APPENDIX B

Technical Paper No. 3 - Air Quality Impact Assessment

Technical Paper No. 3
Air Quality Impact Assessment

Contents

1. INTRODUCTION

Working Paper No. 1 has identified and evaluated noise mitigation measures to redress the impacts by road traffic noise on existing residential buildings along Ap Lei Chau Bridge and Tsing Tsuen Road. The measures comprising inverted L-shaped noise barriers and partial enclosures were considered acoustically effective and aesthetically acceptable in the urban setting. However, these barriers or enclosures have the potential to localize the air pollutants. It remains to be shown therefore that these measures would not result in unacceptable air quality at the air sensitive receivers, which include dwellings, sitting out areas, playgrounds, sports grounds etc., as defined in the HKPSG.

This Technical Paper has been prepared to address the air quality issue that may arise from the potential implementation of the noise mitigation measures. Pedestrians and drivers are not considered as air sensitive in this context because the time they spend on the road is short compared to the averaging time for the calculation of the pollutant concentrations.

2. OPTIMAL MITIGATION SCHEMES

Following an evaluation of several options for the two flyovers based on engineering, environmental and cost considerations, the following mitigation measures, comprising inverted L-shaped barriers and partial enclosures, are considered to be the most optimal schemes for the two sites. Typical cross section of the barriers and enclosures on independent structures are illustrated in Appendix A.

2.1 Ap Lei Chau Bridge

The optimal mitigation scheme for Ap Lei Chau Bridge consists of two sections of 5 m high inverted L-shaped barriers about 45m and 50m in length along the eastbound carriageway to protect the NSRs located adjacent to the flyover.

Figure 2-1 shows the location of the proposed barriers and representative air sensitive receivers (ASRs) likely to be affected as a result of implementation of the noise mitigation measures. Table 2-1 describes the ASRs in further details.

Table 2-1 Description of ASRs along Ap Lei Chau Bridge

ASR ID	Name of ASR	Current Uses
HA	Hans Andersen Club	Vacated
HM	Harbour Mission School	Vacated
SO	Shan On House	Residential
CO	Choi On House	Residential
FM	Fortune Mansion	Residential
BK	Baptist Kindergarten	School
FP	Football pitch	Outdoor Recreation

2.2 Tsing Tsuen Road

The optimal mitigation scheme for Tsing Tsuen Road near Riviera Gardens consists of two segments of partial enclosures, one about 95m in length along the eastbound carriageway and another 185m in length partly covering the eastbound carriageway and along part of its length, covering the full-width of the carriageway, to protect the NSRs at Riviera Gardens.

For the other end of Tsing Tsuen Road near Cheung On Estate, the optimal mitigation scheme consists of a 150m long partial enclosure along the eastbound carriageway in front of Cheung On Estate.

Figures 2-2 and 2-3 show the locations of the proposed partial enclosures and representative air sensitive receivers likely to be affected as a result of implementation of the noise mitigation schemes. Table 2-2 gives further details of the ASRs.

Table 2-2 Description of ASRs along Tsing Tsuen Road

ASR ID	Name of ASR	Current Uses
HS	Hoi Sing Mansion	Residential
HF	Hoi Fung Mansion	Residential
HK	Hoi Kwai Mansion	Residential
SC	Sunley Centre	Industrial
OC	On Pak House	Residential
OP	On Chiu House	Residential
AG	Home for the Aged	Convalescent Home
SP	St. Paul's Village	Residential
V1	Tierra Verde	Residential
V2	Tierra Verde	Residential
TC	Tennis Court	Outdoor Recreation

3. ASSESSMENT METHODOLOGY

3.1 Air Pollutants

Motor vehicles generate a variety of airborne pollutants, including carbon monoxide, nitrogen oxides, particulates, and trace amounts of volatile organic compounds. However, the air pollutants of concern are nitrogen dioxide and respirable suspended particulate since the concentrations of carbon monoxide and volatile organic compounds produced by motor vehicles are usually far below the level that cause health effects.

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. Petrol vehicles contribute more carbon monoxide, while diesel-powered vehicles emit more nitrogen oxides and particulate matter. Under the current emission controls, emissions from petrol vehicles will be reduced as a result of more vehicles being fitted with catalytic converters which convert carbon monoxide to carbon dioxide. In view of the lower emission rates and the high statutory limit for carbon monoxide, the key air pollutants are considered to be Nitrogen Dioxide (NO_2) and

Respirable Suspended Particulate (RSP). Compliance with the concentration levels shown below in Table 3-1 is required.

Table 3-1 Air Quality Objectives

Parameter	Maximum Permitted Average Concentration (μg/m³)		
	1 hour	24 hours	Yearly
RSP	--	180	55
NO_2	300	150	80

Notes: *All criteria are Hong Kong Air Quality Objectives.
*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 Traffic Flows

The existing morning peak hour traffic flows, i.e. traffic flows in 1998 as used for noise impact assessment in Working Paper No. 1, were adopted for the present assessment. These traffic flows are assumed to be free flowing at the speed limit (50 kph) with no queuing.

