evening ANL of 70 dB(A). A detailed list of plant to be used is presented in Table 4.7. Noise mitigation measures will thus be required to reduce maximum noise by up to 17 dB(A) to enable compliance with acceptable limits. However, it should be pointed out that the prediction is based on the assumption that all plant will be operated concurrently. In practice, only a few items of the equipment listed would be operated at one time. Thus the actual noise impacts at any given NSR may in practice be less than those predicted.

Table 4.7 Noise Prediction Assumptions for Construction of Central Pumping Station

Equipment	No. of Pieces	SWL, dB(A)	
		Per Piece	All Pieces
Mobile crane	1	112	112
Truck crane	1	116	116
Lorry concrete mixer	2	109	112
Vibratory poker	2	113	116
Excavator, wheeled	1	112	115
Lorry	4	112	118
Excavator, tracked	2	112	115
Bentonite filtering plant	2	105	108
Compressor, silenced	2	100	103
Generator, silenced	1	100	100
Lorry	3	112	116.8
Dumper	1	106	106
Pickup truck	2	112	115
Dewatering pumps (elec.)	1	88	88
Resulting Noise Level at the facade of the closest NSR			**87 dB(A)**



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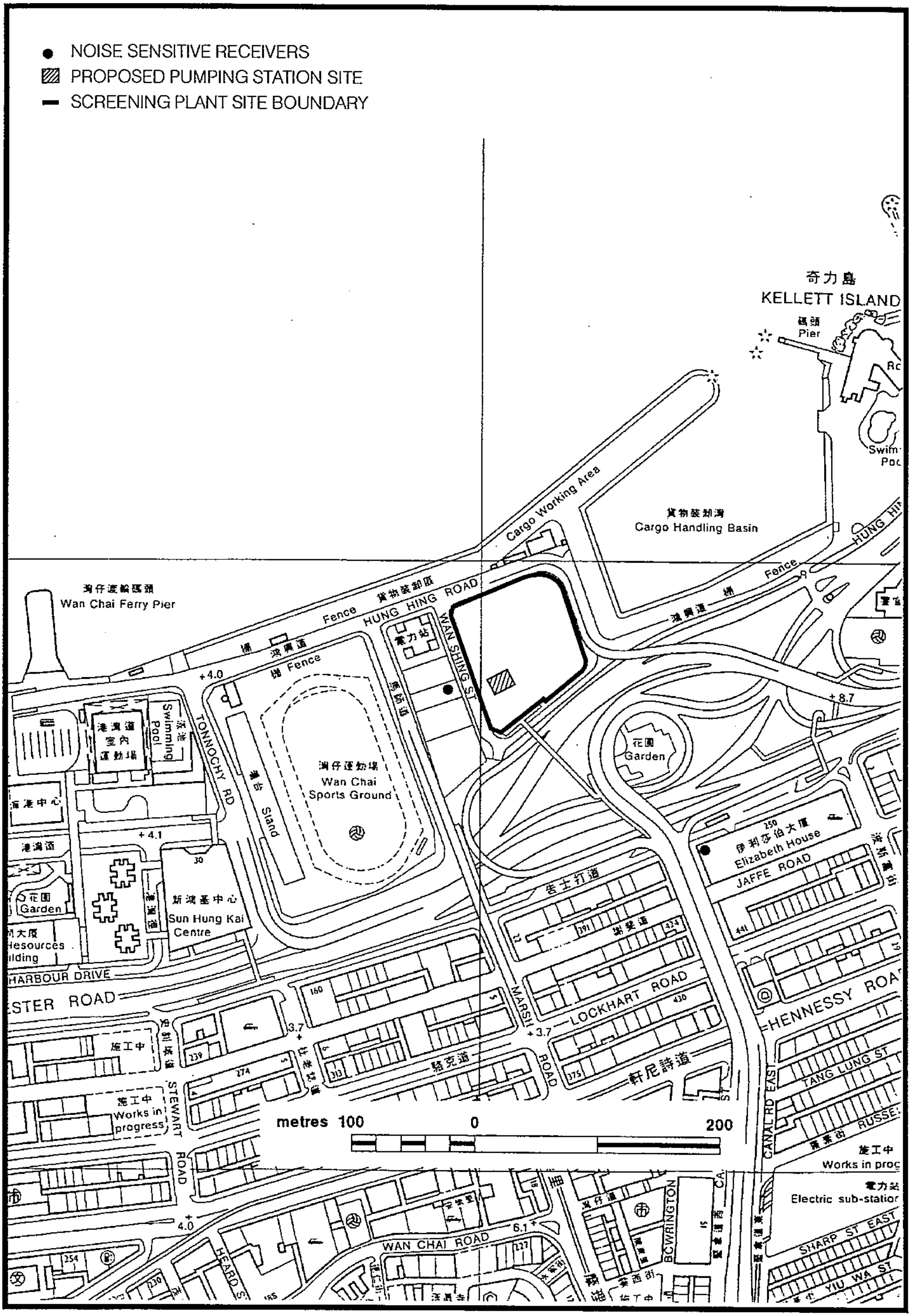
LOCATION OF CENTRAL PUMPING STATION
FIGURE 4.9

Wan Chai East: Due to the influence of traffic noise on the busy road and flyover, an ASR of "C" has been assigned to the site. Residents living in Elizabeth House are identified as the closest NSR [Figure 4.10], located on the south side of Gloucester Road, and about 190 m from the site. The predicted noise level of 75 dB(A) as shown below [Table 4.8] indicates that construction noise would be just at the acceptable limit for daytime but exceed the evening limit of 70 dB(A). Therefore, mitigation will be required for the construction during evening.

Table 4.8 Noise Prediction Assumptions for Construction of Wan Chai East Pumping Station

Equipment	No. of pieces	SWL , dB(A)	
		Per Piece	All Pieces
Mobile crane	1	112	112
Truck crane	2	116	119
Lorry concrete mixer	2	109	112
Vibratory poker	3	113	117.8
Excavator, wheeled	1	112	112
Lorry	4	112	118
Excavator, tracked	2	112	115
Bentonite filtering plant	2	105	108
Compressor, silenced	2	100	103
Generator, silenced	1	100	100
Lorry	3	112	116.8
Dumper	1	106	106
Pickup truck	2	112	115
Dewatering pumps (elec.)	2	88	91
Resulting Noise Level at the facade of the closest NSR			75 dB(A)

The background noise monitoring results indicate that the ambient noise level in the evening is over 70 dB(A). It is likely that NSRs would be more affected by existing traffic noise.



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LOCATION OF WAN CHAI PUMPING STATION

FIGURE 4.10

H-piling is proposed as the foundations for the building enclosing the screening plant facilities. The closest NSR [Figure 4.10] is the Royal Society for the Prevention of Cruelty to Animals, HK which is located due west, some 40 m from the proposed new pumping station. A piling limit of 85 dB(A) is assigned for this site. The SWL of the H-piling machine is assumed to be 132 dB(A). Thus the resulting noise level at the nearest NSRs is predicted to be 95 dB(A), 10 dB(A) higher than the limit. With reference to the TM on Noise from Percussive Piling, it is recommended that piling operations should be restricted to 08:00 - 09:30, 12:30 - 14:00 and 16:30 - 18:00 hours.

4.2.3.3 Reticulation and Interceptor Sewers

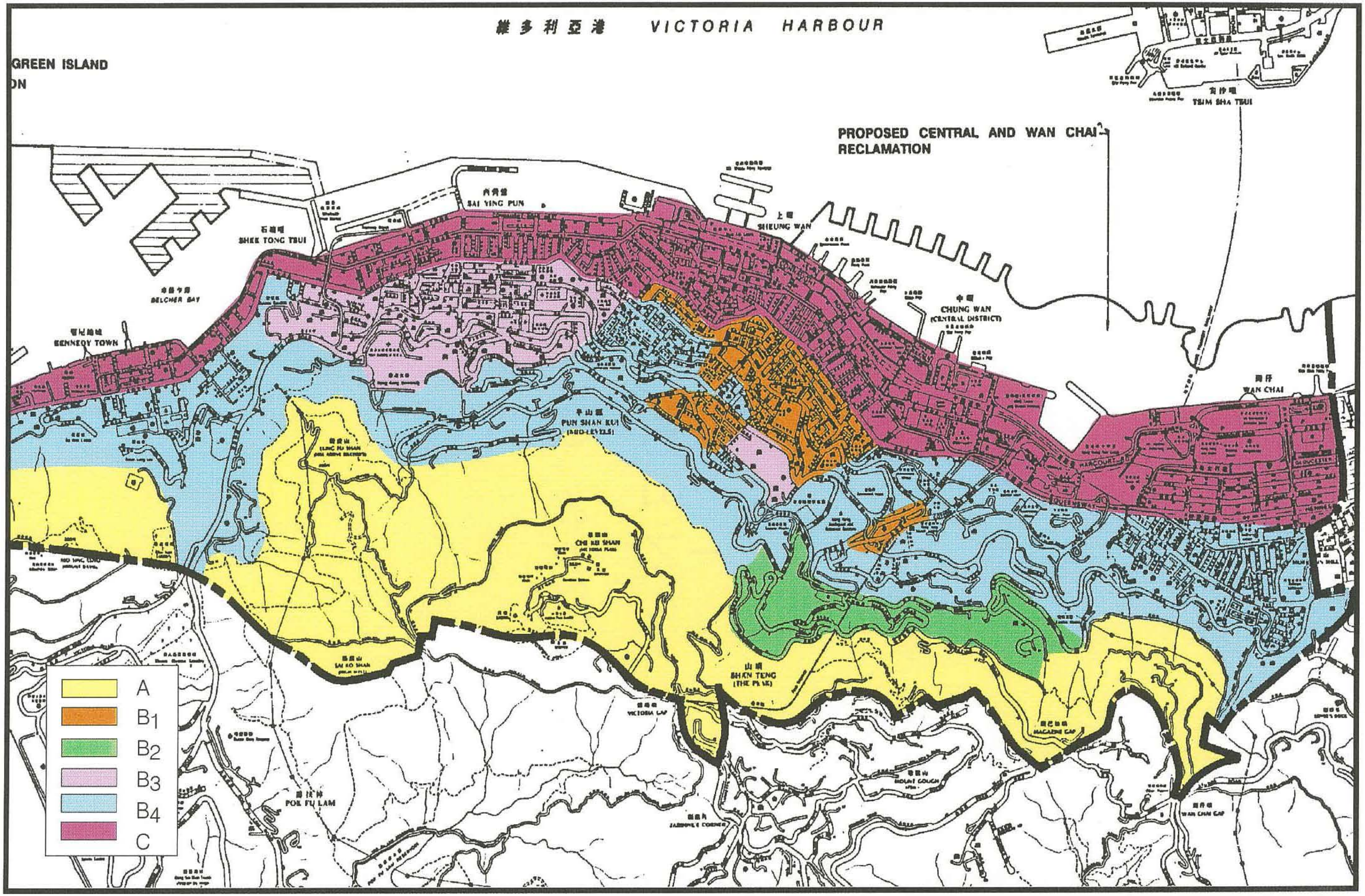
The construction of reticulation and interceptor sewers within the project area will employ an open cut and cover method. The final sewer alignments, however, have yet to be confirmed and in some cases will not be determined until the commissioning of the trunk sewers. Thus it is impossible at this stage to undertake quantitative noise assessments for individual sewer alignments. The following assessment provides an overview of the likely noise impacts on NSRs located in different ASRs (assuming the same construction activities taking place).

The study areas are divided into three major zones according to ASRs of A, B, and C. Under an ASR of 'B', four sub-zones are identified with reference to ambient noise levels, traffic influence, and the nature of NSRs as shown [Figure 4.11]. Altogether, there are six zones. The location of each zone, NSR characteristics, ASRs and degree of noise impact for each zone are summarised in Table 4.9.

In general terms it can be seen that more stringent noise mitigation measures will be required in the areas where NSRs are more sensitive to the construction noise if similar construction activities take place. These areas include zones A, B_2, and B_3. However, the exact impact on NSRs and mitigation measures required should be dependent upon a combination of the following factors:

- Number of PME used at one time;
- Proximity of NSRs to work sites;
- Background environment, including noise conditions.

Generally, night-time work is not recommended due to the close proximity to NSRs, resulting in high noise levels. However, night-time work should not be excluded in places where compliance with relevant construction noise limits can be mitigated to acceptable levels.



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AREA OF NOISE SENSITIVITY RATING
FIGURE 4.11

Table 4.9 Summary of Noise Impacts in Reticulation and Interceptor Sewer Areas

ASR & Zone	Location		NSRs	Description of Impacts	NSRs' Sensitivity Rating to Noise*
C	Across Western, Central and Wan Chai areas, between Connaught - Harcourt - Gloucester Roads and Queen's Road (including west, central and east); and between Kennedy Town Praya and Belcher's Street.		Very high density of residents widely spread in the zone.	Background noise levels from traffic can be very high particularly during daytime and exceeds 75 dB(A) in some areas. Construction noise will not be so apparent compared to other zones.	Very low
B	Across Western, Central, and Wan Chai areas, between Queen's Road to Peak area. Four sub-zones are identified:				
	B_1	Areas in Mid-Levels with highly populated residential areas and directly influenced by traffic.	Mainly residents	Noise levels would be the highest in the B areas due to the impact of traffic and construction. Daytime noise level can be close to 75 dB(A) in some areas.	Low
	B_2	Areas where there is a low density of population and away from major roads to be indirectly affected by traffic, eg along Bowen and Magazine Roads.	Mainly residents	Lowest ambient noise levels in the B areas. NSRs could be more sensitive to construction noise due to lower ambient noise levels.	High
	B_3	Areas where super NSRs, such as schools and hospitals, are situated, eg cluster of schools and hospitals in Western District along the Second Street, Pok Fu Lam Road, and Bonham Road; and Mid-Levels between Caine and Mosque streets.	Schools and hospitals	Ambient noise levels may vary depending upon locations in areas of B_1, B_2, or B_3. They can be high along heavy traffic roads. However, due to NSRs comprising schools and hospitals, special construction limits during teaching and examination hours may have to be adopted.	High
	B_4	The rest of ASR of' 'B' area.	Residents	Ambient noise levels are between B_1 and B_2. Away from major roads.	Medium
A	Peak area		Residents	The lowest ambient noise levels in the whole study area. Noise is mainly caused by local and distanced (background) traffic.	Very high

* *Assuming similar construction activities are adopted.*

4.3 WATER QUALITY

All construction work will be land based, thus no direct impact on marine water in Victoria Harbour is anticipated. Potential impacts would be associated with the discharge of construction wastewaters into storm drains, possible foul sewers and sewerage treatment works. Construction wastewaters will include:

- Rainwater run-off containing debris, and excavated and fill materials;
- Wastewater derived from dust suppression, lubrication process water, damping paved areas, and rinsing of truck exteriors and mix truck interiors;
- Maintenance pumping of groundwater from the tunnels and open-cut and cover trenches during excavation.

These waters will generally contain high concentrations of suspended solids and/or silt. Their discharge could lead to localised problems such as the blocking/silting of drains. The extent of these impacts will depend upon the solid concentrations and quantity entering the drains. Provision of silt traps and sedimentation tanks will minimise such impact.

Groundwater encountered during excavation may be contaminated by leaked sewage at some locations. It is envisaged that this contaminated water will be a localised problem and of small quantity. It should be pumped/discharged to the foul sewer system to be treated.

Adverse water quality impacts could also be caused by discharges containing high levels of fine bentonite particles from diaphragm walling. Bentonite is used for the support of the excavated trench walls prior to concreting the trench. During concreting, the bentonite is displaced from the trench and fed through a recycling unit to separate the bentonite from soil particles. Due to the very fine nature of the bentonite particles, turbidity problems can occur if the suspension is allowed to escape to a water body. Thus precautions such as those discussed in Section 6.3 should be taken to prevent accidental release from the trench itself or recycling process.

Bentonite may also be used to support the tunnel face during tunnelling/pipejacking.

Small amounts of sewage arising from construction sites is expected, thus collection and/ or treatment options should be considered.

4.4 SOLID WASTE

4.4.1 Quantity

Approximately 124,800 m^3 of spoil will be generated during the construction of the project. The principal sources will be:

- Spoil from excavation of shafts/manholes; tunnels for the trunk sewers; pits for the pumping station; and trenches for reticulation/interceptor sewers;

- Excavation of replaced pipelines.

The predicted spoil generation schedule for each of the sites is presented in Table 4.10.

Table 4.10 Estimation of Spoil Generation from Various Sites

Locations	Volume, (m^3)
Central Screening Plant	15,800
Wan Chai Screening Plant	19,000
Trunk Sewers	40,000
Interceptor/Reticulation Sewers	50,000

4.4.2 Spoil Qualities

4.4.2.1 Trunk Sewers

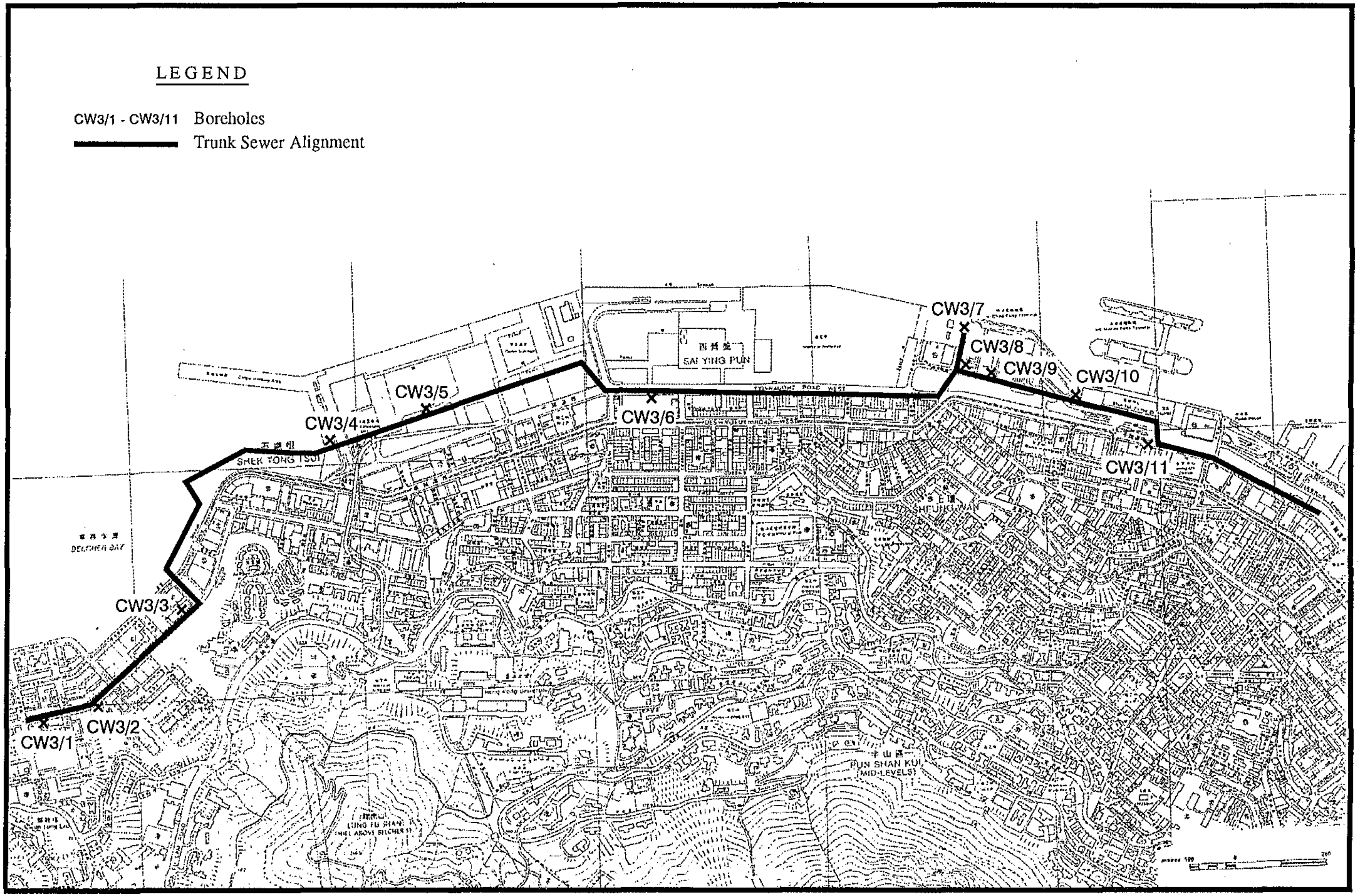
The trunk sewers will be located in low lying reclaimed lands and future reclamations [Figure 4.12]. The existing reclamations were formed between 1901 and 1970, except for the Western Reclamation site which was formed more recently. The future reclamations, ie Central and Wan Chai Reclamations, and Belcher Bay Reclamation, will be completed within the next few years.

