# AGREEMENT NO. CE 37/95
# DESIGN AND CONSTRUCTION
# OF
# WONG CHUK HANG ROAD FLYOVER
# AND
# ASSOCIATED ROAD WIDENING

## ENVIRONMENTAL IMPACT ASSESSMENT
## (FINAL)

**DOCUMENT BBHK/96086/D/010**
**ISSUE 3**



**APRIL 1997**



Highways Department
Major Works Project Management Office
3rd Floor, Ho Man Tin Government Offices
88 Chung Hau Street
Ho Man Tin
Kowloon

Babtie BMT (Hong Kong) Ltd
in association with
Enpac Ltd
Urbis Ltd
and MVA Asia Ltd

Your Ref: ( ) in HyDMWPMO 578TH/EIA Our Ref: 96086/C/ENV-4/317/HL/POC

香港

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7 May 1997

Highways Department
Major Works Project Management Office
3/F, Ho Man Tin Government Offices
88 Chung Hau Street
Kowloon

For the attention of Mr. L.F. Au

Dear Sirs,

**Agreement No. CE 37/95**
**Design and Construction of Wong Chuk Hang Road Flyover and Associated Road Widening**
**Final Environmental Impact Assessment Report**

We are pleased to enclose ten (10) copies of our final "Environmental Impact Assessment" (Document BBHK/96086/D/010, Issue 3) together with English and Chinese language versions for our final "Environmental Impact Assessment Executive Summary" (Document BBHK/96086/D/016, Issue 3) for your retention, as requested in your letter of 2 May 1997.

These final reports address all outstanding comments raised by the ESMG on the EIA. A table of all such comments and our response to these comments is attached to this letter for your reference. In addition, we have amended Figure 2.5 "Preliminary Construction Programme" to take account of the recommendations of the Review Report, and we have amended the format of Figures 2.2, 2.3 and 2.4 to avoid the use of non-standard drawing sizes.

Additional copies of the reports have been circulated as indicated on the attached distribution list.

Yours faithfully,
For and on behalf of
**Babtie BMT (Hong Kong) Ltd.**

Henry Leung
Project Director

Encl

ms/D215/96086.317

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(FINAL)

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# 1.0 INTRODUCTION

## 1.1 Background

Wong Chuk Hang Road is a dual 3-lane primary distributor in the Southern District functioning as a major traffic corridor linking the various areas of Wong Chuk Hang, Aberdeen, Ap Lei Chau, Tin Wan and Pok Fu Lam to the urban north shore and the beach areas on the south side of Hong Kong Island. Currently, the section of Wong Chuk Hang Road between Ocean Park Road and Heung Yip Road carries a daily traffic volume of 56,000 vehicles and peak hour flow of about 3,400 vehicles.

With the gradual completion of various committed developments in the area such as the South Horizon development in Ap Lei Chau and the PSPS housing scheme and school developments in Wong Chuk Hang, the traffic volume is expected to continue to increase in the future and the signalized junction of Wong Chuk Hang Road and Nam Long Shan Road is expected to reach capacity in the near future. The traffic situation will be further aggravated by the proposed large scale developments at several housing sites in Ap Lei Chau and Wong Chuk Hang identified by the Task Force on Land Supply and Property Prices.

It is proposed that a dual two lane flyover be constructed along the centre of Wong Chuk Hang Road to provide uninterrupted east-west flow along the primary distributor route and thus to provide relief to the junction by reducing the number of conflicting turning movements thereat. The construction and operation of the flyover are likely to have a significant effect on the environment, particularly air quality. The Preliminary Project Feasibility Study conducted in 1995 identified air quality as the key issue involved in this Project and recommended that an air quality assessment be carried out.

Babtie BMT (Hong Kong) Ltd in association with ENPAC Limited, MVA Asia Limited and Urbis Limited (the Consultants) have been commissioned by Highways Department to provide design and construction supervision services in relation to the flyover and the associated road widening works. The scope of the services includes the execution on an Environmental Impact Assessment of the Project. This document presents the findings of that Environmental Impact Assessment (EIA).

## 1.2 Study Objectives

The purpose of the Study is to provide information on the nature and extent of the potential impacts on the environment arising from the construction and operation of the Project and all concurrent activities in the area. The following itemizes the key objectives:

Physical Environment

- Identify sensitive receivers likely to be affected by the Project.
- Assess the dust impact, both net and cumulative, on the existing ASRs during the construction phase.
- Assess the impact of vehicular emissions, both net and cumulative, on the existing and planned ASRs during the operational phase.
- Assess the noise impact at Aberdeen Fire Station during the operational phase.
- Examine the need for mitigation to alleviate the impacts during the construction and operational phases.
- Recommend appropriate mitigation measures for incorporation in the road design and dust control provisions for inclusion in the Contract Documentation.
- Assess the residual impact of vehicular emissions following implementation of mitigation measures, if any.

Visual and Landscape Impacts

- Identify and describe the landscape context of the existing site.
- Identify and describe the visual and landscape impact of the project on the existing environment.
- Recommended appropriate landscape measures to be incorporated into the works to enhance the visual and landscape environment along the road for both pedestrians and drivers.
- Assess the residual impact of the Project following incorporation of the recommended landscape measures.

## 1.3 Report Structure

This report considers the environmental impacts of the project under two main groupings, namely the physical environment and the landscape and visual environment, and the report structure reflects this sub-division.

The report presents a description of the existing site and the proposed Project works in general terms, as a necessary background to the detailed impact assessment following. Section 2 of the report contains this description.

The EIA for the physical environment is then presented in Section 3 of the report. This part of the EIA covers air quality during construction and operation of the flyover and noise impact at Aberdeen Fire Station during operation of the flyover, as well as considering other environmental issues that arise specifically during construction. The assessment of impacts during construction, and then after construction during the operation of the scheme are presented separately. Requirements for environmental monitoring and audit during and after construction of the scheme are also identified in this section of the report.

The landscape and visual impact of the scheme is identified in Section 4. This part of the report presents the existing landscape and visual context, followed by an assessment of the likely impact of the Project on that backdrop both during and after completion of construction. Landscape measures to be incorporated in the works to ameliorate the impact of the flyover are identified, and an assessment of the residual impact of the scheme is then made.

The final two sections of the report present the Conclusions (Section 5) and Recommendations (Section 6) of the EIA for both physical environment and the landscape and visual environment.

## 2.0 PROJECT DESCRIPTION

### 2.1 Existing Site

The Hong Kong Island Southern District is linked to the northern urban shoreline, and hence to Kowloon and the New Territories, principally via the Aberdeen Tunnel. Other lower volume links also exist, such as Tai Tam Road, Wong Nai Chung Gap Road and Pok Fu Lam Road.

Wong Chuk Hang Road is a west to east route along the Southern District into which all traffic to and from the Aberdeen Tunnel feeds. To the east of the tunnel, Wong Chuk Hang Road leads to Island Road, which serves Deep Water Bay, Repulse Bay and ultimately, Stanley. To the west, Wong Chuk Hang Road passes through the Wong Chuk Hang industrial area to Aberdeen Praya Road and the Ap Lei Chau Bridge. From this direction, as well as serving the local Wong Chuk Hang and Nam Long Shan areas, it also serves Aberdeen, Ap Lei Chau and Pok Fu Lam.

The improvements to Wong Chuk Hang Road now planned are in the western section of the route, between the Aberdeen Tunnel and Aberdeen Praya Road . The location and extent of the project is indicated on Figure 2.1.

The stretch of Wong Chuk Hang Road to be improved is about 650m in length. The works will commence about 400m east of the junction between the Ap Lei Chau Bridge and Aberdeen Praya Road, and will stretch eastwards as far as the western corner of the Aberdeen Sports Grounds. It is a further 300m eastwards to the exit from Wong Chuk Hang Road to the Aberdeen Tunnel.

The existing road consists of a dual three lane carriageway. It passes through an area that is built up on both sides. Development consists of medium to high rise industrial buildings, their frontage broken only by junctions with side roads and alleyways for drainage and utility reserve/pedestrian access, along with two petrol stations and Aberdeen Fire Station.

### 2.2 Proposed Works

The proposed works are intended to increase the capacity of the junction of Nam Long Shan Road and Wong Chuk Hang Road, thus avoiding predicted congestion at the junction. The junction was operating over capacity prior to the mid-1994 introduction of a one-way gyratory traffic system for the area, which eliminated right turn movements from the Wong Chuk Hang Road eastbound carriageway onto Nam Long Shan Road (except for franchised buses). This gyratory system is an interim solution to the problem only, and with traffic growth forecast to continue in the area, driven by future planned large scale residential developments, the junction is again expected to reach capacity in the next few years. This will result in congestion for through traffic to Aberdeen and Ap Lei Chau, as well as for local traffic on Nam Long Shan Road. The flyover will avoid this by providing unimpeded flow for through traffic and by reducing significantly traffic passing through the ground level junction.

The extent of the works will consist of :

i) construction of a dual two lane flyover of total length 550m;
ii) widening of ground level carriageways where required to accommodate the flyover;
iii) associated at grade carriageway and footpath reconstruction;
iv) ancillary drainage and sewerage works;
v) diversion of watermains as required;
vi) relaying and diversion of utilities as required;
vii) traffic markings, aids and signals;
viii) street furniture and landscaping;
ix) demolition of existing canopies as required to provide for emergency vehicle access at grade; and
x) demolition of existing footbridge across Wong Chuk Hang Road at Nam Long Shan Road junction.

Details of the scheme are shown in Figures 2.2, 2.3 and 2.4.

## 2.3 Construction Activities

The preliminary construction programme is presented in Figure 2.5. Major construction activities include piling and construction of pilecaps, piers, and flyover deck. The flyover will be constructed of reinforced and post-tensioned concrete, with the deck consisting of a twin cell box girder structure over its central portion and twin single cell girders at the ramps at either end.

Foundation support will be provided by bored piles. Driven sheetpile may be required as temporary works to construct the pilecaps. Deck construction is most likely to be using in-situ methods rather than precasting off-site and transportation to site.

# 3.0 PHYSICAL ENVIRONMENT

## 3.1 Existing Environment

The project site is located in a densely developed industrial area where the existing air quality is only fair due to the high traffic flows and continual air emissions from the factories. A number of Air Sensitive Receivers (ASR's) have been identified in the vicinity of the proposed alignment. These include a housing development (Wong Chuk Hang Estate), various GIC developments (e.g. Grantham Hospital, Aberdeen Fire Station, Police Training School, and St Mary's Home for the Aged, children and rehabilitation centre at Nam Long Shan Road/Welfare Road), the Aberdeen Sports Ground at the eastern end of the industrial area, and the industrial buildings along the Project site.

A baseline air quality survey has been conducted between 8th and 22nd of October 1996 as part of this Study to determine the baseline Respirable Suspended Particulate (RSP) and Total Suspended Particulate (TSP) concentrations in the Study Area prior to the construction. The measurement was made at the roof of the Aberdeen Fire Station. Figure 3.1 shows the measurement location.

Two High Volume Samplers were employed to sample the 24-hr RSP and TSP for gravimetric analysis. The method of measurement followed that described in "Generic Environmental Monitoring & Audit Manual" published by the EPD. The results of the analysis are shown in Table 3.1. Based on these results, mean TSP and RSP concentrations of 64.4 $\mu g/m^3$ and 43.4 $\mu g/m^3$ were obtained which may be used to infer the baseline TSP and RSP concentrations.

**Table 3.1 Baseline Monitoring Results for TSP and RSP**

| Date (Oct.96) | TSP ($\mu g/m^3$) | RSP ($\mu g/m^3$) |
|---|---|---|
| 8 | 58.8 | 38.0 |
| 9 | 55.6 | 39.1 |
| 10 | 47.8 | 37.0 |
| 11 | 67.7 | 46.1 |
| 12 | 95.2 | 49.5 |
| 13 | 63.9 | 43.0 |
| 14 | 64.1 | 51.1 |
| 15 | 75.0 | 50.5 |
| 16 | 57.3 | 46.5 |
| 17 | 68.2 | 47.3 |
| 18 | 94.0 | 58.7 |
| 19 | 88.5 | 52.1 |
| 20 | 43.1 | 30.1 |
| 21 | 46.2 | 31.3 |
| 22 | 40.1 | 30.1 |

It was originally intended to carry out $NO_2$ monitoring over the same period as the TSP and RSP sampling to identify baseline $NO_2$ levels. The equipment required to carry out this monitoring is sensitive and is not suitable for monitoring at outdoor locations. It proved not possible to obtain permission to install the equipment at a suitable indoor location, due to the operational requirements within buildings along the study area. In the absence of on-site measurements, reference was made to "Air Quality in Hong Kong 1994" published by the EPD which reports the measurement results at its Air Quality Monitoring Stations. Based on similarity of the Study Area with the Kwai Chung area in which an Air Quality Monitoring Station is located, the background $NO_2$ concentration may be taken to be 46 $\mu g/m^3$ which was the annual average $NO_2$ concentration measured at the station.

The Kwai Chung area is a light industrial area, similar to Wong Chuk Hang. Other industrial areas where Air Quality Monitoring Stations are also maintained by EPD, such as Tsuen Wan and Kwun Tong, are much more highly industrised with a lot of industrial boilers emitting $NO_2$, and are therefore unlikely to be representative of conditions at Wong Chuk Hang.

The background air quality as measured on site (or at Kwai Chung AQMS for $NO_2$ ) will include contributions from the emissions from the industrial buildings along Wong Chuk Hang, as well as from existing traffic. It is not expected that industrial emissions will increase with time within the study area, since future industrial development will be restricted to the redevelopment of existing industrial buildings. Redevelopment will if anything result in a reduction of industrial emissions as modern 'cleaner' technology would be installed to replace old and less environmentally friendly processes.

## 3.2 Construction Impact Assessment

### *3.2.1 Air Quality Standards and Guidelines*

The main air quality issues during the construction and operation of the proposed flyover are dust emissions from the construction site and road traffic emissions from vehicles on the widened Wong Chuk Hang Road and the proposed flyover during its operation. Air pollutants come under the control of the Air Pollution Control Ordinance, which calls for compliance with a set of health-related air quality objectives (AQO) for seven pollutants, of which $NO_2$, TSP and RSP are relevant to this project. Compliance with the concentration levels shown below in Table 3.2 is required.

The AQO contains no hourly criteria for concentrations of TSP and RSP. However, the Dust Suppression Guideline of EPD requires that the maximum acceptable concentration of TSP during construction works should be 500 $\mu g/m^3$ (hourly average), and this is used in the present assessment.

Table 3.2 Air Quality Objectives

| Parameter | Maximum Permitted Average Concentration ($\mu g/m^3$) | | |
|---|---|---|---|
| | 1 hour | 24 hours | Yearly |
| TSP | 500 | 260 | 80 |
| RSP | - | 180 | 55 |
| $NO_2$ | 300 | 150 | 80 |
| CO | 30,000 | 10,000 | - |

Notes:
- All criteria are Hong Kong Air Quality Objectives except hourly TSP concentration, which is an EPD Dust Suppression Guideline.
- Hourly criterion for $NO_2$ not to be exceeded more than three times per year.
- 24-hour criteria not to be exceeded more than once per year.
- Expressed at the reference condition of 298K and 101.325 KPa.

### *3.2.2 Assessment Methodology*

#### 3.2.2.1 Air Quality Model

The Fugitive Dust Model (FDM) has been used to predict the worst-case dust concentrations during the construction of the proposed flyover and the associated works. Dust sources which include excavation, backfilling, bored piling, stockpiling, material handling, scaffolding, concreting, hauling of material, and road paving, have been modelled as a series of line sources with equivalent emission factors along the construction site.

#### 3.2.2.2 Meteorological Conditions

One year of meteorological data, including wind speed, wind direction, stability class, temperature and mixing height, for Kwai Chung which bears similar topographical features to the Study Area was used to compute the daily and hourly average TSP concentrations attributable to the construction activities.

#### 3.2.2.3 Emission Factors

Dust levels generated by construction of the flyover have been modelled as line sources using the US EPA's AP-42 emission factor for heavy construction operations (1.10 x $10^{-7}$ $kg/m^2/sec$). This emission factor is assumed to include all emissions from various dust activities within the construction site.

3.2.2.4 Background Dust Concentration

The background TSP concentration has been taken to be 64 $\mu g/m^3$ which is based on the measured TSP from the Baseline Air Quality Survey.

The inferred background TSP concentration has been included in the calculated concentrations to obtain the total TSP concentrations.

3.2.3 *Existing Air Sensitive Receivers*

Air sensitive receivers likely to be directly affected by the construction of the proposed flyover and the associated works include the following :

- Aberdeen Fire Station
- Aberdeen Sports Ground
- Industrial Buildings along the widened section of Wong Chuk Hang Road
- Sitting-out area near junction of Wong Chuk Hang and Nam Long Shan Road

Wong Chuk Hang Estate, Grantham Hospital, Police Training School, St Mary's Home for the Aged and Children & Rehabilitation Centre at Nam Long Shan Road/Welfare Road situated on the other side of the industrial buildings are unlikely to be adversely affected.

For the purpose of this air quality assessment, fourteen representative ASR's have been identified. These representative receivers are shown in Figure 3.2.

*3.2.4 Dust Impact Assessment*

Construction of the proposed flyover and the associated works is likely to contribute to the suspended particulate in air and hence to the degradation of the air quality at the Air Sensitive Receivers (ASRs) along the existing Wong Chuk Hang Road. Table 3.3 and Table 3.4 present the predicted hourly and daily average TSP concentrations at the representative ASR's resulting from the construction activities, if unmitigated. Sample computer output from the FDM is included in Appendix A.

In addition, isopleths of the hourly and daily average TSP concentrations at ground level, 10m above ground and 20m above ground are presented in Figures 3.3 - 3.8, showing the distribution of TSP from the works site.

The unmitigated situation is that the hourly concentrations at most of the ASR's are likely to be well in excess of the dust guideline level for construction. In particular, the ground level concentrations at VT, GPFB, KTIB and WMB are predicted to be above 1,000 $\mu g/m^3$. Such levels of dust are prone to give rise to dust nuisance. The predicted daily average TSP concentrations also exceed the AQO at VT and WMB at ground level. As expected, dust concentrations decrease with height and as a result, no exceedance of the AQO is anticipated at 10m and above and no exceedance of the hourly guideline at 20m and above. Dust mitigation measures are therefore necessary to reduce the impacts at low levels. Mitigation measures and the residual impacts are discussed in Section 3.4.

Table 3.3 Hourly Average TSP Concentrations (Unmitigated)

| ASR ID/Address | Concentrations at ground level* ($\mu g/m^3$) | Concentrations at 10 m above ground* ($\mu g/m^3$) | Concentrations at 20 m above ground* ($\mu g/m^3$) |
|---|---|---|---|
| VT: 29 WCHR⁺ | 1398 | 374 | 137 |
| GPFB: 33-35 WCHR | 1059 | 758 | 156 |
| RC1:39 WCHR | 463 | 777 | 156 |
| FS:47 WCHR | 686 | 547 | 147 |
| DIB:49-51 WCHR | 522 | 628 | 178 |
| BIFB:61 WCHR | 421 | 603 | 173 |
| GCHC:65 WCHR | 710 | 569 | 161 |
| KTIB:26 WCHR | 2162 | 548 | 153 |
| WMB:34 WCHR | 1317 | 745 | 167 |
| SOA: - | 747 | 714 | 186 |
| RC2:42 WCHR | 534 | 529 | 142 |
| DSWL:50 WCHR | 487 | 845 | 186 |
| EWFB:56-60 WCHR | 418 | 768 | 177 |
| FF: - | 208 | 174 | 100 |

* Background is included.
⁺ Wong Chuk Hang Road

Table 3.4 Daily Average TSP Concentrations (Unmitigated)

| ASR ID/ADDRESS | Concentrations at ground level* ($\mu g/m^3$) | Concentrations at 10 m above ground* ($\mu g/m^3$) | Concentrations at 20 m above ground* ($\mu g/m^3$) |
|---|---|---|---|
| VT:29 WCHR⁺ | 376 | 121 | 79 |
| GPFB:33-35 WCHR | 129 | 159 | 82 |
| RC1:39 WCHR | 94 | 153 | 84 |
| FS:47 WCHR | 101 | 143 | 81 |
| DIB:49-51 WCHR | 101 | 147 | 77 |
| BIFB:61 WCHR | 104 | 128 | 73 |
| GCHC:65 WCHR | 112 | 119 | 73 |
| KTIB:26 WCHR | 252 | 116 | 78 |
| WMB:34 WCHR | 413 | 141 | 78 |
| SOA:- | 117 | 160 | 82 |
| RC2:42 WCHR | 108 | 150 | 82 |
| DSWL:50 WCHR | 106 | 129 | 87 |
| EWFB:56-60 WCHR | 107 | 120 | 76 |
| FF:- | 115 | 102 | 79 |

* Background is included.
⁺ Wong Chuk Hang Road

### *3.2.5 Other Construction Stage Impacts*

The construction works will give rise to other short term environmental impacts such as noise, runoff and waste discharge. In order for all aspects of these construction impacts to meet the established standards and guidelines, control of construction activities by incorporation of a series of clauses into the contract documentation to minimise these impacts is recommended. Suitable clauses are presented in Appendix D.

## 3.3 Operational Impact Assessment

### *3.3.1 Air Quality Assessment Methodology*

#### 3.3.1.1 Road Traffic Emissions Models

The dispersion of vehicular emissions during the operation of the proposed flyover and Wong Chuk Hang Road is strongly influenced by the physical configuration of the proposed flyover and the industrial buildings along the road. Two sets of computer models have been used to simulate the physical dispersion of the air pollutants and are described below.

*Tunnel Model*

For a section of Wong Chuk Hang Road approximately between Zung Fu Aberdeen Garage (36 Wong Chuk Hang Road) and E Wah Factory Building (56-60 Wong Chuk Hang Road), one lane each of the east-bound and westbound traffic is uncovered, while one lane each bound is underneath the flyover. As the proposed flyover covers over 60% of the corridor width in this section, vertical movements of air pollutants generated from the at-grade traffic are likely to be limited. On the other hand, the juxtaposition of the industrial buildings on both sides of Wong Chuk Hang Road tends to restrict also the lateral movements of the air pollutants. The net effect is a confinement of the air pollutants in the space underneath the flyover with longitudinal transport of pollutants promoted by the statistical fluctuation of the traffic density, the meteorological condition, and the turbulence generated by the passing vehicles. This effect is, to some extent, similar to that of a two-way naturally ventilated tunnel with balanced east- and west-bound traffic, though much less prominent than a real tunnel.

As a worst-case situation, the air quality in the space underneath the proposed flyover has been assessed using the theory developed by Ohashi and Koso in their paper entitled "Longitudinal Diffusion of Exhaust Pollutants in Two-way Automobile Tunnels" presented to the International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels, 1985. It should be emphasized that the result applies strictly to a two-way tunnel.

According to Ohashi & Koso's theory, the maximum concentration in a tunnel of a given length is given by :

$$C_{max} = \frac{wLe^2}{\{8D\,A_T\}}$$

where

$C_{max}$ = maximum volumetric concentration of pollutant, ppm

w = emission of the pollutant per unit length, $m^3/s$ m

$L_e$ = effective length of tunnel = L + $L_a$, m

D = longitudinal diffusion coefficient, $m^2/s$

$A_T$ = cross-sectional area of tunnel, $m^2$

L = the physical length of tunnel, m

$L_a$ = additional tunnel length, m

The emission per unit length is given by:

$$w = \frac{\text{emission factor x no. of lanes}}{\text{head to head of vehicles}}$$

The additional length is a measure of the diffusive transport of pollutants at the portal and is given by :

$$L_a = 3 \times d_T$$

where $d_T$ = equivalent diameter of the tunnel, $m^2$

Further details of the calculation method can be found in the quoted reference and Appendix B.

*Line Source Dispersion Model*

The USEPA CALINE4 model which is based on the Gaussian diffusion equation and employs a mixing zone concept to characterize pollutant dispersion over the roadway has been used to model the air quality at the Air Sensitive Receivers above the flyover level. The model uses as input the vehicle emissions from traffic on the flyover.

3.3.1.2 Meteorological Conditions

The following meteorological conditions have been assumed in the air quality modelling using the CALINE4 model :

Mixing height: 500m
Surface Roughness: 1.0 m
Height of Emissions: at the flyover levels
Wind speed: 1m/s
Wind Direction: worst case
Directional Variability: 18 degrees

3.3.1.3 Emission Factors

The EPD's Fleet Average Emission Factors contain emission factors for various types of vehicles in different years of operation. As the worst air quality scenario depends on the vehicle mix and the degree of vehicle emissions control, the model has been run for 2001 and 2011 using the emission factors appropriate for the year of operation and the worst case situation was found to be 2011.

For the purpose of assessing the worst impact, the Fleet Average Emission Factors applicable for 2011 have been used to model the air quality above the flyover using the CALINE4 model.

On the other hand, the air quality underneath the flyover has been assessed based on the PIARC 1991 publication. Details on the calculation of emission factors can be found in Appendix B.

3.3.1.4 Background Pollutant Concentrations

The background pollutant concentrations have been taken to be :

TSP = 64 $\mu g/m^3$
RSP = 43 $\mu g/m^3$
$NO_2$ = 46 $\mu g/m^3$

These concentrations were based on the measured TSP and RSP from the Baseline Air Quality Survey and the estimated $NO_2$ concentration from "Air Quality in Hong Kong 1994", as discussed in 3.1

### 3.3.2 *Existing and Future Air Sensitive Receivers*

Existing air sensitive receivers likely to be directly affected by the operation of the proposed flyover include the following :

- Aberdeen Fire Station
- Aberdeen Sports Ground
- Industrial Buildings along the widened section of Wong Chuk Hang Road
- Sitting-out Area at the junction of Wong Chuk Hang and Nam Long Shan Road.

According to the zoning plan for the Study Area, the strip along Wong Chuk Hang Road is zoned for industrial use, thus new types of future receivers in the Project area are not anticipated.

### 3.3.3 *Predicted Traffic Flows*

As part of this Study, traffic forecasts have been produced for the road network in the Study Area. Figures 3.9 and 3.10 show the traffic forecasts for Wong Chuk Hang Road in 1999 (AM Peak) which represent the construction traffic scenario and in 2011 (AM Peak). Table 3.5 gives the breakdown of the total traffic into vehicle type for the 2011 traffic on the at-grade Wong Chuk Hang Road carriageways. A similar breakdown into vehicle type has been utilised in the assessment of the traffic using the flyover.

Table 3.5 Forecast of Vehicle Composition (2011 AM Peak) (Wong Chuk Hang Road At-grade Carriageways)

| Direction | Traffic Flow (veh/hr) | | | | | | | | | | Total Traffic Flow (veh/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MC | PV | Taxi | PLB | LGV | MGV | HGV | Cont. | Buses | Coach | |
| E/B | 55 | 369 | 184 | 92 | 134 | 145 | 51 | 3 | 174 | 35 | 1242 |
| W/B | 10 | 15 | 10 | 0 | 8 | 10 | 0 | 3 | 398 | 0 | 454 |
| Mean | 33 | 192 | 97 | 46 | 71 | 77 | 26 | 3 | 286 | 17 | 848 |

Source: MVA Asia

### 3.3.4 *Air Quality Impact Assessment*

#### 3.3.4.1 Air Quality Impact Prior to Operation of Flyover

The CALINE4 model has been used to predict the air quality at the representative ASR's in 1999 prior to the operation of the proposed flyover in 2000. It has been assumed in the calculation that no superstructure is constructed at that time to restrict the vertical air movements so that the dispersion model still applies. Tables 3.6 and 3.7 give the predicted hourly concentrations of $NO_2$ and RSP at the first floor level of the ASR's. Assessed against the AQO, the air quality in the Study Area is considered acceptable prior to the opening of the flyover to traffic.

Table 3.6 Predicted Hourly $NO_2$ Concentrations for 1999

| ASR ID/ADDRESS | Height (mPD) | Predicted $NO_2$ Concentration* ($\mu g/m^3$) |
|---|---|---|
| VT:29 WCHR + | 7 | 189 |
| GPFB:33-35 WHCR | 7 | 198 |
| RC1:39 WCHR | 7 | 192 |
| FS:47 WCHR | 7 | 170 |
| DIB:49-51 WCHR | 7 | 182 |
| BIFB:61 WCHR | 7 | 186 |
| GCHC:65 WCHR | 7 | 189 |
| KTIB:26 WCHR | 7 | 207 |
| WMB:34 WCHR | 7 | 196 |
| SOA:- | 7 | 177 |
| RC2:42 WCHR | 7 | 190 |
| DSWL:50 WCHR | 7 | 205 |
| EWFB:56-60 WCHR | 7 | 205 |
| FF:- | 7 | 167 |

* Background is included.
\+ Wong Chuk Hang Road

Table 3.7 Predicted Hourly RSP Concentrations for 1999

| ASR ID/ADDRESS | Height (mPD) | Predicted RSP Concentration* ($\mu g/m^3$) |
|---|---|---|
| VT:29 WCHR + | 7 | 113 |
| GPFB:33-35 WHCR | 7 | 117 |
| RC1:39 WCHR | 7 | 115 |
| FS:47 WCHR | 7 | 104 |
| DIB:49-51 WCHR | 7 | 110 |
| BIFB:61 WCHR | 7 | 111 |
| GCHC:65 WCHR | 7 | 113 |
| KTIB:26 WCHR | 7 | 122 |
| WMB:34 WCHR | 7 | 117 |
| SOA:- | 7 | 107 |
| RC2:42 WCHR | 7 | 114 |
| DSWL:50 WCHR | 7 | 121 |
| EWFB:56-60 WCHR | 7 | 121 |
| FF:- | 7 | 103 |

* Background is included.
\+ Wong Chuk Hang Road

3.3.4.2 Air Quality Impact due to Traffic on Flyover in 2011

As discussed above, the operation of the flyover tends to restrict the vertical movements of air pollutants. On the assumption that no significant air changes occur between the air spaces below and above the flyover in the confined section of Wong Chuk Hang Road, the air quality at the ASRs above the flyover level and ASRs beyond the flyover in 2011 has been predicted using CALINE4. The results, shown in Tables 3.8 and 3.9, indicate that the air quality is still acceptable at 2011. Sample computer output is included at Appendix C. It should be noted that the heights of the ASRs have been adjusted to align with the changing elevations of the flyover. The Sitting Out Area has been excluded from the calculation since no ASR above the flyover level is anticipated for the sitting-out area. In addition, isopleths for the hourly and daily average $NO_2$ and RSP concentrations at 7mPD and 12 mPD at the year 2011 are presented in Figures 3.11 to 3.14.

Table 3.8 Predicted Hourly $NO_2$ Concentrations for 2011

| ASR ID/ADDRESS | Height (mPD) | Predicted $NO_2$ Concentration* ($\mu g/m^3$) |
|---|---|---|
| VT:29 WCHR + | 7.1 | 237 |
| GPFB:33-35 WHCR | 13.6 | 93 |
| RC1:39 WCHR | 18.3 | 91 |
| FS:47 WCHR | 20.1 | 85 |
| DIB:49-51 WCHR | 14.4 | 96 |
| BIFB:61 WCHR | 14.4 | 103 |
| GCHC:65 WCHR | 14.4 | 132 |
| KTIB:26 WCHR | 7.1 | 206 |
| WMB:34 WCHR | 7.9 | 199 |
| RC2:42 WCHR | 20.1 | 79 |
| DSWL:50 WCHR | 20.0 | 82 |
| EWFB:56-60 WCHR | 14.4 | 91 |
| FF:- | 8.5 | 111 |

* Background is included.
\+ Wong Chuk Hang Road

Table 3.9 Predicted Hourly RSP Concentrations for 2011

| ASR ID/ADDRESS | Height (mPD) | Predicted RSP Concentration* ($\mu g/m^3$) |
|---|---|---|
| VT:29 WCHR + | 7.1 | 150 |
| GPFB:33-35 WHCR | 13.6 | 67 |
| RC1:39 WCHR | 18.3 | 65 |
| FS:47 WCHR | 20.1 | 62 |
| DIB:49-51 WCHR | 14.4 | 69 |
| BIFB:61 WCHR | 14.4 | 73 |
| GCHC:65 WCHR | 14.4 | 88 |
| KTIB:26 WCHR | 7.1 | 132 |
| WMB:34 WCHR | 7.9 | 126 |
| RC2:42 WCHR | 20.1 | 59 |
| DSWL:50 WCHR | 20.0 | 61 |
| EWFB:56-60 WCHR | 14.4 | 66 |
| FF:- | 8.5 | 77 |

* Background is included.
\+ Wong Chuk Hang Road

3.3.4.3 Air Quality Impact due to At-Grade Traffic in Confined Section in 2011

Appendix B presents detailed calculations of the $NO_2$ and CO concentrations using the tunnel model for the worse-case scenario. It has been assumed that the worst case scenario consists vehicles moving at 25kph with maximum hourly traffic flow. The calculation shows that the maximum $NO_2$ and CO concentrations in the space underneath the flyover are 122 and 1607 $\mu g/m^3$ respectively. Assuming a background concentration for $NO_2$ and CO being 46 and 50 $\mu g/m^3$ respectively, the total maximum $NO_2$ and CO concentrations are 168 $\mu g/m^3$ and 1657 $\mu g/m^3$ respectively. Hence it is considered the air quality is within the Air Quality Objectives.