3.3 Vehicle Emissions

Emission factors for RSP and NOx were taken from the Fleet Average Emission Factors - EURO2 Model provided by EPD for the year 1998. Based on these figures, the composite emission factors for the road links were calculated as the weighted average of the emission factors of different types of vehicles. No speed correction or other adjustments were made.

3.4 Meteorological Conditions

The worst-case meteorological conditions were adopted in the modelling. This involves a wind speed of 1m/s blowing at a worst wind angle to each sensitive receiver. The standard deviation of the wind direction varies from place to place. A suitable value for use for the various sites is 18 degrees as used previously for other similar sites. The stability is assumed to be Class D during day-time and Class F for night-time.

The following summarizes the meteorological conditions adopted in the model calculations :

Wind Speed	1 m/s
Wind Direction	worst-case
Wind Direction Variation	18 degrees
Stability Class	D or F
Mixing Height	500 m
Temperature	25°C

3.5 Modelling Method

The USEPA California Line Source Dispersion Model - CALINE4 was used to model the air quality at the representative air sensitive receivers. The NO_2 option of the model was adopted to calculate the NO_2 concentrations, and RSP was modelled as particulate in the model.

All at-grade roads have zero elevation and elevated roads have elevations which are equal to the heights of the roads above ground in the model. In order to estimate the effects of the recommended mitigation measures on the air quality at the nearby ASRs, the model was set up to incorporate the type of barriers proposed. According to the model description, there is no exact method to calculate the effects arising from road-side barrier structure.

In the case of inverted L-shaped barriers and partial enclosures, the road link with a barrier was artificially elevated to a height that is equivalent to the height of the barrier. In addition, the road link was laterally shifted by an amount equivalent to the horizontal extent of the barrier into the carriageway.

The Type I partial enclosure covering both carriageway of Tsing Tsuen Road has been further modelled as a tunnel in accordance with the recommendation of PIARC 91. The volume of pollutants was assumed to eject from the portal as a portal jet such that 2/3 of the total emissions was dispersed within the first 50m of the portal and 1/3 of the total emissions within the second 50m.

3.6 Ambient Pollutant Concentrations

In order to be consistent with other similar calculations, the following daily peak values, as recorded at the Central Western Air Quality Monitoring Station in 1996 [Air Quality in Hong Kong, 1996], were adopted in the model calculation of NO_2 at the receiver locations:

O_3 = 0.03 ppm
NO = 0.07 ppm
NO_2 = 0.05 ppm

The annual average NO_2 and RSP background concentrations for Central Western and Tsuen Wan are as follows:

Central Western	Tsuen Wan
NO_2 = 47 μg/m^3	NO_2 = 59 μg/m^3
RSP = 52 μg/m^3	RSP = 53 μg/m^3

4. IMPACT ASSESSMENT

The following sections present an assessment of the air quality impact at the worst-hit levels of the representative ASRs with and without the noise mitigation measures. Sample computer output is given in Appendix B.

4.1 Ap Lei Chau Bridge

The proposed inverted L-shaped barriers tend to limit the lateral dispersion of air pollutants towards the low-rise buildings along the eastbound carriageway of the flyover. At the same time, ASRs locating in front of the barrier will be subject to slightly more severe pollution impact. As shown in Table 4-1, the maximum 1-hour NO_2 and 24-hour RSP concentrations at most of the ASR locations with and without the proposed noise mitigation measures are practically unaffected except for the indicative assessment point at HA, which is located on the opposite side of the barrier. The RSP concentration at HA is slightly higher during the mitigated scenario because of the limited lateral dispersion of pollutants. On the other hand, the football pitch locating behind the barriers will receive some minor benefit from the implementation of the measures.

The 1-hour NO_2 and 24-hour RSP isopleths for the unmitigated and mitigated scenarios are presented in Figures 4-1 to 4-4.

Table 4-1 1-Hour NO_2 and 24-Hour RSP Concentrations at ASRs along Ap Lei Chau Bridge

ASR	NO2, $\mu g/m^3$		RSP, $\mu g/m^3$	
	Unmitigated	Mitigated	Unmitigated	Mitigated
HA	160	160	133	139
HM	216	216	171	171
SO	103	103	93	92
CO	122	122	107	107
FM	103	103	91	91
BK	160	160	129	129
FP	160	122	134	113

Note: Background concentrations are included.

4.2 Tsing Tsuen Road

The proposed partial enclosures tend to limit the lateral dispersion of air pollutants towards Riviera Gardens and Cheung On Estate. The result is a positive impact for the low level receivers at Riviera Gardens and the tennis courts outside of Cheung On Estate. On the other hand, the partial enclosures tend to deflect the air pollutants towards the opposite side of the road and/or towards the portal ends. However, the pollutant concentration levels at ASRs opposite Cheung On Estate (i.e. AG, SP, V1, V2) are practically unaffected by the erection of a partial enclosure. Conversely, the pollutant concentrations at ASR HK are slightly higher after the implementation of the partial enclosures as HK is located near the eastern portal of the enclosure.