Spoil from early reclamation: The early reclaimed lands were generally covered with fill materials on the top of marine deposits, below which are alluvium, and completely decomposed granite and granite bedrock. The depth of each layer is not uniform. As the reclamation took place prior to the discharge of effluents into the harbour, marine deposits are unlikely to be seriously contaminated. However, contamination of soil could have occurred in some manhole areas as a result of pipeline leakage. Soil sampling and analysis at the boreholes should be undertaken to identify the degree of any contamination. These locations are provided in Figures 4.12 and 4.13.

Spoil from Western Reclamation: The site was reclaimed by the deposit of marine sand on to the seabed. Contaminated marine mud was dredged out prior to reclamation. Thus it is unlikely that contaminated spoil would be found in the excavated spoil. However, one sample site is proposed for the area to confirm this, as indicated in Figure 4.12.

Spoil from Future Reclamation: The sources of fill materials for some future reclamations have yet to be determined. Marine deposits within the Tamar Basin site have been proved to be contaminated by heavy metals, and they will be kept on site for the reclamation. The situation at Belcher Bay is unknown. At this stage it is difficult to identify contamination in the spoil due to the lack of firm information regarding:

- Construction methods for the trunk sewers, and the depths of trunk sewers, which affects the depth to which identification of the presence of contaminated marine deposits in the spoil must take place;



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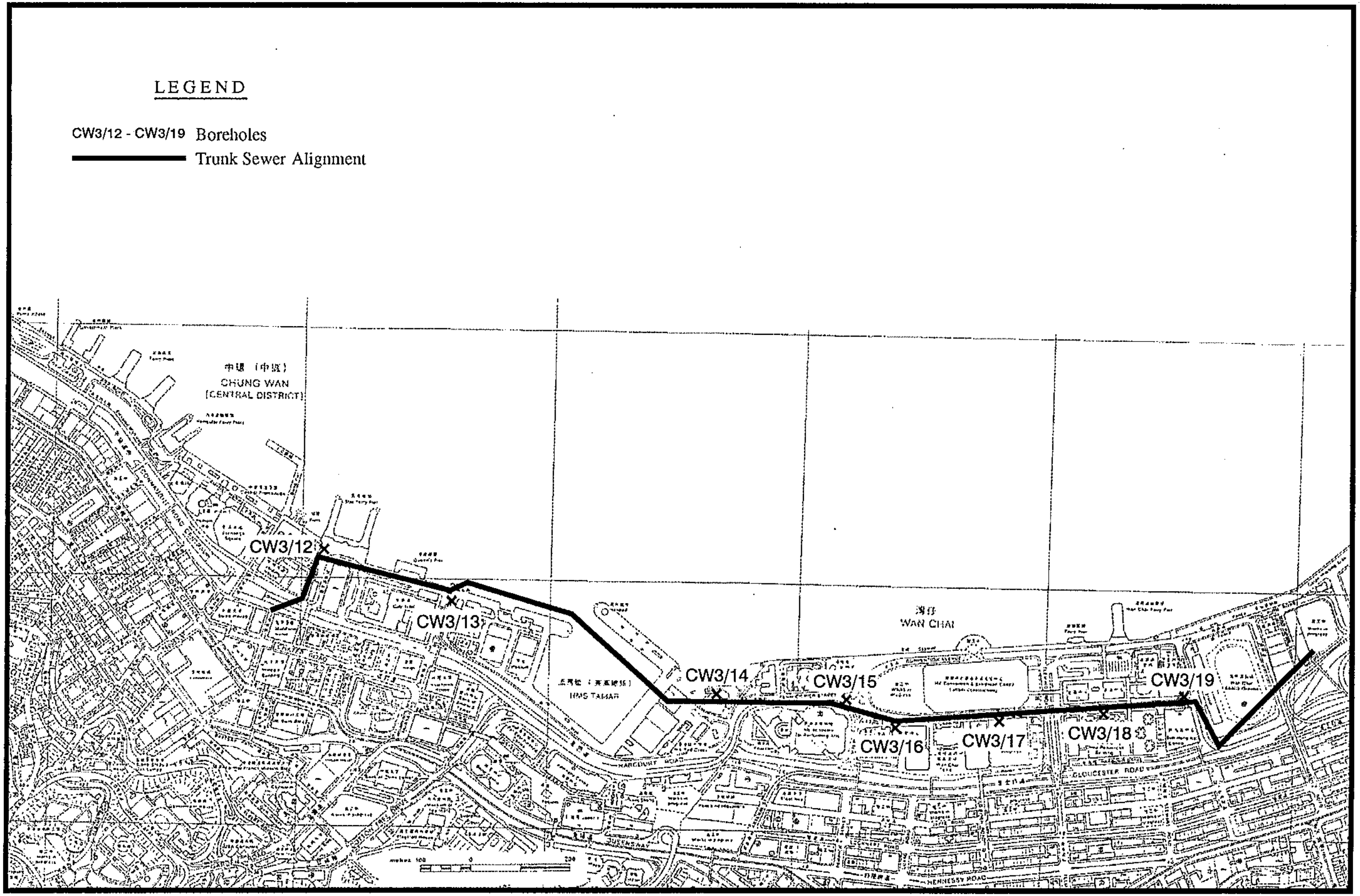
BOREHOLE LOCATIONS FROM CENTRAL TO WESTERN
FIGURE 4.12



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BOREHOLE LOCATIONS FROM CENTRAL TO WAN CHAI

FIGURE 4.13

- Spoil quality and reclamation methods for Belcher Bay and whether the marine deposits will be retained on site.

Thus for these two locations, determination of the presence of contaminated spoil should be carried out at a later stage when the above issues are resolved. However, the current intention is to dig the trunk sewers at a level which passes through new reclamation fill and this therefore may not be an issue.

4.4.2.2 Spoil from the Screening Plants and Trenches of Interceptor/Reticulation Sewers

Spoil from the screening plants and trenches for the interceptor/reticulation sewers may be contaminated by heavy metals due to leakage of pipelines. The significance of this impact will depend upon the degree of leakage. Heavy metal contamination of marine deposits at the screening plants could also be caused by the discharge of sewage effluents to Victoria Harbour prior to reclamation. Site investigation and soil sampling at the two screening plants will be undertaken to determine levels of contamination and disposal requirements. A recommended investigation method is described in Appendix C.

4.4.3 Disposal

Contaminated and uncontaminated spoil should be separated if serious contamination is found. Special handling/disposal will be required if this is the case. Ideally, uncontaminated spoil should be re-used as backfill material and/or fill material elsewhere. Due to construction site space constraints, it will not be feasible to stockpile the spoil temporarily. Re-use of spoil at other construction sites is preferred. However, the opportunity for re-use may not be practical because of:

- Uneven spoil generation rates from time to time, varying between 1 to 20 vehicle loads per day, which may make it difficult to find users;

- Spoil is often heterogeneous, comprising clay, sand, silts, rocks, and even concrete materials from previous seawall structures. Water contents are also high. These factors make it difficult to use the spoil as fill material.

If it is not feasible to re-use the uncontaminated spoil, disposal at a public dump or alternatively at a landfill will be required. If it is disposed of to landfill, the moisture content of the waste must be not greater than 70% by weight, otherwise, it will not be accepted at the landfill sites.

For contaminated spoil where practical, it ideally should be kept in-situ to minimise the requirement for off-site disposal. If off-site disposal is necessary, it should be disposed of either at the public dump, a strategic landfill, or special marine containment pits (eg. East Sha Shau Contaminated Mud Pit under the current arrangement) depending upon the degree of contamination. The marine disposal option should be considered as a last resort when the land-based options are not viable. However, to go for land-based options, detailed assessment on the environmental impact may be required. Approvals from EPD and other relevant departments should be sought. It is considered that contaminated spoil (if any) will constitute only a small portion of the total excavated spoil from landbased materials. Its quantity will be dependent upon: i) the presence of contaminated soil in the marine deposits or areas near manholes; and ii) construction methods which will determine whether any discovered contaminated marine deposits are disturbed.

Redundant and excavated pipelines are expected to be contaminated and may require disposal at a landfill site.

5 ENVIRONMENTAL IMPACTS DURING OPERATIONAL PHASE

5 ENVIRONMENTAL IMPACTS DURING OPERATIONAL PHASE

5.1 AIR QUALITY

The principal air quality impact during the operational stage will arise from odour generated at the sewage screening plants. Typically, odours are emitted most strongly in sewage plants at the screening facilities, inlet chambers and conveyance channels.

The extent of upgrading works to be carried out at both the Central and Wan Chai East Screening Plants, are summarised below:

- Central: The existing screw pumping station will be demolished and a new inlet chamber, coarse screen chamber and pumping station constructed. These will be fully enclosed. It is not intended to upgrade any other parts of the existing screening plant since it will be fully upgraded under the SSDS project;

- Wan Chai East: The existing screw pumping station will be demolished and a new inlet chamber, coarse screen chamber and pumping station constructed. These will be fully enclosed. Extended screening plant facilities including new fine screen and grit traps will also be constructed within a new fully enclosed building. The issue of upgrading of the existing screening plant treatment stream has still to be resolved. For the purpose of this assessment it is assumed that it will not be altered.

5.1.1 Assessment Methodology

5.1.1.1 Quantitative Baseline Assessment

Baseline odour monitoring was conducted at Central and Wan Chai East Screening Plants in March 1995. The purpose of the sampling exercise was twofold; to provide quantitative data against which subsequent odour modelling could be calibrated, and to provide baseline data against which the efficacy of future mitigation measures could be assessed.

Samples were taken both within the screening plant compounds and at selected background locations. Assessment was undertaken by means of a three way odour panel test. A full account of the sampling and testing methodology employed is provided in Appendix D. The results [Table 5.1] indicate that odour levels within both screening plants all exceeded the 2 ou limit.

Table 5.1 Baseline Odour Monitoring Results

Location	Sampling Points		Odour Level (OU)
Wan Chai East Screening Plant	A	Main inlet	25
	B	Solids conveyor belt	3
	C	Solids storage area	7
	D	Drum screens	1
Central Screening Plant	E	Main inlet	16
	F	Coarse screens	4
	G	Channel to drum screens	6
	H	Drum screens	11

5.1.1.2 Odour Emission Modelling

For the purpose of the modelling exercise it was assumed that hydrogen sulphide was the predominant odorous constituent and that odour varies in direct proportion to hydrogen sulphide concentration. The prediction of hydrogen sulphide generation was based on the calculations in Appendix A13 of the SSDS Report, Sulphide Generation Potential. The methodology is founded upon Pomeroy's Equation. An odour level of 5 ou, averaged over five seconds, at SRs was adopted for modelling purposes. Appendix E provides details of the methodology and calculations employed.

Two options were considered in the assessment for both screening plants:

- Option 1: The full enclosure of new facilities, incorporating a collection system designed to vent air from a point at the centre of the pumping station. Existing facilities to be used in future operations would not be enclosed;

- Option 2: The full enclosure of all new and existing facilities to be used for future operation, incorporating a collection system designed to vent air from a point furthest from surrounding SRs.

All the exhaust points for both scenarios were assumed to be 10 m high with an exit velocity of 8 ms^{-1}. Ambient odour level was not taken into account and no odour control was assumed in the predictions.

For both Central and Wan Chai East Screening Plants, the hydrogen sulphide emission rates were calculated on the basis that sewer walls were covered in slime. The areas of sewage/air interface for both future plants were also estimated, and these were used in the modelling for conservative calculation. The predicted hydrogen sulphide emission rates under the worst-case scenario for both screening plants are listed in Table 5.2.

Table 5.2 Estimated Hydrogen Sulphide Emission Rates under the Worst-Case Scenario

Screening Plant	Hydrogen Sulphide Emission Rate (mgs^{-1})		
	Exiting Facilities for Future Operation	New Facilities	Total
Central	2.11	2.44	4.55
Wan Chai East	0.83	5.95	6.78

In comparison to the baseline odour monitoring results, the predicted hydrogen sulphide levels are between 10% and 20% higher than the monitoring results. Thus it is considered that the above empirical equations give reasonable and conservative hydrogen sulphide flux at waste water surface.

5.1.1.3 Odour Dispersion Modelling

Odour dispersion modelling was undertaken using the Industrial Source Complex Short Term Model to assess the odour nuisance. Modelling was undertaken to establish odour levels in the proximity of the screening plants.

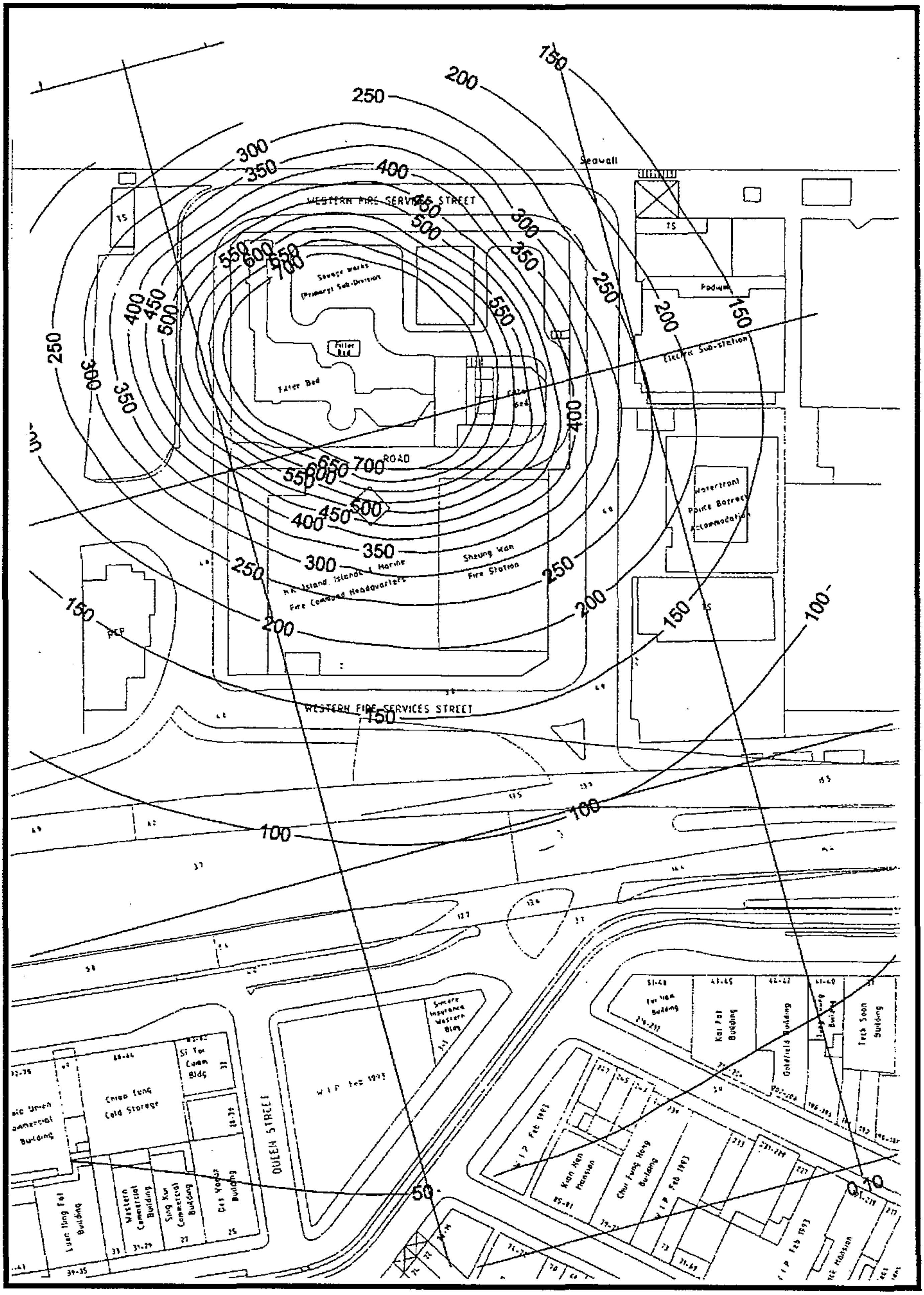
The maximum hourly odour concentrations from the dispersion model were converted to 3-minute average concentrations using the standard power law. The 3-minute average concentrations were then converted to 5-second average concentrations according to *Odour Control - A Concise Guide, Spring Laboratory*: "Typical maximum or peak 5-second concentrations within any 3-minute period appear to be of the order of 5 times the 3-minute average. During very unstable conditions larger ratios, perhaps 10:1, are more appropriate ......". For those hours with stability classes A-D, the 3-minute average concentrations were multiplied by 10 to obtain the 5-second average concentrations. For those hours with stability classes E-F, the 3-minute average concentrations were multiplied by 5 to obtain the 5-second average concentrations.

The calculated 5-second average concentrations were used for the assessment with reference to EPD's guideline. Meteorological data for the year 1992 from the Royal Observatory were used for the assessment.

5.1.2 Impacts on Sensitive Receivers

The predicted odour level in the proximity of the Central and Wan Chai East Screening Plants are presented as 5-second average odour level contours for Option 1 at ground level [Figures 5.1 and 5.2] and 5-second average odour level contours for Option 2 at ground level and 10, 15 and 20 m above ground level [Figures 5.3 to 5.10].