### *3.3.5 Noise Impact Assessment*

Although the entire route of the proposed flyover passes through an industrial area in Wong Chuk Hang and "factory" is not classified as a Noise Sensitive Receiver (NSR) under the Technical Memorandum on the Noise Pollution Control Ordinance, it is envisaged that traffic noise emissions during the operational phase of the proposed flyover may affect the existing 4-storey Aberdeen Fire Station main building and the adjacent 2-storey staff quarters. Hence, a noise impact assessment was carried out for the Aberdeen Fire Station in accordance with method stipulated under the "Calculation of Road Traffic Noise" (CRTN) by the Department of Transport, UK.

The assessment result revealed that the dominating noise contribution affecting the Aberdeen Fire Station and the adjacent staff quarters is from the traffic noise generated along the existing at-grade Wong Chuk Hang Road. Upon the completion of the flyover, most traffic will be directed to the flyover and hence the traffic using the at-grade carriageway will correspondingly be reduced. Indeed, the flyover carriageway in the vicinity of the Fire Station is at 13.5m above the at-grade road level. This is higher than the existing Fire Station buildings. Hence, the noise impact to the Fire Station arising from the traffic at the flyover would be shielded by the flyover itself. As such, direct mitigation measures on the flyover are considered to be ineffective.

The eligibility of the Fire Station for indirect technical remedies in the form of insulation and air conditioning has been assessed in accordance with the criteria of the Noise Insulation Regulations in paragraph 6 of CRTN. However, no noise sensitive receivers are eligible for insulation as the predicted traffic noise levels at the Aberdeen Fire Station would be lower than the existing traffic noise levels and the contribution to the increase in the predicted overall noise level from the flyover would be less than 1dB(A).

## 3.4 Mitigation Measures

### *3.4.1 Construction Phase*

Section 3.2 has shown that significant dust impact can be anticipated from the construction of the proposed flyover and therefore dust suppression measures are required. Potential dust suppression measures which are cost effective include watering of the works site twice per day, maintaining good housekeeping of the site and the implementation of the control clauses as recommended in Appendix D.

According to US EPA AP-42, 5th publication, watering twice a day can reduce dust emissions by about 50 percent. The implementation of other dust suppression measures such as wheel washing of haul vehicles, covering of materials on trucks with tarpaulin sheeting, good housekeeping and the use of wind barriers if necessary, can reduce dust considerably. As some of the measures cannot be quantified, it has been assumed that the dust levels can be reduced by 80% after the implementation of all these measures. Tables 3.10 and 3.11 show the residual impact becomes insignificant after the mitigation. Isopleths of the TSP concentrations at ground level are shown in Figures 3.15 and 3.16.

Table 3.10 Daily Average TSP Concentrations (Mitigated 80%)

| ASR ID/ADDRESS | Concentration levels at ground level* $\mu g/m^3$ | Concentration levels at 10 m above ground* $\mu g/m^3$ | Concentration levels at 20 m above ground* $\mu g/m^3$ |
|---|---|---|---|
| VT:29 WCHR + | 140 | 86 | 80 |
| GPFB:33-35 WHCR | 90 | 96 | 81 |
| RC1:39 WCHR | 83 | 95 | 81 |
| FS:47 WCHR | 85 | 93 | 81 |
| DIB:49-51 WCHR | 85 | 94 | 80 |
| BIFB:61 WCHR | 85 | 90 | 79 |
| GCHC:65 WCHR | 87 | 88 | 79 |
| KTIB:26 WCHR | 115 | 88 | 80 |
| WMB:34 WCHR | 147 | 93 | 80 |
| SOA:- | 88 | 96 | 81 |
| RC2:42 WCHR | 86 | 94 | 81 |
| DSWL:50 WCHR | 85 | 90 | 82 |
| EWFB:56-60 WCHR | 86 | 88 | 80 |
| FF:- | 87 | 85 | 80 |

* Background is included.
\+ Wong Chuk Hang Road

Table 3.11 Hourly Average TSP Concentrations (Mitigated 80%)

| ASR ID/ADDRESS | Concentration levels at ground level* $\mu g/m^3$ | Concentration levels at 10 m above ground* $\mu g/m^3$ | Concentration levels at 20 m above ground* $\mu g/m^3$ |
|---|---|---|---|
| VT:29 WCHR + | 344 | 139 | 92 |
| GPFB:33-35 WHCR | 276 | 216 | 96 |
| RC1:39 WCHR | 157 | 220 | 96 |
| FS:47 WCHR | 202 | 174 | 94 |
| DIB:49-51 WCHR | 169 | 190 | 100 |
| BIFB:61 WCHR | 149 | 185 | 99 |
| GCHC:65 WCHR | 206 | 178 | 97 |
| KTIB:26 WCHR | 498 | 174 | 95 |
| WMB:34 WCHR | 328 | 213 | 98 |
| SOA:- | 214 | 207 | 102 |
| RC2:42 WCHR | 171 | 170 | 93 |
| DSWL:50 WCHR | 162 | 233 | 102 |
| EWFB:56-60 WCHR | 148 | 218 | 100 |
| FF:- | 106 | 99 | 84 |

* Background is included.
\+ Wong Chuk Hang Road

### *3.4.2 Operational Phase*

No mitigation measures are considered necessary for the flyover width and alignment as proposed.

It is noted that the flyover is quite high, with an average clearance of 11m between the at-grade road levels and the underside of the flyover over its central section. This high alignment is beneficial to the environment from the air quality point of view as it affords a greater "area" for dispersion of pollutants under the structure. A lower alignment of the flyover would probably result in greater concentration of pollutants under the flyover. Thus, the proposed flyover alignment is appropriate in terms of minimising the impact of the project on the physical environment.

## 3.5 Environmental Monitoring and Audit

An environmental monitoring and audit (EM&A) programme performs three functions. It ensures that dust from the construction of the project is kept within acceptable levels; it establishes procedures for checking the application and effectiveness of mitigation measures; and it provides the means by which compliance can be checked, exceedances documented, and corrective action recorded.

In view of the close proximity of the proposed Wong Chuk Hang Road Flyover to the identified sensitive receivers, an EM&A programme is considered necessary during the construction period. The proposed EM&A programme for this Project is contained and described in a stand-alone document, the EM&A Manual. A summary of the key components of the EM&A programme is presented in the following sections 3.5.1 to 3.5.3 inclusive.

Detailed monitoring schedules and audit requirements should be incorporated into the construction contract for the proposed flyover and associated works.

As the impacts of the Project on the environment during the operational phase are acceptable without the need for mitigation measures, a programme of monitoring and audit is not proposed.

### *3.5.1 EM&A Team*

The Contractor for the flyover should be required to employ an independent team of suitably qualified personnel to implement the requirements of the EM&A programme. This team should in no way be associated with the Contractor. The EM&A team (ET) leader shall have relevant professional qualifications and sufficient relevant EM&A experience subject to the approval of the Engineers Representative and the Environmental Protection Department (EPD). He shall have sufficient resources made available to him to adequately fulfil the EM&A duties.

### *3.5.2 EM&A Activity*

Monitoring and auditing of TSP levels throughout construction is proposed to detect any deterioration in air quality and ensure timely action can be taken to rectify the situation.

It is proposed that baseline monitoring be carried out over a minimum of 14 consecutive days to obtain daily 24 hour TSP samples, prior to the commencement of construction activity. One hour sampling should also be carried out at least three times per day when the highest dust impact is expected throughout this period.

Impact monitoring during construction is recommended over at least one 24 hour period every six days. A sampling frequency of at least three times over the same period should be adopted for one hour TSP monitoring, and these periods should be at times of highest dust impact.

Regular site inspections should be undertaken at a frequency of at least once per week. These inspections provide a direct means to trigger and enforce the specified environmental protection and pollution control measures, and should not be limited to the site only. The inspections should review the environmental situation outside the site area which is likely to be affected, directly or indirectly, by site activities.

Additional monitoring and audit may be required following receipt of an environmental complaint to assess its validity and to verify the effectiveness of follow-up activity.

*3.5.3 EM& A Reporting*

In addition to the monitoring and auditing requirements outlined above, reporting of the results and findings in accordance with the following programme is recommended.

A Baseline Monitoring Report should be prepared and submitted within ten working days of completion of the baseline monitoring. The key aspects of this document will be reporting on the monitoring results, statistical analysis of the baseline data and determination of Action and Limit Levels for TSP concentrations.

Following this, monthly EM&A Reports should be prepared. These reports should summarise the environmental status of the project, environmental monitoring and auditing activities over the month in question, and the status of environmental complaints, or deficiencies identified, as well as identifying future key issues.

Quarterly EM&A Summary Reports should also be prepared which summarise the environmental issues of concern, identify trends and report on progress in dealing with non-compliances.

## 4.0 LANDSCAPE AND VISUAL IMPACT

### 4.1 Landscape Context of the Existing Site

The existing Wong Chuk Hang Road is a three lane dual carriageway, fronted on both sides by large scale industrial factory and warehouse buildings, with the streetscape between dominated by the road, buildings, canopies, signage, safety barriers and other street furniture. The predominance of hard paved surfaces of poor quality finish and the wide road corridors of the site is common in Hong Kong. The street encompassing the study area has a uniformly hard and utilitarian character the quality of which is considered to be poor, having a low sensitivity to change.

The gaps in the building facade on the northern side of Wong Chuk Hang Road, the vacant lots and the junctions with side roads allow partial views of the vegetation on the slopes of Pan Nap Shan (Bennet's Hill). On the southern side of the road Nam Long Shan Road breaks up the continuous building facade and provides a view to the Wong Chuk Hang Housing Estate and the Cooked Food Market. There are easterly views along the line of the road to the slopes of Mount Cameron behind Grantham Hospital, and westerly views to the Aberdeen Technical School.

The streetscape and visual context plan of the study area is shown in Figure No. 4.1, and photographs of the existing site are shown in Figures 4.2 to 4.4.

The cross-sectional profile of the existing road corridor as illustrated on Figure 4.1 shows the scale of the width of Wong Chuk Hang Road in relation to the footpaths either side and the height of the buildings in relation to the pedestrian and vehicular traffic of the study area. The environmental conditions at street level for pedestrians walking along the road, and especially those waiting at the many bus stops, are very poor. They are characterised by low natural light levels, wind funnelling and vehicle generated air turbulence, a high level of air borne dust and grit, and feelings of entrapment, generated by the scale of the buildings and the proximity to large volumes of traffic, containing a high proportion of heavy goods vehicles.

There are five mature road side trees outside the fire station and Lee Fund Centre (31 Wong Chuk Hang Road) along the northern side of the road, and a further nine newly planted trees in front of the E Wah Factory Building (56-60 Wong Chuk Hang Road) and next to the ESSO Petrol Station (66 Wong Chuk Hang Road), along the southern side. A description of the trees is given in the Tree Survey Report, and their location is shown on the Tree Survey Plan contained therein.

Although the trees are of common species, and none of them have any special ecological value, they are in fair condition, and due to the low quality of the street level environment and the general predominance of hard landscape surfaces the trees have a high degree of amenity value, in particular the three outside the fire station, where the road cross section is slightly more open.

## 4.2 Visual Envelope

The scale of the buildings on both sides of the road which extend beyond the limit of the works will result in the proposed flyover having a strictly localised visual impact. The visual envelope of the road is shown on the Streetscape and Visual Context Plan (Figure 4.1).

Although the buildings on Wong Chuk Hang Road are largely industrial there are a number of more sensitive receivers, including the Nam Long Shan Road sitting out area, several retail and commercial outlets on the southern side, the fire station, some lobbies and canteens at ground level within the larger blocks on the northern side, together with numerous bus stops and pedestrian routes, and the drivers and passengers in vehicles passing through.

There are no sensitive views from outside the study area, as the configuration of the buildings will prevent any possible long range views from surrounding areas. The existing view into the site from Nam Long Shan Road will however be disrupted by the construction of the flyover.

## 4.3 Streetscape Impact of the Works

Even though the quality of the existing streetscape is considered to be very low, the scale and nature of the proposals will result in a substantial change in the character of the road corridor. The construction of the flyover will substantially reduce the amount of natural light reaching the existing street level and will appear as an enclosing element, effectively blocking out many of the views within and out of the study area at the junctions and along the road. The width of the abutment structures at either end of the proposed flyover, as shown on Figure 4.6, will result in a reduction in width of the footpaths on either side. It will represent a substantial worsening in the streetscape quality of the area.

The streetscape impact of the proposed works is indicated on the Streetscape and Visual Impact Plan (Figure 4.5).

In the wider context the proposed road will be encompassed within one urban character zone and will be absorbed into the pattern of industrial buildings and land uses. It will also be in the same context and of a similar scale as the existing road corridor. The landscape impact is considered, therefore, to be strictly localised.

The proposed road will directly affect four of the five mature trees within the project area. The extent of the crown spread of two trees will bring them into conflict with the proposed elevated structure, though it will be possible to retain them with some crown pruning works. The other two will need to be felled because they would lie within the future road carriageway, and they are not considered suitable for transplanting.

The nine newly planted trees will also need to be removed to accommodate the widening at ground level of Wong Chuk Hang Road. Alternative locations within the project limit have been identified to receive these trees.

The reduction in light levels is likely to adversely affect the future growth of the existing and proposed trees. Along the south side, where light levels will be very low, the future growth of the trees is likely to be slow, and ultimately they are unlikely to develop a full crown structure.

## 4.4 Visual Impact of the Works

The visual impact of the proposed works is also indicated on the Streetscape and Visual Impact Plan (Figure 4.5).

The symmetrical curving long profile of the flyover, which rises to a maximum some 14 metres above existing road levels, has been designed both to provide sufficient clearance above the existing footbridges and at the junctions but also to allow greater comfort for the driver.

Despite the 'maximum gradient' solution imposed on the flyover ramps by site constraints, large radius crest curves provided at the top of each ramp results in a longitudinal profile for the flyover that is generally elegant and flowing in appearance, especially as it will be seen mainly in oblique view along the line of the parapet edge from the ground level footpaths. The curve will also be in contrast to the rectilinear appearance of the existing street, which is dominated by the many industrial factory and warehousing buildings, and will be a dynamic and visually interesting element.

There are two sizes of piers to suit the structural design, although the arrangement of the piers has been kept symmetrical about the centre point of the bridge. The size of the piers at ground level has been kept as small as possible to minimise the width of the central median below, rising vertically and to a flared pier head which supports the elevated deck.

The abutment walls have been extended to enclose the area under the deck where the head room would be less than 2.0 metres, in order to avoid maintenance problems. Beyond this point, it is proposed that consideration be given to enclosing the adjacent area under the deck with full height decorative metal railings for use by the Maintaining Authority as storage spaces.

The parapet has been designed to be visually distinct from the deck structure and to avoid the problems of staining of the underside of the deck. It will also be curved in longitudinal section to emphasis the rounding of the main structure.

Natural light underneath the structure will be limited as the openings between the structure and the existing buildings either side will be only some 6 metres wide. Lighting will be supplemented artificially with 'designed in' fixtures located centrally on the underside of the deck.

Surface water from the proposed road surface will be collected and drained through down pipes within the piers to reduce their visual impact. They will be distributed into the existing surface water system.

The elevated road structure will obstruct existing views for all pedestrians within the street corridor, resulting in a high visual impact from the reduction in light levels and loss of views particularly across the street. The width of pavements will also be reduced bringing pedestrians closer to passing vehicles, promoting feelings of enclosure and entrapment, with an increased threat, physical danger and environmental pollution, even though the volume of traffic at ground level is likely to be substantially reduced.

There would be a slight visual impact on the street level retail outlets, banks, workshops and other commercial activities due to the reduction in day light caused by the elevated road. There would be no significant impact on higher levels within the buildings due to the general absence of view points out into the street.

## 4.5 Landscape mitigation measures

The nature of the proposals and the limited area available within the existing road corridor makes the elevated structure impossible to screen. Mitigation measures comprise environmental improvements to the area beneath the elevated deck and to the adjacent pavement areas and the creative design of structural elements of the elevated road at street level.

There will be no space for planting at either side of the existing road due to the reduction in the width of the footpaths which is necessary to accommodate the proposed carriageway realignment and due to the requirements for clearways for emergency vehicles. As a result of the construction of the elevated structure there will also be insufficient natural light and rain water within the street corridor for new planting to be successful.

Every possible effort will be taken to avoid both direct impact on the existing remaining trees and their canopies, and indirect effects of wind tunnelling and shading.

Decorative treatment to a central raised feature in a sinuous profile and using a brightly coloured tiled finish will increase the effects of reflected light and add visual interest at ground level as shown on Figure 4.9 'Perspective View of Flyover'.

Upgrading the quality of the existing pavements within the study area with the use of decorative paving and appropriately co-ordinated street furniture will enhance the streetscape and increase safety for pedestrians.

The landscape mitigation measures including the decorative treatment proposals are shown on Figure 4.6, the Landscape Mitigation Measures Plan.

Landscape mitigation measures also include the architectural treatment of bridge decks and abutments as illustrated in Figures 4.9 and 4.10. "Perspective View of Flyover' and 'Perspective View at Abutment'.

To create a higher quality visual appearance to the flyover and to minimise the dominance of concrete structures within the new streetscape, it is proposed that the transitions between the horizontal and inclined sides of the underside of the deck structure be curved in profile to form a smooth, flowing appearance to the whole deck structure.

In addition the columns would be rounded in cross section and with the flare at the top emphasised with a recessed panel to the centre finished in an hammered ribbed finish.

Recessed patterns will be formed in the surface of the piers, in the formwork, to lighten their appearance as shown on Figure 4.7 'Patterned Concrete Finishes to Support Piers' and in combination with feature uplighting will reduce their visual mass.

Floodlighting to the underside of the deck structure is proposed as this will increase the level of light provided by the street lighting and create a softer more attractive night time setting for the road.

The abutment walls will have a complimentary recessed pattern to that adopted for the piers, as shown in Figure 4.8, 'Arrangement at Viaduct Abutments'.

The method of construction for the elevated deck within the very tight physical constraints of the existing site will be examined in detail by the consulting team to minimise the effect on the existing trees.

## 4.6 Residual Landscape and Visual Impact

The landscape mitigation measures will be carried out on completion of the superstructure and within the construction period. Residual impacts as a result of the proposals are confined to the visual intrusion of the elevated deck and maintenance to the existing trees and new landscape features.

The mitigation measures detailed above, carried out as part of the construction process will reduce the long term visibility of the structure and substantially improve the ground level views within the site.

Maintenance of landscape works in the less accessible areas within the project area may cause operational problems for the maintenance authorities, and particular consideration needs to be given to the provision of proper facilities, especially storage facilities, with such facilities located under the flyover or within their abutment structures. The design of the covered area under the structures needs to be fully considered, with landscape measures and finishes designed to deter the sort of inappropriate pedestrian use that is currently made of these areas, especially at weekends.

# 5.0 CONCLUSIONS

## 5.1 Physical Environment

Construction of the Project has been shown to cause significant dust impacts on the air sensitive receivers in the Study Area. The predicted maximum construction dust levels are well above the dust guideline level and the Air Quality Objectives at most ASR locations. Dust suppression measures are required and the implementation of these measures is expected to reduce the dust impact considerably. The residual dust impact becomes insignificant if the dust control efficiency is 80% or better.

Air quality is expected to deteriorate from 2000 to 2011 because of the increase in traffic on Wong Chuk Hang Road. However, operation of the Project in 2011 is not expected to produce adverse air quality impact for the air sensitive receivers situated above and below the proposed flyover. No mitigation measures are considered necessary.

When compared with the predicted air quality in 1999, when all traffic along Wong Chuk Hang Road is travelling at ground level, the air quality at 2011 is actually seen to be slightly better. From Table 3.6, the predicted hourly $NO_2$ concentrations at 7m above the road level in 1999 are seen to be an average of 180 - 190 $\mu g/m^3$. The maximum $NO_2$ concentration predicted in the "tunnel" area enclosed by the underside of the flyover and the buildings on either side of Wong Chuk Hang Road in 2011 is 169 $\mu g/m^3$ (Section 3.3.4.3).

This slight improvement in air quality at the lower street levels is a result of the large decrease in street level traffic following the opening of the flyover, which more than compensates for the enclosing effect of the flyover itself.

It can thus be concluded that the construction of the flyover will result in an improvement in air quality at the lower level when compared with the "do nothing" scenario.

## 5.2 Landscape and Visual Environment

The new road will constitute a large element in a small scale diverse landscape setting, and will result in significant landscape and visual impact through modification to the existing road network.

The construction of the new road will result in the loss of two existing mature trees, that currently lie in front of the Lee Fund Centre (31 Wong Chuk Hang Road) due to a reduction in the footpath width to accommodate the carriageway realignment underneath the new deck. In addition, crown pruning will be required for two of the three mature trees in front of Aberdeen Fire Station and the nine existing newly planted trees within the project limits will have to be transplanted to alternative locations within the project limits.

The enclosed nature of the existing landscape will mean that the visual envelope of the new road will be localised and the views of the roads will be in the context of the existing industrial and commercial land uses.

The existing urban character of the site will become more concentrated as a result of the elevated road. The landscape improvements proposed however will enhance the pedestrian routes throughout the study area and substantially reduce the visual impact of the structure from street level.

# 6.0 RECOMMENDATIONS

## 6.1 Physical Environment

The following recommendations are made:

- application of dust control measures, including watering the works site twice a day and maintain good housekeeping during the construction phase;
- inclusion of pollution control clauses as recommended in Appendix D to the Contract Documents to control dust and other impacts from the construction works; and
- implementation of the EM&A programme as detailed in the EM&A Manual and summarised in Section 3.5 of this report during the construction stage of the project.

## 6.2 Landscape and Visual Environment

To mitigate the assessed landscape and visual impacts of the scheme as far as possible it is recommended that the following measures be adopted:

- retention of all existing vegetation within the study area not directly affected by the works;
- decorative paving and metal fencing underneath new carriageway in combination with feature lighting and aesthetic treatment to the structural supports; and
- the refinement of the alignments and configurations of all new carriageways, drainage channels and footpaths to minimise potential impacts.

The method of construction of the new flyover should be examined in detail to minimise its impact on the mature trees at the Aberdeen Fire Station.

Due to the very limited space and very low light levels that will prevail at street level following flyover construction, there are very few areas within the project limits that are considered suitable for tree planting. However, some nine standard size trees are proposed in a total of three locations along the route in compensation for those lost.

# APPENDIX A

## Sample Output for Construction Dust Impact Assessment

FDM - (DATED 91109)

IBM-PC VERSION (1.01)
(C) COPYRIGHT 1991, TRINITY CONSULTANTS, INC.
SERIAL NUMBER 8354 SOLD TO ENPAC LIMITED
RUN BEGAN ON 11/14/96 AT 10:36:25

RUN TITLE:
Wong Chuk Hang

INPUT FILE NAME: GO.DAT
OUTPUT FILE NAME: M-10.LST

| | |
|---|---|
| CONVERGENCE OPTION 1=OFF, 2=ON | 1 |
| MET OPTION SWITCH, 1=CARDS, 2=PREPROCESSED | 1 |
| PLOT FILE OUTPUT, 1=NO, 2=YES | 1 |
| MET DATA PRINT SWITCH, 1=NO, 2=YES | 1 |
| POST-PROCESSOR OUTPUT, 1=NO, 2=YES | 1 |
| DEP. VEL./GRAV. SETL. VEL., 1=DEFAULT, 2=USER | 1 |
| PRINT 1-HOUR AVERAGE CONCEN, 1=NO, 2=YES | 3 |
| PRINT 3-HOUR AVERAGE CONCEN, 1=NO, 2=YES | 1 |
| PRINT 8-HOUR AVERAGE CONCEN, 1=NO, 2=YES | 1 |
| PRINT 24-HOUR AVERAGE CONCEN, 1=NO, 2=YES | 3 |
| PRINT LONG-TERM AVERAGE CONCEN, 1=NO, 2=YES | 2 |
| BYPASS RAMMET CALMS RECOGNITION, 1=NO, 2=YES | 1 |
| NUMBER OF SOURCES PROCESSED | 6 |
| NUMBER OF RECEPTORS PROCESSED | 119 |
| NUMBER OF PARTICLE SIZE CLASSES | 5 |
| NUMBER OF HOURS OF MET DATA PROCESSED | 8760 |
| LENGTH IN MINUTES OF 1-HOUR OF MET DATA | 60. |
| ROUGHNESS LENGTH IN CM | 20.00 |
| SCALING FACTOR FOR SOURCE AND RECPTORS | 1.0000 |
| PARTICLE DENSITY IN G/CM**3 | 2.50 |
| ANEMOMETER HEIGHT IN M | 10.00 |

GENERAL PARTICLE SIZE CLASS INFORMATION

| PARTICLE SIZE CLASS | CHAR. DIA. (UM) | GRAV. SETTLING VELOCITY (M/SEC) | DEPOSITION VELOCITY (M/SEC) | FRACTION IN EACH SIZE CLASS |
|---|---|---|---|---|
| 1 | 1.2500000 | ** | ** | .0262 |
| 2 | 3.7500000 | ** | ** | .0678 |
| 3 | 7.5000000 | ** | ** | .1704 |
| 4 | 12.5000000 | ** | ** | .1536 |
| 5 | 20.0000000 | ** | ** | .5820 |

** COMPUTED BY FDM

RECEPTOR COORDINATES (X,Y,Z)

| | | |
|---|---|---|
| ( 34900., 12100., 10.) | ( 34950., 12100., 10.) | ( 35000., 12100., 10.) |
| ( 35050., 12100., 10.) | ( 35100., 12100., 10.) | ( 35150., 12100., 10.) |
| ( 35200., 12100., 10.) | ( 35250., 12100., 10.) | ( 35300., 12100., 10.) |
| ( 35350., 12100., 10.) | ( 35400., 12100., 10.) | ( 35450., 12100., 10.) |
| ( 35500., 12100., 10.) | ( 35550., 12100., 10.) | ( 35600., 12100., 10.) |
| ( 34900., 12150., 10.) | ( 34950., 12150., 10.) | ( 35000., 12150., 10.) |
| ( 35050., 12150., 10.) | ( 35100., 12150., 10.) | ( 35150., 12150., 10.) |
| ( 35200., 12150., 10.) | ( 35250., 12150., 10.) | ( 35300., 12150., 10.) |
| ( 35350., 12150., 10.) | ( 35400., 12150., 10.) | ( 35450., 12150., 10.) |
| ( 35500., 12150., 10.) | ( 35550., 12150., 10.) | ( 35600., 12150., 10.) |
| ( 34900., 12200., 10.) | ( 34950., 12200., 10.) | ( 35000., 12200., 10.) |
| ( 35050., 12200., 10.) | ( 35100., 12200., 10.) | ( 35150., 12200., 10.) |
| ( 35200., 12200., 10.) | ( 35250., 12200., 10.) | ( 35300., 12200., 10.) |
| ( 35350., 12200., 10.) | ( 35400., 12200., 10.) | ( 35450., 12200., 10.) |
| ( 35500., 12200., 10.) | ( 35550., 12200., 10.) | ( 35600., 12200., 10.) |
| ( 34900., 12250., 10.) | ( 34950., 12250., 10.) | ( 35000., 12250., 10.) |
| ( 35050., 12250., 10.) | ( 35100., 12250., 10.) | ( 35150., 12250., 10.) |
| ( 35200., 12250., 10.) | ( 35250., 12250., 10.) | ( 35300., 12250., 10.) |
| ( 35350., 12250., 10.) | ( 35400., 12250., 10.) | ( 35450., 12250., 10.) |
| ( 35500., 12250., 10.) | ( 35550., 12250., 10.) | ( 35600., 12250., 10.) |
| ( 34900., 12300., 10.) | ( 34950., 12300., 10.) | ( 35000., 12300., 10.) |
| ( 35050., 12300., 10.) | ( 35100., 12300., 10.) | ( 35150., 12300., 10.) |
| ( 35200., 12300., 10.) | ( 35250., 12300., 10.) | ( 35300., 12300., 10.) |
| ( 35350., 12300., 10.) | ( 35400., 12300., 10.) | ( 35450., 12300., 10.) |
| ( 35500., 12300., 10.) | ( 35550., 12300., 10.) | ( 35600., 12300., 10.) |
| ( 34900., 12350., 10.) | ( 34950., 12350., 10.) | ( 35000., 12350., 10.) |
| ( 35050., 12350., 10.) | ( 35100., 12350., 10.) | ( 35150., 12350., 10.) |
| ( 35200., 12350., 10.) | ( 35250., 12350., 10.) | ( 35300., 12350., 10.) |
| ( 35350., 12350., 10.) | ( 35400., 12350., 10.) | ( 35450., 12350., 10.) |
| ( 35500., 12350., 10.) | ( 35550., 12350., 10.) | ( 35600., 12350., 10.) |
| ( 34900., 12400., 10.) | ( 34950., 12400., 10.) | ( 35000., 12400., 10.) |
| ( 35050., 12400., 10.) | ( 35100., 12400., 10.) | ( 35150., 12400., 10.) |
| ( 35200., 12400., 10.) | ( 35250., 12400., 10.) | ( 35300., 12400., 10.) |
| ( 35350., 12400., 10.) | ( 35400., 12400., 10.) | ( 35450., 12400., 10.) |
| ( 35500., 12400., 10.) | ( 35550., 12400., 10.) | ( 35600., 12400., 10.) |
| ( 35009., 12186., 10.) | ( 35117., 12192., 10.) | ( 35187., 12221., 10.) |
| ( 35257., 12262., 10.) | ( 35323., 12294., 10.) | ( 35403., 12335., 10.) |
| ( 35483., 12377., 10.) | ( 35008., 12155., 10.) | ( 35079., 12154., 10.) |
| ( 35142., 12165., 10.) | ( 35224., 12204., 10.) | ( 35320., 12258., 10.) |
| ( 35404., 12301., 10.) | ( 35030., 12345., 10.) | ( |