Table 4-2 gives the maximum 1-hour NO_2 and 24-hour RSP concentrations without and with the noise mitigation measures at the identified ASR locations, and Figures 4-5 to 4-12 present the corresponding contours for the unmitigated and mitigated scenarios. As far as these receivers are concerned, the effects are minor and all concentrations are within the AQO.

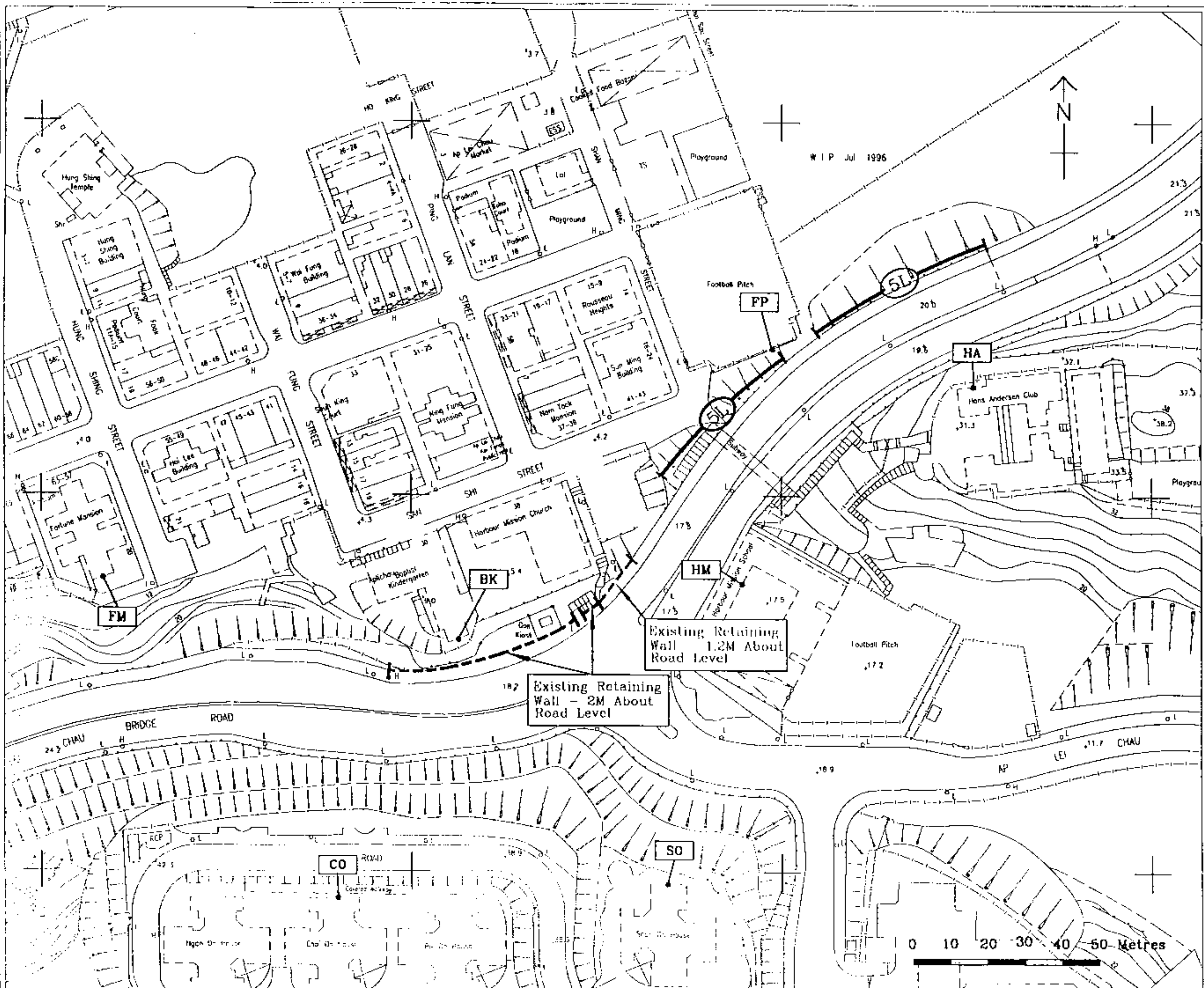
Table 4-2 1-Hour NO_2 and 24-Hour RSP Concentrations at ASRs along Tsing Tsuen Road

ASR	NO2, µg/m3		RSP,µg /m3	
	Unmitigated	Mitigated	Unmitigated	Mitigated
HS	122	103	125	113
HF	160	141	149	138
HK	160	179	154	169
SC	122	122	120	114
OC	141	141	125	125
OP	103	103	108	108
AG	103	103	105	104
SP	103	103	100	100
V1	103	103	100	100
V2	103	103	107	106
TC	141	122	135	122

Note: Background concentrations are included.

5. CONCLUSION

Using the modelling methodology as described above, it has been shown that the proposed noise mitigation measures would not produce any significant, adverse air quality impact on the nearby air sensitive receivers. In some cases, there appears to be minor benefit to the receivers mainly because the noise structures limit the lateral dispersion or diffusion of air pollutants to the receivers.