As shown in Figures 5.1 and 5.2 for Option 1, the odour levels at ground level at the closest SRs of Central and Wan Chai East Screening Plants would be about 600 and 250 ou (5-second



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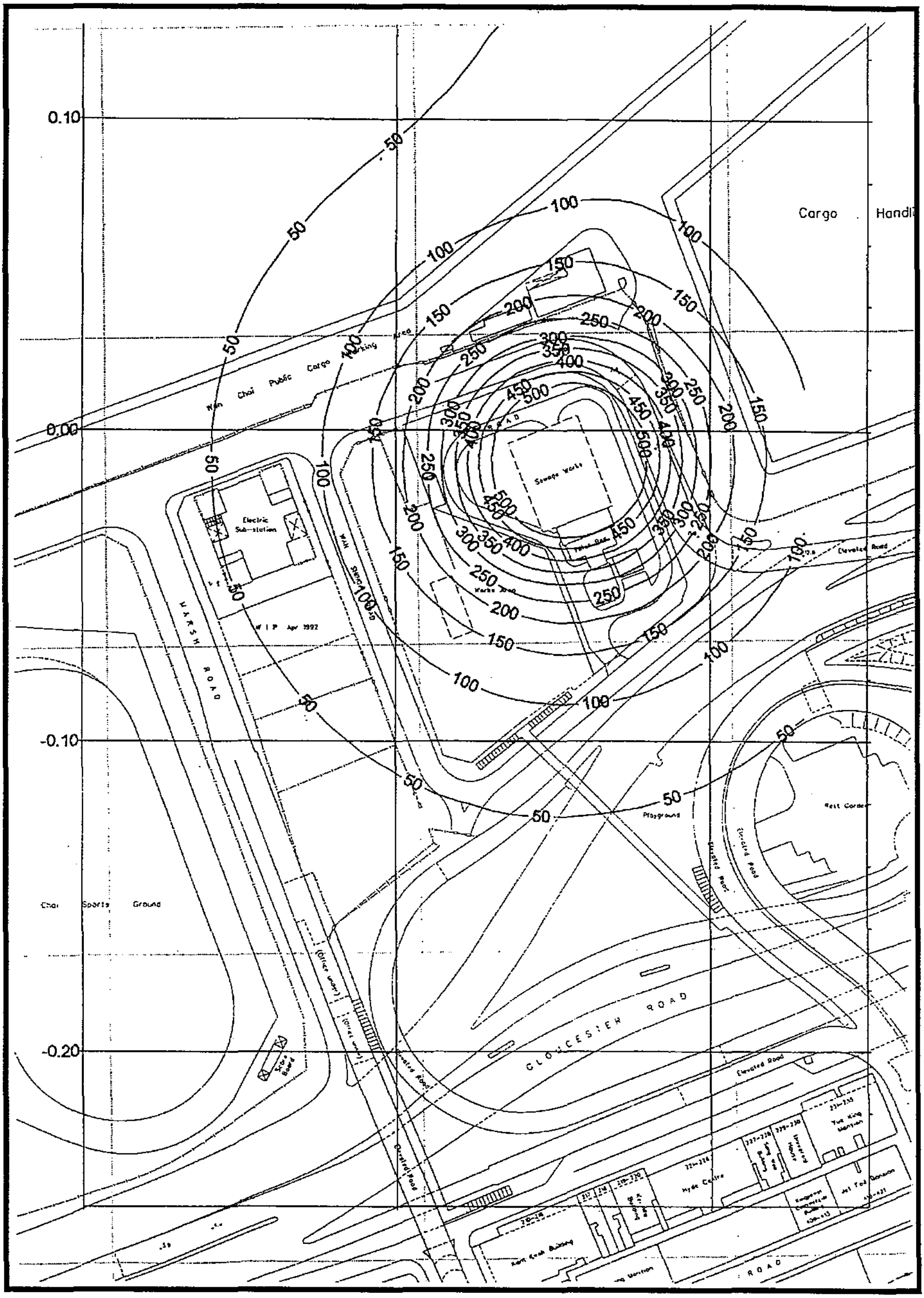
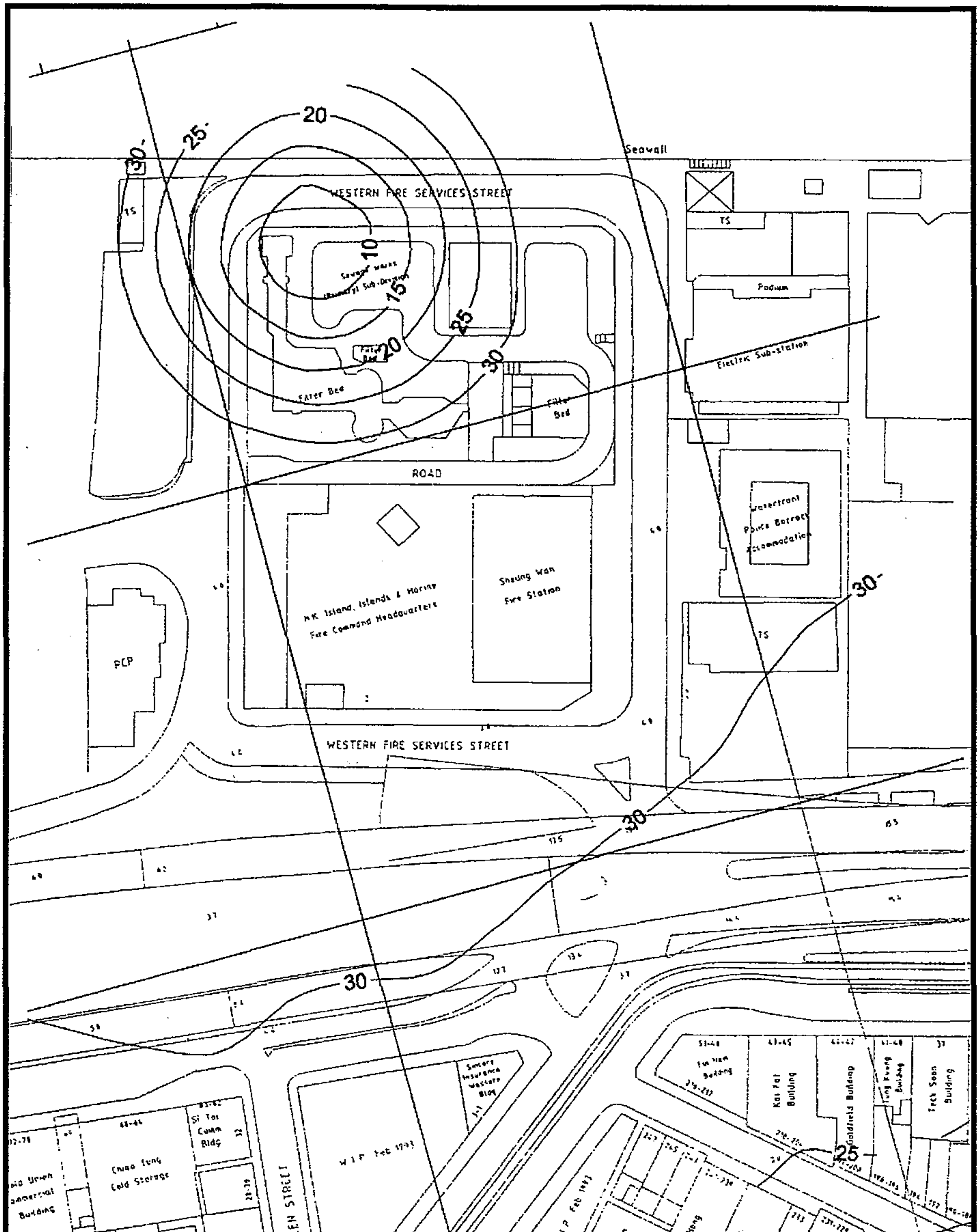
MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT GROUND LEVEL, CENTRAL SCREENING PLANT - OPTION 1

FIGURE 5.1



MAUNSELL MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT GROUND LEVEL, WAN CHAI EAST SCREENING PLANT - OPTION 1

FIGURE 5.2



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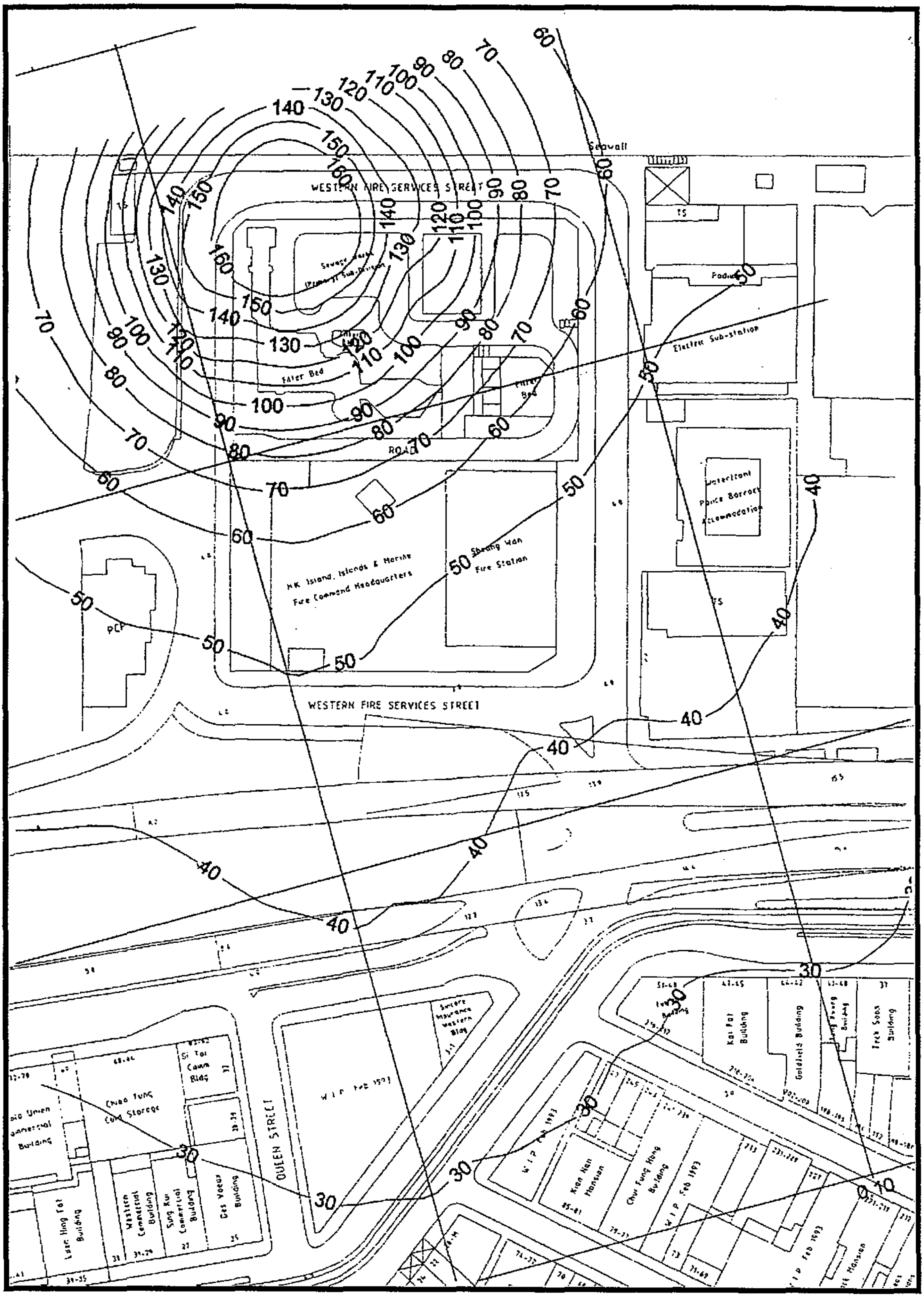
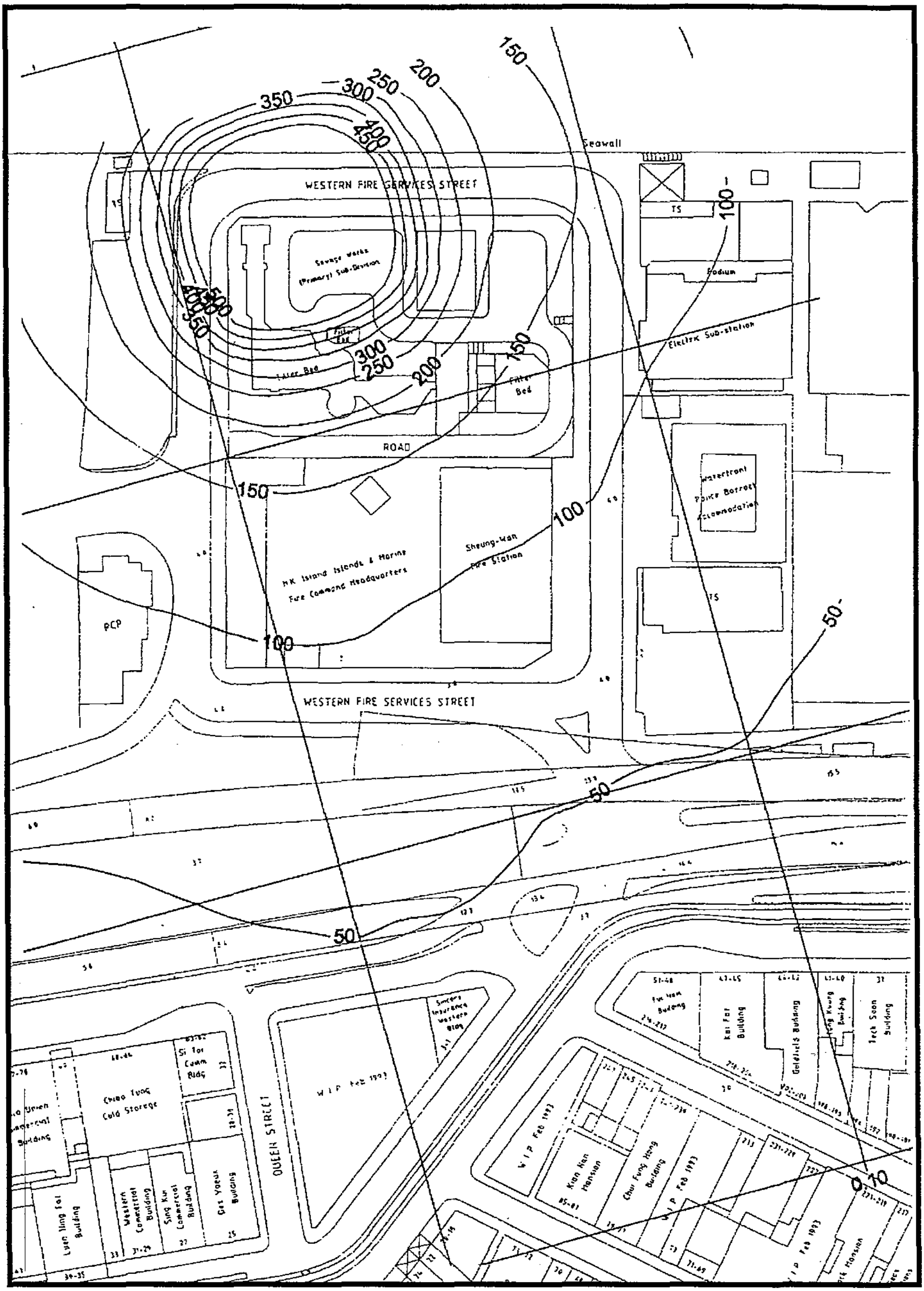
MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT GROUND LEVEL, CENTRAL SCREENING PLANT - OPTION 2

FIGURE 5.3



MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT 10M, CENTRAL SCREENING PLANT - OPTION 2

FIGURE 5.4



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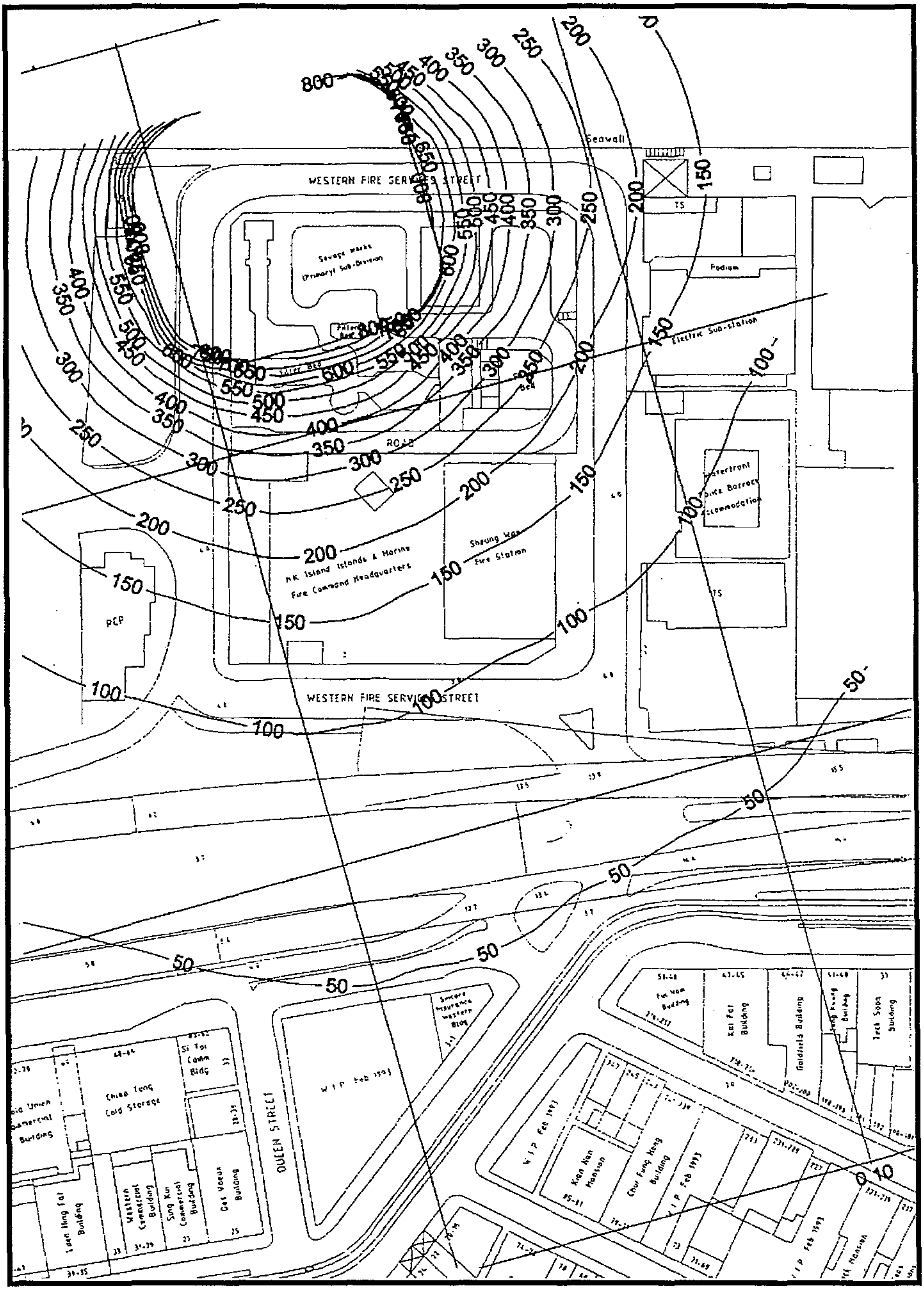
MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT 15M, CENTRAL SCREENING PLANT - OPTION 2