1

SOURCE INFORMATION

| TYPE | ENTERED EMIS. RATE (G/SEC, G/SEC/M OR G/SEC/M**2) | TOTAL EMISSION RATE (G/SEC) | WIND SPEED FAC. | X1 (M) | Y1 (M) | X2 (M) | Y2 (M) | HEIGHT (M) | WIDTH (M) |
|---|---|---|---|---|---|---|---|---|---|
| 2 | .001870000 | .11165 | .000 | 35022. | 12169. | 35082. | 12170. | 1.38 | 17.00 |
| 2 | .001870000 | .19156 | .000 | 35082. | 12170. | 35179. | 12201. | 7.22 | 17.00 |
| 2 | .001760000 | .06502 | .000 | 35179. | 12201. | 35212. | 12218. | 12.11 | 16.00 |
| 2 | .001760000 | .16689 | .000 | 35212. | 12218. | 35296. | 12262. | 13.47 | 16.00 |
| 2 | .001760000 | .04009 | .000 | 35296. | 12262. | 35316. | 12273. | 12.91 | 16.00 |
| 2 | .001760000 | .34291 | .000 | 35317. | 12273. | 35490. | 12363. | 6.85 | 16.00 |
| | | ========== | | | | | | | |
| TOTAL EMISSIONS | | .91813 | | | | | | | |

| RECEPTOR | X-COORDINATE | Y-COORDINATE | HIGHEST VALUE | ENDING HOUR | DEPOSITION |
|---|---|---|---|---|---|
| 1 | 34900.0 | 12100.0 | 324.0954 | 6943. | 5.4521 |
| 2 | 34950.0 | 12100.0 | 256.7689 | 7605. | 4.2928 |
| 3 | 35000.0 | 12100.0 | 461.8049 | 7605. | 8.1953 |
| 4 | 35050.0 | 12100.0 | 290.3538 | 31. | 5.6503 |
| 5 | 35100.0 | 12100.0 | 276.0321 | 31. | 5.6010 |
| 6 | 35150.0 | 12100.0 | 234.7849 | 8065. | 4.9162 |
| 7 | 35200.0 | 12100.0 | 180.8944 | 988. | 3.8818 |
| 8 | 35250.0 | 12100.0 | 162.4787 | 2861. | 3.5766 |
| 9 | 35300.0 | 12100.0 | 129.4940 | 2524. | 2.7333 |
| 10 | 35350.0 | 12100.0 | 116.9893 | 7566. | 2.4546 |
| 11 | 35400.0 | 12100.0 | 107.7624 | 697. | 2.1586 |
| 12 | 35450.0 | 12100.0 | 99.8375 | 697. | 2.0596 |
| 13 | 35500.0 | 12100.0 | 94.0452 | 3366. | 1.7556 |
| 14 | 35550.0 | 12100.0 | 88.5952 | 3366. | 1.7073 |
| 15 | 35600.0 | 12100.0 | 83.2359 | 3366. | 1.6249 |
| 16 | 34900.0 | 12150.0 | 261.7779 | 7461. | 4.4490 |
| 17 | 34950.0 | 12150.0 | 288.0089 | 7461. | 4.9324 |
| 18 | 35000.0 | 12150.0 | 500.6628 | 6943. | 8.9528 |
| 19 | 35050.0 | 12150.0 | 624.3649 | 6943. | 11.2692 |
| 20 | 35100.0 | 12150.0 | 764.9216 | 7605. | 15.0194 |
| 21 | 35150.0 | 12150.0 | 426.9093 | 8065. | 9.5006 |
| 22 | 35200.0 | 12150.0 | 287.7206 | 8065. | 6.1506 |
| 23 | 35250.0 | 12150.0 | 204.0031 | 6507. | 4.4958 |
| 24 | 35300.0 | 12150.0 | 175.8888 | 697. | 3.6820 |
| 25 | 35350.0 | 12150.0 | 153.0324 | 3405. | 3.3563 |
| 26 | 35400.0 | 12150.0 | 139.8036 | 3366. | 2.9063 |
| 27 | 35450.0 | 12150.0 | 123.4574 | 3366. | 2.5860 |
| 28 | 35500.0 | 12150.0 | 116.1892 | 3478. | 2.0659 |
| 29 | 35550.0 | 12150.0 | 108.7436 | 3478. | 1.9709 |
| 30 | 35600.0 | 12150.0 | 103.1947 | 3478. | 1.8972 |
| 31 | 34900.0 | 12200.0 | 172.1902 | 2333. | 3.0166 |
| 32 | 34950.0 | 12200.0 | 197.5698 | 2333. | 3.5225 |
| 33 | 35000.0 | 12200.0 | 240.6227 | 7461. | 4.6987 |
| 34 | 35050.0 | 12200.0 | 326.8470 | 7461. | 6.7290 |
| 35 | 35100.0 | 12200.0 | 479.8670 | 7461. | 10.3357 |
| 36 | 35150.0 | 12200.0 | 991.2179 | 6943. | 21.8969 |
| 37 | 35200.0 | 12200.0 | 701.4903 | 7605. | 14.4917 |
| 38 | 35250.0 | 12200.0 | 391.1605 | 6143. | 7.5948 |
| 39 | 35300.0 | 12200.0 | 309.6800 | 6143. | 5.7654 |
| 40 | 35350.0 | 12200.0 | 243.0469 | 6143. | 4.4062 |
| 41 | 35400.0 | 12200.0 | 200.8866 | 6143. | 3.5639 |
| 42 | 35450.0 | 12200.0 | 172.2963 | 6143. | 3.0075 |
| 43 | 35500.0 | 12200.0 | 149.0307 | 6143. | 2.5490 |

| | | | | | |
|---|---|---|---|---|---|
| 44 | 35550.0 | 12200.0 | 134.0896 | 6143. | 2.2672 |
| 45 | 35600.0 | 12200.0 | 120.4991 | 6143. | 2.0094 |
| 46 | 34900.0 | 12250.0 | 126.6833 | 2333. | 2.3883 |
| 47 | 34950.0 | 12250.0 | 143.6705 | 2333. | 2.7887 |
| 48 | 35000.0 | 12250.0 | 163.2710 | 2333. | 3.2519 |
| 49 | 35050.0 | 12250.0 | 202.1035 | 2333. | 4.1751 |
| 50 | 35100.0 | 12250.0 | 233.6583 | 2333. | 4.9713 |
| 51 | 35150.0 | 12250.0 | 292.1635 | 4943. | 6.5075 |
| 52 | 35200.0 | 12250.0 | 373.0853 | 7461. | 7.6924 |
| 53 | 35250.0 | 12250.0 | 571.1452 | 6943. | 11.1552 |
| 54 | 35300.0 | 12250.0 | 790.7938 | 8722. | 16.5346 |
| 55 | 35350.0 | 12250.0 | 440.1833 | 6499. | 9.4226 |
| 56 | 35400.0 | 12250.0 | 319.6797 | 6499. | 6.2937 |
| 57 | 35450.0 | 12250.0 | 228.4132 | 6499. | 4.2148 |
| 58 | 35500.0 | 12250.0 | 191.4538 | 6143. | 3.9425 |
| 59 | 35550.0 | 12250.0 | 159.0078 | 6143. | 3.1460 |
| 60 | 35600.0 | 12250.0 | 141.9714 | 6143. | 2.7179 |
| 61 | 34900.0 | 12300.0 | 103.0186 | 5138. | 2.0292 |
| 62 | 34950.0 | 12300.0 | 113.0998 | 5138. | 2.2630 |
| 63 | 35000.0 | 12300.0 | 125.4276 | 5138. | 2.5444 |
| 64 | 35050.0 | 12300.0 | 140.4224 | 5138. | 2.8684 |
| 65 | 35100.0 | 12300.0 | 160.0400 | 5503. | 3.5058 |
| 66 | 35150.0 | 12300.0 | 173.7892 | 5503. | 3.8586 |
| 67 | 35200.0 | 12300.0 | 197.4333 | 5503. | 4.3985 |
| 68 | 35250.0 | 12300.0 | 273.8746 | 824. | 5.8566 |
| 69 | 35300.0 | 12300.0 | 388.2092 | 3427. | 9.0110 |
| 70 | 35350.0 | 12300.0 | 855.1154 | 4133. | 18.5139 |
| 71 | 35400.0 | 12300.0 | 716.7109 | 8722. | 14.2102 |
| 72 | 35450.0 | 12300.0 | 373.1394 | 8722. | 7.1043 |
| 73 | 35500.0 | 12300.0 | 266.9571 | 6499. | 5.1921 |
| 74 | 35550.0 | 12300.0 | 224.8257 | 6499. | 4.2876 |
| 75 | 35600.0 | 12300.0 | 188.0445 | 6499. | 3.4765 |
| 76 | 34900.0 | 12350.0 | 84.2041 | 5503. | 1.6700 |
| 77 | 34950.0 | 12350.0 | 93.0268 | 5503. | 1.8885 |
| 78 | 35000.0 | 12350.0 | 104.3099 | 5503. | 2.1316 |
| 79 | 35050.0 | 12350.0 | 106.8744 | 5402. | 2.2202 |
| 80 | 35100.0 | 12350.0 | 124.5366 | 2252. | 2.6769 |
| 81 | 35150.0 | 12350.0 | 129.1966 | 7561. | 2.7138 |
| 82 | 35200.0 | 12350.0 | 144.2381 | 3384. | 3.2125 |
| 83 | 35250.0 | 12350.0 | 177.0943 | 8179. | 3.6765 |
| 84 | 35300.0 | 12350.0 | 245.9070 | 5260. | 5.4077 |
| 85 | 35350.0 | 12350.0 | 328.2324 | 3427. | 7.2472 |
| 86 | 35400.0 | 12350.0 | 428.2357 | 5238. | 8.8843 |
| 87 | 35450.0 | 12350.0 | 677.0452 | 4133. | 12.0867 |
| 88 | 35500.0 | 12350.0 | 532.3798 | 8722. | 8.8827 |
| 89 | 35550.0 | 12350.0 | 350.7927 | 8722. | 6.1001 |
| 90 | 35600.0 | 12350.0 | 210.8863 | 8722. | 3.6235 |
| 91 | 34900.0 | 12400.0 | 75.0407 | 5503. | 1.4085 |
| 92 | 34950.0 | 12400.0 | 78.2210 | 2252. | 1.5803 |
| 93 | 35000.0 | 12400.0 | 86.6892 | 2252. | 1.7732 |
| 94 | 35050.0 | 12400.0 | 91.5766 | 5402. | 1.9259 |
| 95 | 35100.0 | 12400.0 | 99.4956 | 5402. | 2.1052 |
| 96 | 35150.0 | 12400.0 | 106.0073 | 3417. | 2.2844 |
| 97 | 35200.0 | 12400.0 | 119.2950 | 76. | 2.5849 |
| 98 | 35250.0 | 12400.0 | 141.7784 | 844. | 3.0179 |

| | | | | | |
|---|---|---|---|---|---|
| 99 | 35300.0 | 12400.0 | 167.3564 | 8179. | 3.6170 |
| 100 | 35350.0 | 12400.0 | 192.0597 | 824. | 4.1227 |
| 101 | 35400.0 | 12400.0 | 251.0238 | 2659. | 5.2519 |
| 102 | 35450.0 | 12400.0 | 293.9886 | 5238. | 5.8436 |
| 103 | 35500.0 | 12400.0 | 325.5353 | 5238. | 5.5936 |
| 104 | 35550.0 | 12400.0 | 565.5635 | 4133. | 9.3766 |
| 105 | 35600.0 | 12400.0 | 358.6300 | 8722. | 5.7473 |
| 106 | 35009.2 | 12186.3 | 309.4107 | 7461. | 6.0641 |
| 107 | 35116.9 | 12192.3 | 693.2529 | 6943. | 14.3553 |
| 108 | 35186.6 | 12221.2 | 712.7766 | 6943. | 15.2206 |
| 109 | 35257.2 | 12262.1 | 483.0557 | 5238. | 10.4338 |
| 110 | 35323.1 | 12294.2 | 563.5413 | 5238. | 13.0619 |
| 111 | 35402.6 | 12335.2 | 538.7635 | 4133. | 10.5871 |
| 112 | 35482.8 | 12376.7 | 504.2537 | 4133. | 8.9097 |
| 113 | 35008.2 | 12155.0 | 483.3879 | 6943. | 8.7166 |
| 114 | 35078.6 | 12154.1 | 680.1586 | 7605. | 12.3269 |
| 115 | 35141.9 | 12164.7 | 649.8901 | 7605. | 13.2460 |
| 116 | 35224.2 | 12203.8 | 464.3468 | 6499. | 8.4081 |
| 117 | 35320.2 | 12258.3 | 781.3964 | 8722. | 16.4351 |
| 118 | 35403.6 | 12300.9 | 703.5479 | 8722. | 13.8877 |
| 119 | 35030.0 | 12344.7 | 109.7584 | 5503. | 2.2525 |

HIGHEST AND SECOND HIGHEST VALUES FOR 1 HOUR AVERAGES

| RECEPTOR | X-COORDINATE | Y-COORDINATE | HIGHEST VALUE | ENDING HOUR | DEPOSITIO |
|---|---|---|---|---|---|
| 1 | 34900.0 | 12100.0 | 324.0954 | 6943. | 5.4521 |
| 2 | 34950.0 | 12100.0 | 256.7689 | 7605. | 4.2928 |
| 3 | 35000.0 | 12100.0 | 461.8049 | 7605. | 8.1953 |
| 4 | 35050.0 | 12100.0 | 290.3538 | 31. | 5.6503 |
| 5 | 35100.0 | 12100.0 | 276.0321 | 31. | 5.6010 |
| 6 | 35150.0 | 12100.0 | 234.7849 | 8065. | 4.9162 |
| 7 | 35200.0 | 12100.0 | 180.8944 | 988. | 3.8818 |
| 8 | 35250.0 | 12100.0 | 162.4767 | 2861. | 3.5766 |
| 9 | 35300.0 | 12100.0 | 129.4940 | 2524. | 2.7333 |
| 10 | 35350.0 | 12100.0 | 116.9893 | 7566. | 2.4546 |
| 11 | 35400.0 | 12100.0 | 107.7624 | 697. | 2.1586 |
| 12 | 35450.0 | 12100.0 | 99.8375 | 697. | 2.0596 |
| 13 | 35500.0 | 12100.0 | 94.0452 | 3366. | 1.7556 |
| 14 | 35550.0 | 12100.0 | 88.5952 | 3366. | 1.7073 |
| 15 | 35600.0 | 12100.0 | 83.2359 | 3366. | 1.6249 |
| 16 | 34900.0 | 12150.0 | 261.7779 | 7461. | 4.4490 |
| 17 | 34950.0 | 12150.0 | 288.0089 | 7461. | 4.9324 |
| 18 | 35000.0 | 12150.0 | 500.6628 | 6943. | 8.9528 |
| 19 | 35050.0 | 12150.0 | 624.3649 | 6943. | 11.2692 |
| 20 | 35100.0 | 12150.0 | 764.9216 | 7605. | 15.0194 |
| 21 | 35150.0 | 12150.0 | 426.9093 | 8065. | 9.5006 |
| 22 | 35200.0 | 12150.0 | 287.7206 | 8065. | 6.1506 |
| 23 | 35250.0 | 12150.0 | 204.0031 | 6507. | 4.4958 |
| 24 | 35300.0 | 12150.0 | 175.8888 | 697. | 3.6820 |
| 25 | 35350.0 | 12150.0 | 153.0324 | 3405. | 3.3563 |
| 26 | 35400.0 | 12150.0 | 139.8036 | 3366. | 2.9063 |
| 27 | 35450.0 | 12150.0 | 123.4574 | 3366. | 2.5860 |

| | | | | | |
|---|---|---|---|---|---|
| 28 | 35500.0 | 12150.0 | 116.1892 | 3478. | 2.0659 |
| 29 | 35550.0 | 12150.0 | 108.7436 | 3478. | 1.9709 |
| 30 | 35600.0 | 12150.0 | 103.1947 | 3478. | 1.8972 |
| 31 | 34900.0 | 12200.0 | 172.1902 | 2333. | 3.0166 |
| 32 | 34950.0 | 12200.0 | 197.5698 | 2333. | 3.5225 |
| 33 | 35000.0 | 12200.0 | 240.6227 | 7461. | 4.6987 |
| 34 | 35050.0 | 12200.0 | 326.8470 | 7461. | 6.7290 |
| 35 | 35100.0 | 12200.0 | 479.8670 | 7461. | 10.3357 |
| 36 | 35150.0 | 12200.0 | 991.2179 | 6943. | 21.8969 |
| 37 | 35200.0 | 12200.0 | 701.4903 | 7605. | 14.4917 |
| 38 | 35250.0 | 12200.0 | 391.1605 | 6143. | 7.5948 |
| 39 | 35300.0 | 12200.0 | 309.6800 | 6143. | 5.7654 |
| 40 | 35350.0 | 12200.0 | 243.0469 | 6143. | 4.4062 |
| 41 | 35400.0 | 12200.0 | 200.8866 | 6143. | 3.5639 |
| 42 | 35450.0 | 12200.0 | 172.2963 | 6143. | 3.0075 |
| 43 | 35500.0 | 12200.0 | 149.0307 | 6143. | 2.5490 |
| 44 | 35550.0 | 12200.0 | 134.0896 | 6143. | 2.2672 |
| 45 | 35600.0 | 12200.0 | 120.4991 | 6143. | 2.0094 |
| 46 | 34900.0 | 12250.0 | 126.6833 | 2333. | 2.3883 |
| 47 | 34950.0 | 12250.0 | 143.6705 | 2333. | 2.7887 |
| 48 | 35000.0 | 12250.0 | 163.2710 | 2333. | 3.2519 |
| 49 | 35050.0 | 12250.0 | 202.1035 | 2333. | 4.1751 |
| 50 | 35100.0 | 12250.0 | 233.6583 | 2333. | 4.9713 |
| 51 | 35150.0 | 12250.0 | 292.1635 | 4943. | 6.5075 |
| 52 | 35200.0 | 12250.0 | 373.0853 | 7461. | 7.6924 |
| 53 | 35250.0 | 12250.0 | 571.1452 | 6943. | 11.1552 |
| 54 | 35300.0 | 12250.0 | 790.7938 | 8722. | 15.5346 |
| 55 | 35350.0 | 12250.0 | 440.1833 | 6499. | 9.4226 |
| 56 | 35400.0 | 12250.0 | 319.6797 | 6499. | 6.2937 |
| 57 | 35450.0 | 12250.0 | 228.4132 | 6499. | 4.2148 |
| 58 | 35500.0 | 12250.0 | 191.4538 | 6143. | 3.9425 |
| 59 | 35550.0 | 12250.0 | 159.0078 | 6143. | 3.1460 |
| 60 | 35600.0 | 12250.0 | 141.9714 | 6143. | 2.7179 |
| 61 | 34900.0 | 12300.0 | 103.0186 | 5138. | 2.0292 |
| 62 | 34950.0 | 12300.0 | 113.0998 | 5138. | 2.2630 |
| 63 | 35000.0 | 12300.0 | 125.4276 | 5138. | 2.5444 |
| 64 | 35050.0 | 12300.0 | 140.4224 | 5138. | 2.8684 |
| 65 | 35100.0 | 12300.0 | 160.0400 | 5503. | 3.5058 |
| 66 | 35150.0 | 12300.0 | 173.7892 | 5503. | 3.8566 |
| 67 | 35200.0 | 12300.0 | 197.4333 | 5503. | 4.3985 |
| 68 | 35250.0 | 12300.0 | 273.8746 | 824. | 5.8566 |
| 69 | 35300.0 | 12300.0 | 388.2092 | 3427. | 9.0110 |
| 70 | 35350.0 | 12300.0 | 855.1154 | 4133. | 18.5139 |
| 71 | 35400.0 | 12300.0 | 716.7109 | 8722. | 14.2102 |
| 72 | 35450.0 | 12300.0 | 373.1394 | 8722. | 7.1043 |
| 73 | 35500.0 | 12300.0 | 266.9571 | 6499. | 5.1921 |
| 74 | 35550.0 | 12300.0 | 224.8257 | 6499. | 4.2876 |
| 75 | 35600.0 | 12300.0 | 188.0445 | 6499. | 3.4765 |
| 76 | 34900.0 | 12350.0 | 84.2041 | 5503. | 1.6700 |
| 77 | 34950.0 | 12350.0 | 93.0268 | 5503. | 1.8885 |
| 78 | 35000.0 | 12350.0 | 104.3099 | 5503. | 2.1316 |
| 79 | 35050.0 | 12350.0 | 106.8744 | 5402. | 2.2202 |
| 80 | 35100.0 | 12350.0 | 124.5366 | 2252. | 2.6769 |
| 81 | 35150.0 | 12350.0 | 129.1966 | 7561. | 2.7138 |
| 82 | 35200.0 | 12350.0 | 144.2381 | 3384. | 3.2125 |

| | | | | | |
|---|---|---|---|---|---|
| 83 | 35250.0 | 12350.0 | 177.0943 | 8179. | 3.6765 |
| 84 | 35300.0 | 12350.0 | 245.9070 | 5260. | 5.4077 |
| 85 | 35350.0 | 12350.0 | 328.2324 | 3427. | 7.2472 |
| 86 | 35400.0 | 12350.0 | 428.2357 | 5238. | 8.8843 |
| 87 | 35450.0 | 12350.0 | 677.0452 | 4133. | 12.0867 |
| 88 | 35500.0 | 12350.0 | 532.3798 | 8722. | 8.8827 |
| 89 | 35550.0 | 12350.0 | 350.7927 | 8722. | 6.1001 |
| 90 | 35600.0 | 12350.0 | 210.8863 | 8722. | 3.6235 |
| 91 | 34900.0 | 12400.0 | 75.0407 | 5503. | 1.4085 |
| 92 | 34950.0 | 12400.0 | 78.2210 | 2252. | 1.5803 |
| 93 | 35000.0 | 12400.0 | 86.6892 | 2252. | 1.7732 |
| 94 | 35050.0 | 12400.0 | 91.5766 | 5402. | 1.9259 |
| 95 | 35100.0 | 12400.0 | 99.4956 | 5402. | 2.1052 |
| 96 | 35150.0 | 12400.0 | 106.0073 | 3417. | 2.2844 |
| 97 | 35200.0 | 12400.0 | 119.2950 | 76. | 2.5849 |
| 98 | 35250.0 | 12400.0 | 141.7784 | 844. | 3.0179 |
| 99 | 35300.0 | 12400.0 | 167.3564 | 8179. | 3.6170 |
| 100 | 35350.0 | 12400.0 | 192.0597 | 824. | 4.1227 |
| 101 | 35400.0 | 12400.0 | 251.0238 | 2659. | 5.2519 |
| 102 | 35450.0 | 12400.0 | 293.9886 | 5238. | 5.8436 |
| 103 | 35500.0 | 12400.0 | 325.5353 | 5238. | 5.5936 |
| 104 | 35550.0 | 12400.0 | 565.5635 | 4133. | 9.3766 |
| 105 | 35600.0 | 12400.0 | 358.6300 | 8722. | 5.7473 |
| 106 | 35009.2 | 12186.3 | 309.4107 | 7461. | 6.0641 |
| 107 | 35116.9 | 12192.3 | 693.2529 | 6943. | 14.3553 |
| 108 | 35186.6 | 12221.2 | 712.7766 | 6943. | 15.2206 |
| 109 | 35257.2 | 12262.1 | 483.0557 | 5238. | 10.4336 |
| 110 | 35323.1 | 12294.2 | 563.5413 | 5238. | 13.0619 |
| 111 | 35402.6 | 12335.2 | 538.7635 | 4133. | 10.5571 |
| 112 | 35482.8 | 12376.7 | 504.2537 | 4133. | 8.9097 |
| 113 | 35008.2 | 12155.0 | 483.3879 | 6943. | 8.7166 |
| 114 | 35078.6 | 12154.1 | 680.1586 | 7605. | 12.3289 |
| 115 | 35141.9 | 12164.7 | 649.8901 | 7605. | 13.2460 |
| 116 | 35224.2 | 12203.8 | 464.3468 | 6499. | 8.4081 |
| 117 | 35320.2 | 12258.3 | 781.3964 | 8722. | 16.4351 |
| 118 | 35403.6 | 12300.9 | 703.5479 | 8722. | 13.8877 |
| 119 | 35030.0 | 12344.7 | 109.7584 | 5503. | 2.2525 |

HIGHEST AND SECOND HIGHEST VALUES FOR 24 HOUR AVERAGES

| RECEPTOR | X-COORDINATE | Y-COORDINATE | HIGHEST VALUE | ENDING HOUR | DEPOSITION |
|---|---|---|---|---|---|
| 1 | 34900.0 | 12100.0 | 23.4308 | 4248.C | .5100 |
| 2 | 34950.0 | 12100.0 | 27.7438 | 6840.C | .6272 |
| 3 | 35000.0 | 12100.0 | 45.7253 | 6840.C | 1.0368 |
| 4 | 35050.0 | 12100.0 | 55.0816 | 6840.C | 1.2377 |
| 5 | 35100.0 | 12100.0 | 50.3807 | 8544. | 1.2104 |
| 6 | 35150.0 | 12100.0 | 49.2608 | 8544. | 1.2025 |
| 7 | 35200.0 | 12100.0 | 46.3033 | 5664.C | .9671 |
| 8 | 35250.0 | 12100.0 | 52.5336 | 5664.C | 1.1741 |
| 9 | 35300.0 | 12100.0 | 51.5922 | 5664.C | 1.1950 |
| 10 | 35350.0 | 12100.0 | 45.3602 | 5664.C | 1.0369 |
| 11 | 35400.0 | 12100.0 | 40.3515 | 5664.C | .9010 |

| | | | | | |
|---|---|---|---|---|---|
| 12 | 35450.0 | 12100.0 | 34.4841 | 5664.C | .7372 |
| 13 | 35500.0 | 12100.0 | 31.1086 | 5664.C | .6496 |
| 14 | 35550.0 | 12100.0 | 25.6607 | 5664.C | .5478 |
| 15 | 35600.0 | 12100.0 | 22.1562 | 5664.C | .4779 |
| 16 | 34900.0 | 12150.0 | 33.1070 | 7632. | .7730 |
| 17 | 34950.0 | 12150.0 | 39.2661 | 7632. | .9171 |
| 18 | 35000.0 | 12150.0 | 46.6607 | 7632. | 1.0876 |
| 19 | 35050.0 | 12150.0 | 58.1996 | 6840.C | 1.3199 |
| 20 | 35100.0 | 12150.0 | 82.5834 | 6840.C | 1.9203 |
| 21 | 35150.0 | 12150.0 | 70.6015 | 6840.C | 1.6935 |
| 22 | 35200.0 | 12150.0 | 66.7001 | 5664.C | 1.5506 |
| 23 | 35250.0 | 12150.0 | 74.1597 | 5664.C | 1.8140 |
| 24 | 35300.0 | 12150.0 | 62.7454 | 5664.C | 1.5507 |
| 25 | 35350.0 | 12150.0 | 53.5963 | 5664.C | 1.2862 |
| 26 | 35400.0 | 12150.0 | 44.5184 | 5664.C | 1.0173 |
| 27 | 35450.0 | 12150.0 | 37.7005 | 5664.C | .8253 |
| 28 | 35500.0 | 12150.0 | 34.9914 | 5664.C | .7618 |
| 29 | 35550.0 | 12150.0 | 27.6155 | 5664.C | .6180 |
| 30 | 35600.0 | 12150.0 | 21.8780 | 5664.C | .4958 |
| 31 | 34900.0 | 12200.0 | 30.3003 | 7632. | .7297 |
| 32 | 34950.0 | 12200.0 | 36.4848 | 7632. | .8884 |
| 33 | 35000.0 | 12200.0 | 51.2483 | 5520.C | 1.0827 |
| 34 | 35050.0 | 12200.0 | 74.7616 | 5520.C | 1.5705 |
| 35 | 35100.0 | 12200.0 | 83.1901 | 7632. | 2.1575 |
| 36 | 35150.0 | 12200.0 | 100.0111 | 7632. | 2.5812 |
| 37 | 35200.0 | 12200.0 | 95.6332 | 2952.C | 2.5398 |
| 38 | 35250.0 | 12200.0 | 69.2738 | 8448.C | 1.7359 |
| 39 | 35300.0 | 12200.0 | 66.2062 | 5664.C | 1.8004 |
| 40 | 35350.0 | 12200.0 | 63.5556 | 5664.C | 1.5957 |
| 41 | 35400.0 | 12200.0 | 45.6532 | 5664.C | 1.0574 |
| 42 | 35450.0 | 12200.0 | 43.0241 | 5664.C | .9786 |
| 43 | 35500.0 | 12200.0 | 39.3540 | 5664.C | .8831 |
| 44 | 35550.0 | 12200.0 | 29.7010 | 5664.C | .6852 |
| 45 | 35600.0 | 12200.0 | 23.0670 | 3528.C | .6172 |
| 46 | 34900.0 | 12250.0 | 33.8765 | 5520.C | .6996 |
| 47 | 34950.0 | 12250.0 | 42.0770 | 5520.C | .8843 |
| 48 | 35000.0 | 12250.0 | 53.7519 | 5520.C | 1.1513 |
| 49 | 35050.0 | 12250.0 | 64.6426 | 5520.C | 1.4306 |
| 50 | 35100.0 | 12250.0 | 77.1380 | 5520.C | 1.7738 |
| 51 | 35150.0 | 12250.0 | 91.2036 | 5520.C | 2.1954 |
| 52 | 35200.0 | 12250.0 | 93.8384 | 5256.C | 2.3372 |
| 53 | 35250.0 | 12250.0 | 64.7038 | 7464.C | 1.7954 |
| 54 | 35300.0 | 12250.0 | 63.8807 | 6984.C | 2.0713 |
| 55 | 35350.0 | 12250.0 | 60.1921 | 8448.C | 1.5331 |
| 56 | 35400.0 | 12250.0 | 50.0207 | 408.C | 1.1539 |
| 57 | 35450.0 | 12250.0 | 45.8695 | 5664.C | 1.0819 |
| 58 | 35500.0 | 12250.0 | 42.9926 | 5664.C | .9992 |
| 59 | 35550.0 | 12250.0 | 30.6760 | 1128.C | .7689 |
| 60 | 35600.0 | 12250.0 | 23.9537 | 1128.C | .5879 |
| 61 | 34900.0 | 12300.0 | 34.0141 | 5520.C | .6991 |
| 62 | 34950.0 | 12300.0 | 38.8602 | 5520.C | .8175 |
| 63 | 35000.0 | 12300.0 | 44.7508 | 5520.C | .9668 |
| 64 | 35050.0 | 12300.0 | 51.1245 | 5520.C | 1.1363 |
| 65 | 35100.0 | 12300.0 | 56.6369 | 5520.C | 1.2851 |
| 66 | 35150.0 | 12300.0 | 61.0182 | 5520.C | 1.3943 |

| | | | | | |
|---|---|---|---|---|---|
| 67 | 35200.0 | 12300.0 | 66.6501 | 5520.C | 1.5246 |
| 68 | 35250.0 | 12300.0 | 77.9914 | 5304.C | 1.7840 |
| 69 | 35300.0 | 12300.0 | 94.0673 | 5256.C | 2.4447 |
| 70 | 35350.0 | 12300.0 | 72.0942 | 7032.C | 1.6930 |
| 71 | 35400.0 | 12300.0 | 54.7790 | 8736.C | 1.2087 |
| 72 | 35450.0 | 12300.0 | 53.8703 | 2952.C | 1.3682 |
| 73 | 35500.0 | 12300.0 | 44.0474 | 8448.C | 1.0338 |
| 74 | 35550.0 | 12300.0 | 30.8497 | 1128.C | .7565 |
| 75 | 35600.0 | 12300.0 | 21.7225 | 2952.C | .5717 |
| 76 | 34900.0 | 12350.0 | 29.1760 | 5520.C | .5972 |
| 77 | 34950.0 | 12350.0 | 31.5321 | 5520.C | .6583 |
| 78 | 35000.0 | 12351.0 | 34.3776 | 5520.C | .7331 |
| 79 | 35050.0 | 12350.0 | 37.2617 | 5520.C | .8078 |
| 80 | 35100.0 | 12350.0 | 42.6241 | 1248.C | .9744 |
| 81 | 35150.0 | 12350.0 | 48.7849 | 1248.C | 1.1503 |
| 82 | 35200.0 | 12350.0 | 53.3283 | 1248.C | 1.2810 |
| 83 | 35250.0 | 12350.0 | 57.2666 | 1248.C | 1.3710 |
| 84 | 35300.0 | 12350.0 | 65.2747 | 5304.C | 1.4615 |
| 85 | 35350.0 | 12350.0 | 79.2820 | 5256.C | 1.9604 |
| 86 | 35400.0 | 12350.0 | 80.3310 | 5256.C | 1.9581 |
| 87 | 35450.0 | 12350.0 | 56.3425 | 7032.C | 1.2114 |
| 88 | 35500.0 | 12350.0 | 54.3752 | 6120.C | 1.5448 |
| 89 | 35550.0 | 12350.0 | 29.0148 | 6120.C | .8242 |
| 90 | 35600.0 | 12350.0 | 23.0192 | 2928.C | .4903 |
| 91 | 34900.0 | 12400.0 | 22.7736 | 5520.C | .4607 |
| 92 | 34950.0 | 12400.0 | 24.0224 | 3696.C | .6275 |
| 93 | 35000.0 | 12400.0 | 27.4500 | 1248.C | .6007 |
| 94 | 35050.0 | 12400.0 | 32.5173 | 1248.C | .7289 |
| 95 | 35100.0 | 12400.0 | 36.8955 | 1248.C | .8493 |
| 96 | 35150.0 | 12401.0 | 41.7445 | 1248.C | .9820 |
| 97 | 35200.0 | 12400.0 | 45.2534 | 1248.C | 1.0697 |
| 98 | 35250.0 | 12400.0 | 46.4505 | 1248.C | 1.0787 |
| 99 | 35300.0 | 12400.0 | 47.4107 | 5256.C | 1.1827 |
| 100 | 35350.0 | 12400.0 | 58.3204 | 5256.C | 1.4406 |
| 101 | 35400.0 | 12400.0 | 65.8159 | 5256.C | 1.6036 |
| 102 | 35450.0 | 12400.0 | 76.0758 | 5256.C | 1.8187 |
| 103 | 35500.0 | 12400.0 | 54.0858 | 5256.C | 1.2134 |
| 104 | 35550.0 | 12400.0 | 32.5444 | 4152.C | .5581 |
| 105 | 35600.0 | 12400.0 | 21.0096 | 8736.C | .3801 |
| 106 | 35009.2 | 12186.3 | 56.6909 | 7632. | 1.3840 |
| 107 | 35116.9 | 12192.3 | 94.8949 | 7632. | 2.4154 |
| 108 | 35186.6 | 12221.2 | 88.6845 | 7464.C | 2.4571 |
| 109 | 35257.2 | 12262.1 | 78.5359 | 6504.C | 1.9056 |
| 110 | 35323.1 | 12294.2 | 82.9092 | 5256.C | 2.2192 |
| 111 | 35402.6 | 12335.2 | 63.2023 | 7032.C | 1.4744 |
| 112 | 35482.8 | 12376.7 | 54.1502 | 4152.C | 1.3581 |
| 113 | 35008.2 | 12155.0 | 51.8767 | 7632. | 1.2098 |
| 114 | 35078.6 | 12151.1 | 76.7238 | 6840.C | 1.7591 |
| 115 | 35141.9 | 12164.7 | 96.0769 | 6840.C | 2.3320 |
| 116 | 35224.2 | 12203.8 | 85.5394 | 2952.C | 2.2750 |
| 117 | 35320.2 | 12258.3 | 64.9251 | 2952.C | 1.7414 |
| 118 | 35403.6 | 12300.9 | 55.7626 | 2952.C | 1.4402 |
| 119 | 35030.0 | 12344.7 | 37.2833 | 5520.C | .8066 |