LEGEND

FM — LOCATION OF REPRESENTATIVE ASR

5L — PROPOSED 5M INVERTED L-SHAPED BARRIER

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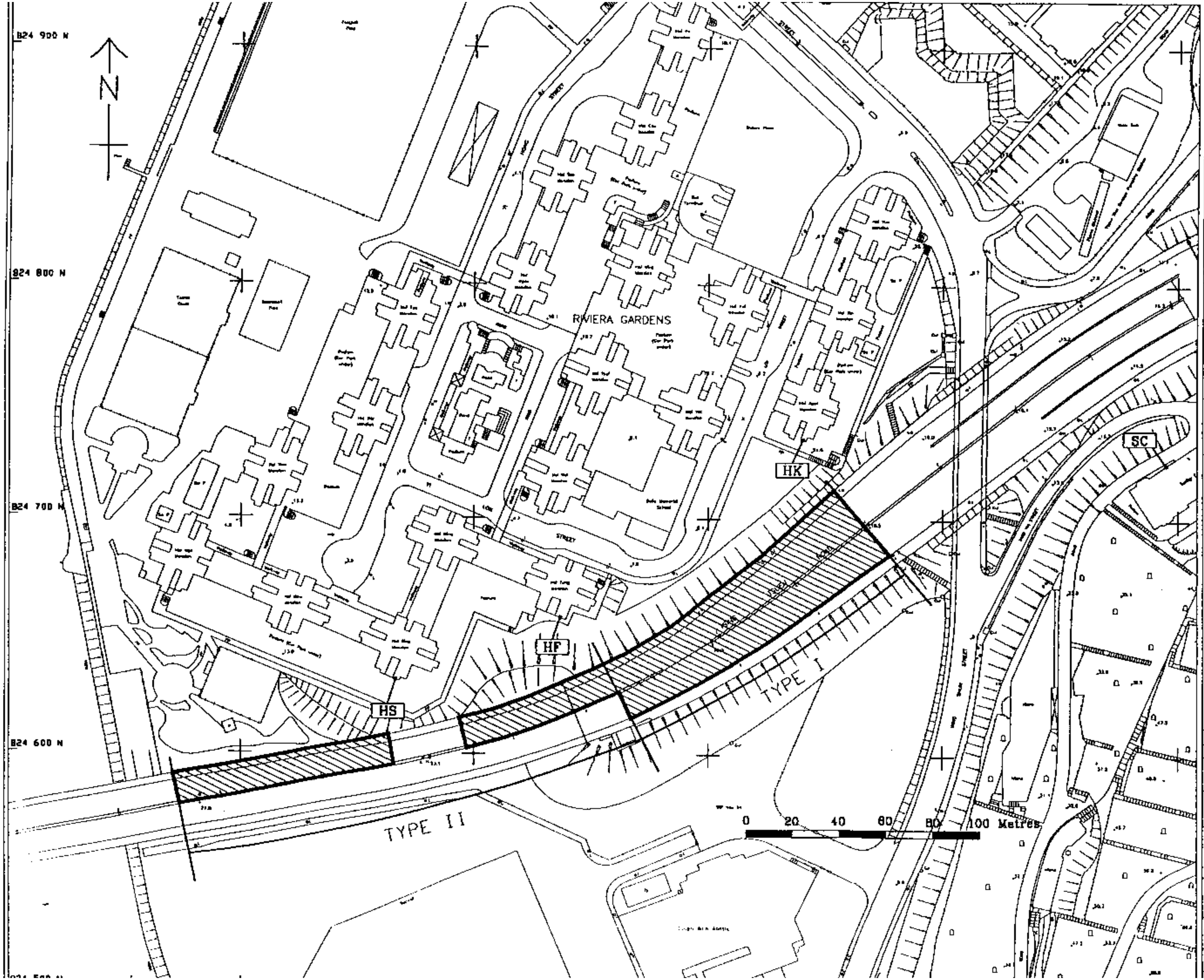
FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

LOCATIONS OF REPRESENTATIVE AIR SENSITIVE RECEIVERS AND RECOMMENDED NOISE MITIGATION MEASURES

MAUNSELL CONSULTANTS ASIA

FIGURE NO. FIGURE 2-1

SCALE AS SHOWN



LEGEND

HS — LOCATION OF REPRESENTATIVE ASR

TYPE I - PARTIAL ENCLOSURE COVERING THE ENTIRE WIDTH OF CARRIAGEWAY

TYPE II - PARTIAL ENCLOSURE COVERING EASTBOUND CARRIAGEWAY

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FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