FIGURE 5.5



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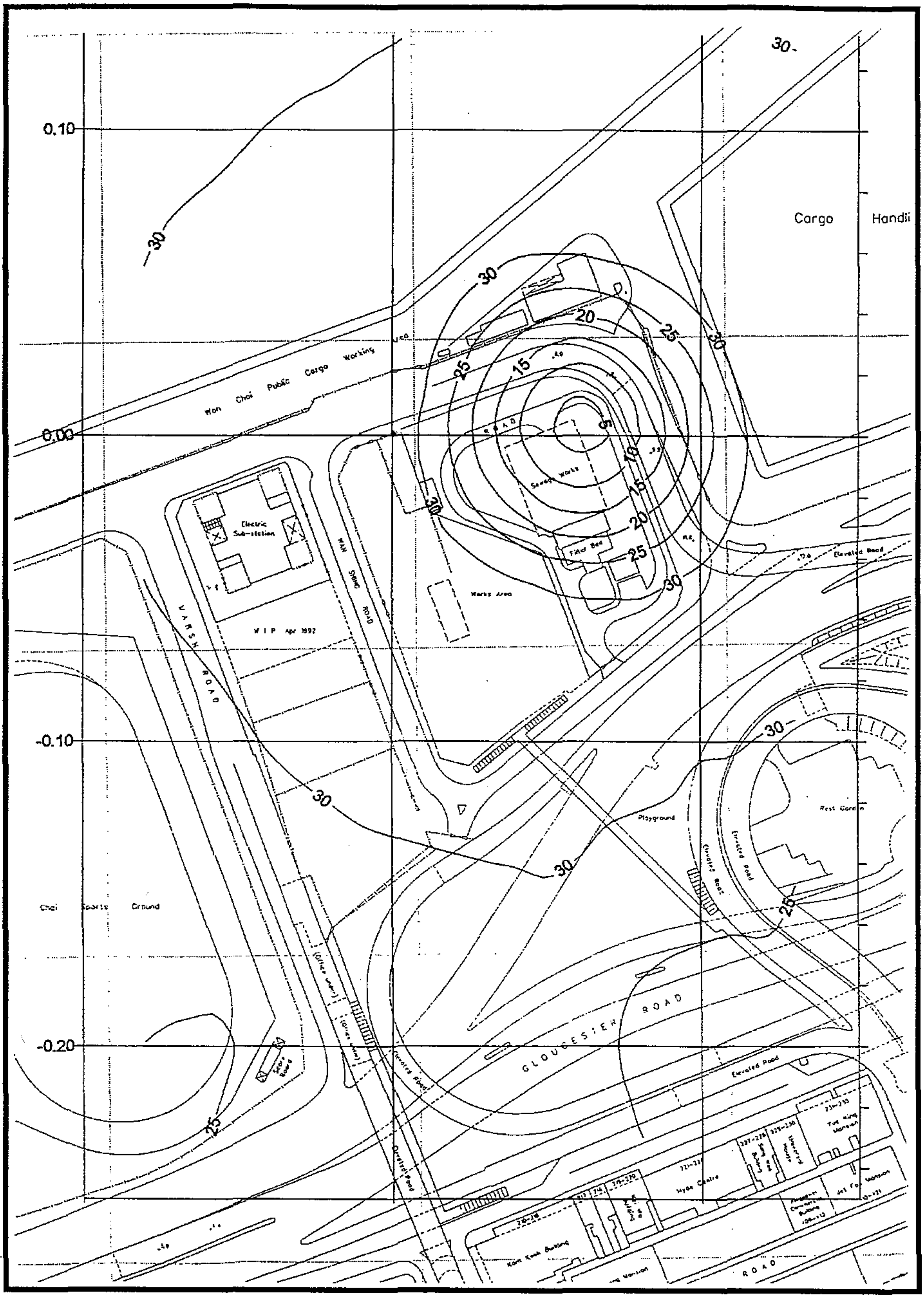
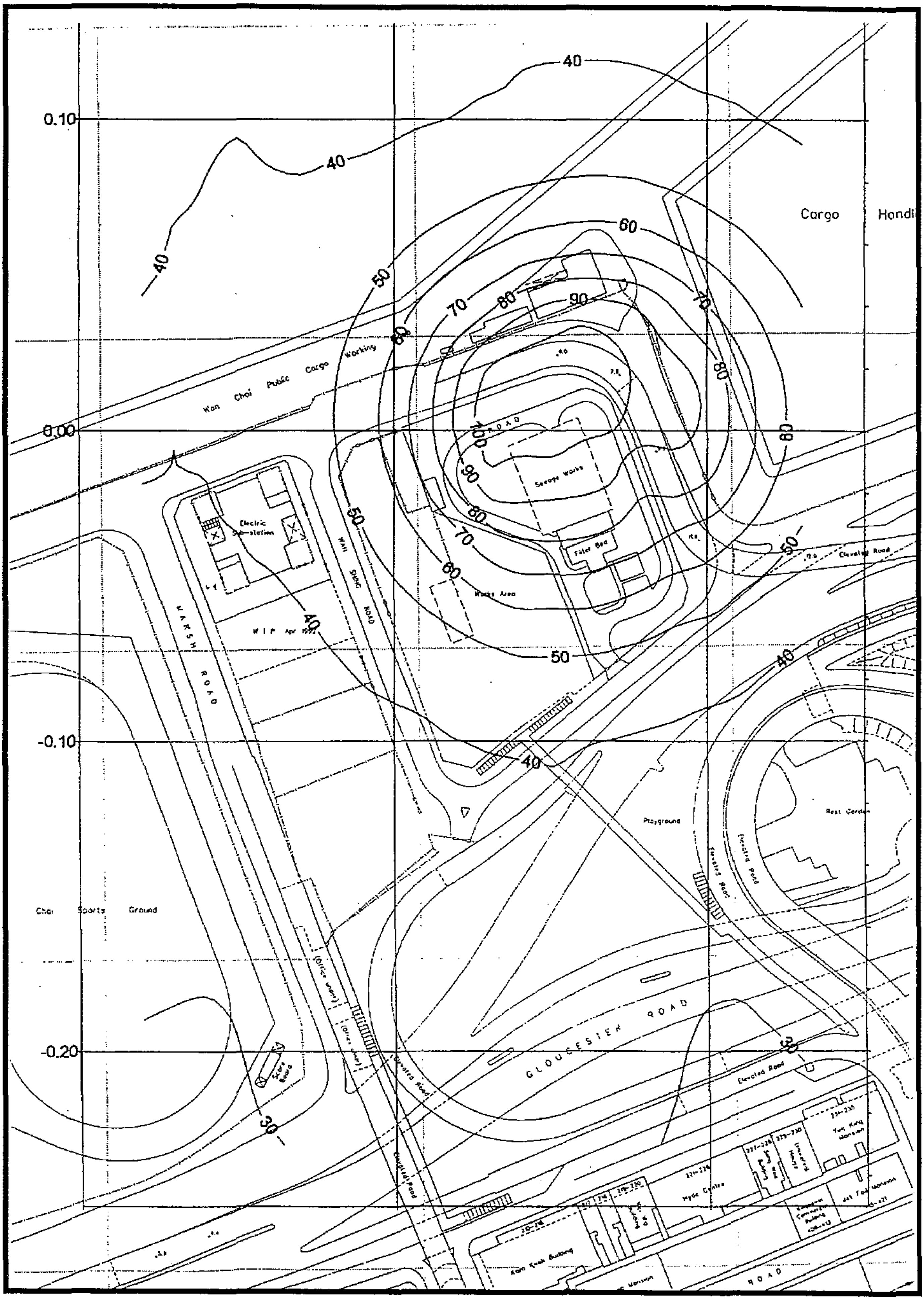
MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT 20M, CENTRAL SCREENING PLANT - OPTION 2

FIGURE 5.6



MAUNSELL MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT GROUND LEVEL, WAN CHAI EAST SCREENING PLANT - OPTION 2

FIGURE 5.7



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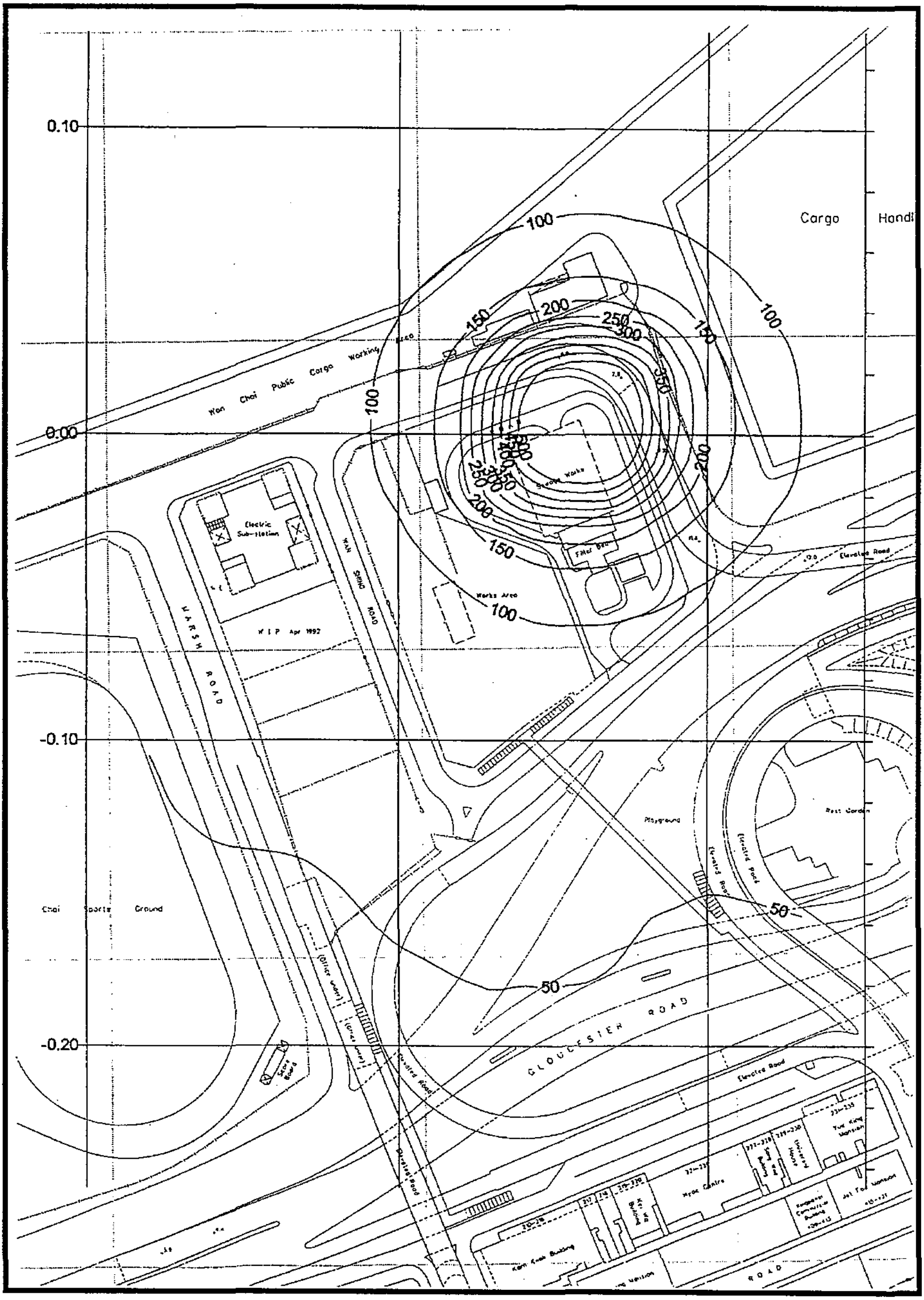
MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT 10M, WAN CHAI EAST SCREENING PLANT - OPTION 2

FIGURE 5.8



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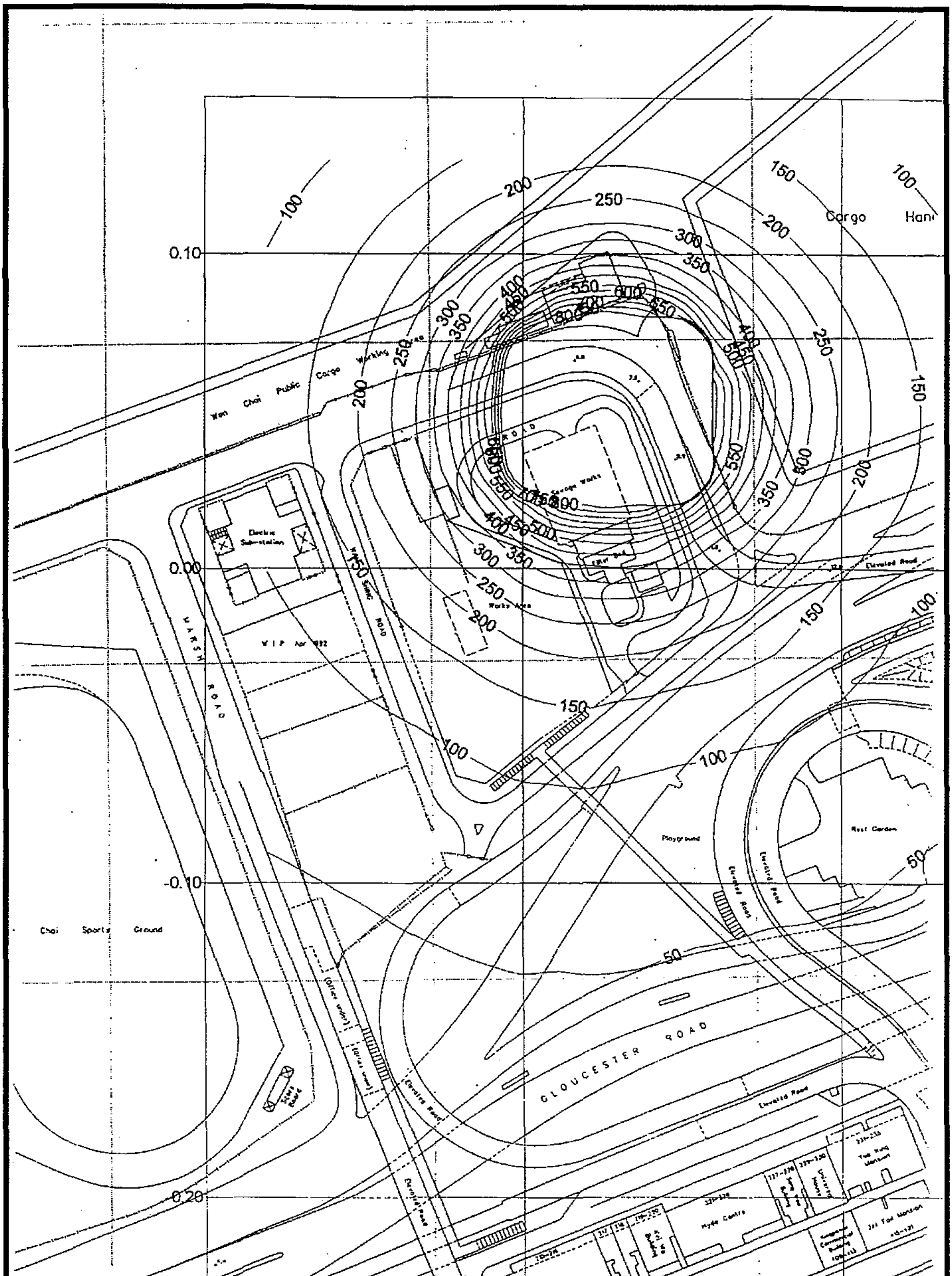
MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT 15M, WAN CHAI EAST SCREENING PLANT - OPTION 2

FIGURE 5.9



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MAXIMUM 5-SECOND AVERAGE ODOUR LEVEL CONTOURS AT 20M, WAN CHAI EAST SCREENING PLANT - OPTION 2

FIGURE 5.10

average concentration) respectively. Since most of the odour emissions at ground level were from the existing facilities, adverse odour impacts at nearby SRs would be expected for no enclosure of the existing facilities.

Figures 5.3 to 5.6 for Central Screening Plant and Figures 5.7 to 5.10 for Wan Chai East Screening Plant present the odour levels in the proximity of the plants different elevations for Option 2. Since it was assumed that all the odorous emissions would be collected to a common stack (located at the far end to the receivers) and exhausted at a height of 10 m, elevated odour levels were predicted at higher levels. After considering the heights of all the nearby SRs of both plants, it is determined that the highest odour levels at the SRs of Central and Wan Chai East Screening Plants would be approximately 180 and 160 ou (5-second average concentration) respectively.

On the basis of these predictions, it is considered that control efficiencies of at least 98% and 97% will be required respectively for Central and Wan Chai East in order to ensure compliance with the guideline.

5.2 NOISE

The following assessment examines noise impact resulting from the installation of new facilities at the two screening plants. It is based upon criteria given in the TM for the Assessment of Noise From Places Other Than Domestic Premises, Public Places or Construction Sites and HKPSG.

5.2.1 Central Screening Plant

The nearest NSR is the fire station, approximately 35 m from the proposed pumping station building.

The most likely noise impact is expected to arise from PME installed in the pumping stations. The estimated SWL at the source is 101 dB(A). The resulting noise level at the facade of SRs would be 65 dB(A) including distance attenuation of 39 dB(A). Additionally, all PME will be housed within reinforced concrete buildings with walls approximately 0.25 m thick. Thus the received noise levels will be further reduced by at least 10 dB(A), taking into account the effect of windows and doors. Thus noise level at the facade of SRs can be further reduced to 55 dB(A), which is within the statutory limits of 70 dB(A) for the daytime and evening, and 60 dB(A) for the night-time. Details of noise prediction are presented in Table 5.3.

Considering that the present ambient noise level is over 70 dB(A), it is likely that SRs would not be able to distinguish operational noise from the existing background levels.

Table 5.3 Equipment List for Central Sewage Screening Plant

Plant	SWL Per Piece dB(A)	No of Equipment	SWL of All Pieces dB(A)
Pumps/motors	83	4	89
Ventilation fans	95	3	100
Deodorizer	95	1	95
Total SWL			101 dB(A)
Distance Attenuation (35 m)			-39 dB(A)
Facade Effect			+3 dB(A)
Screening Effect			-10 dB(A)
Resulting Noise Level at SRs			55 dB(A)

5.2.2 Wan Chai East Screening Plant

New facilities at this location will include two grit traps, a screening plant and a pumping station to replace the existing one. Drawing from experiences with the existing screening plants, it is considered that noise impact from the grit traps and screening plant will be minimal. Moreover, because they will be housed in a purpose built building, the impact would be even less significant. Thus the main noise source would be derived from the pumping station which is examined in detail as follows.

The nearest NSRs (commercial and residential buildings) are located some 190 m from the pumping station house.

The maximum SWL from the pumping station is 101 dB(A). A further reduction of 10 dB(A) can be achieved since all PME will be housed in a similar fashion to the Central plant. With distance attenuation this is reduced to a received noise level of 40 dB(A) at the facade of the NSR, which is within the statutory limits of 70 dB(A) for daytime and evening, and 60 dB(A) for night-time. Detailed calculations are presented in Table 5.4. In reality, NSRs would be more affected by traffic noise from Gloucester Road due to the close proximity.

Table 5.4 Equipment List for Wan Chai East Sewage Screening Plant

Plant	SWL Per Piece dB(A)	No of Equipment	SWL of All Piece dB(A)
Pumps/motors	83	5	90
Ventilation fans	95	3	100
Deodorizer	95	1	95
Total SWL			101 dB(A)
Distance Attenuation (190 m)			- 54 dB(A)
Facade Effect			+ 3 dB(A)
Screening Effect			- 10 dB(A)
Resulting Noise Level at SRs			40 dB(A)

5.2.3 Summary

It should be noted that the new pumping stations will replace the existing ones at Central and Wan Chai East. Thus noise from the new pumping stations will not be new emission sources. The future situation may not be any worse than the existing situation. Thus overall noise impacts on SRs due to operation of the new facilities are likely to be small.

5.3 WATER QUALITY

5.3.1 Background

The Government's overall strategy for improving the water quality in Victoria Harbour is set out in the Sewerage Strategy Study. This will involve implementation of the SSDS Stage III/IV at which time flows from the existing screening plants on the northern shore of Hong Kong Island will be discharged after screening and degritting to the SSDS deep tunnel system. Therefore the existing submarine outfalls will no longer discharge into the harbour.