RUN ENDED ON 11/14/96 AT 12:00:39

# APPENDIX B

## Detailed Calculations for $NO_2$ and CO Concentrations

## for

## At-Grade Traffic under Flyover

## APPENDIX B - Detailed Calculations of the $NO_2$ Concentration Underneath the Flyover

### 1. Emission Data

Forecast Traffic Flow of Wong Chuk Hang Road in Year 2011

| Direction | Traffic Flow (veh/hr) | | | | | | | | | | Total Traffic Flow (veh/hr) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | MC | PV | Taxi | PLB | LGV | MGV | HGV | Cont. | Buses | Coach | |
| E/B | 50 | 345 | 152 | 138 | 126 | 152 | 41 | 2 | 259 | 29 | 1294 |
| W/B | 13 | 61 | 125 | 57 | 34 | 36 | 3 | 0 | 278 | 13 | 620 |
| Mean | 32 | 203 | 139 | 98 | 304 | 944 | 22 | 1 | 269 | 21 | 959 |
| $NO_2$ | 0.548 | 1.321 | 0.779 | 1.782 | 1.540 | 4.594 | 7.061 | 7.016 | 8.378 | 7.029 | Weighted = 3.90 |
| CO | 25.508 | 1.032 | 0.910 | 1.089 | 0.990 | 8.407 | 8.410 | 8.410 | 9.017 | 8.332 | Weighted = 5.13 |

Assume 10% conversion of NO to $NO_2$, the emission factor per unit length is given by:

$$w_{NO2} = 0.1 \times (3.90/1000) \times 2 \times (959/3600)\ \text{g/m-s} = 0.000208\ \text{g/m-s}$$

$$w_{CO} = (5.13/1000) \times 2 \times (959/3600)\ \text{g/m-s} = 0.002735\ \text{g/m-s}$$

and, the emission factor per unit length of CO is:

### 2. Vehicle Data

Nominal dimensions of vehicles are given in Transport Planning and Design Manual, Vol. 2 (Ref. 1) as:

| | |
|---|---|
| Cars and Taxi: | 1.7m (W) x 1.5m (H) x 4.6m (L) |
| Light Goods Vehicle: | 2.1m (W) x 1.6m (H) x 5.2m (L) |
| Medium Goods Vehicle: | 2.5m (W) x 4.0m (H) x 11m (L) |
| Heavy Goods Vehicles: | 2.5m (W) x 4.6m (H) x 16m (L) |
| Articulated Container Vehicles: | 2.5m (W) x 4.6m (H) x 16m (L) |
| Double Deck Buses: | 2.5m (W) x 4.6m (H) x 12m (L) |
| Light Bus (Coach): | 2.0m (W) x 3.0m (H) x 6.5m (L) |

Assumed Motor Cycle Size: 0.8m (W) x 1.2m (H) x 2.0m (L)

Based on these figures, the nominal sectional area and length of vehicles in the tunnel are calculated as below:

Nominal sectional area

$$= \frac{32\times0.8\times1.2 + (203+139)\times1.7\times1.5 + (98+80)\times2.1\times1.6 + 94\times2.5\times4.0 + (22+1+269)\times2.5\times4.6 + 21\times2.0\times3.0}{959}$$

$= 6.18\ m^2$

Nominal length

$$= \frac{32\times2 + (203+139)\times4.6 + (98+80)\times5.2 + 94\times11 + (22+1)\times16 + 269\times12 + 21\times6.5}{959}$$

$= 7.64$ m

Equivalent vehicle sectional area for each direction, assuming two lanes per direction:

$A_v = 2 \times 6.18 = 12.36\ m^2$

Equivalent diameter of vehicle, $d_v$

$$d_v = \sqrt{\frac{4A_v}{\pi}} = \sqrt{\frac{4 \times 12.36}{\pi}} = 3.97\,m$$

For normal traffic condition, traffic density per two lanes

$N = 959/3600 = 0.266$ veh/s

Since $N = 2v/l$

Head to head distance of vehicles on a lane,

$l = (2 \times 25 \times 1000/3600) / 0.266$
$= 52.14$ m

where v = average vehicle speed = 25 kph

During traffic congestion, head to head distance of vehicles on a lane, l

$l$ = nominal length of vehicle + $l'$ m

so $l' = 52.14 - 7.64 = 44.49$ m

3. **Tunnel Parameters**

Tunnel length, $L = 350$ m
Tunnel size, $A_T = 22(10)$
$= 220\ m^2$

Equivalent diameter of the tunnel, $d_T$

$$d_T = \sqrt{\frac{4A_T}{\pi}} = \sqrt{\frac{4 \times 220}{\pi}} = 16.74\,m$$

Effective length, $L_e$ $= L + 3d_T$
$= 350 + 3 \times 16.74 = 400.22$ m

4. **Diffusion Parameters**

I. Traffic Congestion

Since $l/d_T = 52.14/16.74 = 3.12$

According to Fig. 16 in Ref. 2,

$D/N\ d_T^2 R_e^{0.13} = 0.32$

where $R_e$ = Reynolds number = $v \cdot d_t/\tau$
= $(25 \times 10^3 \times 3.97)/(3600 \times 1.56 \times 10^{-5}) = 1.767 \times 10^6$

where $\tau$ = kinetic viscosity = $15.6 \times 10^{-6}$ at 20 °C (Ref. 4)

Then $D = 0.32 \times 0.266 \times 16.74^2 \times (1.767 \times 10^6)^{0.13} = 154.92\ m^2/s$

5. **Maximum Concentration Calculation**

According to Ohashi & Koso's theory, the maximum concentration in a tunnel of a given length is given by :

$$C_{max} = \frac{wL_e^2}{8DA_T}$$

where $C_{max}$ = maximum volumetric concentration of pollutant, $\mu g/m^3$
$w$ = emission of the pollutant per unit length, g/s-m
$L_e$ = effective length of tunnel = $L + L_a$, m
$D$ = longitudinal diffusion coefficient, $m^2/s$
$A_T$ = cross-sectional area of tunnel, $m^2$
$L$ = the physical length of tunnel, m
$L_a$ = additional tunnel length, m

The additional length is a measure of the diffusive transport of pollutants at the portal and is given by:

$L_a = 3 \times d_T$

where $d_T$ = equivalent diameter of the tunnel, $m^2$

Then $[NO_2]_{max}$ $= 0.000208 \times (400.21)^2 / (8 \times 154.92 \times 220)$
$= 122.1\ \mu g/m^3$

and $[CO]_{max}$ $= 0.002735 \times (400.21)^2 / (8 \times 154.92 \times 220)$
$= 1607\ \mu g/m^3$

# APPENDIX C

## Sample Output for Operational

## Phase Air Quality Assessment

## for

## Traffic on Flyover

IBM-PC VERSION 1.20
(C) COPYRIGHT 1987 , TRINITY CONSULTANTS, INC.
SERIAL NUMBER 5540
SOLD TO HONG KONG POLYTECHNIC
RUN BEGAN ON 02-14-97 AT 20:02:23

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JULY 1985 VERSION
PAGE 1

JOB: Wong Chuk Hang Flyover - Flyover 2011
RUN: 11-RSP-ASR (WORST CASE ANGLE)
POLLUTANT: Particulates - RSP
(NOTE: OUTPUT IN MICRO-GRAMS/METER**3. IGNORE PPM LABEL)

I. SITE VARIABLES

| | | | |
|---|---|---|---|
| U= | 1.0 M/S | Z0= | 100. CM |
| BRG= | WORST CASE | VD= | .1 CM/S |
| CLAS= | 4 (D) | VS= | .7 CM/S |
| MIXH= | 500. M | AMB= | .0 PPM |
| SIGTH= | 18. DEGREES | TEMP= | 25.0 DEGREE (C) |

II. LINK VARIABLES

| LINK DESCRIPTION | LINK COORDINATES (M) X1 | Y1 | X2 | Y2 | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|
| A. S1 | -417 | 159 | -300 | 206 | AG | 1914 | .7 | -4.6 | 35.0 |
| B. S2 | -300 | 206 | -61 | 182 | AG | 1914 | .7 | -4.4 | 28.0 |
| C. S3 | -61 | 182 | 22 | 169 | AG | 1914 | .7 | -4.9 | 32.0 |
| D. S4 | 22 | 169 | 82 | 170 | BG | 3091 | .3 | -4.1 | 24.0 |
| E. S5 | 82 | 170 | 179 | 201 | BG | 3091 | .3 | 1.6 | 23.0 |
| F. S6 | 179 | 201 | 212 | 218 | BG | 3091 | .3 | 6.3 | 22.0 |
| G. S7 | 212 | 218 | 294 | 261 | BG | 3091 | .3 | 8.1 | 22.0 |
| H. S8 | 294 | 261 | 320 | 274 | BG | 3091 | .3 | 8.0 | 22.0 |
| I. S9 | 320 | 274 | 490 | 363 | BG | 3091 | .3 | 2.4 | 22.0 |
| J. 10 | 490 | 363 | 569 | 396 | AG | 1696 | .7 | -3.6 | 32.0 |
| K. 11 | 569 | 396 | 653 | 413 | AG | 1696 | .7 | -3.5 | 29.0 |
| L. 12 | 653 | 413 | 742 | 410 | AG | 1696 | .7 | -2.0 | 33.0 |

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JULY 1985 VERSION
PAGE 2

JOB: Wong Chuk Hang Flyover - Flyover 2011
RUN: 11-RSP-ASR (WORST CASE ANGLE)
POLLUTANT: Particulates - RSP
(NOTE: OUTPUT IN MICRO-GRAMS/METER**3. IGNORE PPM LABEL)

III. RECEPTOR LOCATIONS

| RECEPTOR | * | COORDINATES (M) X | Y | Z |
|---|---|---|---|---|
| 1. A | * | 9 | 186 | 7.1 |
| 2. B | * | 117 | 192 | 13.6 |
| 3. C | * | 187 | 221 | 18.3 |
| 4. D | * | 257 | 262 | 20.1 |
| 5. E | * | 323 | 294 | 14.4 |
| 6. F | * | 403 | 335 | 14.4 |
| 7. G | * | 483 | 377 | 14.4 |
| 8. H | * | 8 | 155 | 7.1 |
| 9. I | * | 79 | 154 | 7.9 |
| 10. J | * | 142 | 165 | 13.6 |
| 11. K | * | 224 | 204 | 20.1 |
| 12. L | * | 320 | 258 | 20.0 |
| 13. M | * | 404 | 301 | 14.4 |
| 14. N | * | 503 | 345 | 8.5 |

IV. MODEL RESULTS (WORST CASE WIND ANGLE)

| RECEPTOR | BRG (DEG) | PRED CONC (PPM) | CONC/LINK (PPM) A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. A | 268. | 106.6 | 3.3 | 45.8 | 57.4 | .0 | .0 | .0 | .0 | .0 |
| 2. B | 69. | 23.8 | .0 | .0 | .0 | .0 | 1.9 | 3.6 | 6.1 | 1.3 |
| 3. C | 68. | 22.3 | .0 | .0 | .0 | .0 | .0 | .0 | 6.5 | 1.8 |
| 4. D | 69. | 19.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | 1.3 |
| 5. E | 70. | 25.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 6. F | 72. | 29.7 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 7. G | 80. | 44.6 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 8. H | 289. | 89.1 | 1.2 | 31.5 | 56.4 | .0 | .0 | .0 | .0 | .0 |
| 9. I | 281. | 82.7 | 2.1 | 27.0 | 32.9 | 20.7 | .0 | .0 | .0 | .0 |
| 10. J | 274. | 53.5 | 2.2 | 19.0 | 16.0 | 13.7 | 2.6 | .0 | .0 | .0 |
| 11. K | 58. | 16.4 | .0 | .0 | .0 | .0 | .0 | .0 | 2.8 | 1.7 |
| 12. L | 256. | 18.1 | .9 | 3.2 | 2.1 | 1.2 | 3.2 | 1.7 | 5.8 | .0 |
| 13. M | 252. | 22.6 | .6 | 2.4 | 1.7 | 1.0 | 2.5 | 1.2 | 5.0 | 2.7 |
| 14. N | 49. | 34.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JULY 1985 VERSION
PAGE 3

JOB: Wong Chuk Hang Flyover - Flyover 2011
RUN: 11-RSP-ASR (WORST CASE ANGLE)
POLLUTANT: Particulates - RSP
(NOTE: OUTPUT IN MICRO-GRAMS/METER**3. IGNORE PPM LABEL)

IV. MODEL RESULTS (WORST CASE WIND ANGLE) (CONT.)

| RECEPTOR | CONC/LINK (PPM) I | J | K | L |
|---|---|---|---|---|
| 1. A | .0 | .0 | .0 | .0 |
| 2. B | 4.8 | 3.4 | 1.3 | 1.4 |
| 3. C | 6.5 | 4.2 | 1.6 | 1.6 |
| 4. D | 8.6 | 5.6 | 2.0 | 1.9 |
| 5. E | 11.7 | 8.7 | 2.8 | 2.5 |
| 6. F | 5.7 | 16.3 | 4.3 | 3.3 |
| 7. G | .0 | 23.1 | 16.2 | 5.3 |
| 8. H | .0 | .0 | .0 | .0 |
| 9. I | .0 | .0 | .0 | .0 |
| 10. J | .0 | .0 | .0 | .0 |
| 11. K | 7.0 | 2.2 | 1.5 | 1.1 |
| 12. L | .0 | .0 | .0 | .0 |
| 13. M | 5.5 | .0 | .0 | .0 |
| 14. N | .0 | 25.9 | 7.1 | 1.2 |

```
CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
         JULY 1985 VERSION
         PAGE   1

     JOB: Wong Chuk Hang Flyover - Flyover 2011
     RUN: 11-NO2-ASR          (WORST CASE ANGLE)
POLLUTANT: Nitorogen Dioxides - NO2
```

I. SITE VARIABLES

```
   U=   1.0  M/S              Z0= 100. CM
 BRG= WORST CASE              VD=    .0 CM/S
CLAS=     4  (D)              VS=    .0 CM/S
MIXH=  500.  M               AMB=    .0 PPM
SIGTH=  18.  DEGREES        TEMP= 25.0 DEGREE (C)
```

II. LINK VARIABLES

| LINK DESCRIPTION | X1 | Y1 | X2 | Y2 | TYPE | VPH | EF (G/MI) | H (M) | W (M) |
|---|---|---|---|---|---|---|---|---|---|
| A. S1 | -417 | 159 | -300 | 206 | AG | 1914 | 628.2 | -4.6 | 35.0 |
| B. S2 | -300 | 206 | -61 | 182 | AG | 1914 | 628.2 | -4.4 | 28.0 |
| C. S3 | -61 | 182 | 22 | 169 | AG | 1914 | 628.2 | -4.9 | 32.0 |
| D. S4 | 22 | 169 | 82 | 170 | BG | 3091 | 300.3 | -4.1 | 24.0 |
| E. S5 | 82 | 170 | 179 | 201 | BG | 3091 | 300.3 | 1.6 | 23.0 |
| F. S6 | 179 | 201 | 212 | 218 | BG | 3091 | 300.3 | 6.3 | 22.0 |
| G. S7 | 212 | 218 | 294 | 261 | BG | 3091 | 300.3 | 8.1 | 22.0 |
| H. S8 | 294 | 261 | 320 | 274 | BG | 3091 | 300.3 | 8.0 | 22.0 |
| I. S9 | 320 | 274 | 490 | 363 | BG | 3091 | 300.3 | 2.4 | 22.0 |
| J. 10 | 490 | 363 | 569 | 396 | AG | 1696 | 696.9 | -3.6 | 32.0 |
| K. 11 | 569 | 396 | 653 | 413 | AG | 1696 | 696.9 | -3.5 | 29.0 |
| L. 12 | 653 | 413 | 742 | 410 | AG | 1696 | 696.9 | -2.0 | 33.0 |

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JULY 1985 VERSION
PAGE 2

JOB: Wong Chuk Hang Flyover - Flyover 2011
RUN: 11-NO2-ASR (WORST CASE ANGLE)
POLLUTANT: Nitorogen Dioxides - NO2

III. RECEPTOR LOCATIONS

| RECEPTOR | COORDINATES (M) X | Y | Z |
|---|---|---|---|
| 1. A | 9 | 186 | 7.1 |
| 2. B | 117 | 192 | 13.6 |
| 3. C | 187 | 221 | 18.3 |
| 4. D | 257 | 262 | 20.1 |
| 5. E | 323 | 294 | 14.4 |
| 6. F | 403 | 335 | 14.4 |
| 7. G | 483 | 377 | 14.4 |
| 8. H | 8 | 155 | 7.1 |
| 9. I | 79 | 154 | 7.9 |
| 10. J | 142 | 165 | 13.6 |
| 11. K | 224 | 204 | 20.1 |
| 12. L | 320 | 258 | 20.0 |
| 13. M | 404 | 301 | 14.4 |
| 14. N | 503 | 345 | 8.5 |

IV. MODEL RESULTS (WORST CASE WIND ANGLE)

| RECEPTOR | BRG (DEG) | PRED CONC (PPM) | CONC/LINK (PPM) A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. A | 266. | 50.8 | 1.5 | 20.8 | 28.5 | .0 | .0 | .0 | .0 | .0 |
| 2. B | 70. | 12.6 | .0 | .0 | .0 | .0 | 1.2 | 2.1 | 3.3 | .7 |
| 3. C | 68. | 11.9 | .0 | .0 | .0 | .0 | .0 | .0 | 3.7 | 1.0 |
| 4. D | 69. | 10.3 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .7 |
| 5. E | 70. | 13.4 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 6. F | 72. | 15.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 7. G | 80. | 22.8 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |
| 8. H | 289. | 42.6 | .6 | 14.9 | 27.1 | .0 | .0 | .0 | .0 | .0 |
| 9. I | 281. | 40.6 | 1.0 | 12.7 | 15.7 | 11.3 | .0 | .0 | .0 | .0 |
| 10. J | 274. | 26.6 | 1.0 | 9.0 | 7.7 | 7.5 | 1.5 | .0 | .0 | .0 |
| 11. K | 58. | 8.8 | .0 | .0 | .0 | .0 | .0 | .0 | 1.6 | 1.0 |
| 12. L | 256. | 9.6 | .4 | 1.5 | 1.0 | .6 | 1.7 | .9 | 3.3 | .0 |
| 13. M | 252. | 12.0 | .3 | 1.1 | .8 | .5 | 1.3 | .7 | 2.7 | 1.5 |
| 14. N | 49. | 17.2 | .0 | .0 | .0 | .0 | .0 | .0 | .0 | .0 |

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JULY 1985 VERSION
PAGE 3

JOB: Wong Chuk Hang Flyover - Flyover 2011
RUN: 11-NO2-ASR (WORST CASE ANGLE)
POLLUTANT: Nitorogen Dioxides - NO2

IV. MODEL RESULTS (WORST CASE WIND ANGLE) (CONT.)

| RECEPTOR | CONC/LINK (PPM) I | J | K | L |
|---|---|---|---|---|
| 1. A | .0 | .0 | .0 | .0 |
| 2. B | 2.5 | 1.6 | .6 | .7 |
| 3. C | 3.5 | 2.1 | .8 | .8 |
| 4. D | 4.8 | 2.8 | 1.0 | .9 |
| 5. E | 6.5 | 4.3 | 1.4 | 1.2 |
| 6. F | 3.2 | 8.2 | 2.1 | 1.7 |
| 7. G | .0 | 11.9 | 8.2 | 2.7 |
| 8. H | .0 | .0 | .0 | .0 |
| 9. I | .0 | .0 | .0 | .0 |
| 10. J | .0 | .0 | .0 | .0 |
| 11. K | 3.9 | 1.1 | .8 | .5 |
| 12. L | .0 | .0 | .0 | .0 |
| 13. M | 3.1 | .0 | .0 | .0 |
| 14. N | .0 | 13.1 | 3.5 | .6 |

# APPENDIX D

## Recommended Pollution Control Clauses

# APPENDIX D RECOMMENDED POLLUTION CONTROL CONDITIONS FOR CONSTRUCTION CONTRACTS

## 1. AVOIDANCE OF NUISANCE

(a) All works are to be carried out in such a manner as to cause as little inconvenience as possible to nearby residents, property and to the public in general, and the Contractor shall be held responsible for any claims which may arise from such inconvenience.

(b) The Contractor shall be responsible for the adequate maintenance and clearance of channels, gullies, etc., and shall also provide and maintain such pedestrian and vehicular access as shall be directed within the works site.

(c) Water shall be used to prevent dust rising and the Contractor shall take every precaution to prevent the excavated materials from entering into the public drainage system.

(d) The Contractor shall carry out the Works in such a manner as to minimize adverse impacts on the environment during execution of the Works.

## 2. NOISE POLLUTION CONTROL

(a) The Contractor shall comply with and observe the Noise Control Ordinance and its subsidiary regulations in force in Hong Kong.

(b) The Contractor shall provide an approved integrating sound level meter to IEC 651:1979 (Type 1) and 804:1985 (Type 1) and THE manufacturer's recommended sound level calibrator for the exclusive use of the Engineer at all times. The Contractor shall maintain the equipment in proper working order and provide a substitute when the equipment are out of order or otherwise not available.

The sound level meter including the sound level calibrator shall be verified by the manufactures every two years to ensure they perform the same levels of accuracies as stated in the manufacturer's specifications. That is to say at the times of measurements, the equipment shall have been verified within the last two years.

(c) In addition to the requirements imposed by the Noise Control Ordinance, to control noise generated from equipment and activities for the purpose of carrying out any construction work other than percussive piling during the time period from 07:00 to 19:00 hours on any day not being a general holiday (including Sundays), the following requirements shall also be complied with:

(i) The noise level measured at 1 m from the most affected external facade of the nearby noise sensitive receivers from the construction work alone during any 30 minute period shall not exceed an equivalent sound level ($L_{eq}$) of 75 dB(A).

(ii) The noise level measured at 1 m from the most affected external facade of the nearby schools from the construction work alone during any 30 minute period shall not exceed an equivalent sound level ($L_{eq}$) of 70 dB(A) [65 dB(A) during school examination periods].

The Contractor shall liaise with the schools and the Examination Authority to ascertain the exact dates and times of all examination periods during the course of the contract.

(iii) Should the limits stated in the above sub-clauses (i) and (ii) be exceeded, the construction shall stop and shall not recommence until appropriate measures acceptable to the Engineer that are necessary for compliance have been implemented.

Any stoppage or reduction in output resulting from compliance with this clause shall not entitle the Contractor to any extension of time for completion or to any additional costs whatsoever.

(d) Before the commencement of any work, the Engineer may require the methods of working, equipment and sound-reducing intended to be used on the Site to be made available for inspection and approval to ensure that they are suitable for the project.

(e) The Contractor shall devise, arrange methods of working and carry out the Works in such a manner so as to minimise noise impacts on the surrounding environment, and shall provide experienced personnel with suitable training to ensure that these methods are implemented.

The noise reduction methods shall include, but not be limited to, scheduling of works; Siting of facilities; selection of quiet equipment; and use of purpose-built acoustic panels and enclosures.

(f) The Contractor shall ensure that all plant and equipment to be used on site are properly maintained in good operating condition and noisy construction activities shall be effectively sound-reduced by means of silencers, mufflers, acoustic linings or shields, acoustic sheds or screens or other means to avoid disturbance to any nearby noise sensitive receivers.

(g) Notwithstanding the requirements and limitations set out in clause (c) above and subject to compliance with clauses (e) and (f) above, the Engineer may, upon application in writing by the Contractor, allow the use of any equipment and the carrying out of any construction activities for any duration provided that he is satisfied with the application which, in his opinion, to be of absolute necessity and adequate noise insulation has been provided to the educational institutions to be affected, or of emergency nature, and not in contravention with the Noise Control Ordinance in any respect.

(h) No excavator mounted breaker shall be used within 125 m from any nearby noise sensitive receivers. The Contractor shall use hydraulic concrete crusher wherever applicable.

(i) The only equipment that shall be allowed on the Site for rock drilling works will be quiet drilling rigs with a sound power level not exceeding 110 dB(A). Conventional pneumatically driven drilling rigs are specifically prohibited.

(j) For the purposes of the above clauses, any domestic premises, hotel, hostel, temporary housing accommodation, hospital, medical clinic, educational institution, place of public worship, library, court of law, or performing arts centre or office building shall be considered a noise sensitive receiver.

(k) The Contractor shall, when necessary, apply as soon as possible for a construction noise permit in accordance with the Noise Control (General) Regulations, display the permit as required and copy to the Engineer.

3. DUST SUPPRESSION MEASURES

(a) The Contractor shall undertake at all times to prevent dust nuisance as a result of his activities. The air pollution control system installed shall be operated whenever the plant is in operation.

(b) The Contractor shall at his own cost, and to the satisfaction of the Engineer, install effective dust suppression equipment and take such other measures as may be necessary to ensure that at the Site boundary and any nearby sensitive receiver the concentration of air-borne dust shall not exceed 0.5 milligrams per cubic meter, at standard temperature (25°C) and pressure (1.0 bar) averaged over one hour, and 0.26 milligrams per cubic metre, at standard temperature (25°C) and pressure (1.0 bar) averaged over 24 hours.

(c) In the process of material handling other than cement and the like, any material which has the potential to create dust shall be treated with water or spraying with wetting agent.

(d) Where dusty materials are being discharged to a vehicle from a conveying system at a fixed transfer point, a three-sided roofed enclosure with a flexible curtain across the entry shall be provided. Exhaust should be provided for this enclosure and vented to a fabric filter system.

(e) Any vehicle with an open load carrying area used for moving materials which have the potential to create dust shall have properly fitting side and tail boards. Materials having the potential to create dust shall not be loaded to a level higher than the side and tail boards, and shall be covered by a clean tarpaulin. The tarpaulin shall be properly secured and shall extend at least 300 mm over the edges of the side and tail boards.

(f) Stockpiles of sand and aggregate greater than 20 $m^3$ shall be enclosed on three sides, with walls extending above the pile and 2 metres beyond the front of the pile. In addition, water sprays shall be provided and used, both to dampen stored materials and when receiving raw material.

(g) The Contractor shall frequently clean and water the site to minimize the fugitive dust emissions.

(h) The Contractor shall restrict all motorized vehicles to a maximum speed of 8 km per hour and confine haulage and delivery vehicles to designated roadways inside the site. Areas of roadway longer than 100 m where movement of motorized vehicles exceeds 100 vehicular movements per day, or as directed by the Engineer, shall be furnished with a flexible pavement surfacing.

(i) Wheel washing facilities shall be installed and used by all vehicles leaving the site.

No earth, mud, debris, dust and the like shall be deposited on public roads. Water in the wheel cleaning facility shall be changed at frequent intervals and sediments shall be removed regularly. The Contractor shall submit details of proposals for the wheel cleaning facilities to the Engineer prior to construction of the facility. Such wheel washing facility shall be usable prior to the commencement of any earthworks excavation activity on the Site. The Contractor shall also provide a hard-surfaced road between the washing facility and the public road.

(j) Conveyor belts shall be fitted with windboards, and conveyor transfer points and hopper discharge areas shall be enclosed to minimize emission of dust. All conveyors carrying materials which have the potential to create dust shall be totally enclosed and fitted with belt cleaners.

## 4. CONSENT TO EQUIPMENT AND PROCESSES

(a) The Contractor shall not install any furnace, boiler or other plant or equipment or use any fuel that might in any circumstance produce smoke or any other air pollution without the prior consent of the Engineer. Unless specifically instructed by the Engineer, the Contractor shall not light fires on site for the burning of debris or any other matter.

(b) The Contractor's attention is drawn to the Air Pollution Control Ordinance and its subsidiary legislation, particulary the Air Pollution (Furnaces, Ovens and Chimneys) (Installation and Alteration) Regulations and the Air Pollution Control (Smoke) Regulations.

## 5. REMOVAL OF WASTE MATERIAL

(a) The Contractor shall not permit any sewage, waste water or effluent containing sand, cement, silt or any other suspended or dissolved material to flow from the site onto any adjoining land or allow any waste matter or refuse to be deposited anywhere within the Site or onto any adjoining land and shall have all such matter removed from the Site.

(b) The Contractor shall be liable for any damages caused to adjoining land through his failure to comply with clause 5(a).

(c) The Contractor shall be responsible for temporary training, diverting or conducting of open streams or drains intercepted by any works and for reinstating these to their original courses on completion of the Works.

(d) The Contractor shall be responsible for adequately maintaining any existing site drainage system at all times, including removal of solids in sand traps, manholes and stream beds.

(e) Any proposed stream course and nullah temporary diversions shall be submitted to the Engineer for agreement one month prior to such diversion works being commenced. Diversions shall be constructed to allow the water flow to discharge without overflow, erosion or washout. The area through which the temporary diversion runs is to be reinstated to its original condition or as agreed by the Engineer after the permanent drainage system has been completed.

(f) The Contractor shall furnish, for the Engineer's information, particulars of the Contractor's arrangements for ensuring that material from any earthworks does not wash into the drainage system. If at any time such arrangements prove to be ineffective the Contractor shall take such additional measures as the Engineer shall deem necessary and shall remove all silt which may have accumulated in the drainage system whether within the Site or not.

(g) The Contractor shall segregate all inert construction waste material suitable for reclamation or land formation and shall dispose of such material at such public dumping area(s) as may be specified from time to time by the Director of Civil Engineering Services.

(h) All non-inert construction waste material deemed unsuitable for reclamation or land formation and all other waste material shall be disposed of at a public landfill.

(i) The Contractor's attention is drawn to the Waste Disposal Ordinance, the Public Health and Municipal Services Ordinance, and the Water Pollution Control Ordinance.

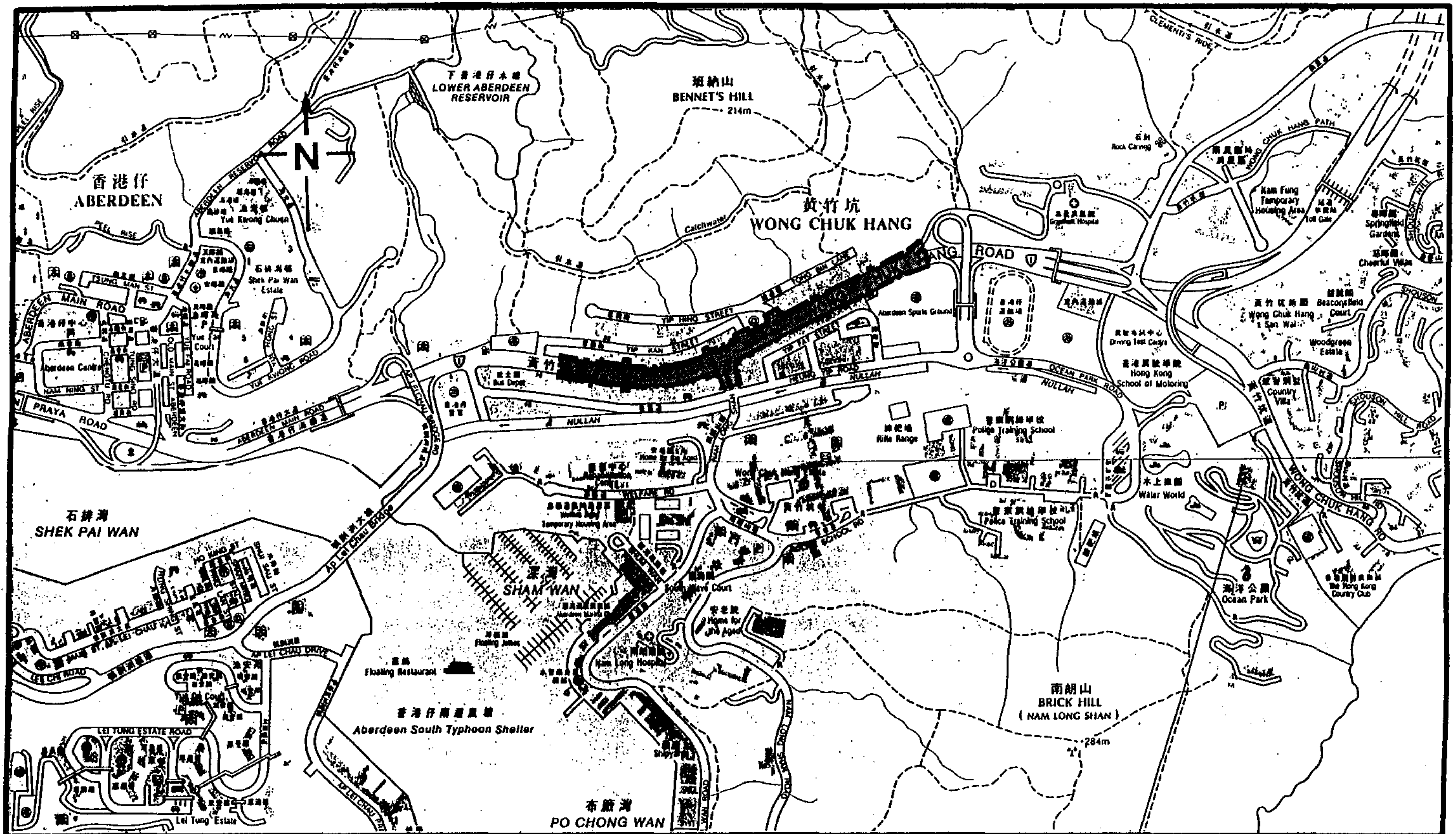
## 6. DISCHARGE INTO SEWERS AND DRAINS

(a) The Contractor shall not discharge directly or indirectly (by runoff) or cause or permit or suffer to be discharged into any public sewer, storm-water drain, channel, stream-course or sea any effluent or foul or contaminated water or cooling or hot water without the prior consent of the Engineer who may require the Contractor to provide, operate and maintain at the Contractor's own expense, within the premises or otherwise, suitable works for the treatment and disposal of such effluent or foul or contaminated or cooling or hot water. The design of such treatment works shall be submitted to the Engineer for approval not less than one month prior to the commencement of construction or as agreed by the Engineer.