LOCATIONS OF REPRESENTATIVE AIR SENSITIVE RECEIVERS AND RECOMMENDED NOISE MITIGATION MEASURES

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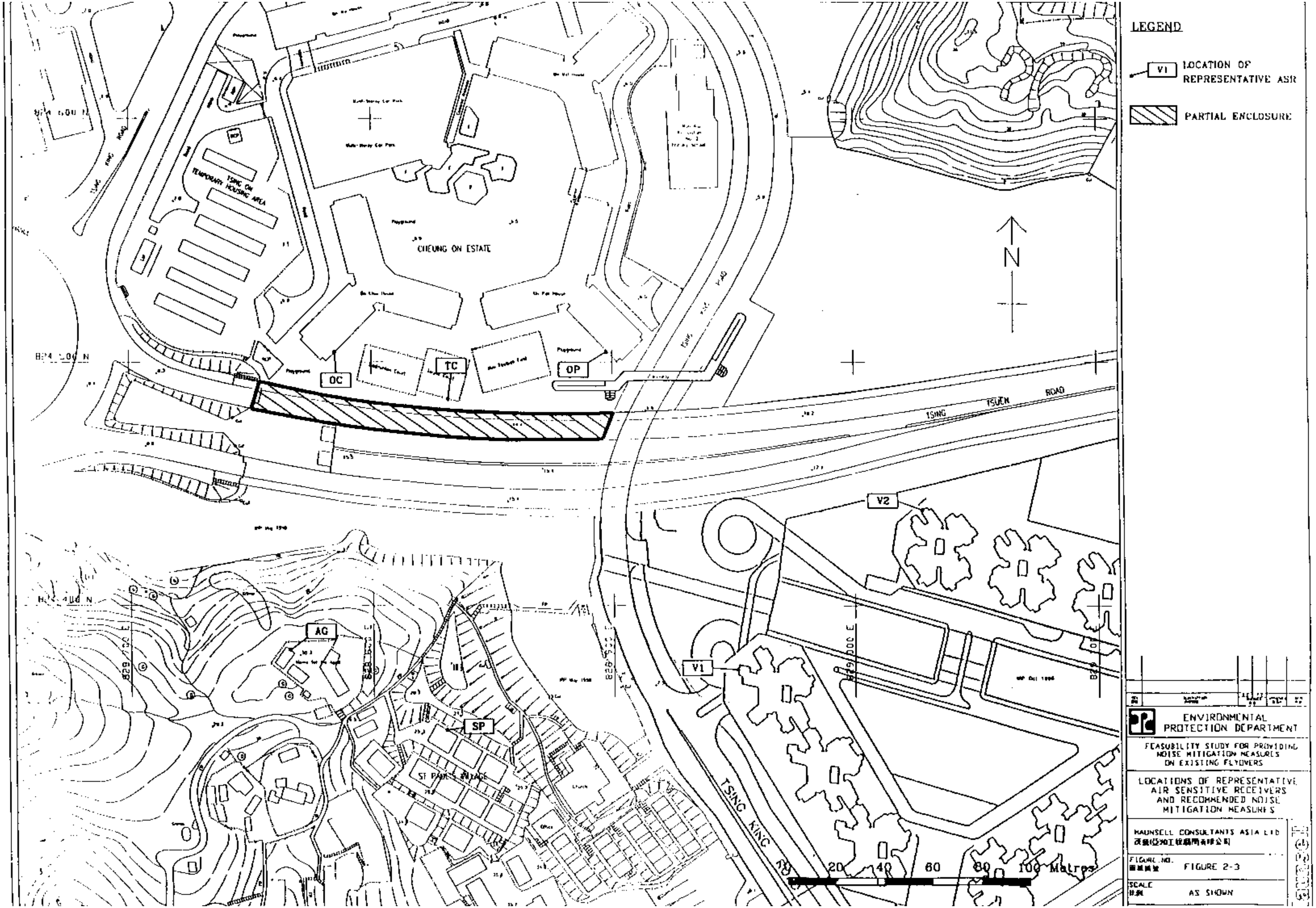
FIGURE NO 圖表編號 FIGURE 2.2