The Central Western and Wan Chai West Sewerage (CW3) project is an important initial step in the implementation of Government's strategy to reduce the pollution of Victoria Harbour. The Central Western and Wan Chai West Sewerage Master Plan Study (1993) identified that approximately 50% of the total pollution load from the study area enters the harbour directly via the storm drainage system without receiving any treatment. Interception of these foul flows, through the removal of expedient connections, is both required as a step towards the long term goal set out above and also as a means of achieving early improvements in water quality prior to the implementation of the SSDS Stage III/IV. Substantial improvements in near shore water quality are expected following implementation of the CW3 project.

As noted above, implementation of the SSDS Stage III/IV remains the Government's ultimate goal. Works carried out prior to completion of the SSDS must be planned and carried out with this in mind, and should not compromise the implementation of the SSDS. They should be a step towards this objective. Bearing this in mind, the existing Wan Chai West Outfall and Wan Chai East Outfall, and any subsequent re-provision and enlargement of these outfalls as a result of the Wan Chai Phase II Reclamation (if applicable) should only be regarded as an interim sewage disposal solution prior to commissioning of SSDS Stage III/IV.

Similarly, the implementation of the CW3 works should not compromise the feasibility of subsequent projects. For example, Wan Chai Reclamation Phase II (WRII) is likely to be implemented prior to the SSDS Stage III/IV. Design and implementation of the CW3 works must therefore be carried out in such a way to provide minimum restriction and maximum flexibility for this and other subsequent projects to determine solutions to water quality problems. Ideally the implementation of these subsequent projects should achieve another step towards Government's long term goal.

5.3.2 Strategy

Based on known information and currently anticipated project implementation timetables, the following sequence has been determined for achieving the Government's target of improving the marine water quality:

Interim Step 1: Implementation of CW3 works to upgrade the screening plants and sewerage system.

Interim Step 2: Implementation of WRII which will affect the existing outfall from Wan Chai West and Wan Chai West Screening Plants.

Final Step: Implementation of SSDS Stage III/IV.

5.3.2.1 Interim Step 1 : CW3 Sewerage Works

The proposed sewerage improvement works will be designed to intercept those flows currently being discharged to the harbour via the storm drainage system. Interception of these flows through the removal of expedient connections will lead to early environmental gains through a substantial improvement in near shore water quality.

These intercepted flows will be transferred to the existing screening plants at Wan Chai East, Wan Chai West and Central where they will be screened and degritted prior to discharge to the harbour via existing outfalls. These outfalls have been designed to accommodate the total flows from their respective catchments. However they have been prevented from doing so previously because of deficiencies in the existing sewerage collection system. The design capacities of the existing outfall will not be exceeded and therefore there can be no deterioration in water quality over that previously allowed for.

In the interim period, operation of the Wan Chai West Screening Plant will continue as at present and the incoming flow will be maintained within design capacity. This will remain the case until either SSDS Stage III/IV is implemented, or it is determined that the screening plant can be decommissioned and flows transferred to the Wan Chai East Screening Plant for discharge through an enlarged Wan Chai East Outfall.

The ultimate design flows for the CW3 project will exceed the available cumulative capacity of the existing Wan Chai East and Wan Chai West outfalls. The timing of this exceedance is dependant on the implementation programme for the various reclamation phases and the build up of flows from both the reclamation areas and the general increase in flows in the study area. It is anticipated that the exceedance will not be great until Central Reclamation Phase III and WRII are implemented. Current projections indicate that this scenario would not occur until 2002 at the earliest. This overall exceedance is expected to be of the order of 250 l/s at peak flows by the year 2011 if WRII is not implemented based on information currently available. The timing of this exceedance is not expected to be before the end of 2006 and could be even later if flows do not build up as currently anticipated. This problem could be overcome by either implementation of an enlarged outfall under WRII (WRII is also a significant contributor to the increased flows) or implementation of the SSDS Stage III/IV.

It should be also noted that the peaking factors employed in the design of the screening plants and outfalls have a significant contingency allowance. Relaxation of these to a peaking factor of 2.0 would be required. In addition, backing up of excess flows in the trunk sewer system until the flows dropped below the outfall design capacities may occur. (The corresponding estimated peaking factor is 2.25 if WRII is not implemented).

The preferred scenario under this situation is that all CW3 works in Central catchment be completed and the surplus flows from Central catchment transferred to the Wan Chai East Screening Plant. Approximately 15% of the Wan Chai catchment would continue to discharge to the Wan Chai West Screening Plant.

In the remaining area of Wan Chai which will not be connected to Wan Chai East, much of the proposed upgrading of individual sections of sewer can be completed subject to downstream sewer capacity and level constraints as part of the Contract No. DC/95/08 - Wan Chai West Upper Catchment. On completion of this contract, most of the existing overflows from the sewerage system into the storm drains would be eliminated. Any misconnections from the storm drains to the sewerage system would also be rectified. Proper sewerage connections would be carefully enforced in the new reclamation. Therefore, pollution of the harbour due to untreated sewage discharging through storm drains would be much reduced even without connection of all of the upstream sewerage system to the proposed trunk sewer.

The elements of CW3 that would have to be delayed are mainly confined to the interceptors and their connection to the proposed trunk sewer. These works could be completed in about a year, following decommissioning of Wan Chai West Screening Plant.

5.3.2.2 Interim Step 2 : Wan Chai Reclamation Phase II

The proposed WRII works will affect the existing Wan Chai West and Wan Chai East outfalls through:

- Increased surcharge loading on the outfalls;
- Changes to the future shoreline.

Action will therefore have to be taken under this project to upgrade the existing outfalls.

Options available to Government under that project are as described below:

Option A: Decommissioning of the Wan Chai West Screening Plant and transfer of flows to Wan Chai East Screening Plant for discharge to the harbour via an enlarged and extended outfall. This option moves Government closer to their ultimate goal. It would also allow all CW3 sewerage improvements to be completed. The PPFS for WRII has recommended Option A based on currently available information.

Option B: Extension of both outfalls and continued operation of both the Wan Chai West and Wan Chai East Screening Plants. Under this arrangement some of the CW3 upgrading within the Wan Chai West Sewerage System cannot be completed. The need for further investigation of both the Wan Chai West Outfall capacity and any modifications required to the Wan Chai West Screening Plant would have to be identified once the expected build up in flow from the reclamation projects is confirmed and the SSDS Stage III/IV implementation programme is known.

These options will have to be studied under the WRII project, primarily in terms of reclamation implementation constraints, cost and water quality impacts before a final decision is made by Government. It must, however, be recognised that both options constitute an interim step in improving the water quality until implementation of the SSDS Stage III/IV.

The proposed CW3 works should not compromise the decision to be taken as they will facilitate the adoption of either two outfalls or a single outfall.

The CW3 project works also retain sufficient flexibility to allow the Wan Chai West Screening Plant to be decommissioned some time in the future, should the two outfalls option be selected, and flows to be transferred to Wan Chai East Screening Plant once the SSDS Stage III/IV is constructed.

The proposed CW3 works will not compromise decisions to be taken by Government on the WRII project provided that flows through the two outfalls in the two outfall option are not increased above the current design capacity. Drainage Services Department will also remain committed to assisting Government to achieve an acceptable solution to water quality issues during and following the implementation of WRII.

Extension of both outfalls further into the harbour is not anticipated to present a water quality problem as essentially they will be discharging into the same body of water, i.e. the mixing zones will simply be moved. It is assumed that they will be moved to the centre of the channel, but the precise locations required will depend on the revised shoreline, the layout and number of diffusers and sensitive users at the shoreline. The key beneficial uses of the area of Victoria Harbour where the outfalls discharge are predominantly navigation and the abstraction of seawater for cooling/flushing purposes. These uses are not particularly sensitive nor susceptible to the deterioration effects of outfall discharges provided caution and proper attention have been taken in the hydraulic design (e.g. number of diffusers, diffusers layout and geometry, etc.), outfall location and the layout of the shoreline of the future reclamation.

It should also be noted that the existing outfalls currently discharge to the south of the existing fairway where the water depth is estimated to range from 10 to 12 m. Extension of the existing outfalls further northward into the Central Fairway or Hung Hom Fairway would permit discharges into an area with estimated water depth greater than 15 m. This would provide a greater spatial allowance for the dispersion and dilution of the effluent plume arising from the outfall discharge.

Previous desktop ecology studies carried out for the Central Reclamation project concluded that the soft bottom marine environment of Victoria Harbour is polluted and generally lacks a macrobenthic community. The seabed of Victoria Harbour is therefore an ecologically degraded habitat which supports only those species which have adapted to high pollution conditions and extreme anaerobic conditions in the lower water and sediment. In addition it is understood that the area is not an important biological/ecological zone for passage of migrating fish. This will permit greater flexibility in the determination of allowable dimensions of the size of the mixing zones for the future outfalls. A similar situation would apply to an extension of a larger combined Wan Chai East Outfall. The mixing zone will be larger than either of the mixing zones for the Wan Chai East and Wan Chai West outfalls, but will avoid the area of cumulative water quality impacts where the two mixing zones overlap. The benefits and disadvantages of a combined outfall will have to be the subject of an appropriate modelling assessment. However, it is recognised that Central Reclamation Phase III and WRII will form an embayment at the seafront near Lung King Street and the existing MTR Harbour Crossing. A relocation of the discharge from the original Wan Chai West Outfall to the new combined Wan Chai East Outfall will have the advantage of moving the mixing zone further east away from the embayment. This should prevent the outfall discharge from inducing any localised water quality deterioration in the embayment.

Implementation of the CW3 sewerage works prior to the WRII project will result in improved water quality impacts for that project. The reduction in pollution load being discharged through the storm drainage system will provide for an improved near shore water quality which will be benefit to shore based sensitive receivers.

5.3.2.3 Final Step: SSDS Stage III/IV

Once the SSDS Stage III/IV is completed, flows from Wan Chai West will be transferred to the Wan Chai East Screening Plant (if not already done so) for screening and degritting prior to discharge to the SSDS tunnel system. Flows will then no longer be discharged to the harbour via the outfalls and the most significant benefit to water quality will be achieved. Final upgrading works within the Wan Chai West sewerage system can also then be completed, although expedient connections which have been identified will have been removed previously.

5.3.3 Effects of Delayed Implementation of WRII

There are two basic scenarios to be considered if WRII implementation is delayed. These are dependent on:

- Timing of SSDS Stage III/IV and whether it will be implemented in advance of WRII or not;.

- Anticipated timing of WRII, i.e. duration of construction delay.

These are considered below.

Scenario 1 : WRII delayed until after SSDS III/IV

This scenario is relatively straightforward once the SSDS is operational. Flows can be diverted from Wan Chai West to Wan Chai East Screening Plant for discharge to the SSDS deep tunnel system. There would be no real effect on the CW3 works. The flows from WRII are approximately 50-60% of the total excess flows over and above the existing outfall design capacities. Therefore, any problems are significantly reduced if WRII is not implemented and may not occur if general flows in the study area have not built up as estimated. Without WRII, it is anticipated that flows would start to exceed the outfall capacities in 2006 and build up to an estimated 250 l/s at peak flows in 2011 based on information currently available. A reduction in peaking factor and storage in the trunk sewer will offset the problem. It should be noted that the existing outfall capacities cannot be exceeded and therefore water quality impacts cannot be increased.

Scenario 2 : WRII implemented but SSDS III/IV not implemented

This situation is described in section 5.3.2.1 under Interim Stage 1 and is really dependent on whether the outfall capacity can be improved as shown by required water quality modelling by the WRII proponent.

5.3.4 Summary

Issues affecting the water quality in Victoria Harbour are summarised in Table 5.5. It must be stressed that the ultimate goal will not be achieved until the SSDS Stage III/IV is implemented. Various interim steps have been identified to help the Government achieve early water quality benefits, but which still work towards the ultimate goal.

Table 5.5 Joint Qualitative Water Impact Assessments in Victoria Harbour Summary

Stage (Construction Period)	Description/ Activities	Water Quality Impacts/Comments
Existing	WCE & WCW STPs and outfalls with half pollution load discharging through stormwater drains at seawall outfalls	Status quo (baseline)
Interim Step 1	Maintain flows to WCE & WCW STPs and outfalls within design capacities and intercept polluted flow from stormwater drains for treatment and discharge through outfalls under CW3	Significant improvements over baseline in near shore water quality but still interim solution before SSDS III/IV; CW3 will minimise potential embayment problem associated with WRII and GID if it goes ahead in good time.
Interim Step 2	Option A • Upgrade and extend WCE outfall by WRII • Decommission WCW STP and outfall; and • Complete CW3 Option B • Maintain flows to WCE and WCW STPs and extend both outfalls; • Further investigation of the modification to the outfalls and to the WCW STP is dependent in project implementation programmes and the build up of flows • Do not complete whole of CW3	Under either option there are improvements over baseline but still interim solution before SSDS III/IV. Option A is marginally better than option B because it would enable the completion of whole of CW3 to achieve earlier improvement to the water quality. Further assessment and choice will be made by Government when WRII goes ahead.
Final Step (No fixed dates)	• Commission SSDS III/IV • Complete CW3 if step 2B has been taken; • Decommission all outfalls	Best improvement to water quality over the baseline in Victoria Harbour to satisfy WPCO

WCE STP - *Wan Chai East Sewage Treatment Plant*
WCW STP - *Wan Chai East Sewage Treatment Plant*
CRII, CRIII - *Central Reclamation Phase II, Central Reclamation Phase III*
GID - *Green Island Development*
WQ - *Water Quality*

6 MITIGATION MEASURES

6 MITIGATION MEASURES

6.1 AIR QUALITY

6.1.1 Dust

Dust emissions at construction sites can be controlled by following good working practices:

- Use of regular watering, with complete coverage to reduce dust emissions from unpaved areas;
- Regular cleaning of pavements and roads in surrounding areas will help minimise the transfer of dust by vehicle movements;
- Use of enclosures around the main activities to contain spreading of dust;
- Establishment and frequent use of vehicle wheel and body washing stations at site exits, where practical;
- Tarpaulins covering spoil transferred in lorries to and from the work area.

6.1.2 Odour

6.1.2.1 Mitigation Measures

On the basis of the assessment results and the proposed modifications to be carried out, the following odour control measures should be implemented at each screening plant:

<u>For existing facilities</u>: Full enclosure of all conveyor belts, inlets, drum screens and other exposed odour sources, eg. channels. Exhaust air should be ducted to odour removal equipment.

<u>For new facilities</u>: New buildings housing sewerage treatment plant should be effectively isolated from external ambient air and should be provided with a ventilation system capable of a minimum 5 air changes per hour. Exhaust air should be ducted to odour removal equipment.

All contained odorous emissions should be routed to a centralised odour treatment unit. Based on the modelling results, the odour removal efficiencies should be at least 98% for Central and 97% for Wan Chai East screening plants in order to meet EPD guidelines. The exhaust stack should be elevated at least 10 m above ground level and the exit velocity should be at least 8 m per second. The stack should be located as far from SRs as is possible.

In addition, good housekeeping measures should be implemented, and these should include, inter alia, floor sweeping, regular hosing down and cleaning. In accordance with the standardisation of handling methods, a single type of container should be utilised for both screenings and grits. The container should have a sliding top cover to prevent the escape of odours and ingress of rain water.

6.1.2.2 Evaluation of Odour Treatment Technology

In evaluating odour control technology several factors were considered:

- Emission characteristics and amenability to treatment;
- Equipment simplicity;
- Equipment cost;
- Equipment performance and operational reliability.

Activated carbon, or impregnated carbon, adsorption: The use of activated carbon for the treatment of humid odorous gases may not be cost effective. Moisture competes with odorous compounds for sorption sites. To ensure maximum efficiency and carbon cell life, an upstream dehumidification plant would be required prior to carbon filtration. The capital cost of dehumidifiers for this volume of air would be high. Operational costs would also be high, since required regeneration heaters have a high power consumption. Carbon cells would begin to need replacement within 6 months, decreasing further the cost effectiveness of this technology.

Biofiltration: In Europe biofilters have been employed extensively for the most stringent odour control requirements (sewage treatment works, abattoirs etc.). In Hong Kong small biofilters have been installed at Western Wholesale Market and have been specified at North Point Sewage Treatment Plant and Shek O Treatment Plant. Biofilters typically attain an odour removal efficiency ranging from 95% to 99%, and are thus comparable to chemical scrubber and carbon adsorption systems. The humid and biodegradable nature of gases generated from sewage make them highly amenable to biofiltration remediation. Due to lower operating costs biofiltration can provide considerable economic advantages over other technologies. Environmental benefits include low energy requirements and the avoidance of cross media transfer of pollutants.

In summary the advantages of biofiltration are:

- High efficiency/effectiveness;
- Relative compactness (although heavy);
- Easy replacement of filtration media;
- Spent media is harmless and can be either sold or sent to landfill;
- Capacity to cope with high air flow rates;
- Greater dust toleration than carbon filter systems;
- Good performance at high humidity levels;

- Relatively easy performance monitoring capabilities, by means of simple differential pressure sensors and pH meters;

- Low capital and operational costs.

Wet scrubbing: Odour control can also be achieved by wet scrubbing. Wet scrubbing is currently used at the Wan Chai West Sewage Screening Plant to treat odour and is a proven technology.

Compared to biofilters, the major disadvantages of wet scrubbing are:

- Production of an aqueous waste stream requiring collection, treatment and disposal. Resultant high COD waste water may require special treatment;

- Higher operational costs than biofiltration due to continuous consumption of scrubbing chemicals;

- Residual scrubbing chemicals may themselves emit odours (eg hypochlorite);

- Performance is highly sensitive to the flow and dosing rate of scrubbing chemicals;

- The technology is generally not as robust as biofiltration, and performance is also harder to monitor.

6.2 NOISE

6.2.1 General

The required degree of noise mitigation will depend upon the ANLs assigned to each individual site, the construction programme and plant schedules. Nevertheless, the following list of options should be adopted for each work site where it is practical to minimise the impact:

- Acoustic screening of receivers from direct line of site from construction activities;

- Use of acoustic barriers/shields to enclose or partially enclose noisy activities. A purpose-built barrier with a cover on top normally can achieve reductions of 5 - 10 dB(A);

- Use of silenced equipment;

- Carefully planning the construction programme through:

  - Restriction of times at which concrete breaking and/or piling is carried out. Details of piling operation hours for the trunk sewers and Wan Chai Pumping Station are presented in Section 4.2.

- Minimisation of surface construction and underground excavation work during evening and night-time periods.

- Observation of school hours: noisy operations such as concrete breaking, excavation plant operation, and/or piling should be avoided near the existing schools during teaching or exam hours. This is particularly relevant to the construction of reticulation and interception sewers at B_3 zone [Figure 4.11];

- A common sense approach: the placing of noisy equipment and the conducting of activities as far from SRs as is practical. The turning off of idle equipment;

- Proper plant and equipment maintenance.

It should be noted that when construction work during the restricted hours using PME and/or percussive piling is taking place, the contractors should strictly follow all conditions specified in their obtained CNPs.

6.2.2 Mitigation for Individual Trunk Sewer Sections

Particular measures appropriate to each trunk sewer alignment are recommended and presented in Table 6.1.