(b) If any office, site canteen or toilet facilities are erected, foul water effluent shall be directed to a foul sewer or to a sewage treatment facility either directly or indirectly by means of pumping or other means approved by the Engineer.

(c) The Contractor's attention is drawn to the Buildings Ordinance and to the Water Pollution Control Ordinance.

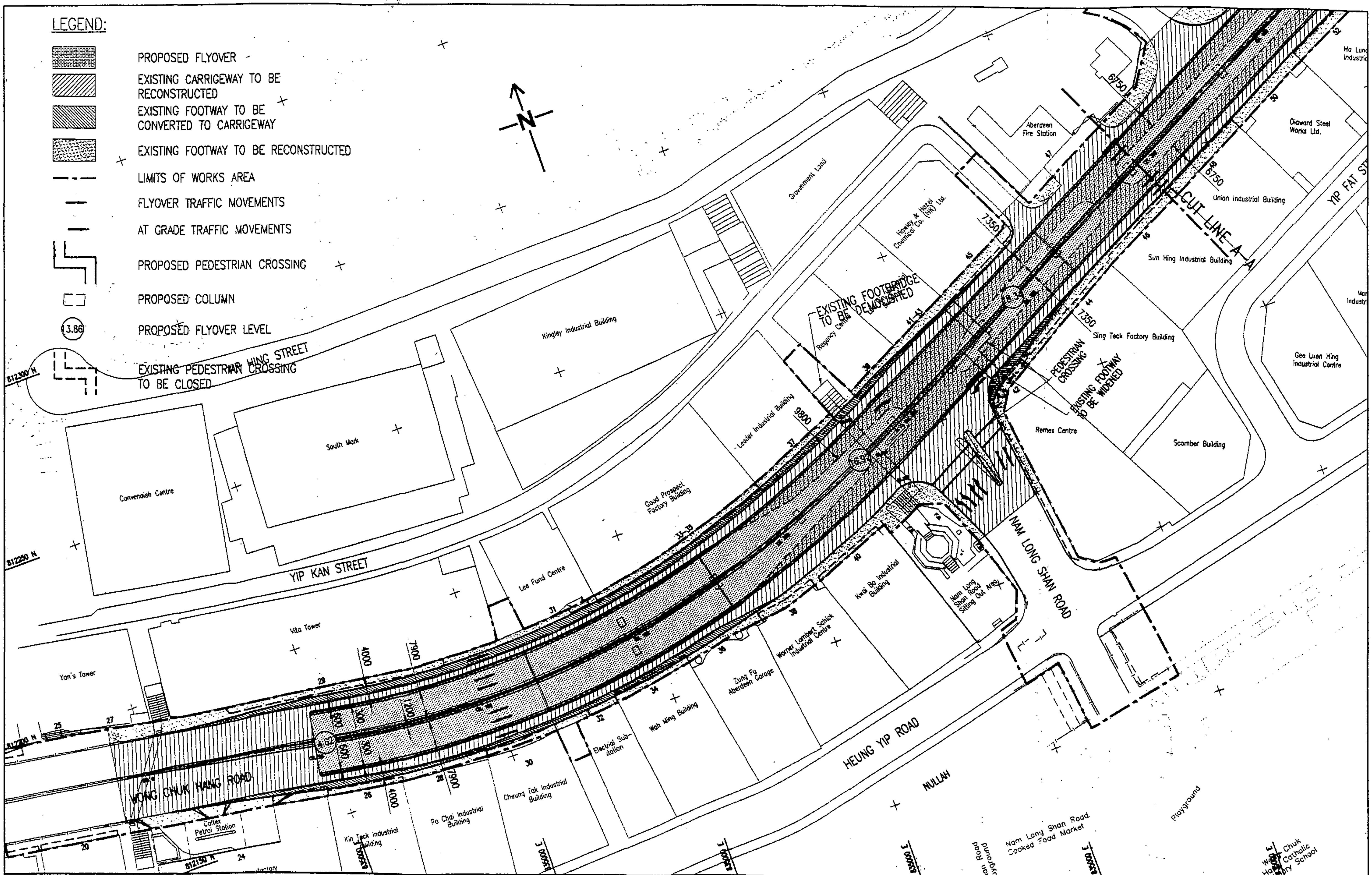
# FIGURES




# SITE LOCATION PLAN

FIGURE 2.1

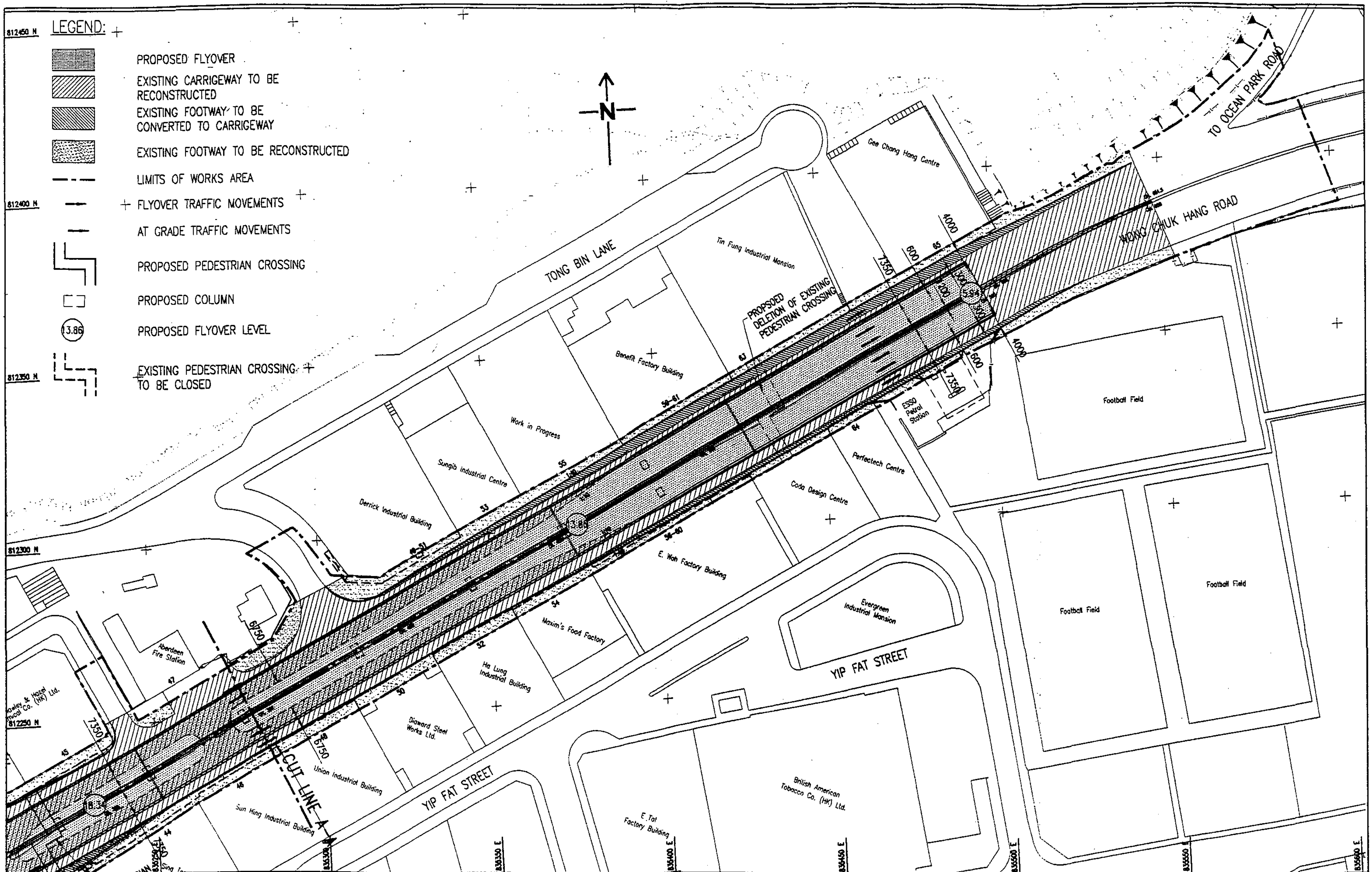
**Babtie BMT ( Hong Kong ) Ltd.**
**Consulting Engineers**




# LAYOUT OF PROPOSED WORKS (SHEET 1 OF 2)

**Figure 2.2**

**Babtie BMT (Hong Kong) Ltd.**
**Consulting Engineers**



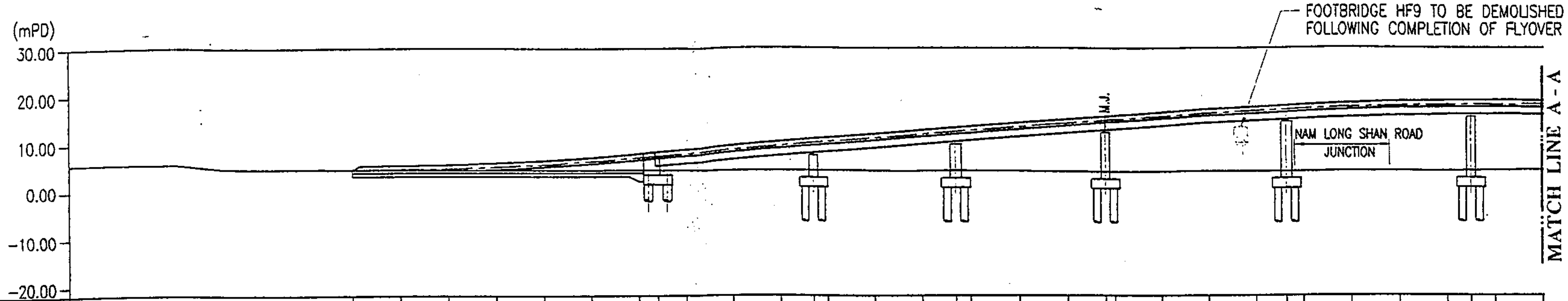

# LAYOUT OF PROPOSED WORKS (SHEET 2 OF 2)

**Figure 2.3**

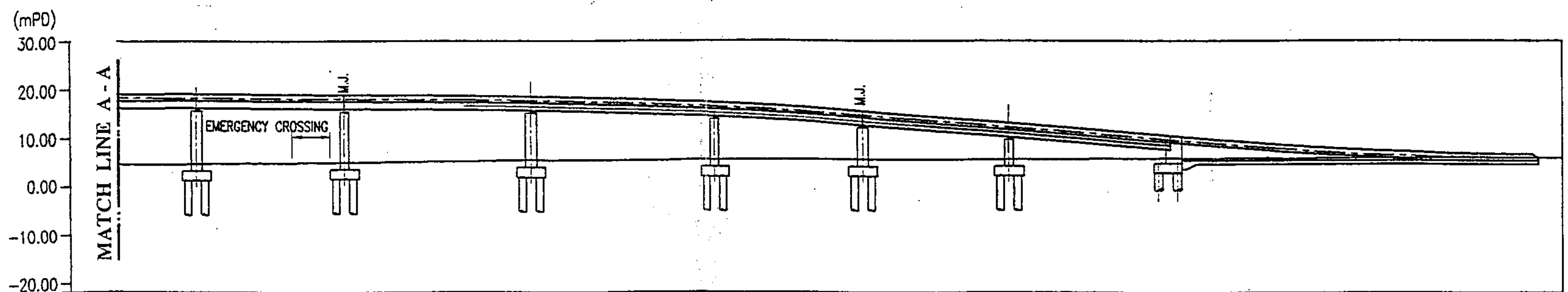
**Babtie BMT (Hong Kong) Ltd.**
**Consulting Engineers**

NOTES :

M.J. = MOVEMENT JOINT




| CHAINAGE | EXISTING ROAD LEVEL | PROPOSED FLYOVER LEVEL |
|---|---|---|
| 0.000 | 5.626 | |
| 10.000 | 5.626 | |
| 20.000 | 5.026 | |
| 30.000 | 4.736 | |
| 40.000 | 4.686 | |
| 50.000 | 4.617 | 4.621 |
| 55.585 | 4.638 | |
| 60.000 | 4.640 | 4.661 |
| 70.000 | 4.583 | 4.855 |
| 80.000 | 4.569 | 5.204 |
| 90.000 | 4.521 | 5.707 |
| 100.000 | 4.534 | 6.359 |
| 110.000 | 4.533 | 7.177 |
| 114.000 | 4.502 | 7.574 |
| 120.000 | 4.480 | 8.021 |
| 130.000 | 4.372 | 8.821 |
| 140.000 | 4.384 | 9.621 |
| 147.000 | 4.363 | 10.181 |
| 150.000 | 4.357 | 10.421 |
| 160.000 | 4.315 | 11.221 |
| 170.000 | 4.239 | 12.021 |
| 177.000 | 4.325 | 12.581 |
| 180.000 | 4.330 | 12.821 |
| 190.000 | 4.258 | 13.621 |
| 200.000 | 4.167 | 14.419 |
| 208.000 | 4.141 | 15.021 |
| 210.000 | 4.135 | 15.163 |
| 220.000 | 4.165 | 15.828 |
| 230.000 | 4.189 | 16.414 |
| 240.000 | 4.214 | 16.921 |
| 246.500 | 4.230 | 17.209 |
| 250.000 | 4.238 | 17.351 |
| 260.000 | 4.263 | 17.703 |
| 270.000 | 4.285 | 17.977 |
| 280.000 | 4.330 | 18.175 |
| 285.000 | 4.386 | 18.245 |
| 290.000 | 4.442 | 18.295 |
| 300.000 | 4.522 | 18.338 |




| CHAINAGE | EXISTING ROAD LEVEL | PROPOSED FLYOVER LEVEL |
|---|---|---|
| 300.000 | 4.522 | 18.338 |
| 310.000 | 4.585 | 18.305 |
| 316.000 | 4.632 | 18.265 |
| 320.000 | 4.669 | 18.238 |
| 330.000 | 4.771 | 18.175 |
| 340.000 | 4.854 | 18.104 |
| 347.000 | 4.907 | 18.057 |
| 350.000 | 4.939 | 18.037 |
| 360.000 | 5.044 | 17.970 |
| 370.000 | 5.147 | 17.903 |
| 380.000 | 5.277 | 17.809 |
| 385.500 | 5.332 | 17.725 |
| 390.000 | 5.335 | 17.639 |
| 400.000 | 5.389 | 17.392 |
| 410.000 | 5.427 | 17.067 |
| 420.000 | 5.447 | 16.665 |
| 424.000 | 5.461 | 16.483 |
| 430.000 | 5.483 | 16.186 |
| 440.000 | 5.514 | 15.628 |
| 450.000 | 5.530 | 14.991 |
| 455.000 | 5.552 | 14.6433 |
| 460.000 | 5.569 | 14.275 |
| 470.000 | 5.585 | 13.488 |
| 480.000 | 5.587 | 12.688 |
| 485.000 | 5.605 | 12.288 |
| 490.000 | 5.615 | 11.888 |
| 500.000 | 5.638 | 11.088 |
| 510.000 | 5.748 | 10.288 |
| 518.500 | 5.804 | 9.681 |
| 520.000 | 5.709 | 9.488 |
| 530.000 | 5.775 | 8.688 |
| 540.000 | 5.753 | 7.889 |
| 550.000 | 5.778 | 7.185 |
| 560.000 | 5.821 | 6.636 |
| 570.000 | 5.861 | 6.241 |
| 580.000 | 5.886 | 6.000 |
| 590.000 | 5.907 | 5.913 |
| 595.035 | 5.923 | 5.927 |
| 600.000 | 5.935 | |

# ELEVATION OF PROPOSED FLYOVER

SCALE 1:1000

Figure 2. 4

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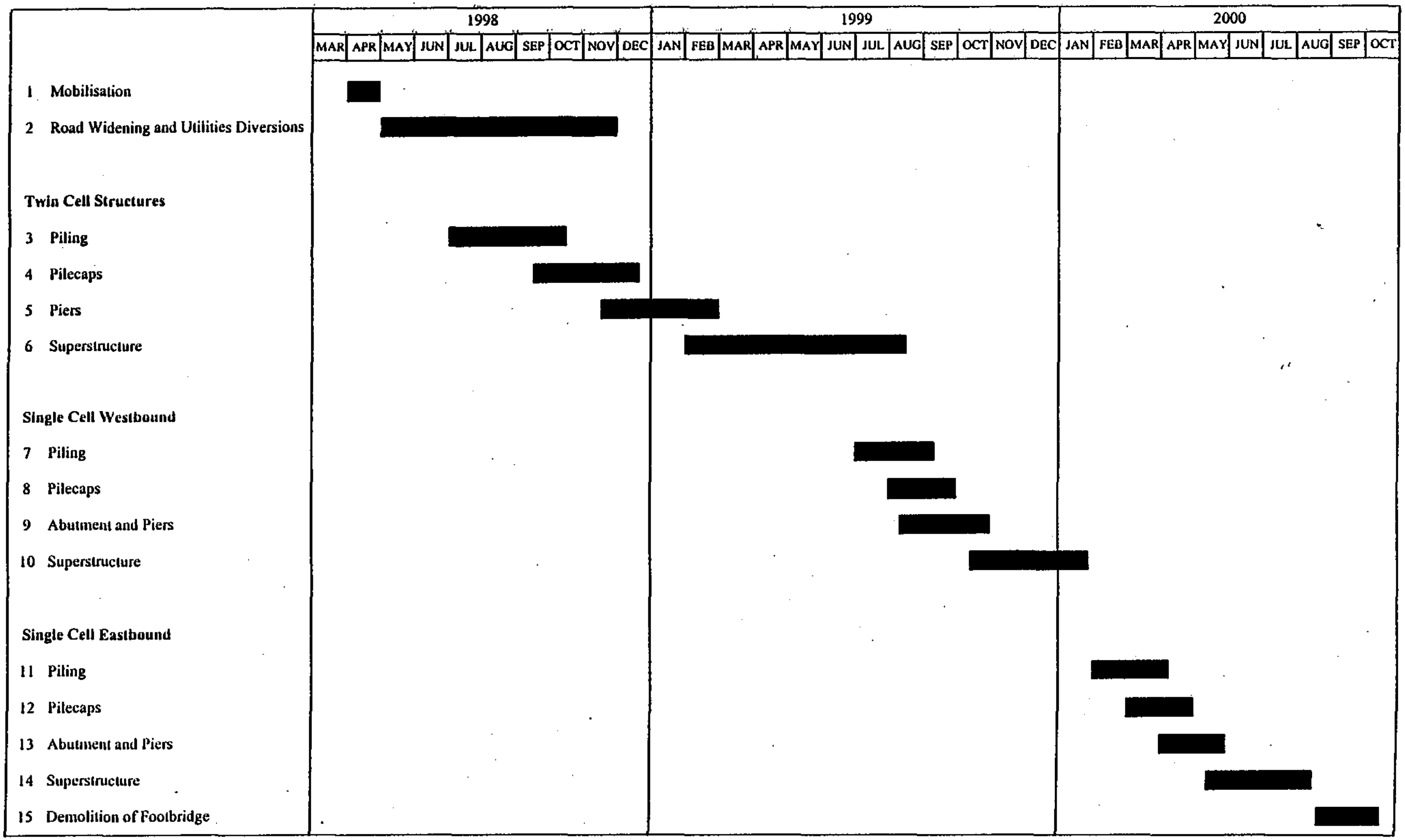
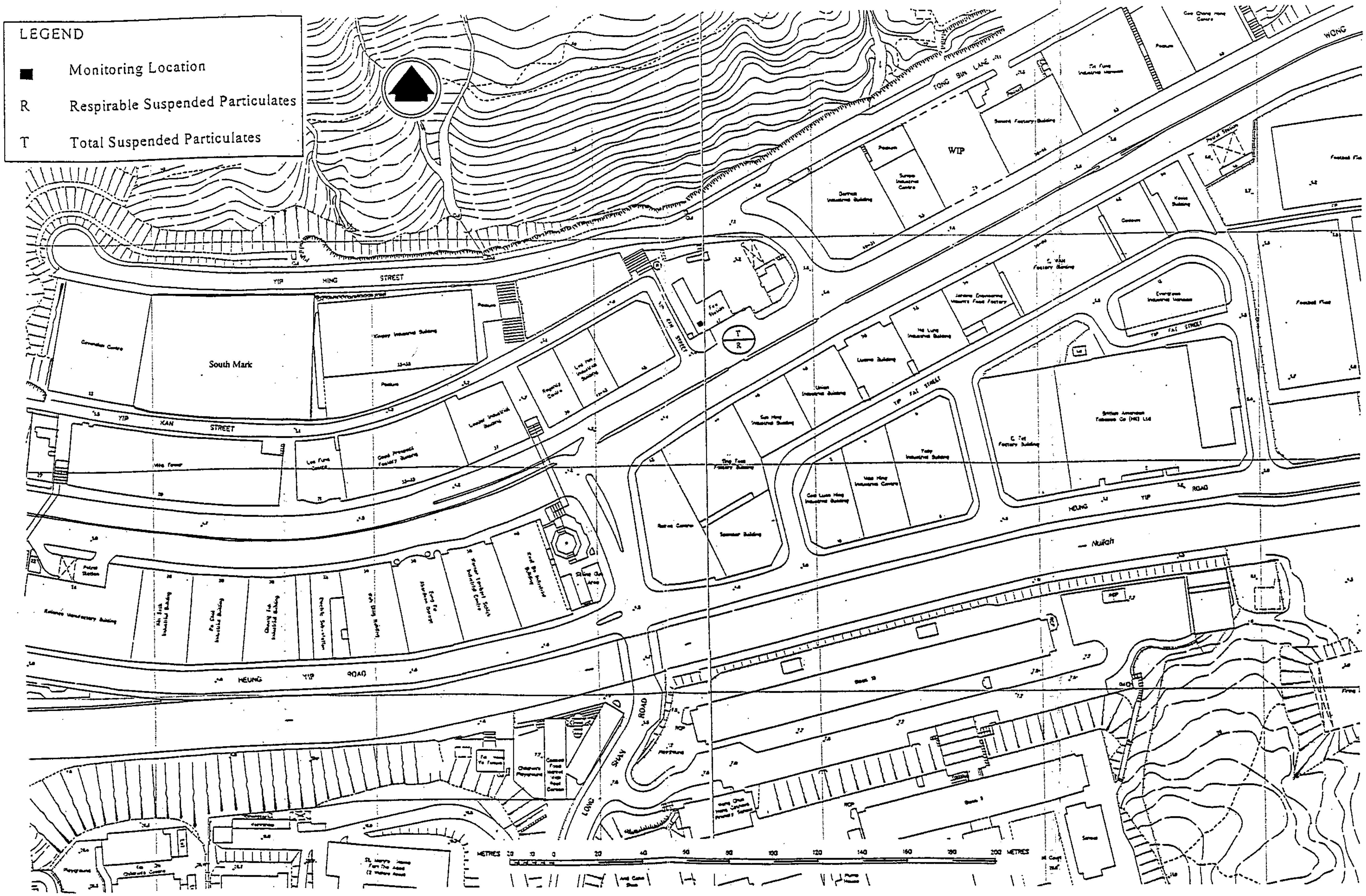
Consulting Engineers




PRELIMINARY CONSTRUCTION PROGRAMME

Figure 2.5

Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




LOCATION OF AIR MONITORING STATION

FIGURE 3.1

Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers

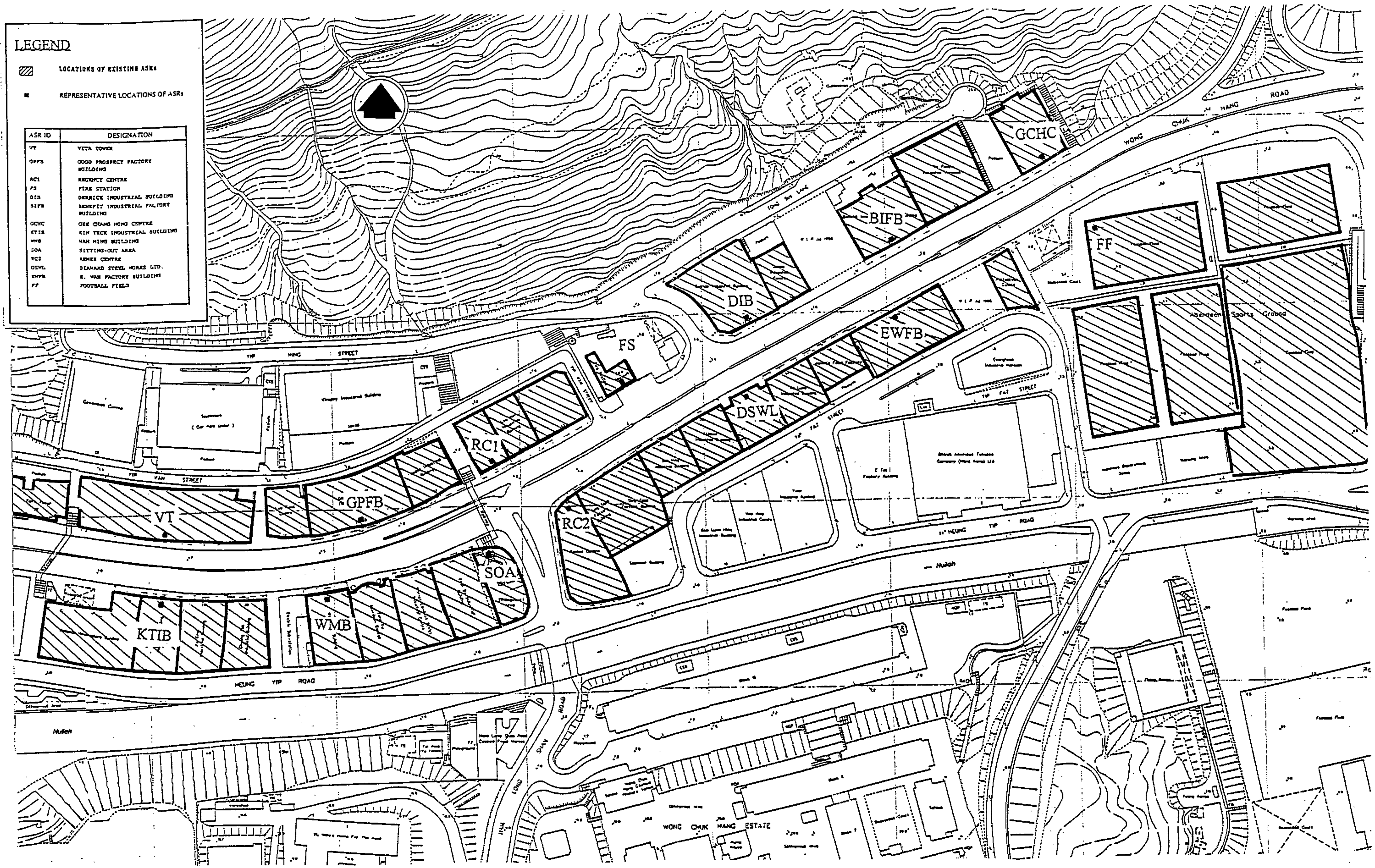
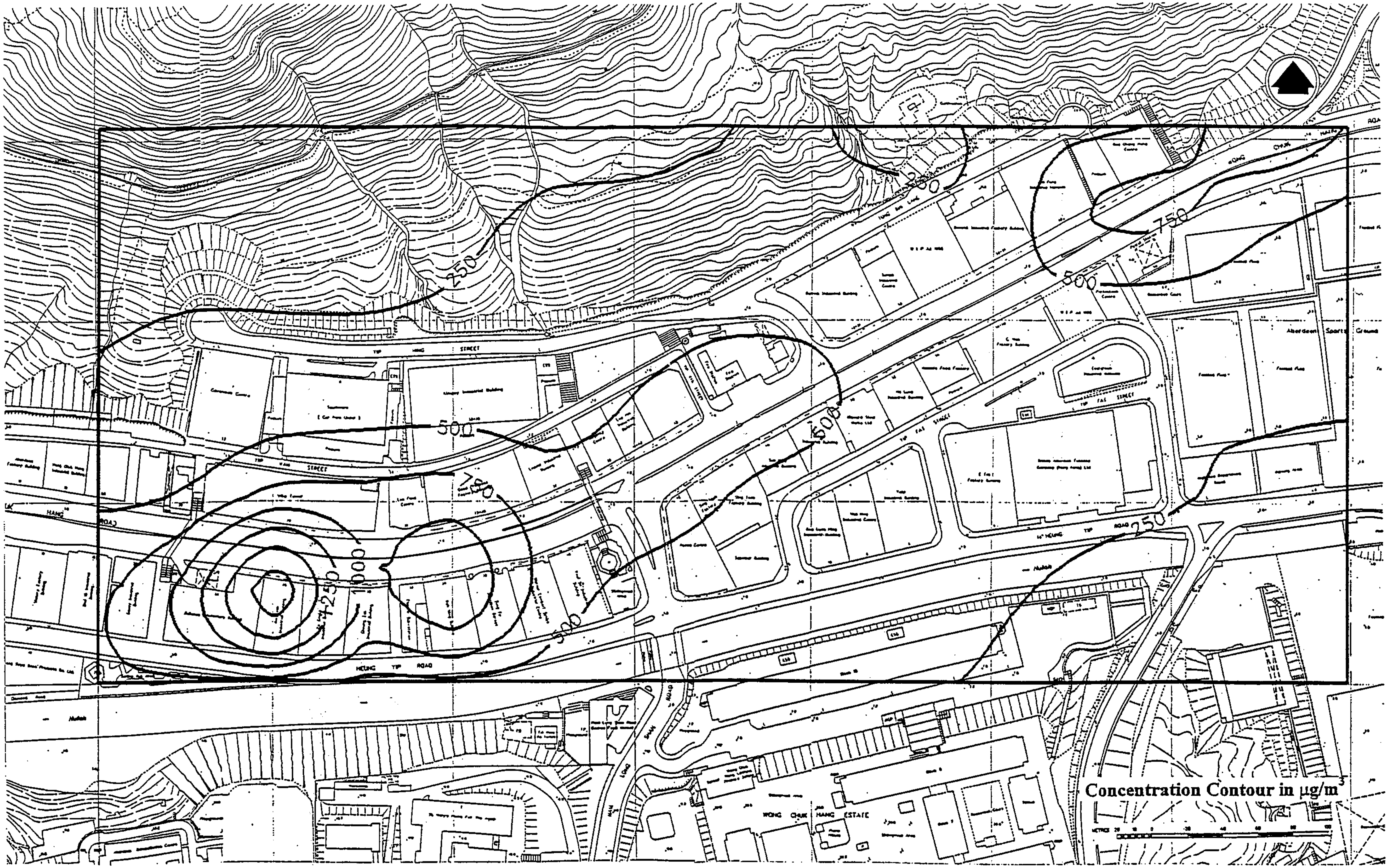



FIGURE 3.2

LOCATION OF EXISTING AIR SENSITIVE RECEIVER (ASRs)