SCALE 比例 AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

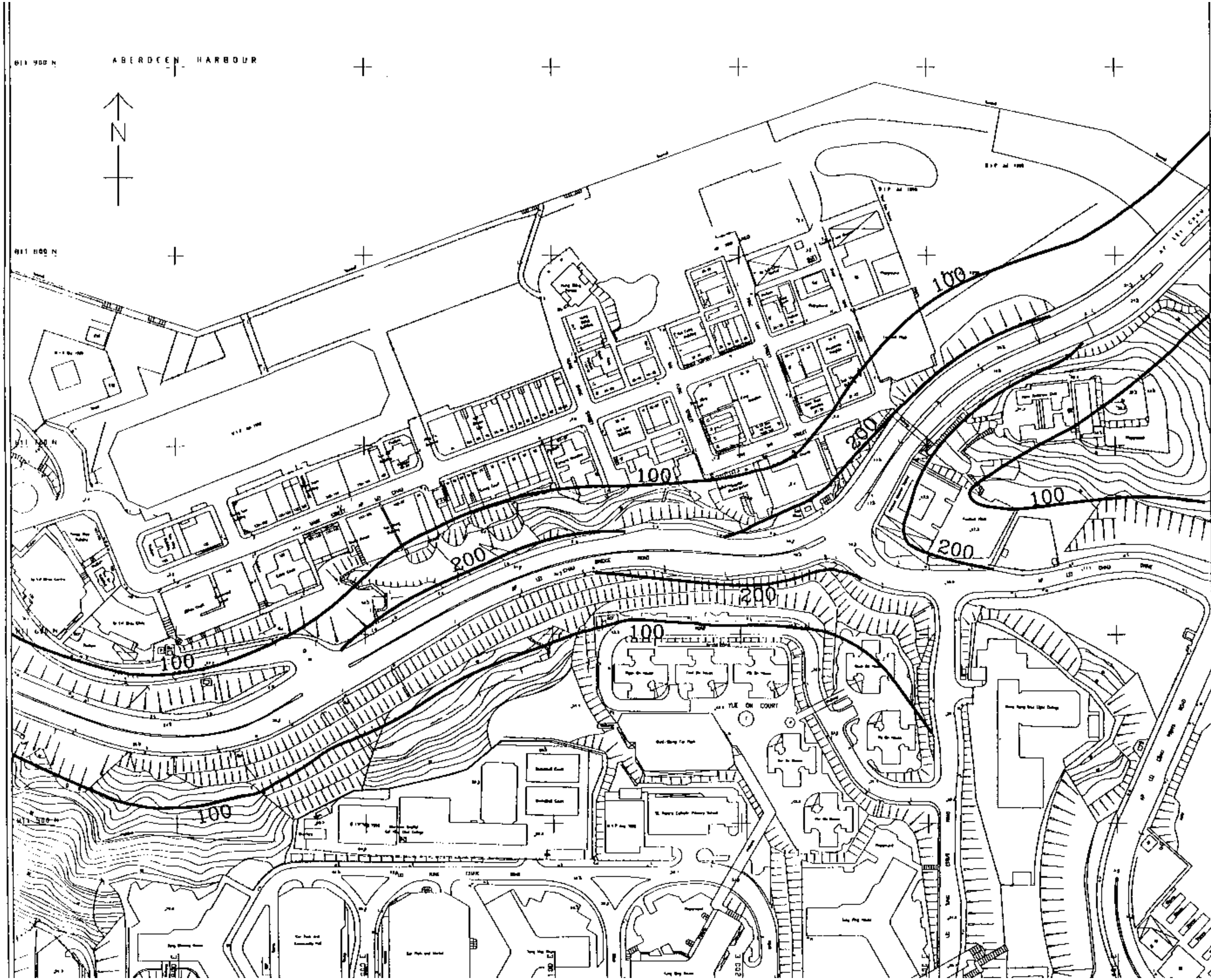
FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

LOCATIONS OF REPRESENTATIVE AIR SENSITIVE RECEIVERS AND RECOMMENDED NOISE MITIGATION MEASURES

MAUNSELL CONSULTANTS ASIA LTD

FIGURE NO. FIGURE 2-3

SCALE AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - UNMITIGATED

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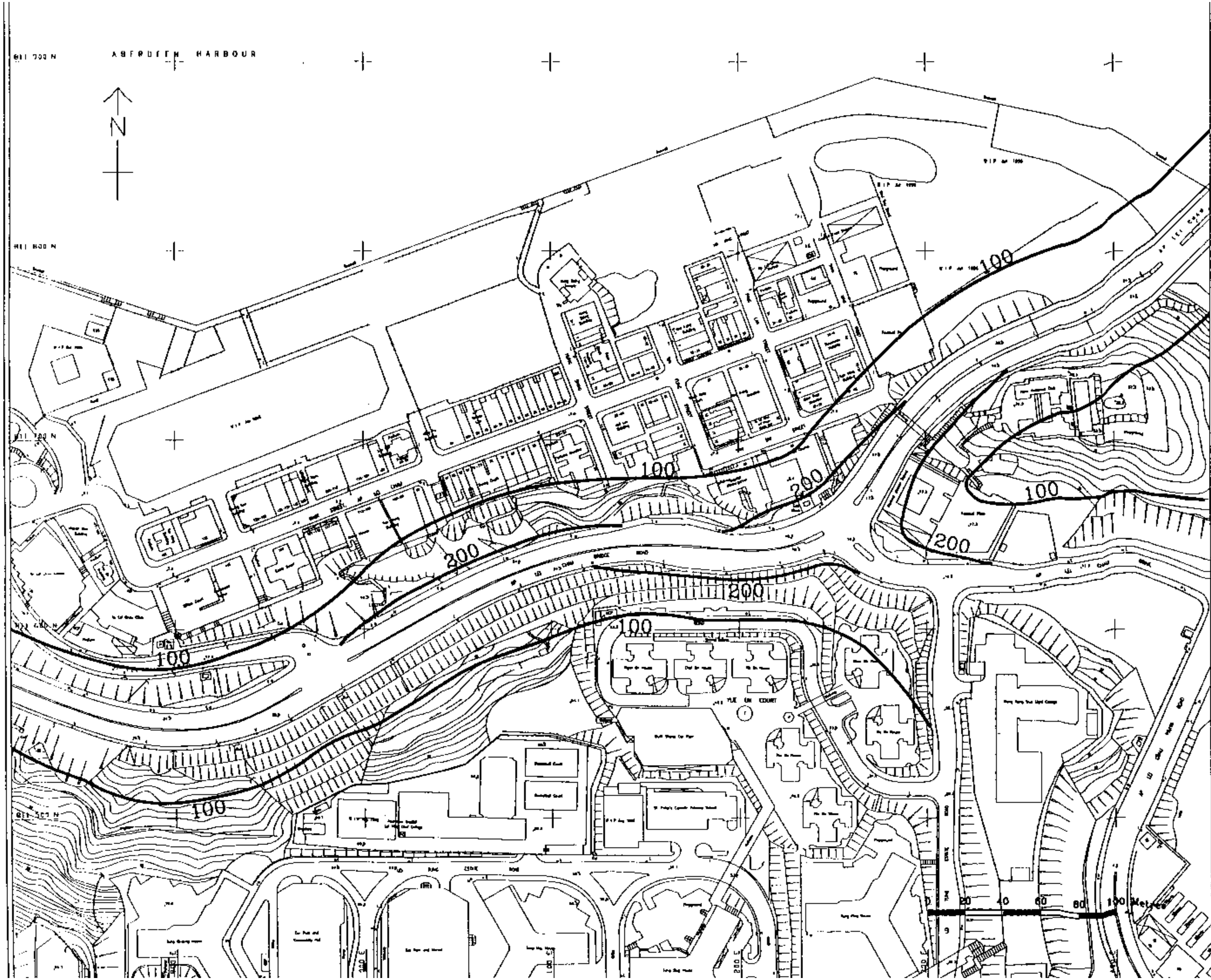
FIGURE NO. 圖表編號 FIGURE 4-1