Table 6.1 Potential Noise Mitigation Measures Applicable to Trunk Sewer Alignments

Alignment Section	Sensitive Receivers	Predicted Noise Impact		Mitigation
		No Dig	Open Cut	
A•B	1 - 11	N/A	SEVERE	No evening and night-time construction work. Restrict daytime work , ie. 08:00 - 18:00 hours. Use purpose built noise barriers / enclosure to prevent direct line of sight from the receivers as well as super silenced equipment. If resulting noise is still too high, manual equipment may have to be adopted. Close liaison with general public: providing construction notices and progress report.
B•C	No	N/A	N/A	N/A
C•E	12	N/A	MODERATE	Open Cut: Small degree of mitigation for evening work; Substantial measures for night-time work.
	13	MODERATE	N/A	No Dig: Small degree of mitigation for evening and night-time work.
E•F	No	N/A	N/A	N/A
F•H	14	SEVERE	N/A	Night-time work may not be possible.
	15	MODERATE		
H•J	16	SEVERE	N/A	Night-time work may not be possible. Location of shaft away from the hotel as far as is practical.
J•K	No	N/A	N/A	Evening and night-time work would be more favourable when SRs are absent.
L•M	17	MODERATE	SEVERE	Use 'no dig' method and avoid night-time work. Location of shaft away from the hotel as far as is practical.
	18	N/A	MODERATE	Night-time work would be more favourable when SRs are absent.
	19	N/A	SEVERE	
M•N	20	N/A	SEVERE	Relocation of SRs may occur, thus would not be an issue.
N•O	21	SEVERE	N/A	Night-time work would be more favourable when SRs are absent. To locate shaft site away from the SRs as far as is practical.
	22-23 25-27	MODERATE	N/A	Location of shaft sites away from hotels (SRs 23, 24, & 27) as far as is practical and avoid night-time work in close proximity to hotels. Night-time work would be favoured for site close to the district court (SR 26).
	24	SEVERE		

Note: *Low:* *predicted noise levels at SRs below 70 dB(A)*
Moderate: *predicted noise levels at SRs between 70 and 80 dB(A)*
Severe: *predicted noise levels at SRs above 80 dB(A)*

6.3 WATER QUALITY

Silt traps and sedimentation tanks should be provided at construction sites and wastewater (site run-off) should be channelled to the basins. Regular maintenance of the sediment traps, eg. digging out, should be carried out to ensure their efficiency.

Measures to intercept rainwater run-off onto the work sites should be provided so that it will not flow across the sites.

Processing water should be re-used. Prior to its discharge, it should be channelled to the sedimentation tanks.

Bentonite should be stored in silos prior to use. To prevent possible release during application, earth bunds should be constructed around the areas where diaphragm walling is being installed. Any release of bentonite should then be contained within the bunded area and remain available for recycling. If the disposal of a certain residual quantity cannot be avoided, the used bentonite slurry may be disposed of in marine spoil grounds subject to obtaining a marine dumping licence from EPD on a case-by-case basis. If the slurry is intended to be disposed of through a public drainage system, it should be treated to respective effluent standards applicable to foul sewers, storm drains or receiving waters as set out in the TM on Effluent Standards under the WPCO.

Excavation of open-cut and cover trenches should be avoided during monsoon or rainy seasons if possible. Measures should be taken to minimise the flow of rainwater into trenches. Trenches should be dug and backfilled in short sections. Water pumped from the trenches should be channelled to sedimentation tanks prior to its discharge into storm drains.

Sewage arising from construction sites should be collected and treated prior to discharge.

It should be noted that discharges wastewater from the construction sites to surface water and/or public drainage systems should comply with the terms and conditions in the licences.

7 ENVIRONMENTAL MONITORING AND AUDIT

7 ENVIRONMENTAL MONITORING AND AUDIT

7.1 MONITORING

Environmental monitoring will be necessary to determine the extent of impacts on identified SRs. This section examines the requirements for two categories of monitoring: baseline and impact. The former is necessary in order to determine existing conditions so that relevant EQOs for SRs can be established.

Detailed requirements for each set of parameters are discussed below. A summary of these requirements in terms of parameter, location, time, frequency and duration is provided [Table 7.1].

7.1.1 Baseline Monitoring

Background noise and dust monitoring will be necessary to establish ANLs and ambient dust levels. In addition, spoil analysis for contamination will also be required to determine disposal site.

7.1.1.1 Baseline Air Quality Monitoring

Ambient dust levels should be measured at the two screening plants. Both 1-hour and 24-hour TSP should be monitored daily for two consecutive weeks at each screening plant site boundary. Dust monitoring should be undertaken prior to commencement of construction work.

7.1.1.2 Baseline Noise Monitoring

It will be necessary to undertake background noise monitoring at one NSR for each screening plant and along Belcher's Street before construction commences. This will enable existing ambient noise levels in the vicinity of the SRs to be determined and allow acceptable limits to protect nearby SRs to be set. Noise control can then be achieved by including this figure in construction contract documents for each of the work sites.

Baseline monitoring should comprise the measurement of the A-weighted equivalent continuous sound pressure level $L_{Aeq\,(30\,min)}$ during the daytime and $L_{Aeq\,(5min)}$ during restricted hours. Measurement of L_{10} and L_{90} should also be carried out as these parameters provide additional information for interpreting ambient noise conditions. The monitoring should be carried out daily for two weeks.

7.1.1.3 Spoil Analysis

As described in Section 4.4.2, spoil contamination (if it occurs) would either be caused by sewage leakage from the pipes and manholes, or in old reclamation areas the buried marine sediments which were polluted by effluent discharges in 60 and 70's. Thus if off-site disposal of spoil is required by the contractors, prior to excavation, soil samples should be taken at locations identified in Section 4.4.2, including the two screening plants, the Western Reclamation site and some manhole/shaft locations.

The most likely contamination caused by sewerage would be heavy metals. Thus analysis parameters should include cadmium, chromium, copper, lead, mercury, nickel and zinc.

7.1.2 Compliance - Construction Impact Monitoring

7.1.2.1 Construction Dust

Continuous 24-hour TSP monitoring should be undertaken once every six days at the site boundary of two screening plants during construction. Monitoring frequency and duration may change subject to approval by EPD after review of monitoring data.

Regular dust monitoring may not be required due to the relatively small scale of construction. However, 1-hour TSP should be conducted using a portable dust meter when substantial dust is generated or when complaints are received.

7.1.2.2 Construction Noise

Noise measurements should be undertaken at one NSR at each screening plant and one NSR along Nos 46 - 86 Belcher's Street at any time. The measurement should be made over a 30 minute day time period on normal weekdays for each receiver on a weekly basis. Three consecutive five minute L_{Aeq} measurements per week should be employed during restricted hours (19:00-07:00) and public holidays (including Sundays) where CNP apply. The compliance monitoring programme must be designed around the timing of construction work at each site, having regard to the need for 24-hour working.

Timing of the measurements is critical during all monitoring periods and should coincide with the periods when new plant is being used on site and when most plant is operating concurrently. Close liaison with the resident engineer on each site will be required to determine when new equipment will commence operation. It will be necessary to draw up an exact and formalised monitoring programme based on the above recommendations when evening and night-time working requirements at each of the working sites are known.

Regular compliance monitoring will not be necessary along the trunk sewer alignments (except for Belcher's Street) as well as the reticulation and interception sewer alignments. However, monitoring and/or investigation will be required when complaints are received.

7.1.3 Compliance - Operational Impact Monitoring

Key parameters to be considered for compliance monitoring should include noise and odour.

7.1.3.1 Operational Air Quality

Daily patrol monitoring for odour is considered necessary at the two screening plants, particularly at the initial operational stage, eg for the first six months of operation, to verify the performance efficiency of odour control measures. Thereafter, the frequency of monitoring can be modified subject to the review of the monitoring results. If an excessive odour has been detected, frequent monitoring should be instigated until the situation has been rectified. A formal odour panel test should also be conducted.

7.1.3.2 Operational Noise

The noise assessment in Section 5.2 indicated that noise impact from pumping stations on NSRs will be minimal. The predicted noise levels at currently identified nearest SRs will be within the ANLs. Noise monitoring programmes to confirm these predictions are recommended at the two screening plants following the commencement of operation. If such confirmation is obtained it is not considered necessary to implement a comprehensive and periodical monitoring programme. However, the noise issue should be reconsidered at the audit stage.

At Wan Chai East screening plant site, the nearest SRs would be likely to be affected more by the traffic noise than the noise from the pumping station due to close proximity. Measurements at the SRs, therefore, would not provide representative data of impacts caused by the screening plant. As a result, it is considered more reasonable to undertake noise measurements at the site boundary and then calculate noise impact on SRs using methods stated in the TM for construction noise impact.

Impact monitoring should involve measurement of the A weighted equivalent continuous sound pressure level $L_{Aeq\,(30\,min)}$ at different times of the day.

7.2 AUDIT

The purpose of an environmental audit is to:

- Establish the degree of compliance of the facility with statutory limits and guidelines for EQOs;
- Review changes in measured parameters since commissioning of the operation to detect deterioration in performance or to record improvements;
- Examine management practice and its efficiency in achieving environmental protection;
- Recommend improvements to the system and its operation in the event that performance is unsatisfactory.

Audits during construction phase should be carried out on a monthly basis. Audits during commissioning are recommended to take place at six months and twelve months for the first year, with further audits at frequencies to be determined based on findings of the first two audits.

The audit should be carried out by an independent team employed by the Project Management Team and approved by Government. Audit reports should contain indications of rates of compliance, recommendations for mitigation measures, summary and interpretation of monitoring data, results of any additional monitoring undertaken by the audit team, recommendations for additional mitigation measures, the improvement of management systems and requirements for further compliance monitoring.

Table 7.1 Environmental Monitoring Requirements

Monitoring Requirement	Period	Parameter	Location	Frequency	Additional Requirements	Limit
Air	Baseline prior to Construction	TSP (1-hr & 24-hr)	Site boundary of Screening Plant	Daily x 2 consecutive weeks	-	-
	Construction	TSP (24 hr)	Site boundary of Screening Plant	Every 6 days	More frequent monitoring required if deterioration occurs	500 μgm^{-3} (1hr)[i] 260 μgm^{-3} (24 hr)
		TSP (1-hour)	Other locations	Complaints received	Occasional *ad hoc* monitoring using portable dust meter at other work sites	
	Operation	Odour patrol	Site boundary	Daily for the first 6 months	To be determined after completion of the first 6 months	2 ou (100% compliance requirement)
		Odour Panel	Site boundary		Once complaint received	2 ou (100% compliance requirement)
Noise	Baseline	L_{Aeq} 5 min, L_{Aeq} 30 min L_{10} & L_{90}	1 NSR for each screening plant	Daily x 2 weeks	-	-
	Construction	L_{Aeq} 30 min (0700-1900) L_{Aeq} 5 min (1900-0700) & whole days for public holidays including Sundays	1 NSR along Nos 46-86 Belcher's Street at any time	Weekly	More frequent monitoring required if deteriorating situation occurs	<u>0700-1900</u>[i]: 75 dB(A) 70 dB(A): school teaching 65 dB(A) school exam <u>1900-0700 & Public Holidays:</u> ANLs
	Operation	L_{Aeq} 30 min	NSRs close to two screening plants, or site boundaries	Weekly x 4	-	ANLs
Soil/Spoil	Prior to Construction	Heavy metals: Cd, Cr, Cu, Pb, Hg, Zn, & Ni subject to be approved by EPD	Screening Plants, Man-holes/shafts Reclamation	Once prior to excavation	-	To be confirmed with EPD

(i) Non-statutory limits

8 SUMMARY AND CONCLUSIONS

8 SUMMARY AND CONCLUSIONS

This report has examined the environmental impacts resulting from construction and operation of the sewerage scheme. The assessment considered noise, air quality (dust and odour), water pollution, and solid waste disposal. Mitigation measures and monitoring framework are also proposed.

Overall, environmental impacts either can be considered small or can be mitigated to an extent where the impacts on SRs are acceptable with the exception of:

- Construction noise generated at 'open cut' alignment along Belcher's Street due to very close proximity to the SRs. However, because it is envisaged that construction works will be undertaken in lengths of approximately 50 m and for a short duration, limited number of NSRs would be affected at one time and for a short duration. If necessary, it is recommended to use manual equipment.

Comparison of impacts for both 'open cut' and 'no dig' options were undertaken for trunk sewer alignments where final decisions of construction methods are yet to be made. The results show that the 'no dig' option will cause less environmental impact with respect to dust and noise. Thus, in terms of environmental impact it will be the preferred construction method wherever it is practical.

Construction work during evening and night-time at some locations in Central areas would be favourable due to the absence of SRs. This will also relieve traffic congestion problems.

A system of effective odour control by taking a holistic approach to mitigation should be devised. The objective will be to completely isolate odorous air prior to odour removal and subsequent release to the atmosphere.

In terms of water quality, the project is an important initial step in the implementation of Government's strategy to reduce the pollution of Victoria Harbour. However, its ultimate goal will be achieved when the SSDS Stage III/IV is implemented.

It should be noted that the findings of this assessment are based on information currently available at this stage of the overall design process. The contractor will be required to review the odour mitigation methods proposed and confirm that these are realistic for the actual site situation and that his designed mitigation measures will achieve the required odour control.

Noise impact assessment, including mitigation measures for proposed shaft and manhole sites, and of piling for two screening plants, will have to be confirmed during the construction. This shall be based on actual shaft locations, working methods and plant used.

Spoil disposal options will have to be determined based on the results of soil investigations.

A summary of above information is provided in Table 8.1.

Table 8.1 Summary of Environmental Impacts

Parameter		Potential Impact	Significant Residual Impacts After Mitigation	Further Work
Construction Phase	Dust	Dust impact from general construction activity, this should be controllable within acceptable levels.	None	None
	Noise	<u>Trunk Sewer Alignment</u> Noise impacts on SRs can be mitigated to acceptable levels except at Belcher's Street section. <u>Screening Plant</u> Noise impacts on SRs can be mitigated to acceptable levels. <u>Reticulation/Interception Sewers</u> No quantitative assessment due to the lack of definite sewer alignment information.	Significant noise impact on SRs along Belcher's Street. No evening and night-time work should be carried out. None	To re-examine/confirm noise impact assessment and consider mitigation measures in detail.
	Water	No significant impact as construction work will be land based.	None	None
	Solid Wastes	Proper spoil handling and disposal procedures should be adopted depending upon the outcome of soil analysis.	None	To determine spoil disposal options based upon results of soil sampling and analysis when information becomes available
Operational Phase	Noise	None	None	None
	Odour	Odour emission from the proposed new pumping stations can be mitigated to acceptable levels.	Odour can still be emitted from existing facilities (except for the pumping stations).	To verify the prediction and design odour control system for both existing and proposed facilities together.
	Water	Initial step to improve water quality in Victoria Harbour	Interim solution before the implementation of SSDS Stage III/IV	Commission SSDS Stage III/IV (not part of this project)

APPENDIX A
KEY PLANS OF PROPOSED WORKS

APPENDIX B
BASELINE NOISE MONITORING DATA

Central, Western and Wan Chai West Sewerage Project - Baseline Noise Monitoring Data

Date	Baseline Noise Monitoring Results, dB(A)																	
	Station A			Station B			Station C			Station D			Station E			Station F		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
3.10.94	74.7			78.9			79.1			78.6			77.7			76.9		
18.10.94		74.9	74.2		73.0	73.7		74.0	73.6		78.0	73.5		79.2	71.4		88.4	70.0
24.10.94		74.2	74.4		72.9	71.9		73.9	73.4		74.2	70.8		77.5	72.7		73.1	68.7
26.10.94		75.3	74.4		78.5	71.7		75.6	74.8		74.9	73.7		72.3	73.0		74.9	74.9
28.10.94	73.4			73.4			76.8			90.2			72.8			76.2		
31.10.94	75.9			74.2			74.2			76.1			77.6			79.1		
Mean	*74.7*	*74.8*	*74.3*	*75.8*	*74.8*	*72.4*	*76.7*	*74.5*	*73.9*	*81.6*	*75.7*	*2.7*	*76.0*	*76.3*	*72.3*	*77.4*	*78.8*	*71.2*

Notes

Station A — Podium of Sun Hung Kai Centre facing Gloucester Road (free field measurement)
Station B — Ground floor and in front of Evergo House facing Gloucester Road (measurement includes facade effect)
Station C — Footbridge over Harcourt Road by Hutchison House (free field measurement)
Station D — Footbridge and in front of Exchange Square facing Connaught Road Central (free field measurement)
Station E — Ground floor and in front of 570-572 Queen's Road West (measurement includes facade effect)
Station F — Ground floor and in front of 23 Belcher's Street (measurement includes facade effect)
Daytime measurements = $L_{Aeq\ (30\ min)}$
Evening/Night-time measurements = $L_{Aeq\ (5\ min)}$
For locations of these monitoring locations see Figure 3.1.

APPENDIX C
SCREENING PLANT GROUND CONTAMINATION INVESTIGATION

1 INTRODUCTION

1.1 General

As part of the Central, Western and Wan Chai West sewerage project, the Central and Wan Chai East Screening Plants will each require the construction of a new pumping station to convey sewage from the proposed trunk sewer to ground level for treatment. The construction of each pumping station will involve excavation to a depth of up to 40 m (for diaphragm walling) resulting in the generation of approximately 34,800 m^3 spoil, equivalent to 35% of the total.

Each of the proposed construction sites is in very close proximity to existing main raw sewage inlets and existing screening process areas. It is therefore considered possible that the soil to be excavated could have become contaminated by leakage or spillage of raw sewage from these areas. Both of the screening plants have been constructed on reclaimed land. Marine deposits beneath the reclamation fill material may also have been contaminated in the past to some degree as a result of previously uncontrolled discharge of effluent into Victoria Harbour.

Investigation is therefore required to confirm the presence and degree of any persistent inorganic contamination, rather than any biological or organic material which may be present. This is in order that spoil generated during the construction phase of the new pumping stations could be appropriately disposed of. The proposed layouts showing pumping station construction sites for both Central and Wan Chai East Screening Plants are shown in Figures C-1 and C-2 respectively.