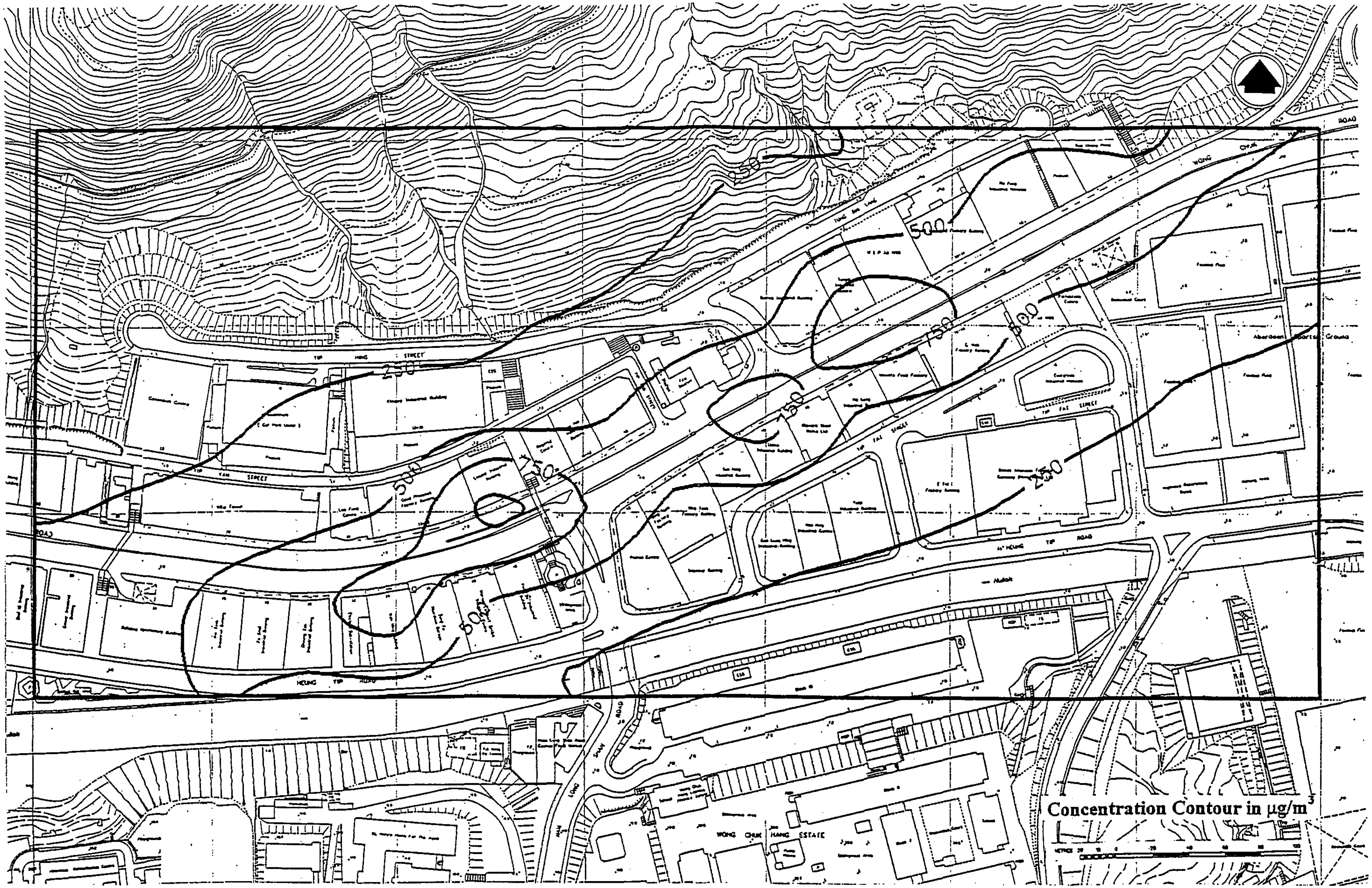
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF HOURLY AVERAGE TSP CONCENTRATIONS AT GROUND LEVEL (UNMITIGATED) DURING CONSTRUCTION

FIGURE 3.3

Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF HOURLY AVERAGE TSP CONCENTRATIONS AT 10 m ABOVE GROUND LEVEL (UNMITIGATED) DURING CONSTRUCTION

FIGURE 3.4

Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers

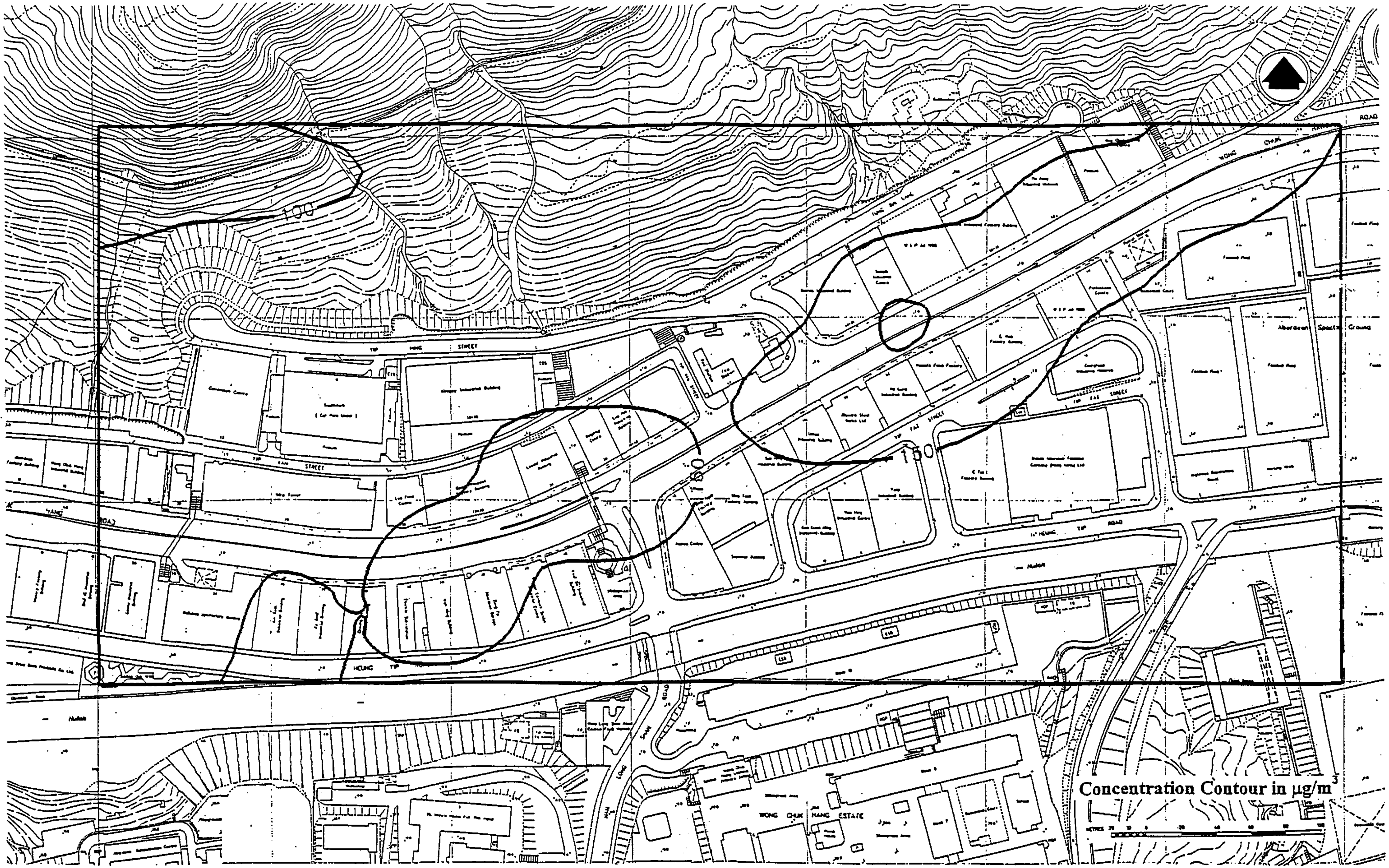
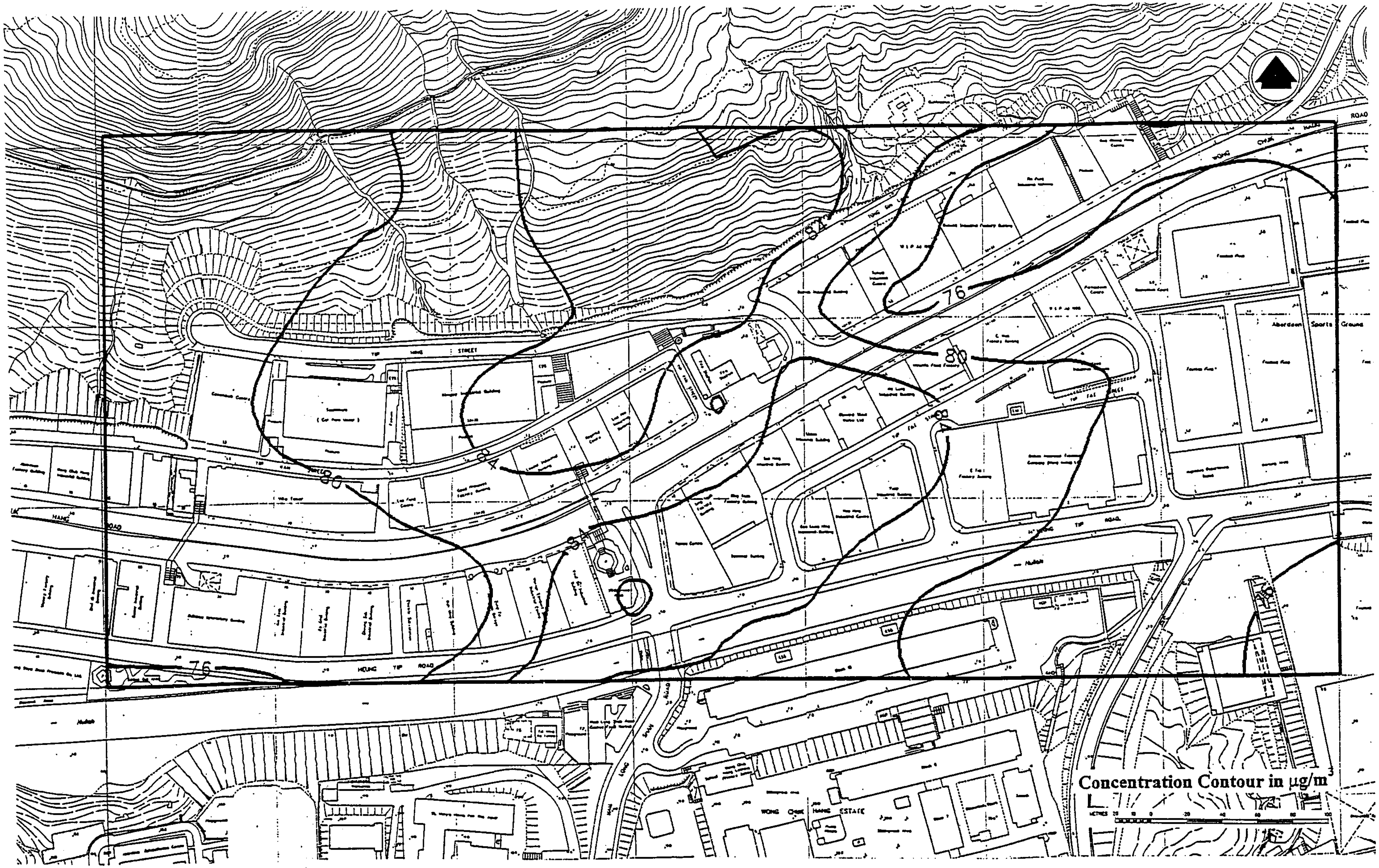



FIGURE 3.5

ISOPLETHS OF HOURLY AVERAGE TSP CONCENTRATIONS AT 20 m ABOVE GROUND LEVEL (UNMITIGATED) DURING CONSTRUCTION

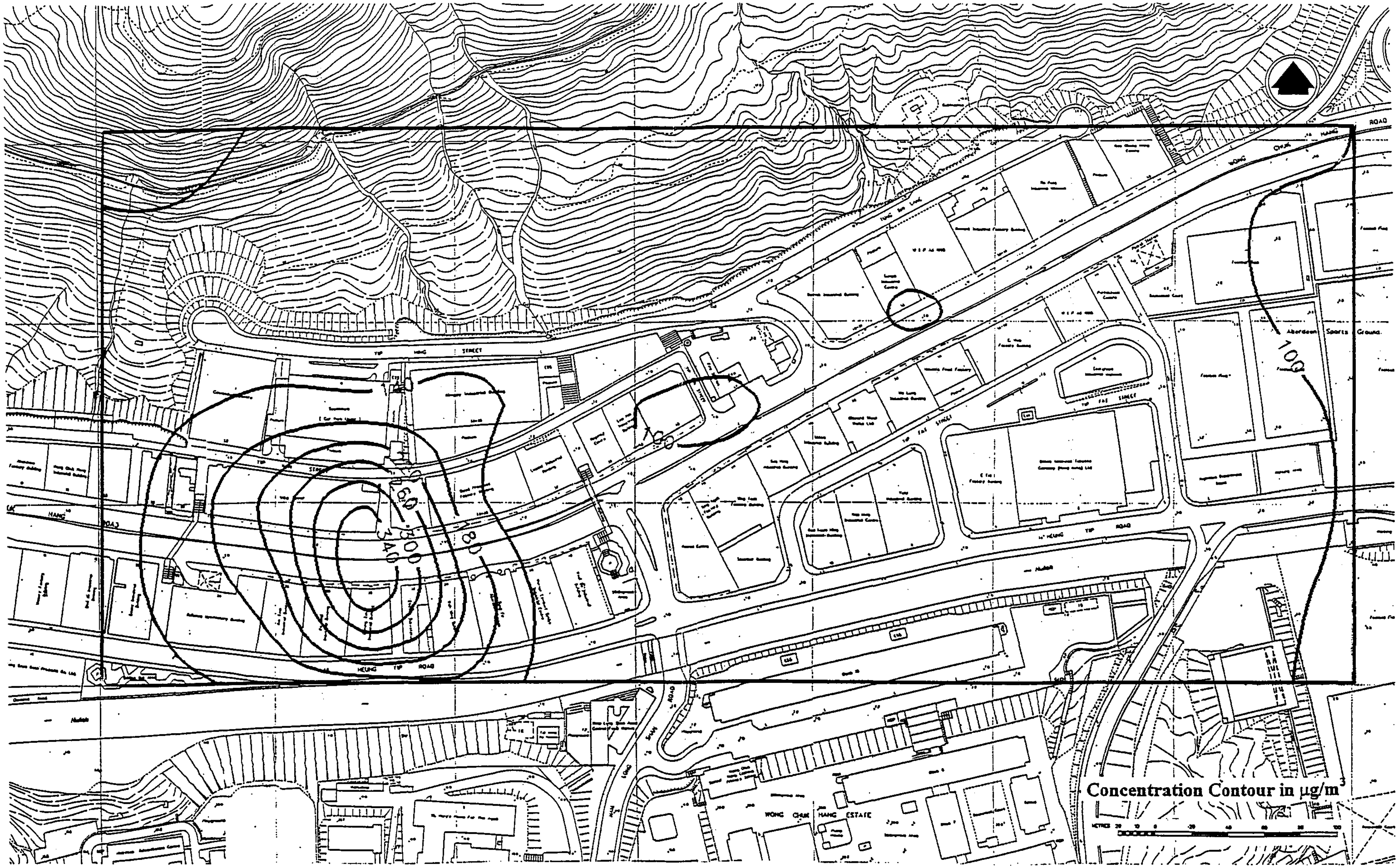
Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers




ISOPLETHS OF DAILY AVERAGE TSP CONCENTRATIONS AT GROUND LEVEL (UNMITIGATED) DURING CONSTRUCTION

FIGURE 3.6

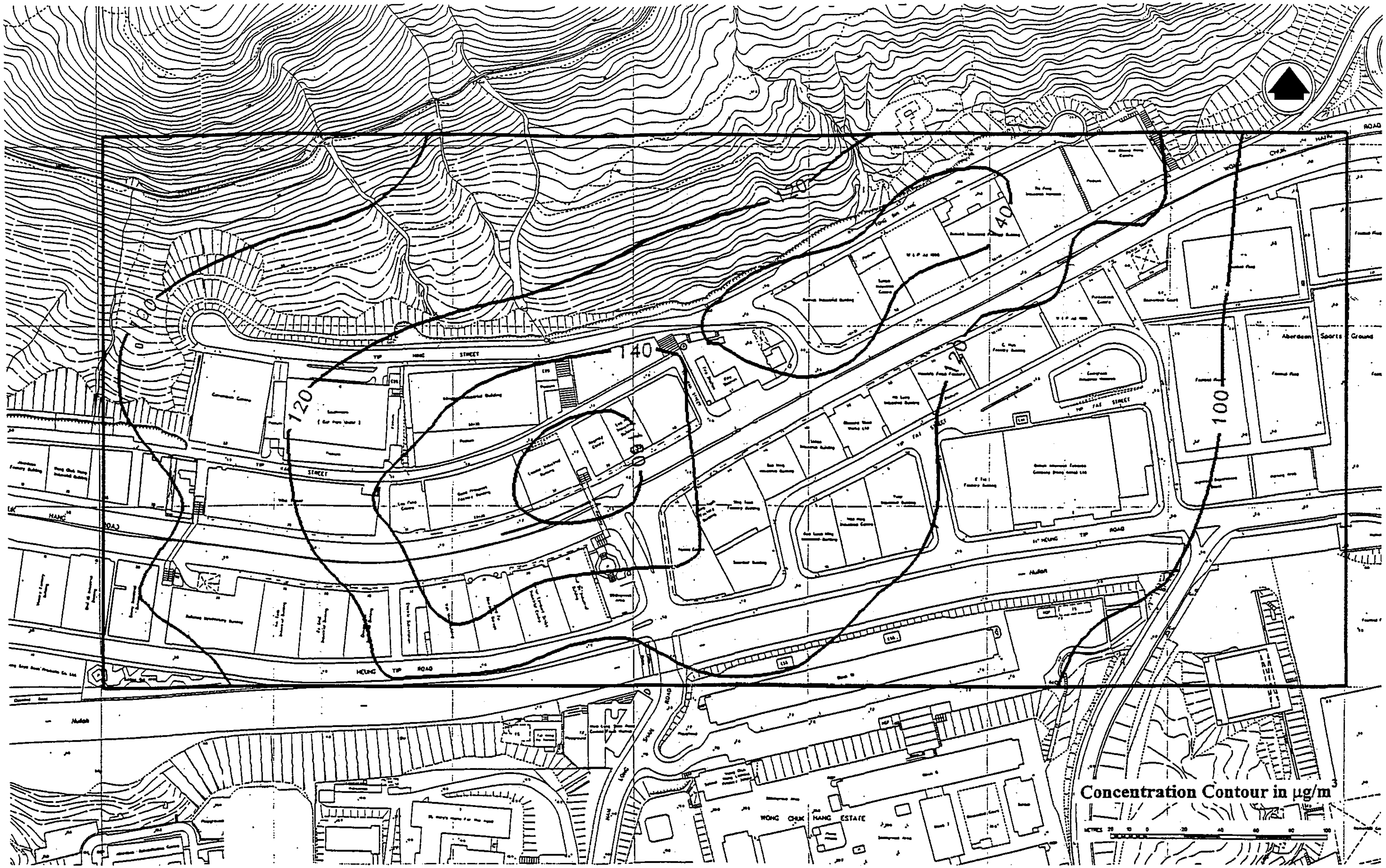
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF DAILY AVERAGE TSP CONCENTRATIONS AT 10 m ABOVE GROUND LEVEL (UNMITIGATED) DURING CONSTRUCTION

FIGURE 3.7

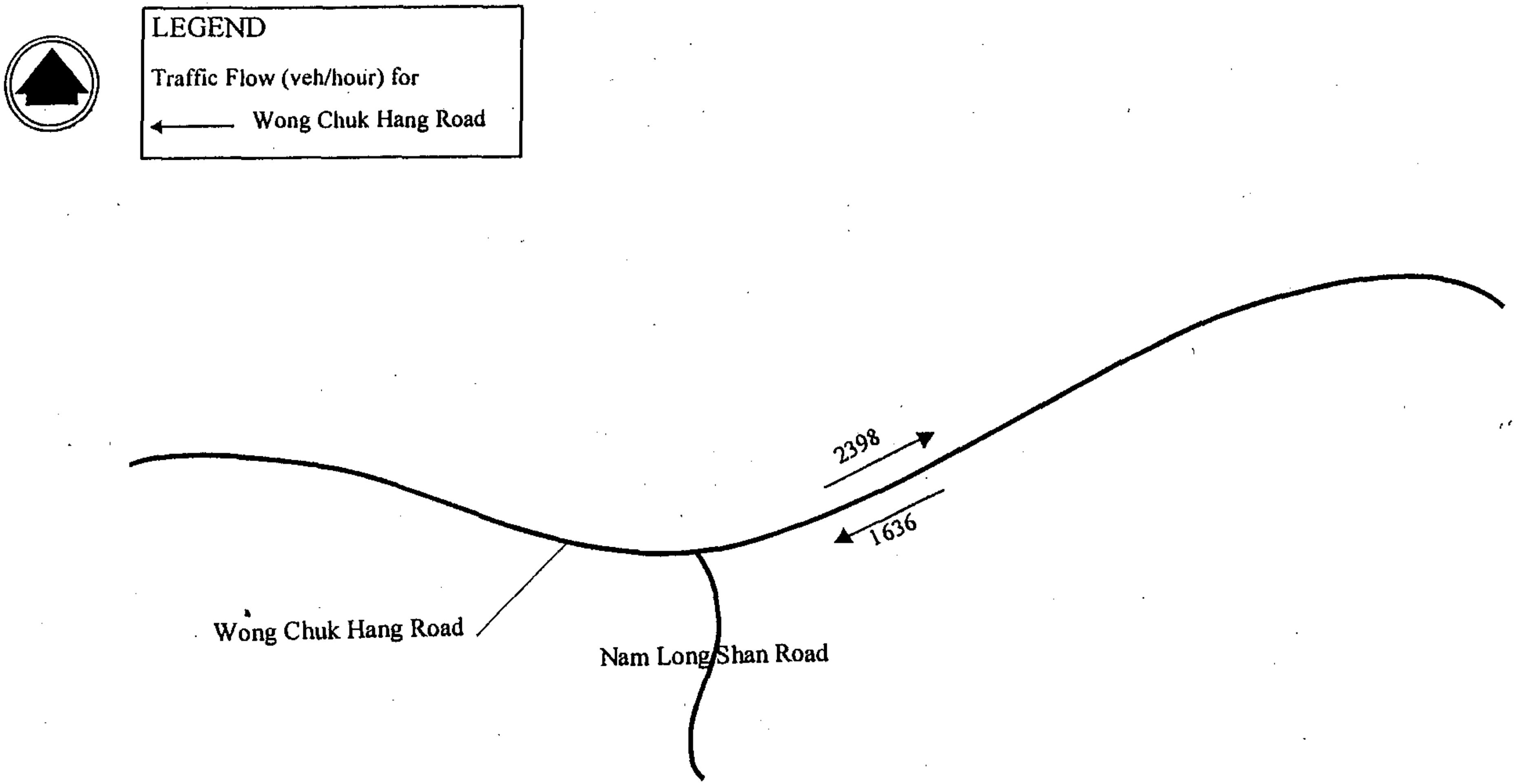
Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers




ISOPLETHS OF DAILY AVERAGE TSP CONCENTRATIONS AT 20 m ABOVE GROUND LEVEL (UNMITIGATED) DURING CONSTRUCTION

FIGURE 3.8

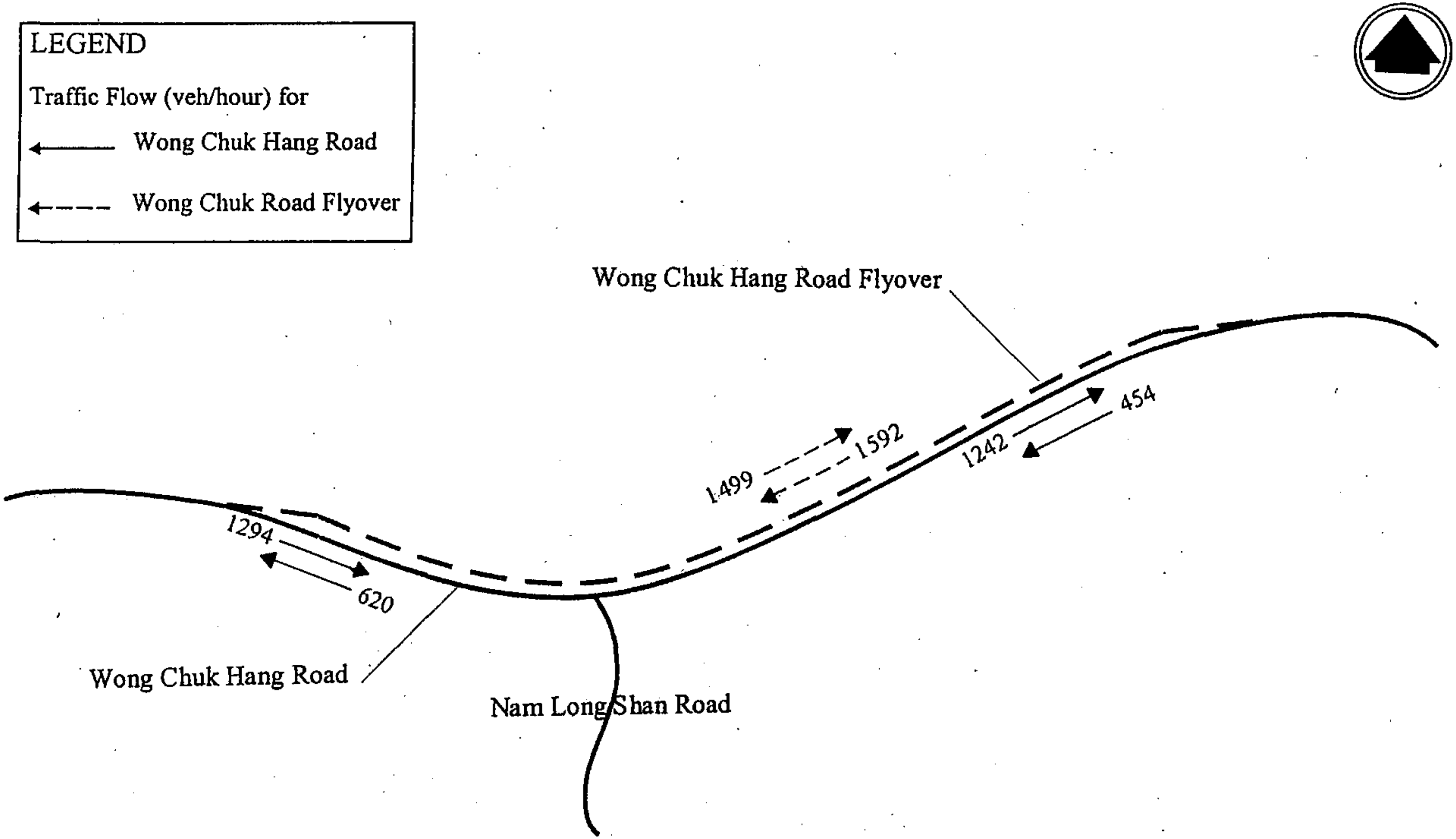
Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers




TRAFFIC FLOW DIAGRAM - 1999 (AM PEAK)

FIGURE 3.9

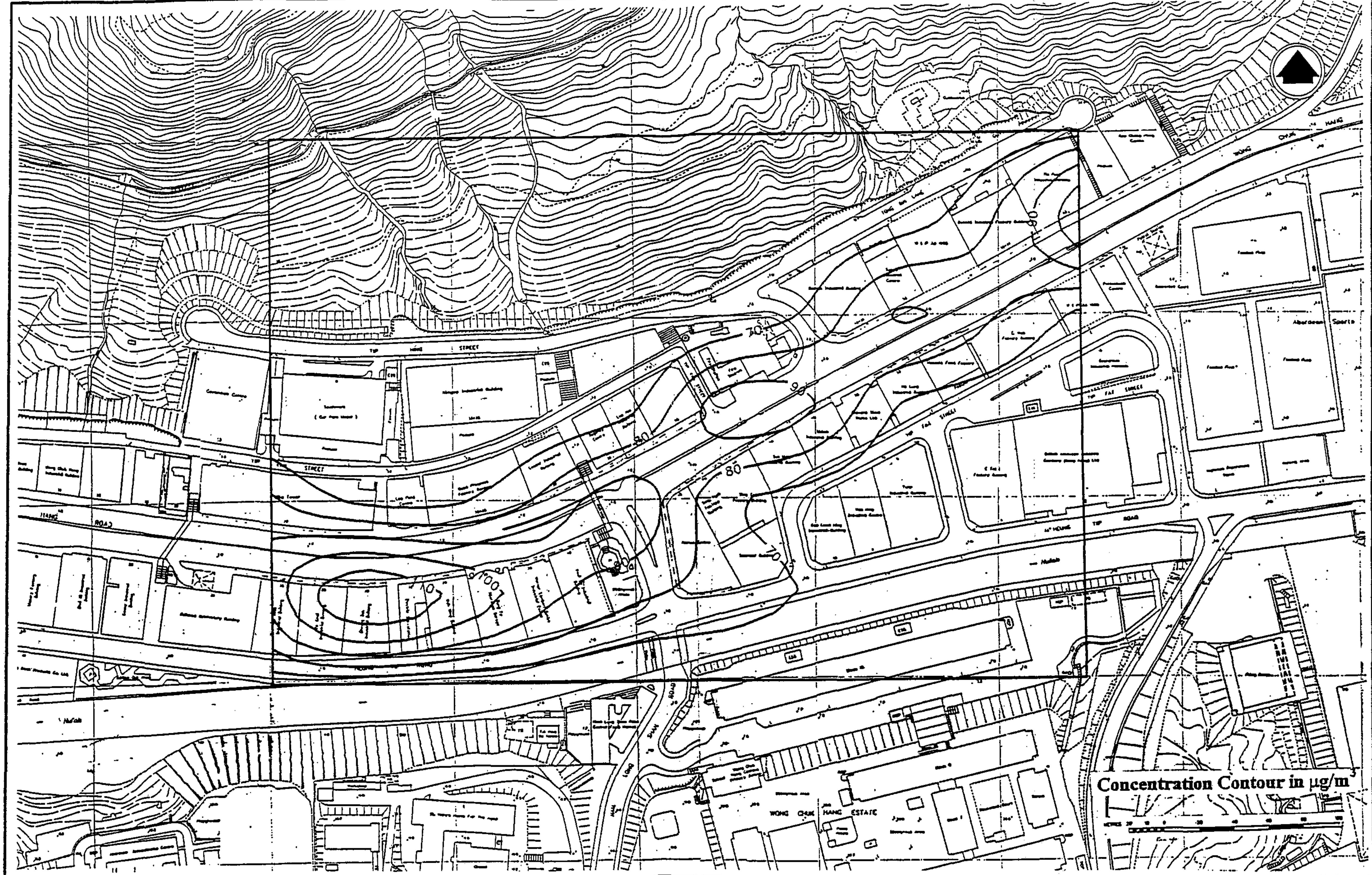
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




TRAFFIC FLOW DIAGRAM - 2011 (AM PEAK)

FIGURE 3.10

Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF HOURLY AVERAGE RSP CONCENTRATIONS AT 7 mPD LEVEL (2011)

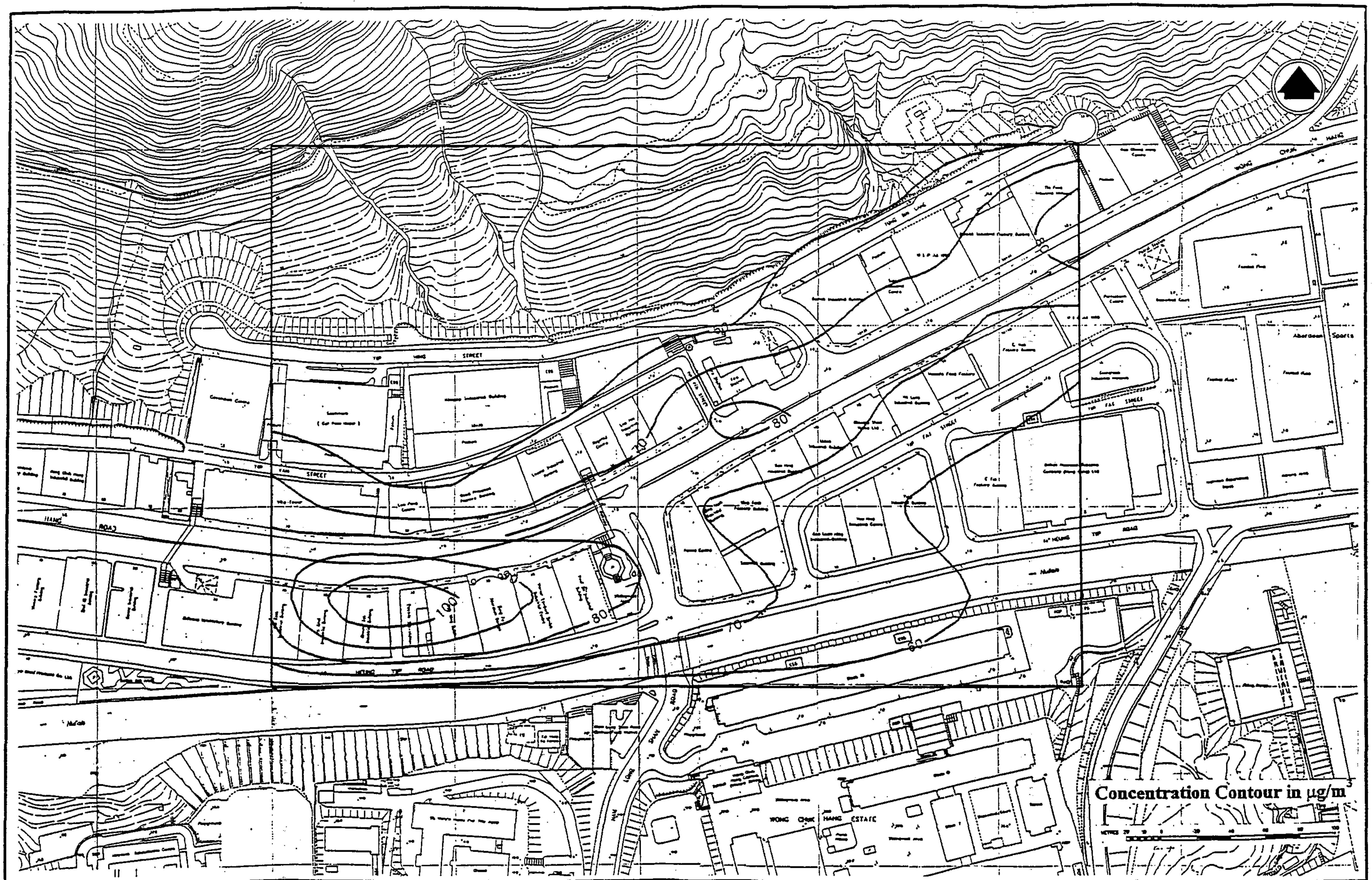
FIGURE 3.11

Babtie BMT (Hong Kong) Ltd.
Consulting Engineers


ISOPLETHS OF HOURLY AVERAGE $NO_2$ CONCENTRATIONS AT 7 mPD LEVEL (2011)