SCALE 比例 AS SHOWN

Maunsell



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - MITIGATED

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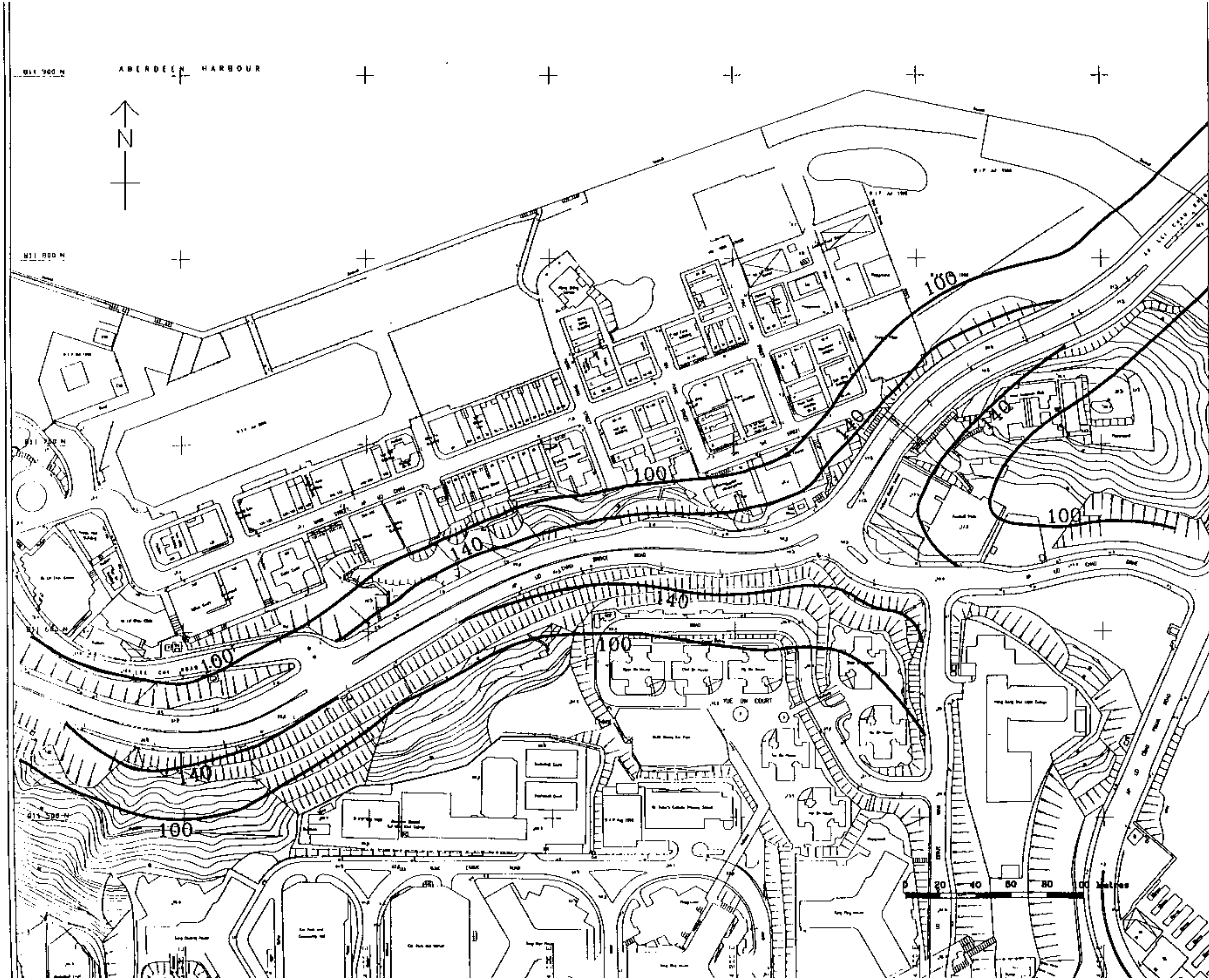
FIGURE NO. 圖表編號 FIGURE 4-2