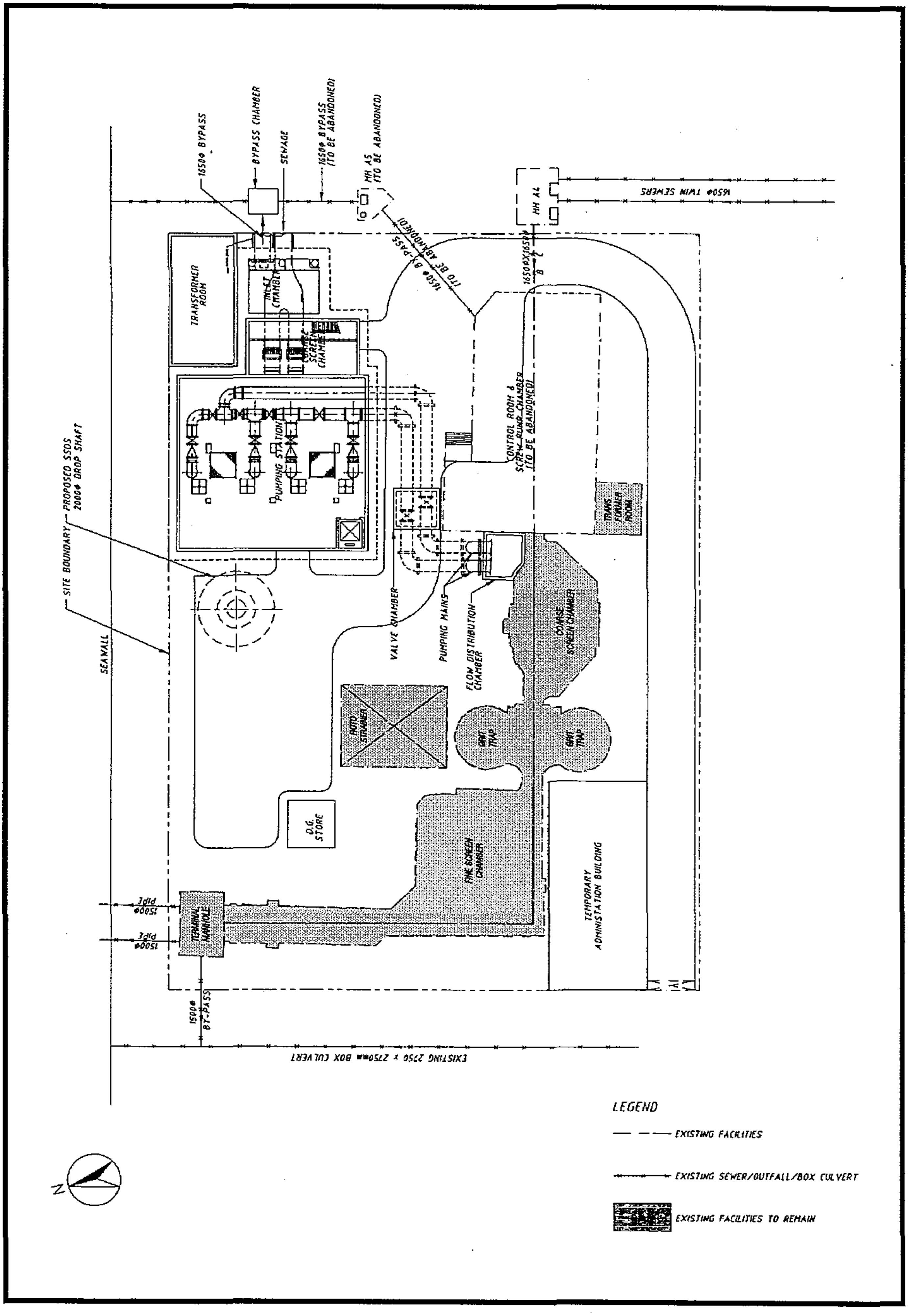
1.2 Sewage Characteristics

Sewage can contain a wide range of metals and other elements in varying - and sometimes very high - concentrations. The precise chemical forms in which the metals and other elements are present vary, but frequently the metals are chemically combined with solid matter present in the sewage. The sewage received by Central and Wan Chai East Screening Plants is predominantly domestic in nature and is therefore not expected to be exposed to exceptional heavy metal concentrations as experienced by screening plants serving more heavily industrialised areas.

2 SITE DESCRIPTIONS

2.1 Central Screening Plant

A site walk-over revealed that the whole site was concreted over and that there was no visible evidence of any contamination. The proposed location for the pumping station was currently occupied by administration buildings and thus inaccessible. The Consultants were informed by resident staff that an existing pipeline leading from the existing pumping station inlet and running immediately in front of the administration buildings was an emergency overflow outfall to Victoria Harbour. Otherwise all the sewage pipelines were as indicated on Figure C-1.



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CENTRAL SCREENING PLANT
PROPOSED LAYOUT
FIGURE C-1

Raw sewage arrives at the main inlet at approximately 16 m below ground level before being raised by screw pumps for screening. The southern edge of the proposed location of the new pumping station is approximately 3 to 4 m distant from the existing pumping station. There is therefore a possibility that contamination of the proposed site may have taken place.

The Central Screening Plant is constructed on land reclaimed from Victoria Harbour. A borehole investigation undertaken close to the site revealed that the fill material used for the reclamation extends to approximately -10 mPD and consists of silty sand with gravel. Marine deposits are from -10 mPD to -15 mPD and alluvium is below the marine deposits, to a depth of approximately -24 mPD.

The water table is expected to be found between 1 to 1.5 m below ground level at both sites.

2.2 Wan Chai East Screening Plant

A site visit revealed that the majority of the site was either tarmacked or concreted over, though a considerable amount of vegetation had been planted around the periphery of the site for aesthetic and screening purposes. Once again no evidence of surface contamination was found and the below ground pipeline layout was as indicated on Figure C-2, except for minor drains servicing the site's own sewage requirements. These minor drains are not considered to be a significant potential source of contamination.

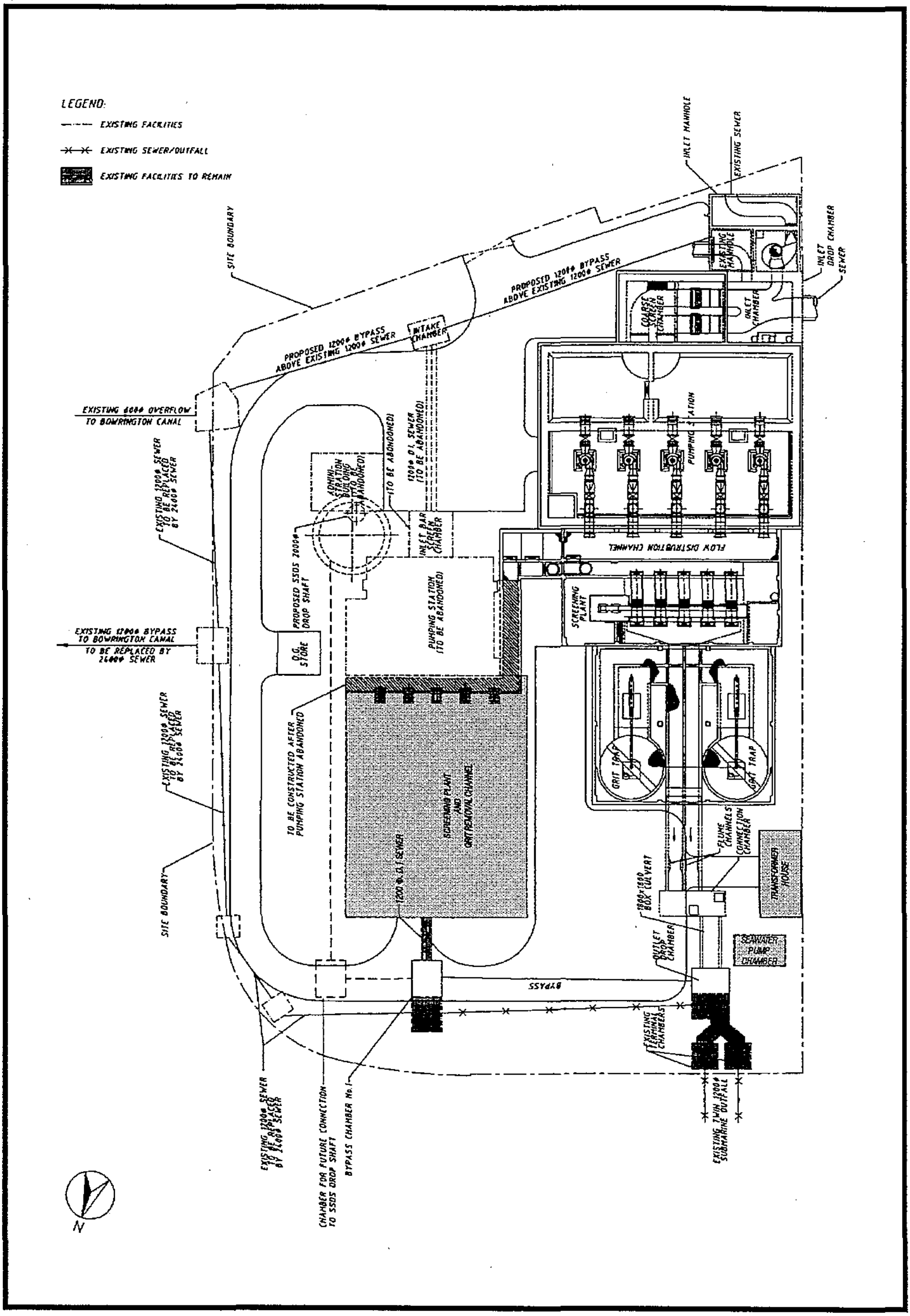
The majority of the proposed pumping station site falls outside the existing screening plant site boundary to the west. However, the existing inlet chamber into which the main sewer empties and the coarse screens which treat the raw sewage are only 10 m to the east of the proposed pumping station site and as such could pose a potential source of contamination. The inlet sewer is approximately 6 m below ground level.

Wan Chai East Screening Plant is also constructed on land that has been reclaimed from Victoria Harbour. Fill material extends to approximately -3 mPD (8 m below ground level). Below this, extending to -15 mPD, are marine deposits, and below this alluvium extends to -29 mPD.

3 PROPOSED INVESTIGATION

3.1 Investigation Guidelines

Preliminary screening of raw sewage removes up to 60 - 70% of the suspended matter present and this may contain a wide range of metals and other elements in varying concentrations. The ICRCL 23/79 document 'Redevelopment of Contaminated Land: Notes on Sewage Works and Farms' states that a survey for the presence of toxic elements will usually be required when sites are redeveloped or undergo a change of use. It is possible that accidental contamination of areas within the works may have occurred during plant operation.



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WAN CHAI EAST SCREENING PLANT PROPOSED LAYOUT

FIGURE C-2

3.2 Sampling Sites

UK DD175 recommends a minimum number of sampling points for a given site area. The smallest site area quoted is 0.5 ha, for which a recommended minimum of 15 sampling points should be established. In comparison to typical contaminated land investigations the two sites are very small at 400 m^2. Interpolating from the quoted minimum number of sampling points produces a figure of 1.2 samples for each site. ICRCL 23/79 recommends sampling a site suspected of contamination on a grid basis, with grid intervals of 10 - 15 m for smaller sites.

EPD recommends a minimum grid spacing of 18 m for a site of 1 ha. This translates to a maximum of 60 sampling sites for a 1 ha site which is equivalent to 2.4 sampling points for 400 m^2.

3.3 Sample Depth

As can be seen the recommendations for the number and depths of samples to be taken at each trial pit or borehole vary to some extent, though all state that the final number of sampling sites selected should reflect the degree of accuracy required and the likelihood of finding contamination based on the preliminary investigation. ICRCL 23/79 and EPD are similar in that they both require a near surface sample and do not specify a maximum number of samples, only a graduation of depths. UK DD175 recommends a sample within 200 mm of the surface, a sample at the greatest depth of interest and a sample of random depth between these two extremes.

3.4 Proposed Sampling

With regard to the design of the sampling strategy several factors have been taken into consideration:

- Surface areas to be excavated at the two plants are small;
- There is no known history of contaminative land use prior to the commissioning of the screening plants. Both sites are currently concreted over and no evidence of surface contamination was seen;
- It is unlikely that fill material used in the original land reclamation would be a source of contamination. Contamination, if any, would be caused by leakage of pipes;
- Contamination, if any, could also be found in the marine deposits due to previous uncontrolled discharge of effluents. The pollutant loading, if any, of remaining in-situ marine deposits is not known;
- The water table is expected to be within 1.5 m of ground level at both of the sites, therefore any pollutants less dense than sea water are likely to be found above this.

Thus the contamination, if any, would occur from fill material at water table level to the layer of the marine deposit. In light of this, and the above mentioned sampling recommendations, the following is proposed:

Central Screening Plant

A single borehole to be drilled in the south eastern corner 1 m from the proposed pumping station construction site boundaries. This will optimise proximity to the existing screw pumping station and emergency overflow outfall. Soil samples should be taken immediately above the water table, and then once every 5 m to a depth of - 20 mPD where a final sample will be taken. This will allow the sampling of fill material, marine deposits and alluvium. A sample of the top layers of the marine deposits should be taken. These occur at approximately -10 mPD.

Wan Chai East Screening Plant

A single borehole to be drilled 1m inside, and half way along, the eastern boundary of the proposed pumping station. This will provide proximity to the existing trunk sewer inlet which is a potential source of contamination. Soil sampling will be as for Central Screening Plant. A sample of the top layers of the marine deposits should be taken. These occur approximately between -3 mPD and -5 mPD.

APPENDIX D
BASELINE ODOUR MONITORING METHODOLOGY

1 Introduction

Baseline odour assessment was undertaken at Central and Wan Chai East screening plants. Assessment was made using an odour panel test. This method measures the level of odorous discharge by means of dynamic olfactometry, a dilution to threshold technique.

The method first involved obtaining representative samples of ambient odorous air. Each sample was then dynamically diluted in the laboratory with odour free air and presented to a panel of three observers. A plot of the number of dilutions versus the percentage of positive panel response was then made. The number of dilutions necessary for a 50% positive panel response was the odour level of the sample.

The method was based on the Standard Analytical Procedures - Source Emission Measurement as published by Environment Protection Authority (Victoria) Air Quality Branch - Technical Services Section.

2 Sampling

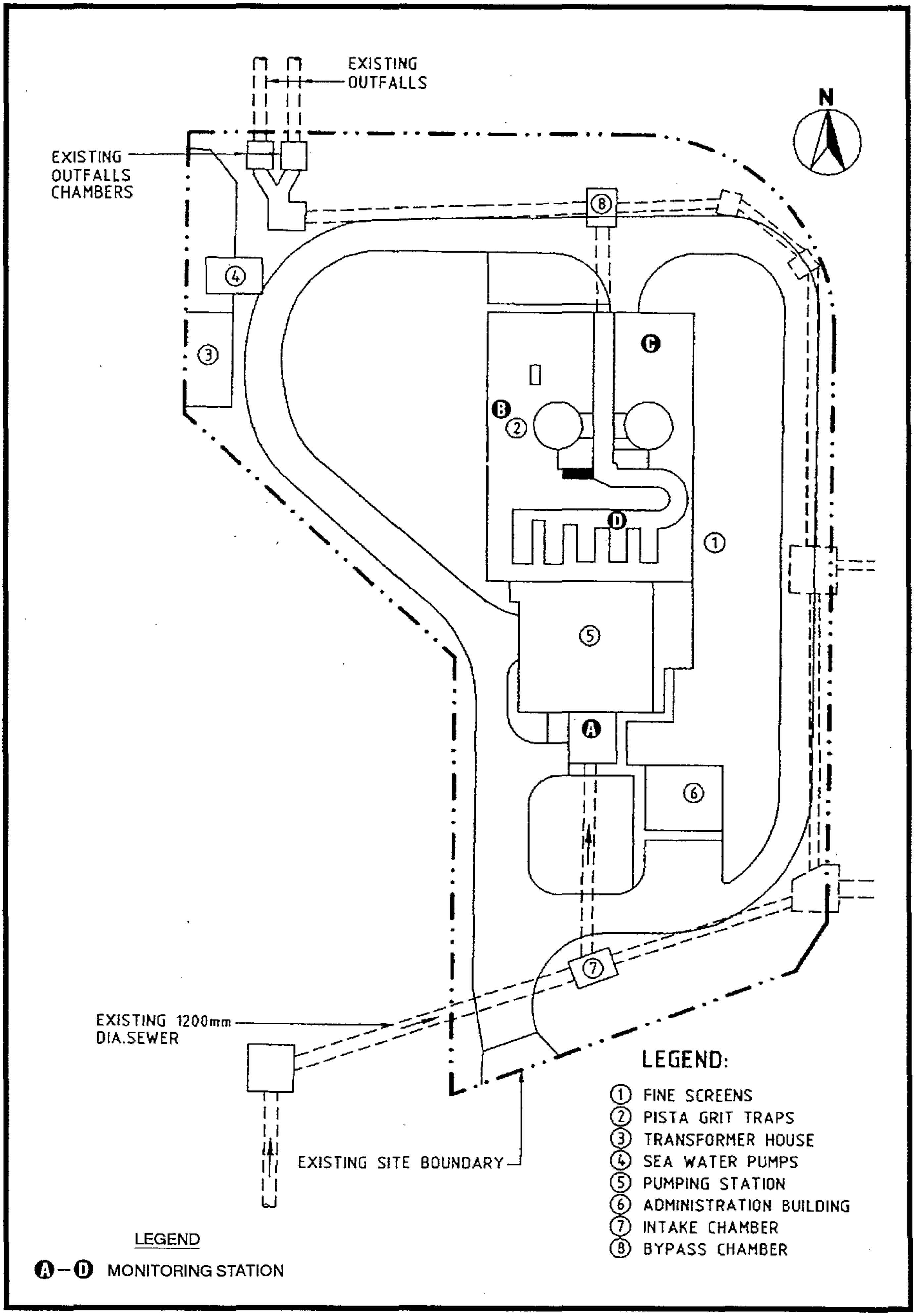
Four samples were taken at each of the screening plants. In addition 2 background samples were taken in the immediate locality of each screening plant for control purposes. Sampling sites were selected to represent the areas of highest odour emission. All samples were taken at a point as close to the source as was possible. Sampling locations are provided in Figures D-1 and D-2.

For each of the sampling locations 40 litres of ambient air was collected as close to the odorous source as was possible. Odour free Tedlar plastic bags were used for sample collection. Portable electric pumps were employed to inflate the bags, and these were left running for two minutes prior to connection to the sample bags in order to flush through with ambient air. Inflation of the bags was typically completed in 10 minutes. General observations were also made during the sampling process and these appear in Tables D-1 and D-2.

3 Laboratory analysis

Air samples were returned to the laboratory immediately following the sampling process. Panellists were screened from each other to prevent any possible conference and possible bias. Each bag was then connected to the dynamic dilution apparatus for testing by the odour panel (Figure D-3). The dilution apparatus was first flushed with odour free compressed air. Following this step the sample air was introduced in increasing concentrations whilst the dilution air was still flowing, until all of the panel provided a positive response. This allowed the panel to become familiar with the odour.

The sample was then introduced at random dilution levels to the panellists, alternating with zero sample flow. The sample air flow rate meter setting and the corresponding number of positive panel responses were then recorded for each variation. A spectrum of sample dilution levels were provided to the panel such that positive responses by at least 33.3% and 66.6% of the panel were elicited.