FIGURE 3.12

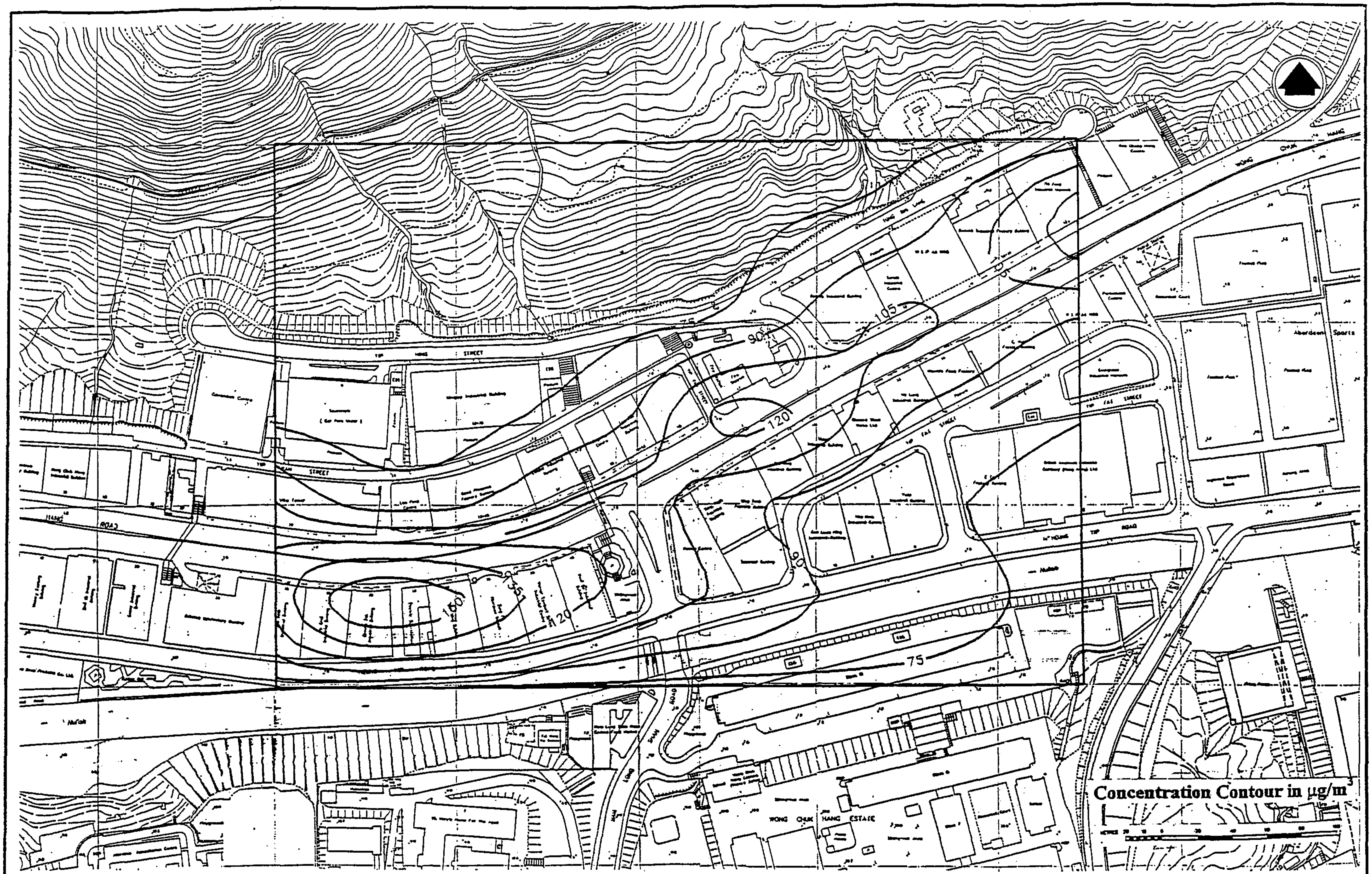
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF HOURLY AVERAGE RSP CONCENTRATIONS AT 12 mPD LEVEL (2011)

FIGURE 3.13

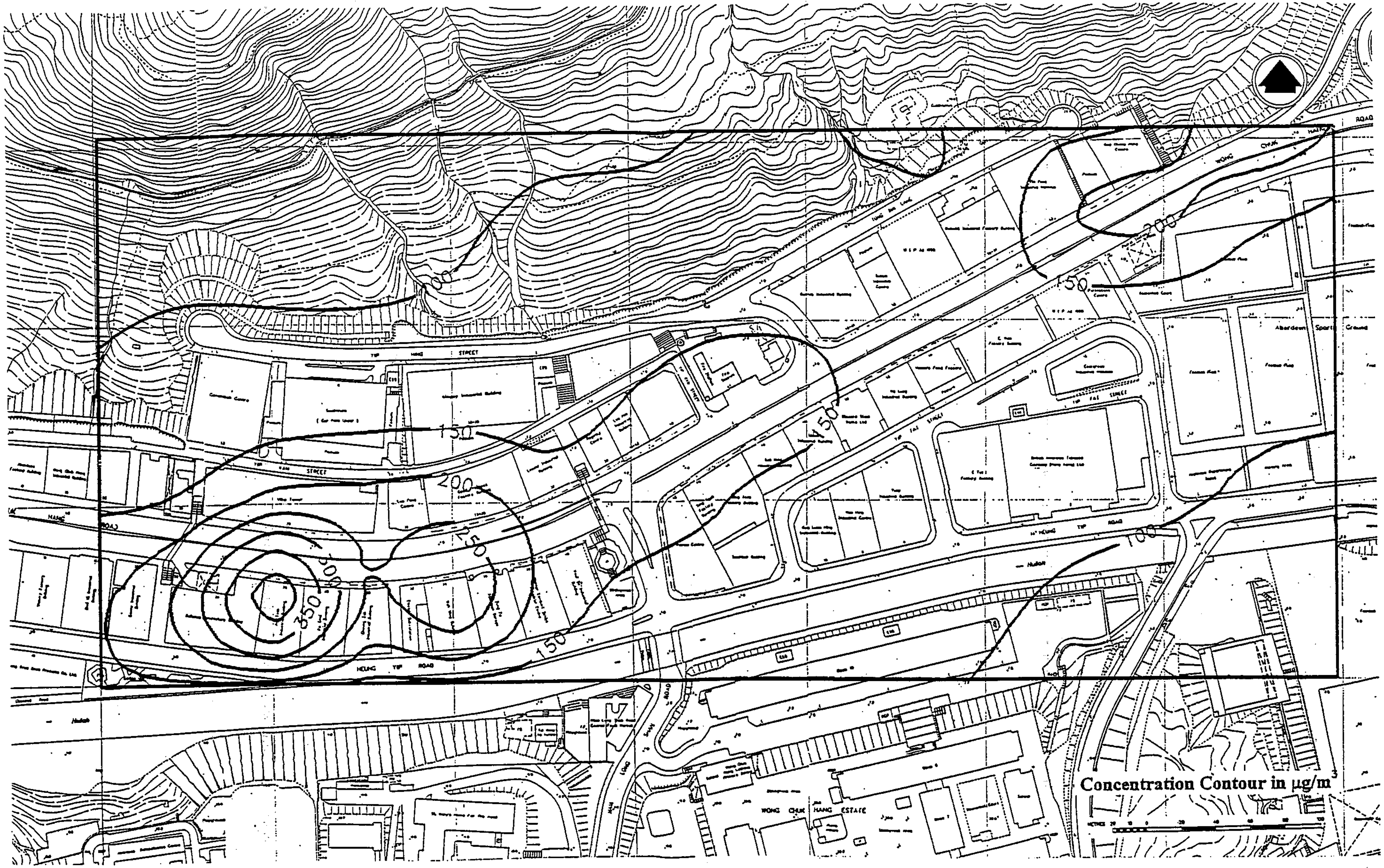
Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers




ISOPLETHS OF HOURLY AVERAGE $NO_2$ CONCENTRATIONS AT 12 mPD LEVEL (2011)

FIGURE 3.14

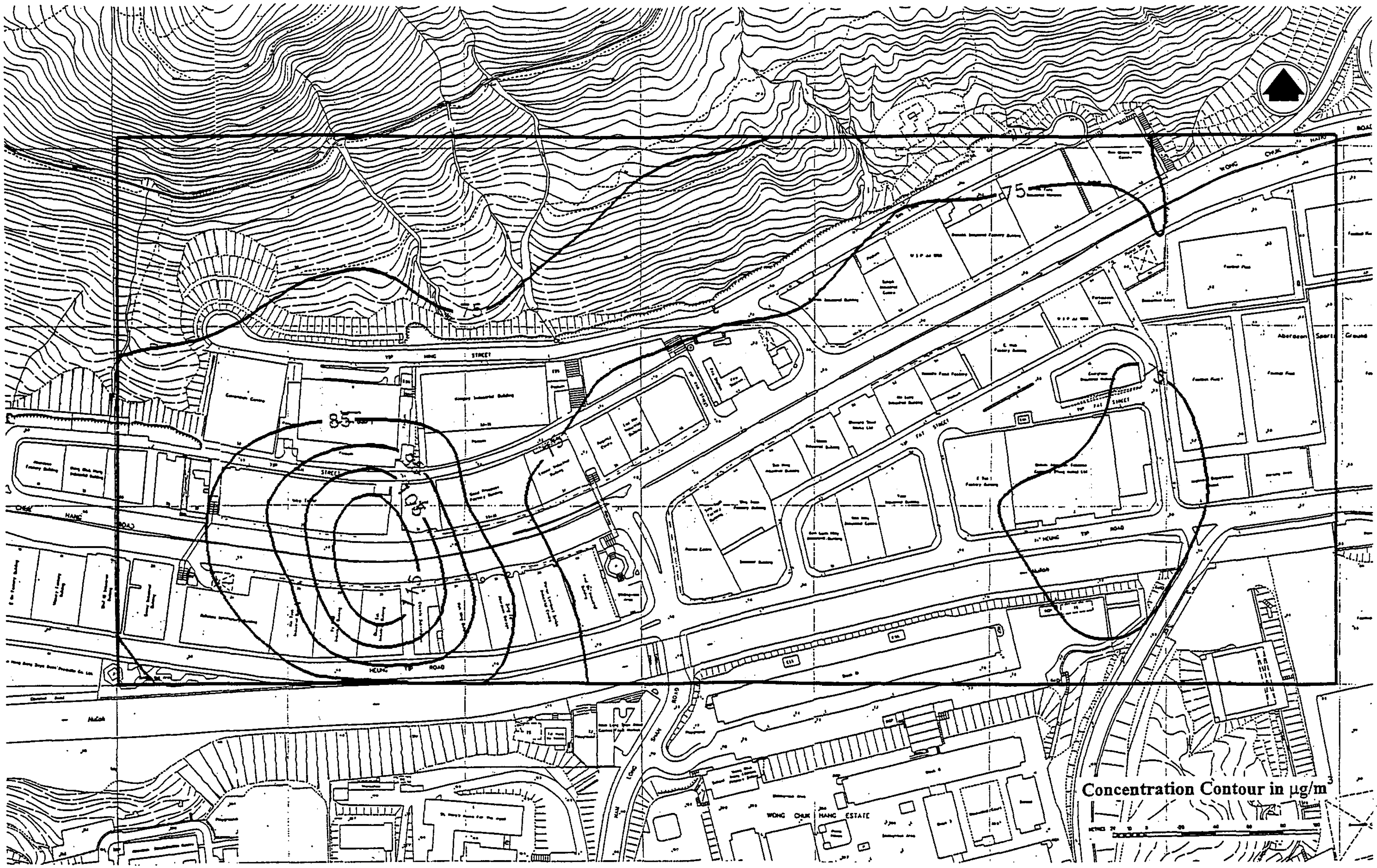
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF HOURLY AVERAGE TSP CONCENTRATIONS AT GROUND LEVEL (MITIGATED) DURING CONSTRUCTION

FIGURE 3.15

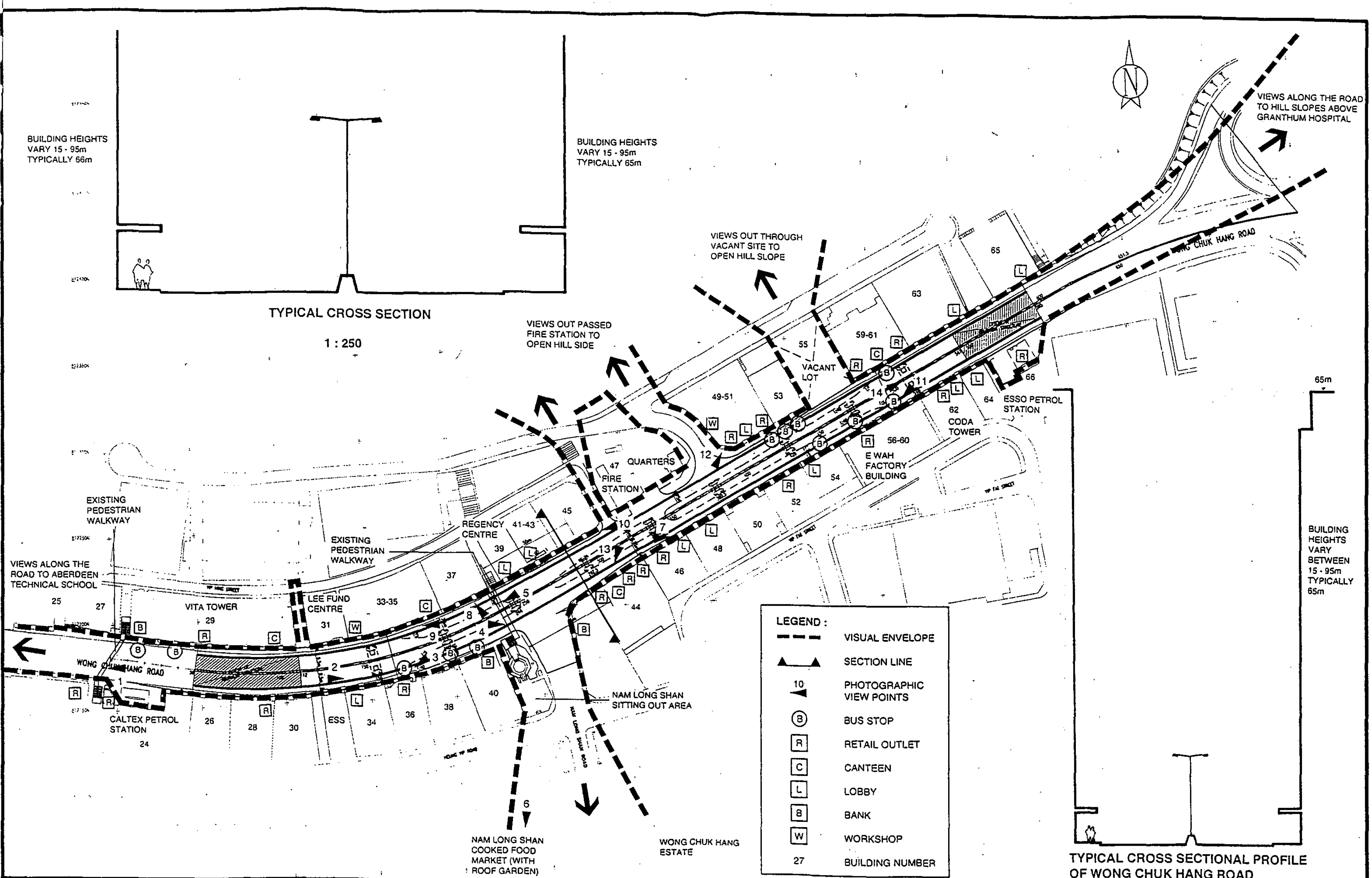
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ISOPLETHS OF DAILY AVERAGE TSP CONCENTRATIONS AT GROUND LEVEL (MITIGATED) DURING CONSTRUCTION

FIGURE 3.16

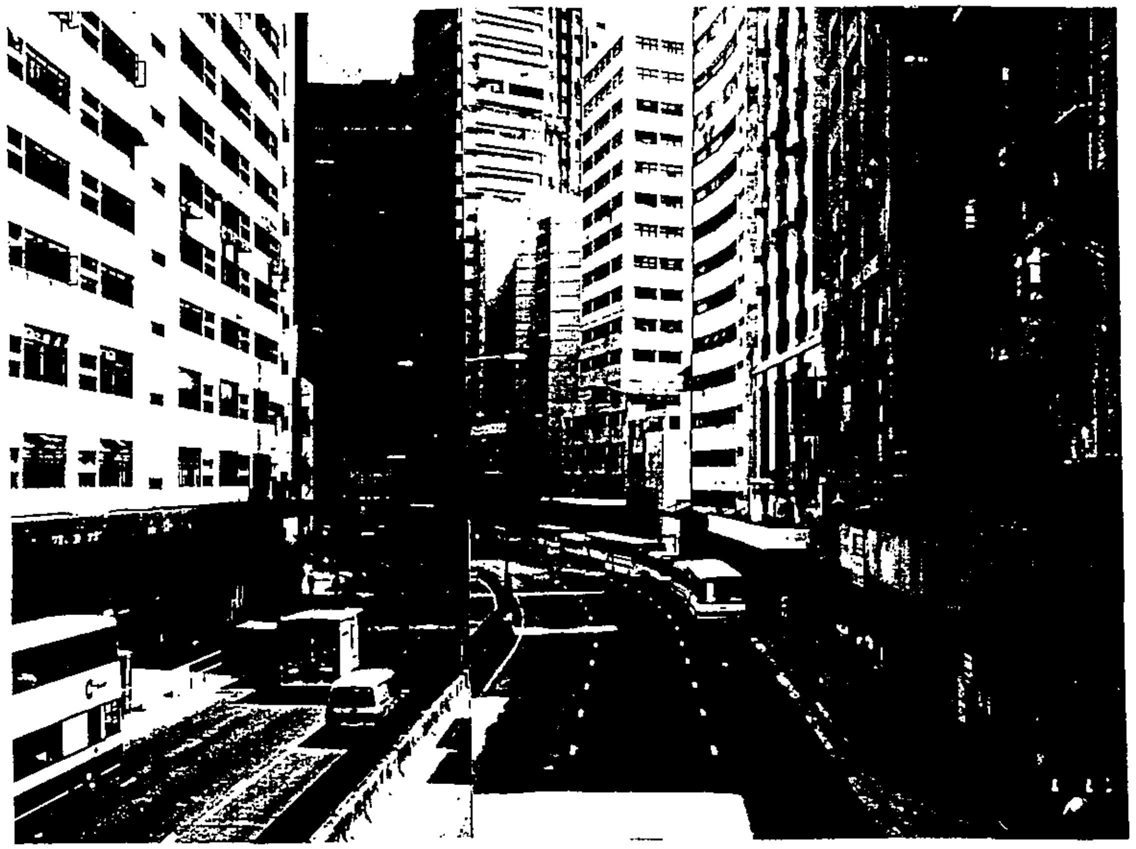
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




STREETSCAPE AND VISUAL CONTEXT PLAN

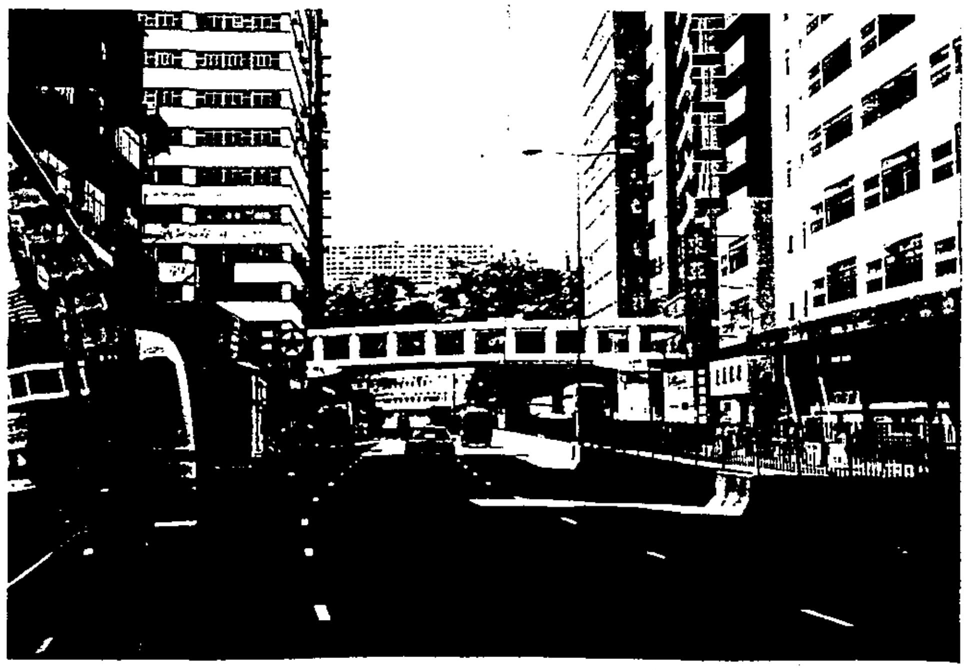
FIGURE 4.1

Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers



PHOTOGRAPHIC VIEW POINT 1

PHOTOGRAPHIC VIEW POINT 2



PHOTOGRAPHIC VIEW POINT 3

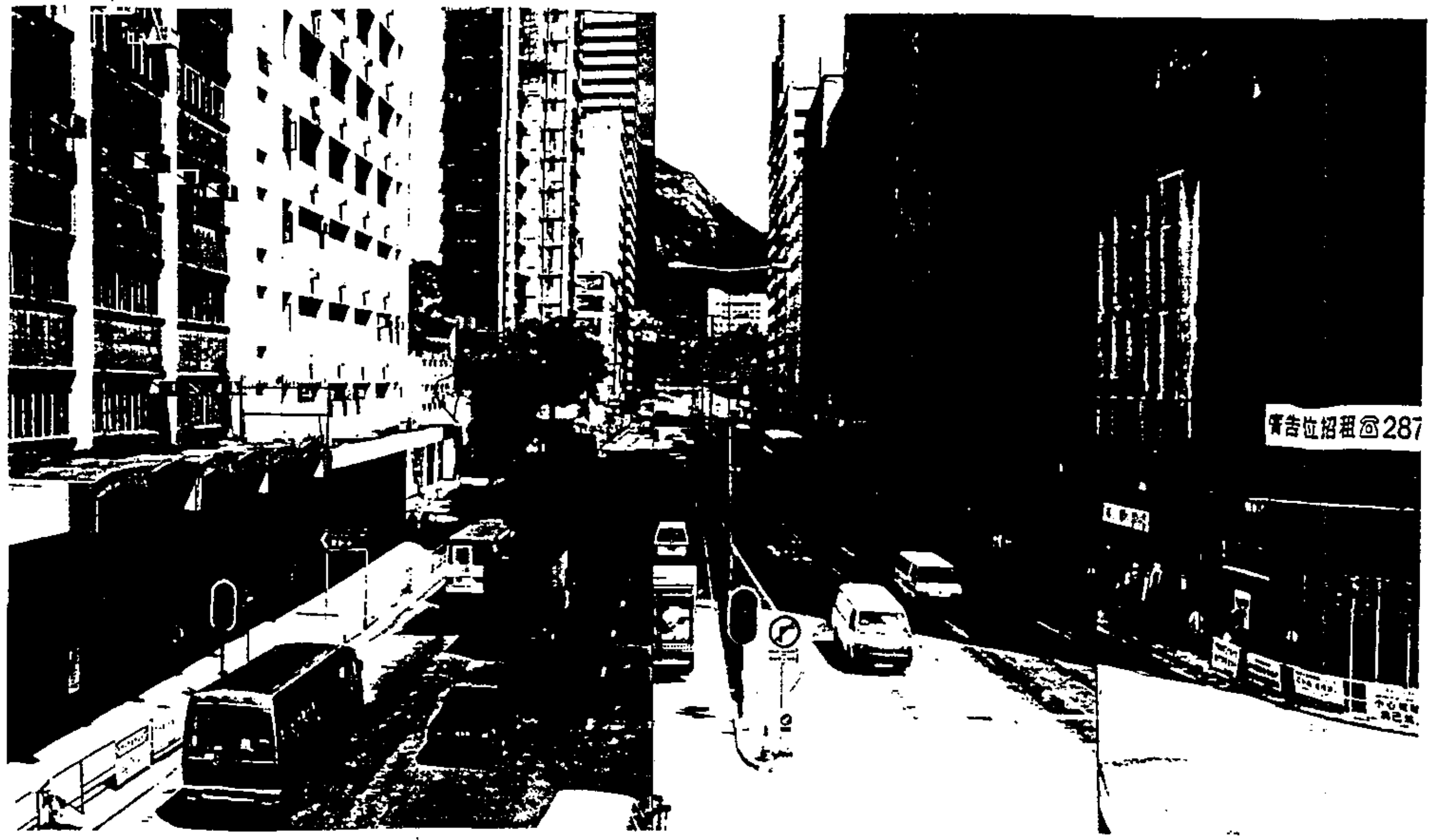
PHOTOGRAPHIC VIEW POINT 4

THE LOCATION OF ALL VIEW POINTS IS SHOWN ON THE STREETSCAPE AND VISUAL CONTEXT PLAN

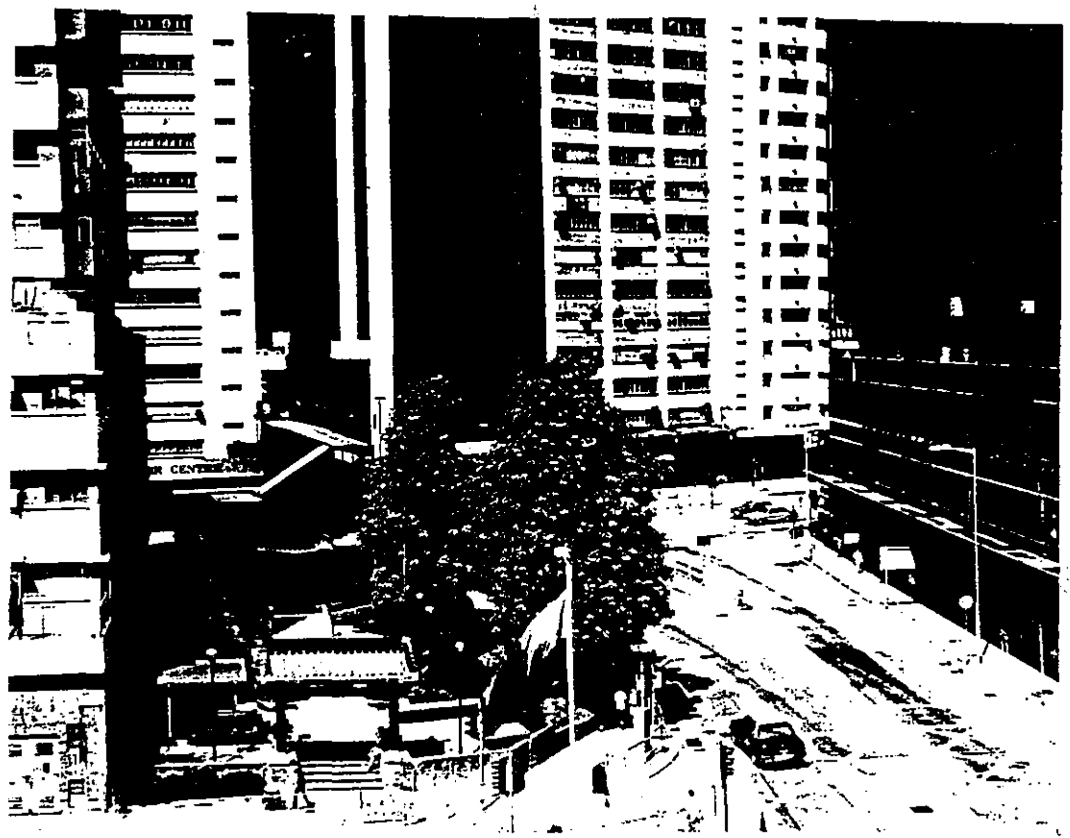
EXISTING SITE PHOTOGRAPHS

FIGURE 4.2

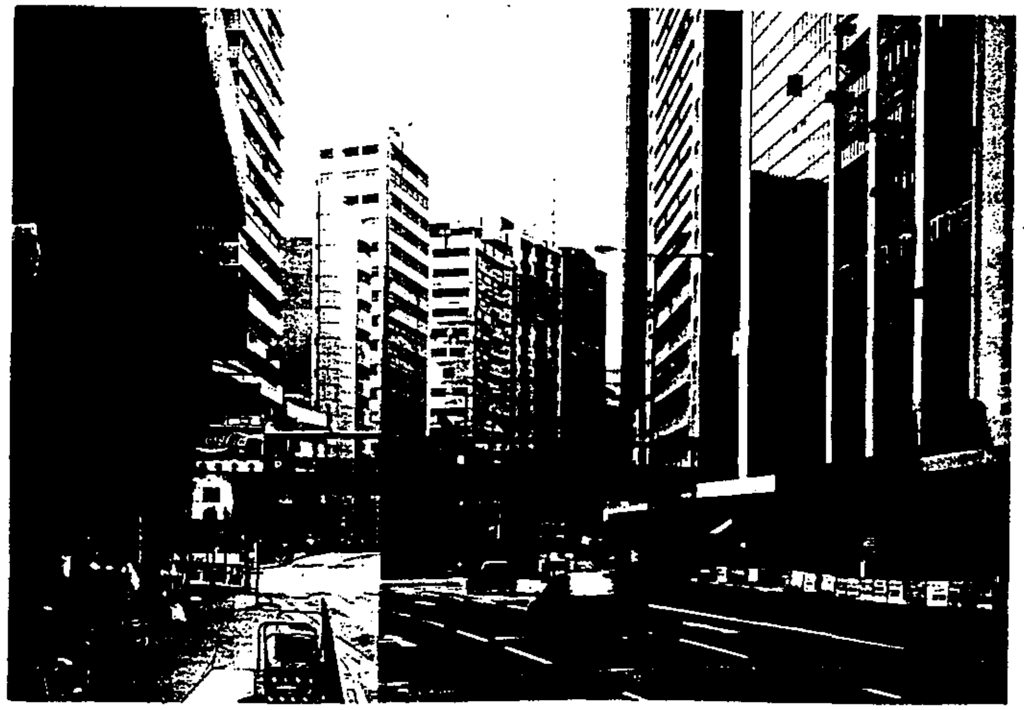
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers



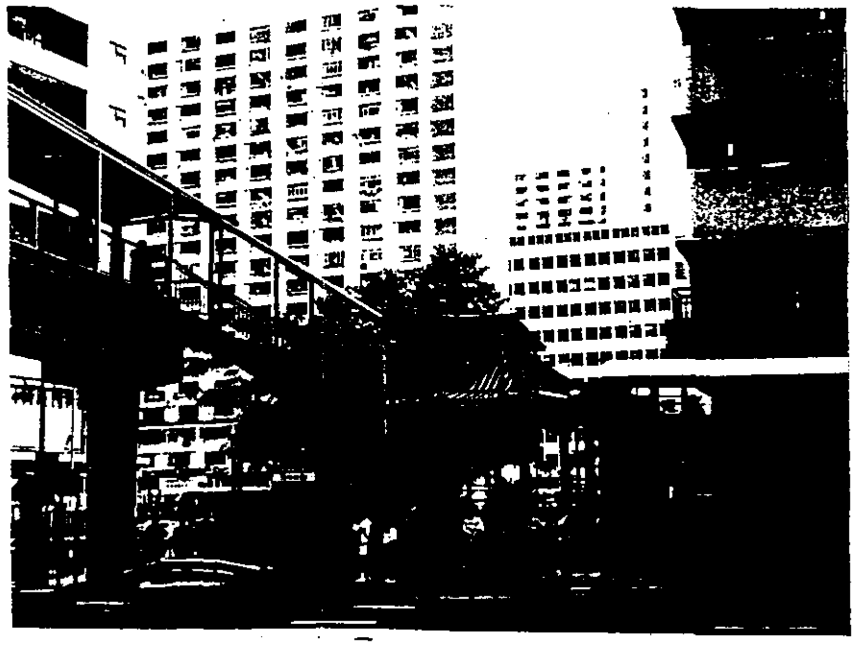

PHOTOGRAPHIC VIEW POINT 5



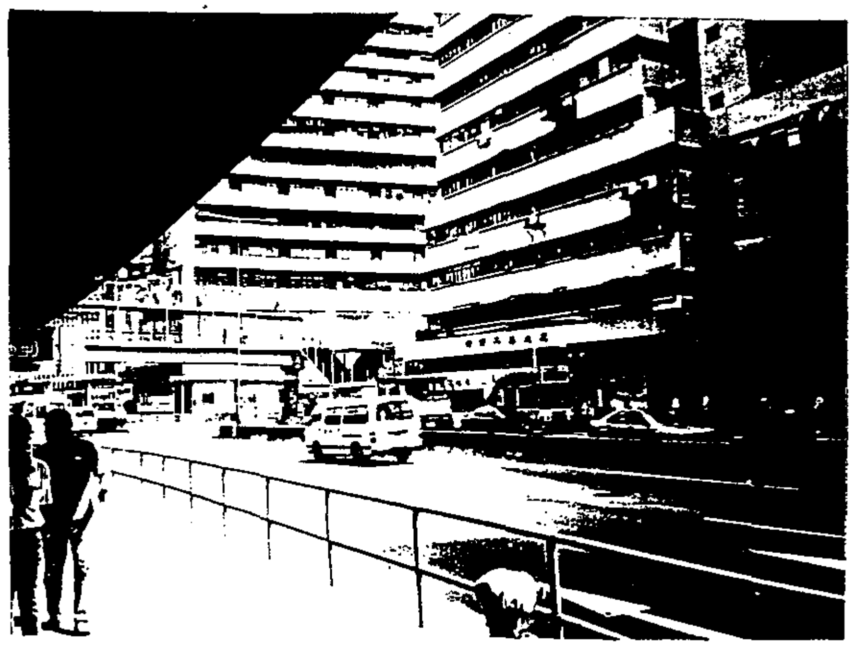
PHOTOGRAPHIC VIEW POINT 6



PHOTOGRAPHIC VIEW POINT 7



PHOTOGRAPHIC VIEW POINT 8



PHOTOGRAPHIC VIEW POINT 9

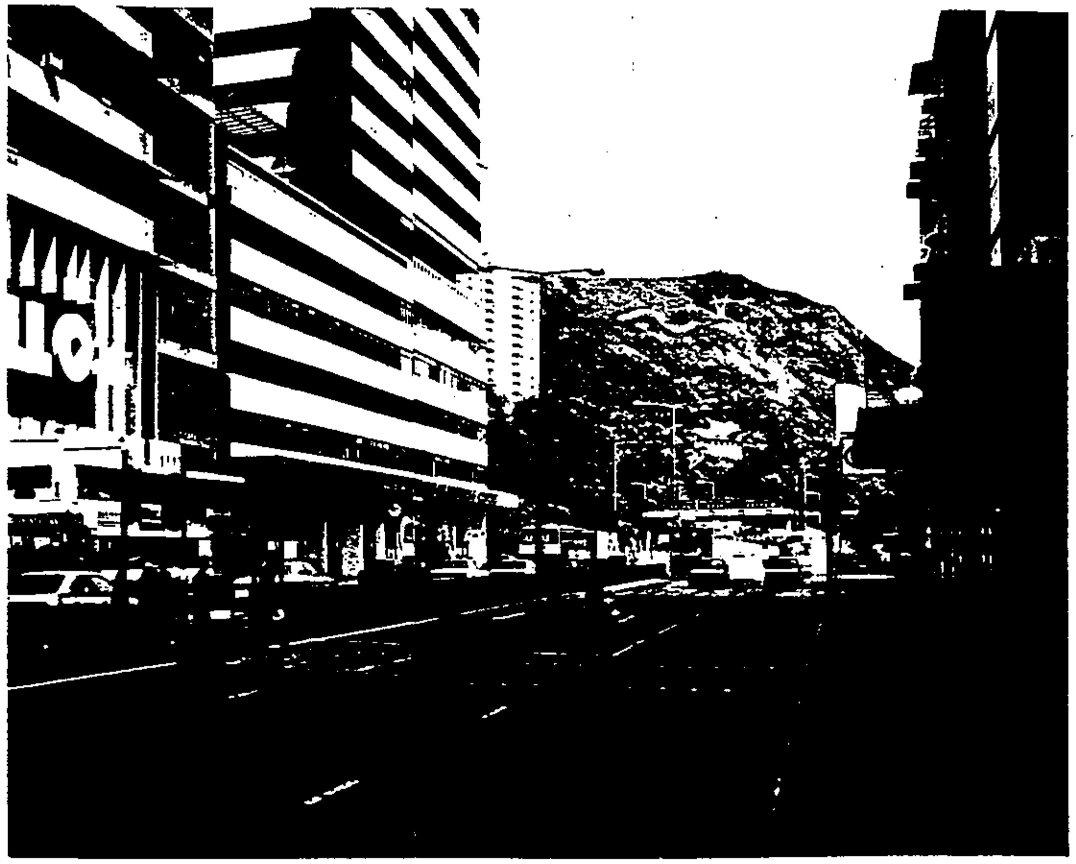
THE LOCATION OF ALL VIEW POINTS IS SHOWN ON THE STREETSCAPE AND VISUAL CONTEXT PLAN

EXISTING SITE PHOTOGRAPHS

FIGURE 4.3

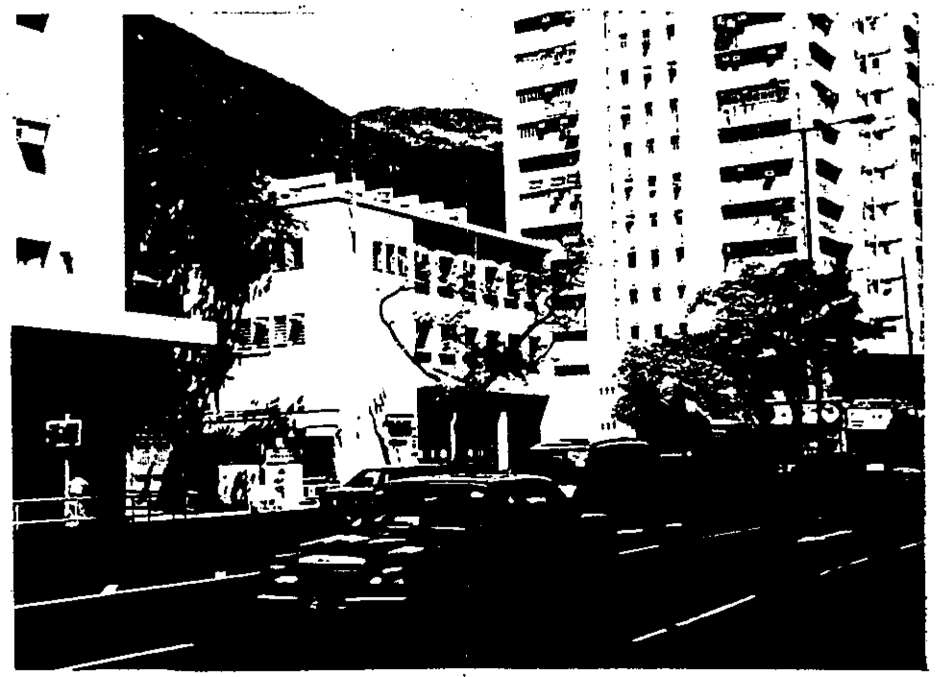
Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers

PHOTOGRAPHIC VIEW POINT 10



PHOTOGRAPHIC VIEW POINT 11

PHOTOGRAPHIC VIEW POINT 12



PHOTOGRAPHIC VIEW POINT 13

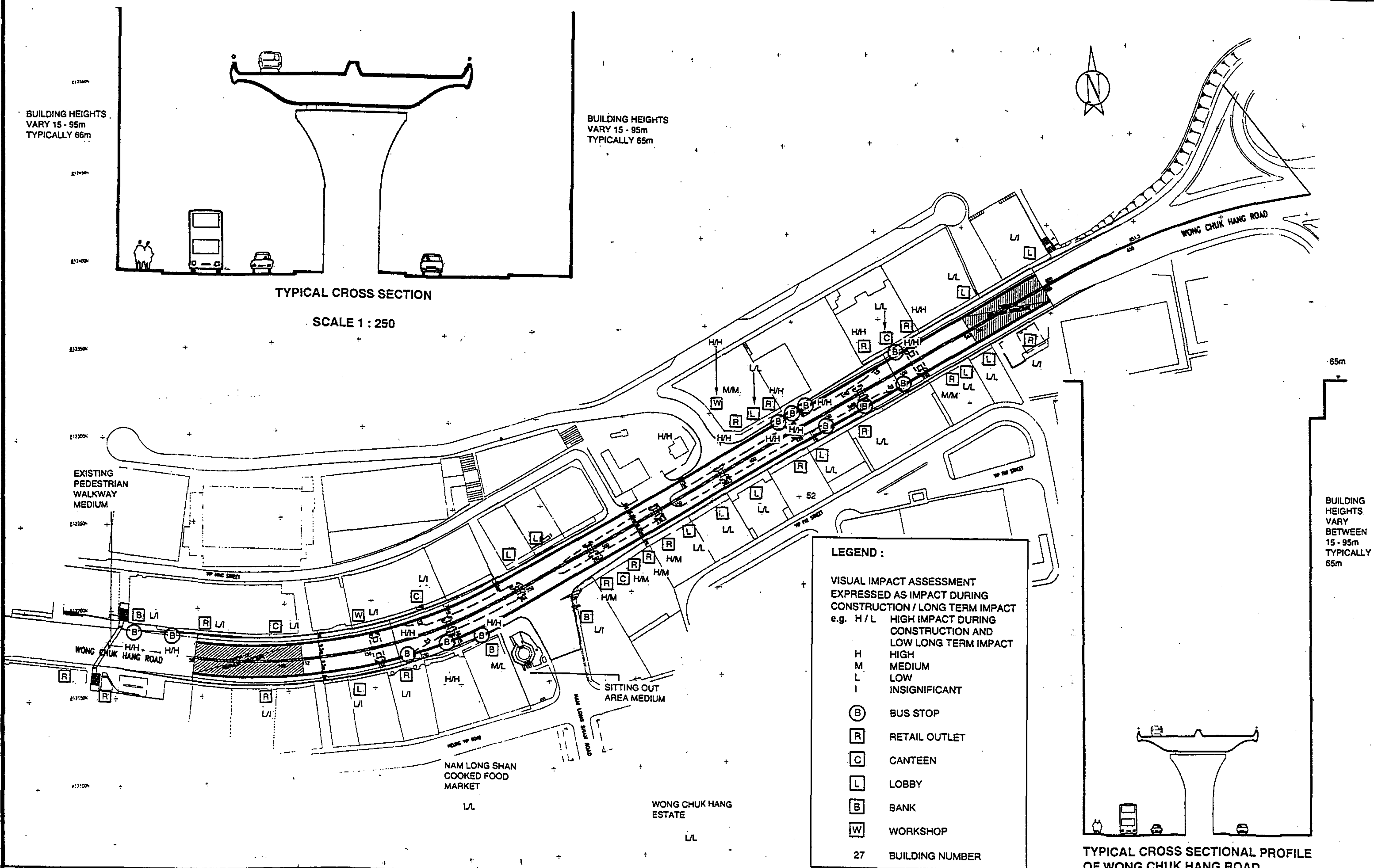
PHOTOGRAPHIC VIEW POINT 14

THE LOCATION OF ALL VIEW POINTS IS SHOWN ON THE STREETSCAPE AND VISUAL CONTEXT PLAN

EXISTING SITE PHOTOGRAPHS

FIGURE 4.4

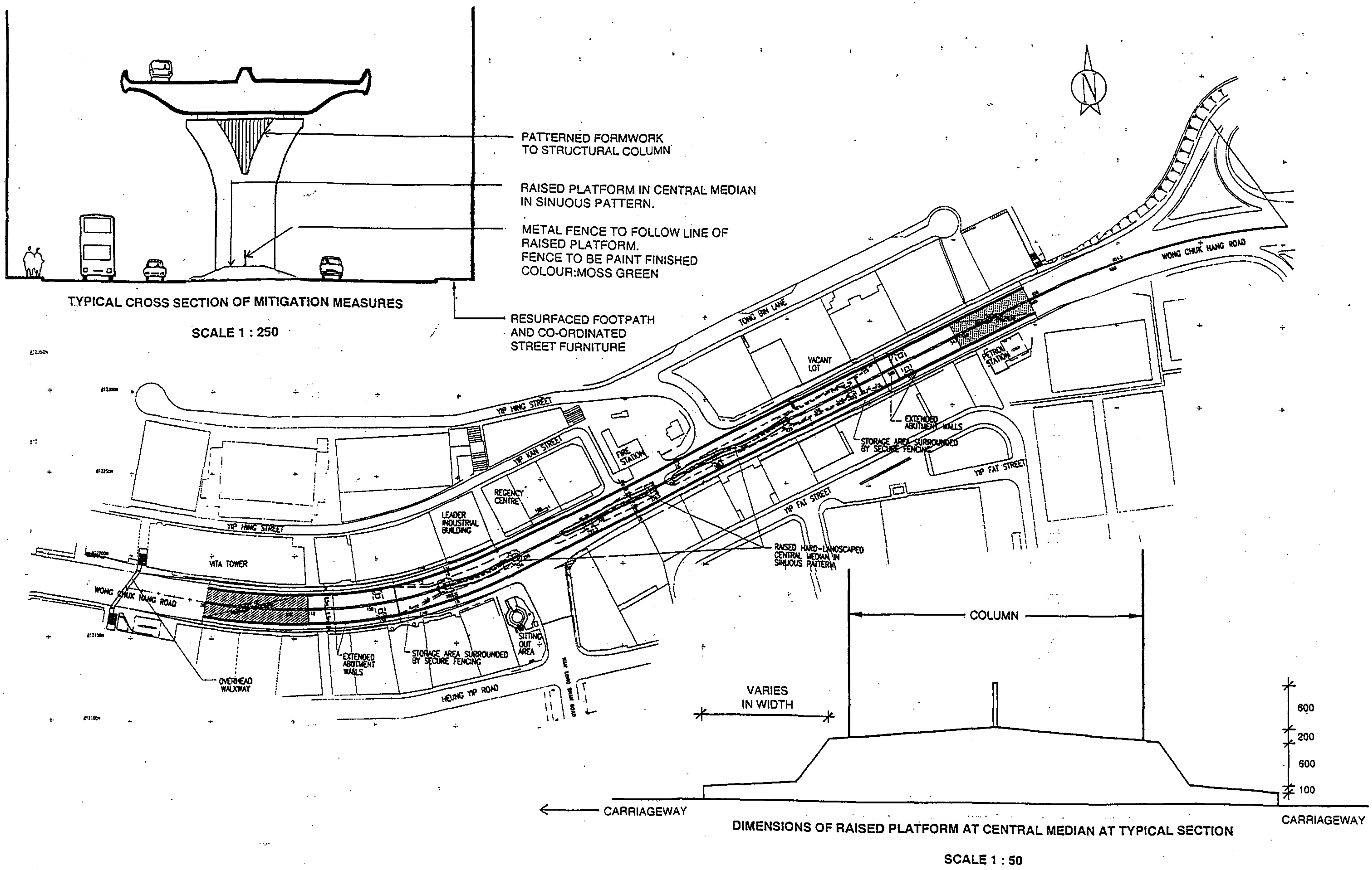
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




STREETSCAPE AND VISUAL IMPACT PLAN

FIGURE 4.5

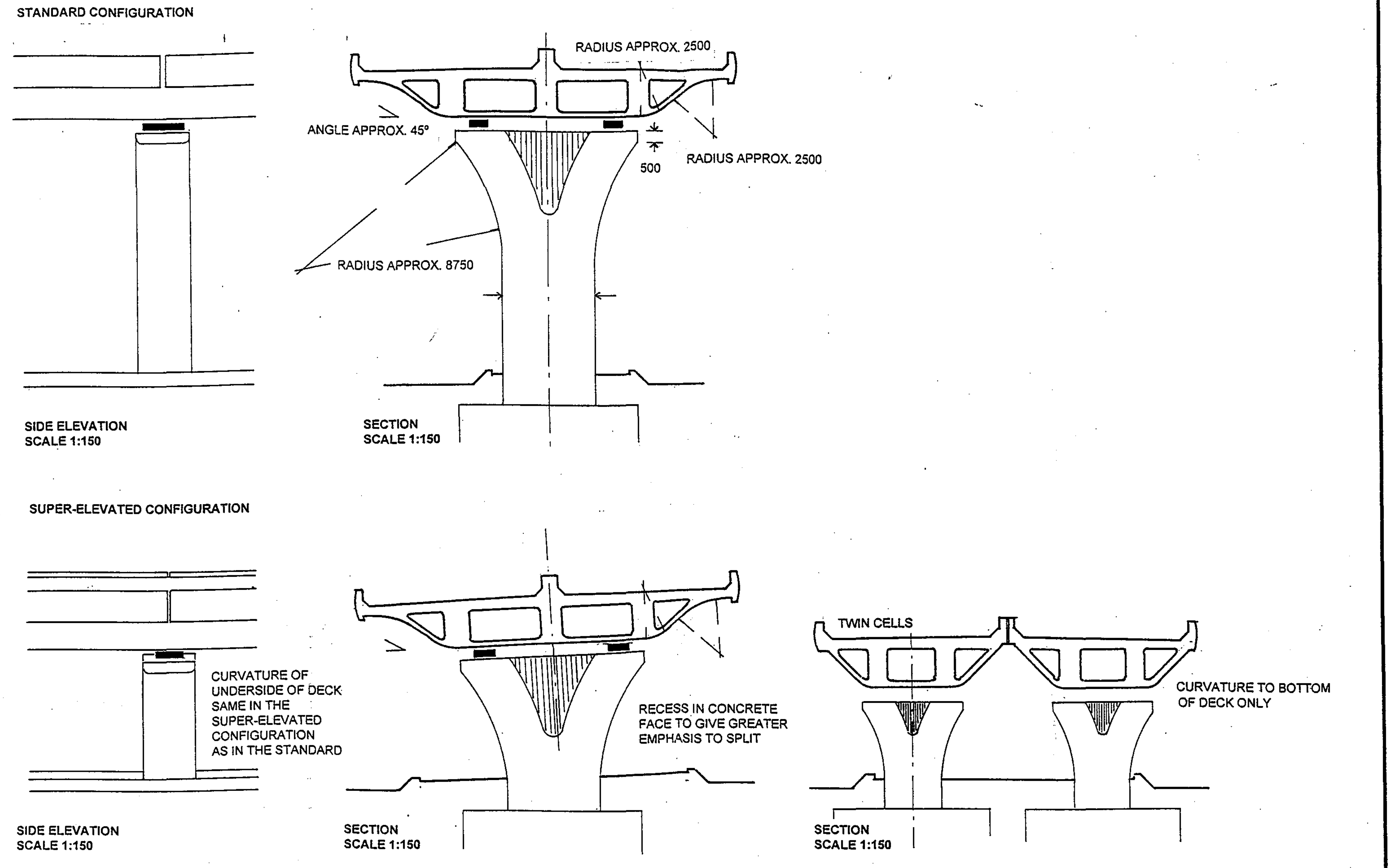
Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers




LANDSCAPE MITIGATION MEASURES PLAN

FIGURE 4.6

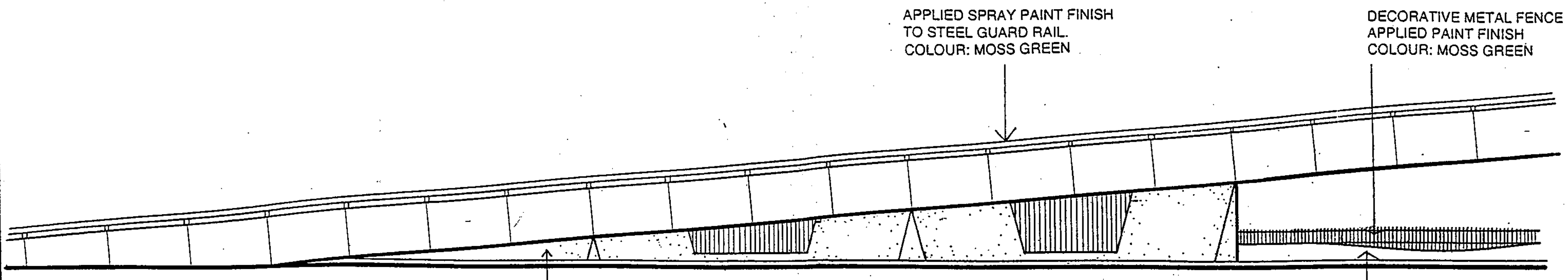
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers



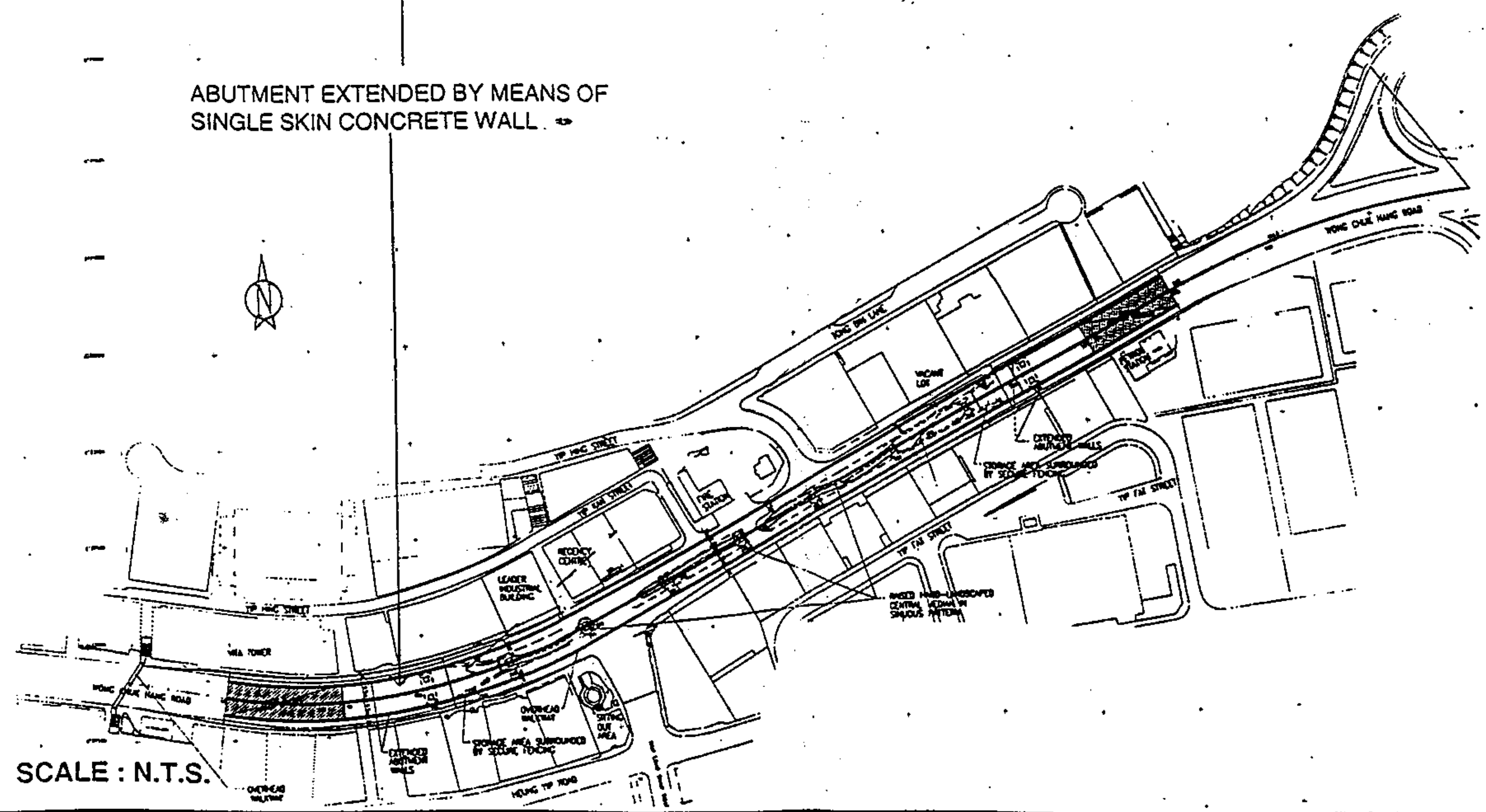

COLUMN DESIGN

FIGURE 4.7

Babtie BMT (Hong Kong) Ltd.
Consulting Engineers




ELEVATION SCALE 1 : 250

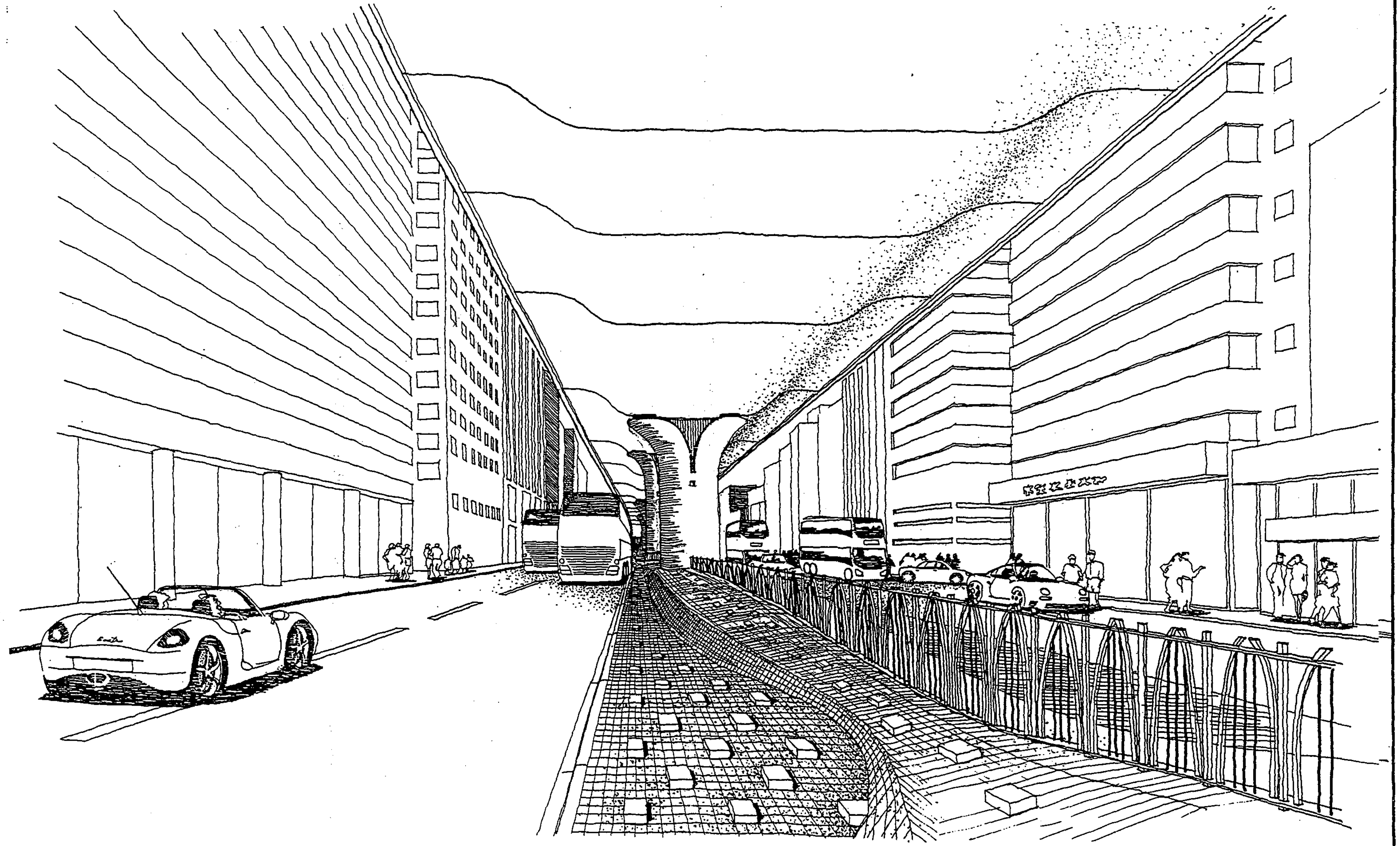


LANDSCAPE PLAN SCALE : N.T.S.

ARRANGEMENT AT VIADUCT ABUTMENT

FIGURE 4.8

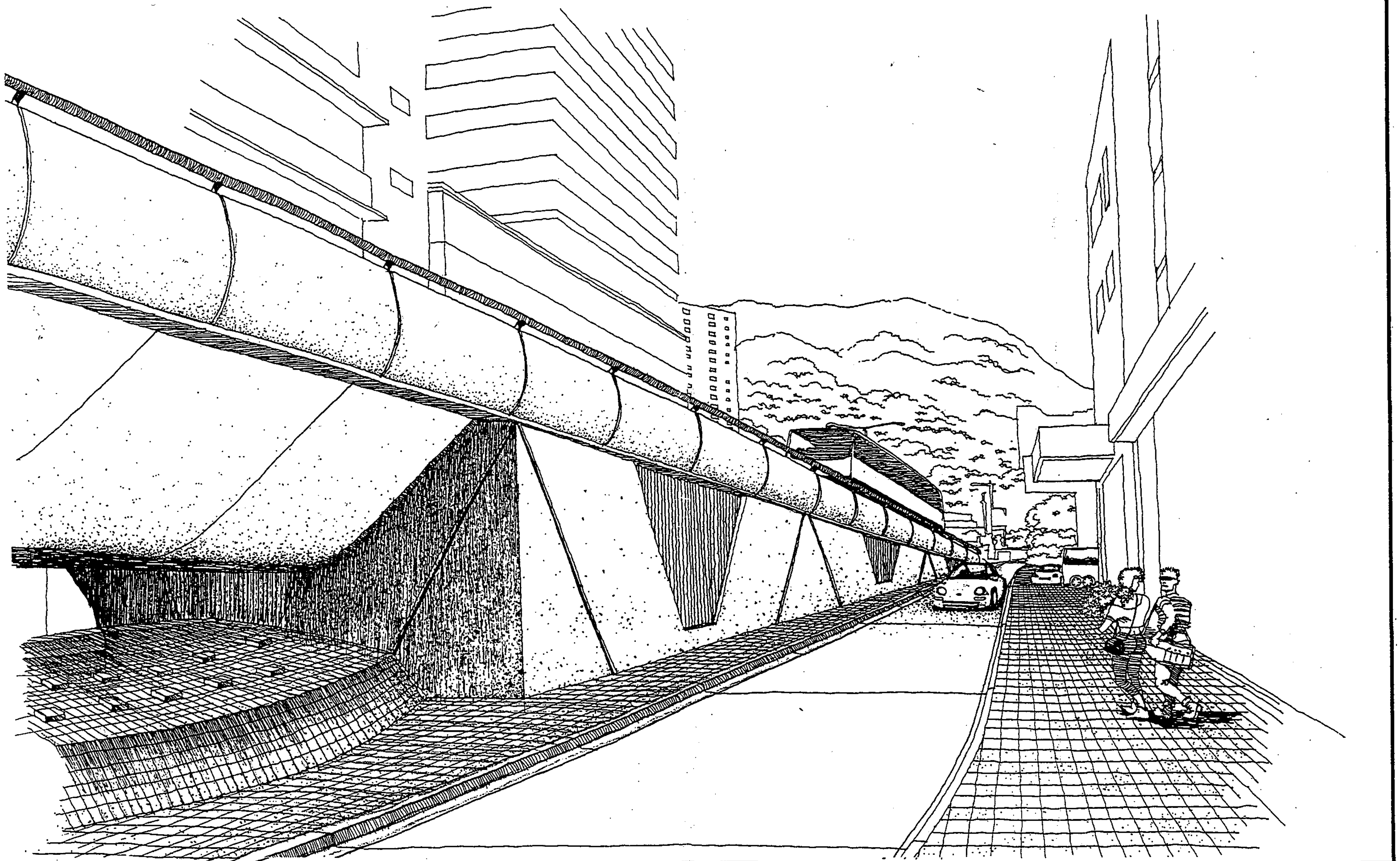
Babtie BMT (Hong Kong) Ltd.
Consulting Engineers



PERSPECTIVE VIEW OF FLYOVER CENTRE

FIGURE 4.9

Babtie BMT (Hong Kong) Ltd.
Consulting Engineers



PERSPECTIVE VIEW AT ABUTMENT

FIGURE 4.10

Babtie BMT ( Hong Kong ) Ltd.
Consulting Engineers