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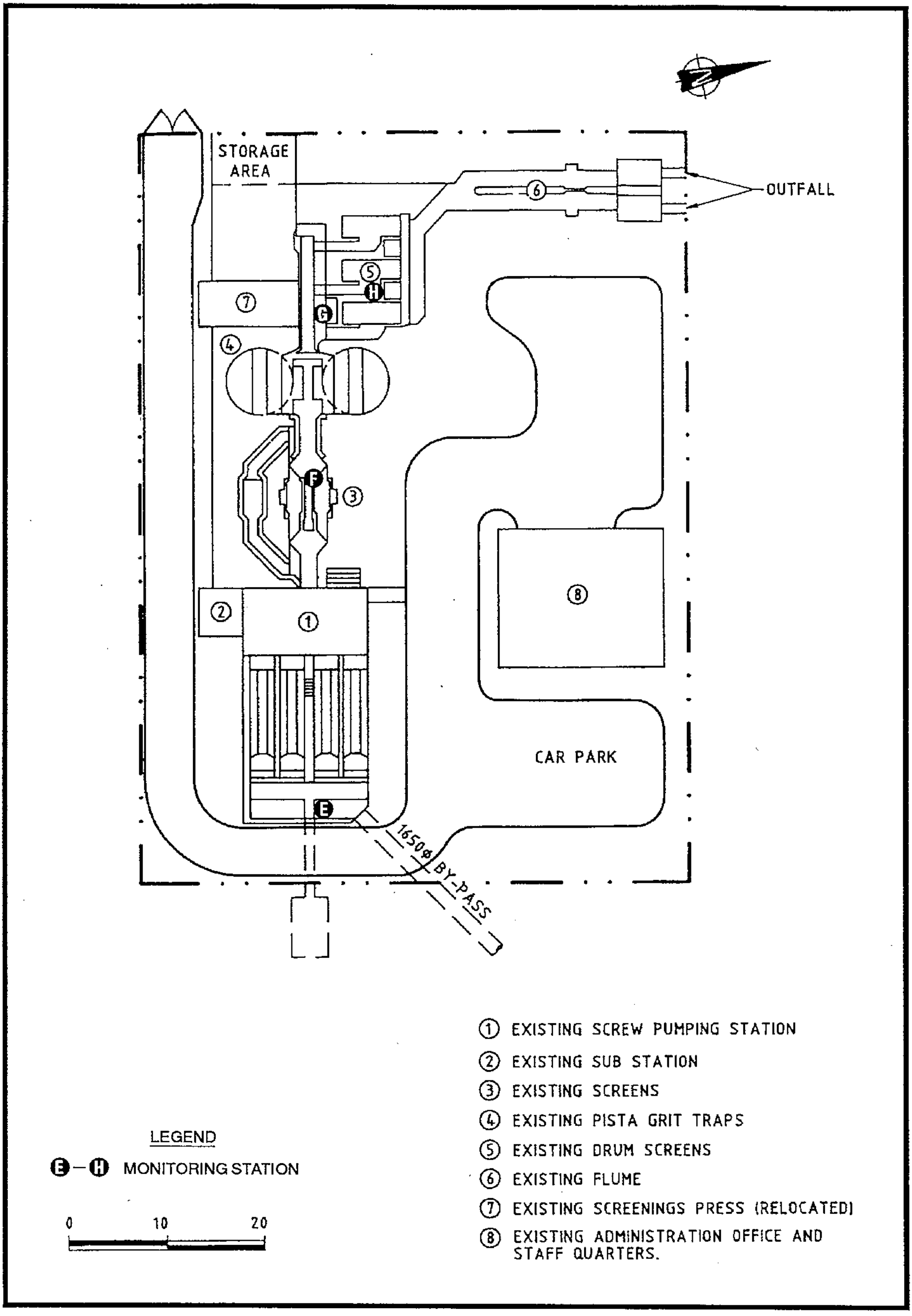
BASELINE ODOUR MONITORING STATIONS
WAN CHAI EAST SCREENING PLANT
FIGURE D-1



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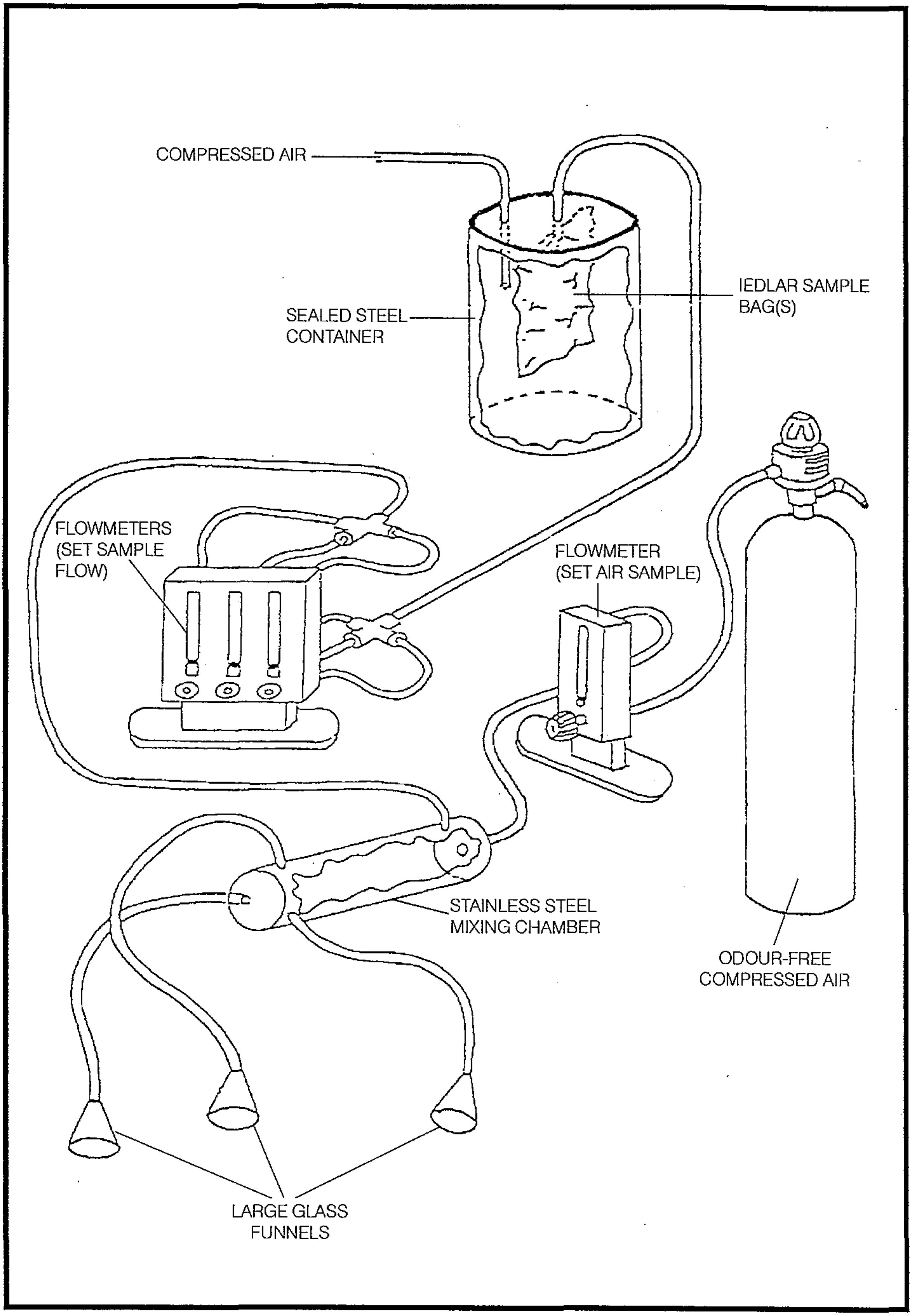
BASELINE ODOUR MONITORING STATIONS
CENTRAL SCREENING PLANT
FIGURE D-2



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SCHEMATIC DIAGRAM SHOWING DYNAMIC DILUTION APPARATUS
FIGURE D-3

A log probability graph showing the percentage positive panel responses against the number of dilutions was plotted. The odour level of each sample was then determined by calculating the level of dilution for a 50% positive response.

Table D-1 Wan Chai East Odour Sampling 8/3/95

Site ID	Site Description	Sampling Commenced	Estimates		
			Odour Source Surface Area (m^2)	Wind Speed (m/sec)	Temp °C
A	Main inlet	08.35	4	0	18
B	Solids conveyor belt	08.55	6	0	18
C	Solids storage area	09.10	1.5	0 - 1	18
D	Drum screens	09.22	1	0	18

Notes:

1. *Residue drums at site C were covered.*
2. *One screening drum was in operation continuously over the whole sampling period.*

Table D-2 Central Screening Plant Odour Monitoring 14/3/95

Site ID	Site Description	Sampling Time	Estimates		
			Odour Source Surface Area (m^2)	Wind Speed (m/sec)	Temp °C
E	Main inlet	8.35-8.45	24	0-1	14
F	Coarse screens	8.55-9.05	16	1-2	14
G	Channel to drum screens	9.10-9.20	15	1-2 plus gusts	14
H	Drum screens	9.28-9.37	5	1-2	14

Notes:

1. *Odour fluctuated noticeably due to strong wafts from sewer inlet and clearance by wind*
2. *Screens in operation throughout sampling*

APPENDIX E
PREDICTION OF HYDROGEN SULPHIDE GENERATION

The prediction of sulphide generation was based on the calculations in Appendix A13 of Strategic Sewage Disposal Scheme Report, Sulphide Generation Potential. With reference to the Appendix, Pomeroy's equation gives:

$$G = MBOD_5 1.07^{T-20}$$

where G = Sulphide flux from wall slimes, $gm^{-2}hr^{-1}$
BOD_5 = Biochemical oxygen demand, gm^{-3} or mgl^{-1}
T = Temperature, °C
M = Coefficient, mhr^{-1}

From the appendix, data available for Hong Kong shows that the average BOD_5 concentration is 300 mgl^{-1}, and that the temperature varies seasonally between 17°C and 28°C. 28°C was taken for conservative calculation. M was taken as 2.9×10^{-3} by assuming that the wastewater contained a significant proportion of seawater.

The build-up in sulphide concentration by both slime activity and generation within the wastewater is given by:

$$Cs = 4G(1 + 0.4D)t/D$$

where Cs = Sulphide concentration build-up, mgl^{-1}
D = Pipe diameter, m
G = Sulphide wall flux, $gm^{-2}hr^{-1}$
t = Retention time in pipeline, hr

If slimes are stripped, the approximate build-up would be:

$$Cs = 1.6Gt$$

Since sulphide in wastewater can be in both insoluble (precipitated) and soluble forms, from the appendix, it would be reasonable to assume that approximately half of the sulphides will be bound as insoluble metal sulphides, the remaining will be dissolved sulphides. The dissolved sulphide will be present in both dissociated form and molecular form. The concentration of molecular hydrogen is dependent on the pH value of the wastewater and its temperature. The relationship is shown in the graph of *Dissociated Equilibria for Hydrogen Sulphide in Aqueous Solution.* Therefore, we have

$$Cs_{sol} = ABCs$$

where Cs_{sol} = Soluble molecular hydrogen sulphide, mgl^{-1}
A = Fraction of soluble sulphide in total sulphides
B = Fraction of aqueous hydrogen sulphide in the molecular form

For conservative calculation, A was taken as 0.5 from the appendix and B was taken as 0.20 from the dissociated equilibria graph assuming the wastewater temperature of 28°C with pH value of 7.5.

Hydrogen sulphide flux at the wastewater surface is given by:

$F = 0.7\ (SV)^{3/8} Cs_{sol}$

where		
	F	= Surface flux, $gm^{-2}hr^{-1}$
	S	= Sewer gradient
	V	= Wastewater velocity, ms^{-1}
	Cs_{sol}	= Soluble molecular hydrogen sulphide, mgl^{-1}

For the Central Screening Plant, based on the engineering data

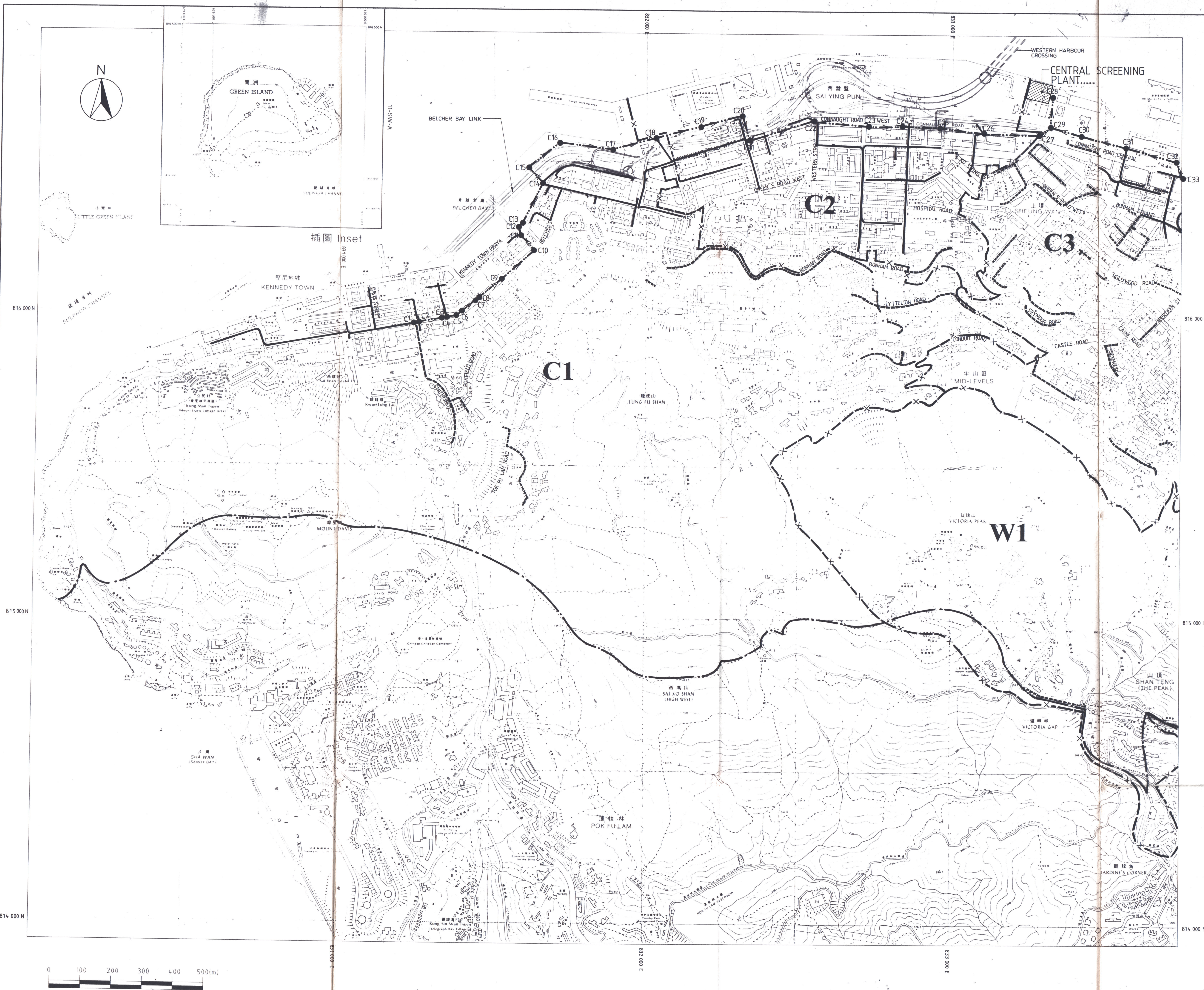
Retention time in pipeline	= 2 hours
Pipe diameter	= 1.65 m (average)
$(SV)^{3/8}$	= 0.050038

Hydrogen sulphide flux was calculated to be 0.01675 $gm^{-2}hr^{-1}$ for the case without slime condition and 0.04214 $gm^{-2}hr^{-1}$ for the case with slime condition.

For the Wan Chai East Screening Plant, based on the engineering data

Retention time in pipeline	= 2 hours
Pipe diameter	= 1.80 m (average)
$(SV)^{3/8}$	= 0.050038

Hydrogen sulphide flux was calculated to be 0.01675 $gm^{-2}hr^{-1}$ for without slime condition and 0.04002 $gm^{-2}hr^{-1}$ for with slime condition.



LEGEND :-

- PROJECT BOUNDARY
- TRUNK SEWER AND ACCESS SHAFT (WORKS TO BE CONSTRUCTED UNDER CN1)
- RETICULATION SEWER (WORKS TO BE CONSTRUCTED UNDER CN6)
- SEWERAGE CATCHMENT BOUNDARY
- RETICULATION SEWER (WORKS TO BE CONSTRUCTED UNDER CN4 & CN5 FOR SEWERS IN CENTRAL & WAN CHAI CATCHMENTS RESPECTIVELY)

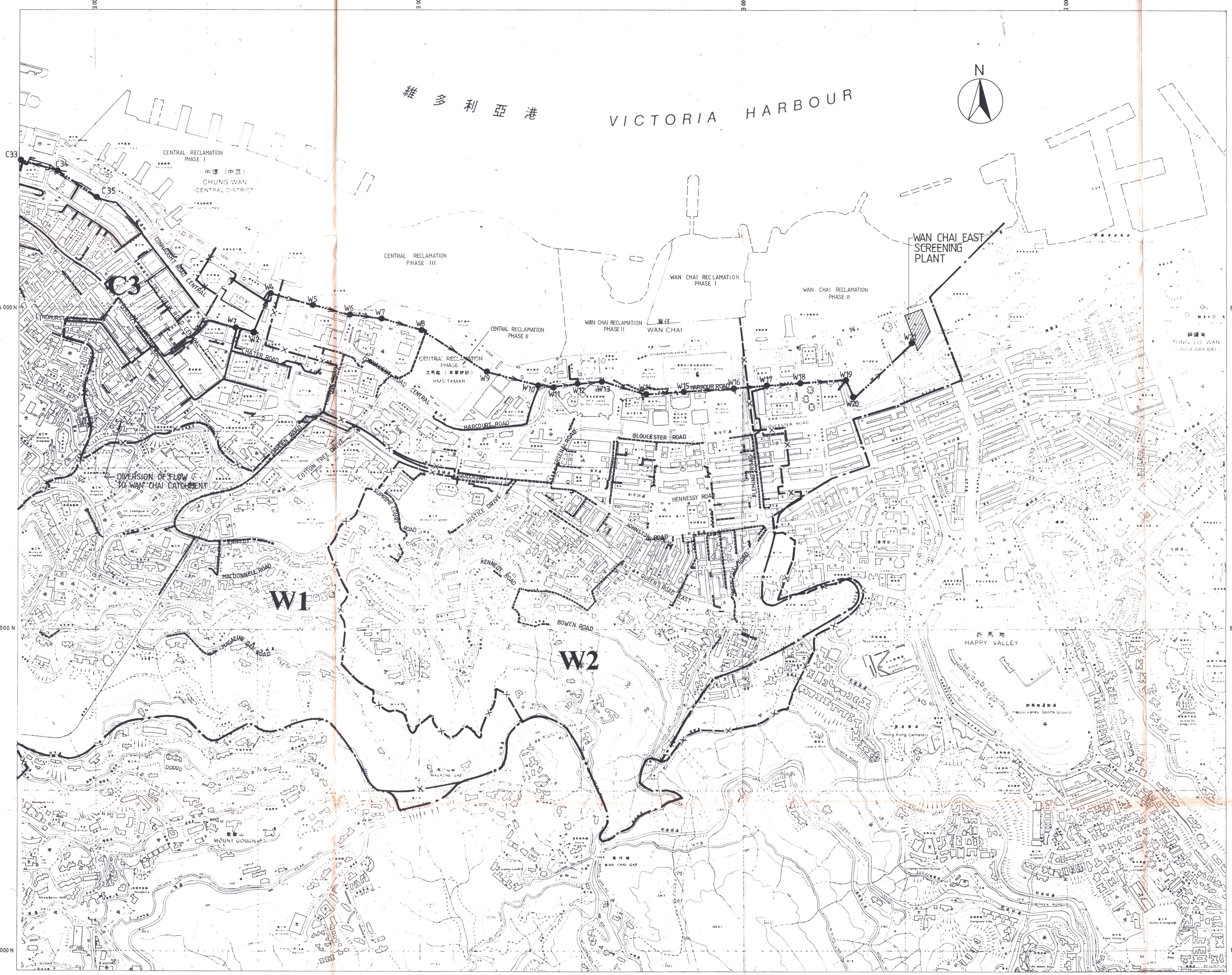
NOTE :

1. ALL TRUNK SEWER CONSTRUCTION BY TRENCHLESS TECHNIQUES EXCEPT C1 TO C11 AND C12 TO C14.

OVERALL KEY PLAN OF PROPOSED WORKS

SHEET 1 OF 2

FIGURE A-1



LEGEND :

- PROJECT BOUNDARY
- TRUNK SEWER AND ACCESS SHAFT (WORKS TO BE CONSTRUCTED UNDER CN1)
- RETICULATION SEWER (WORKS TO BE CONSTRUCTED UNDER CN6)
- SEWERAGE CATCHMENT BOUNDARY
- RETICULATION SEWER (WORKS TO BE CONSTRUCTED UNDER CN4 & CN5 FOR SEWERS IN CENTRAL & WAN CHAI CATCHMENTS RESPECTIVELY)

NOTE :

1. ALL TRUNK SEWER CONSTRUCTION BY TRENCHLESS TECHNIQUES EXCEPT W1 TO W2

OVERALL KEY PLAN OF PROPOSED WORKS

SHEET 2 OF 2

FIGURE A-2