SCALE 比例 AS SHOWN

Maunsell



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

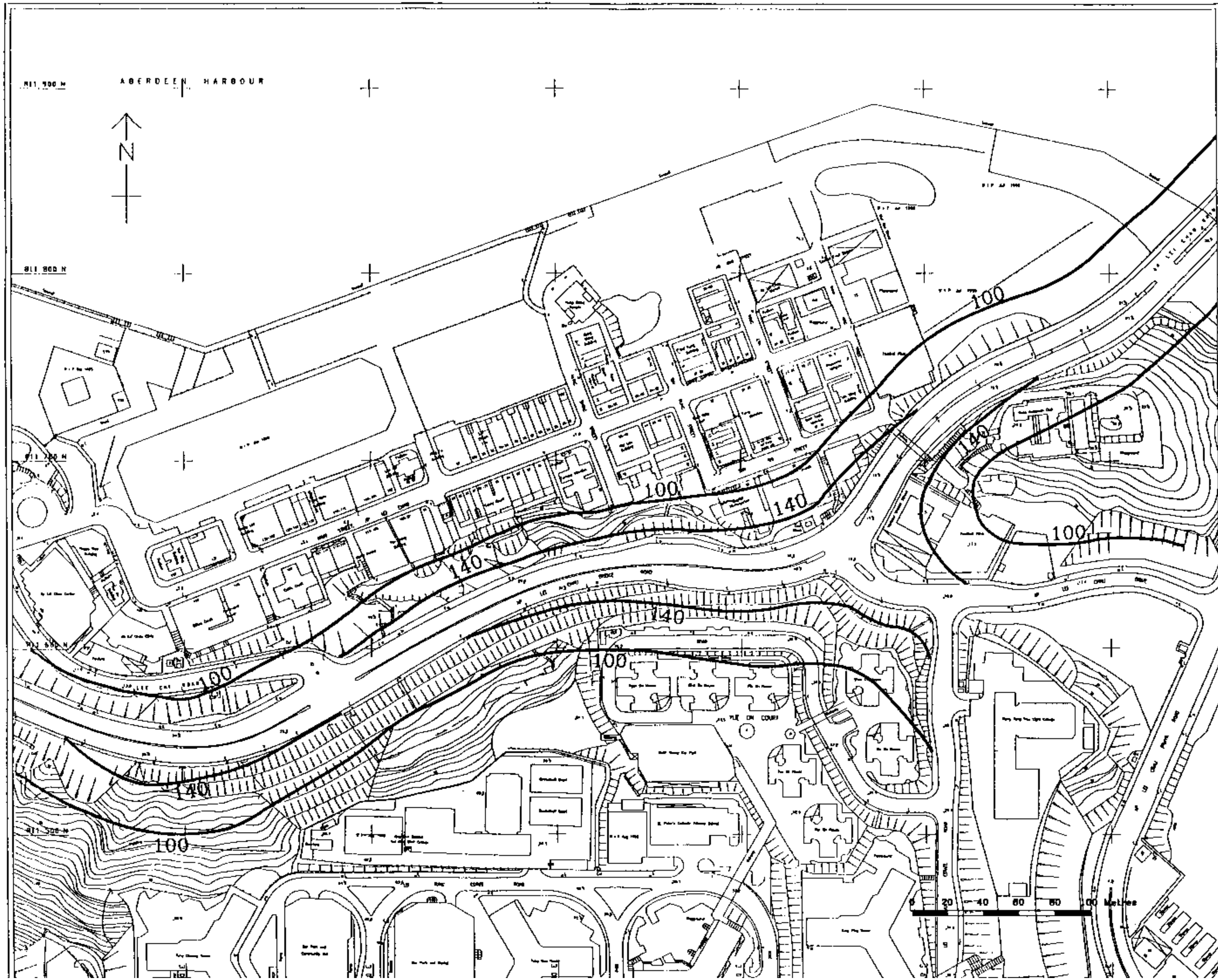
PREDICTED 24-HOUR AVERAGE RSP CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - UNMITIGATED

MAUNSELL CONSULTANTS ASIA LTD.

FIGURE NO. FIGURE 4-3

SCALE AS SHOWN

Maunsell



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 24-HOUR AVERAGE RSP CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - MITIGATED

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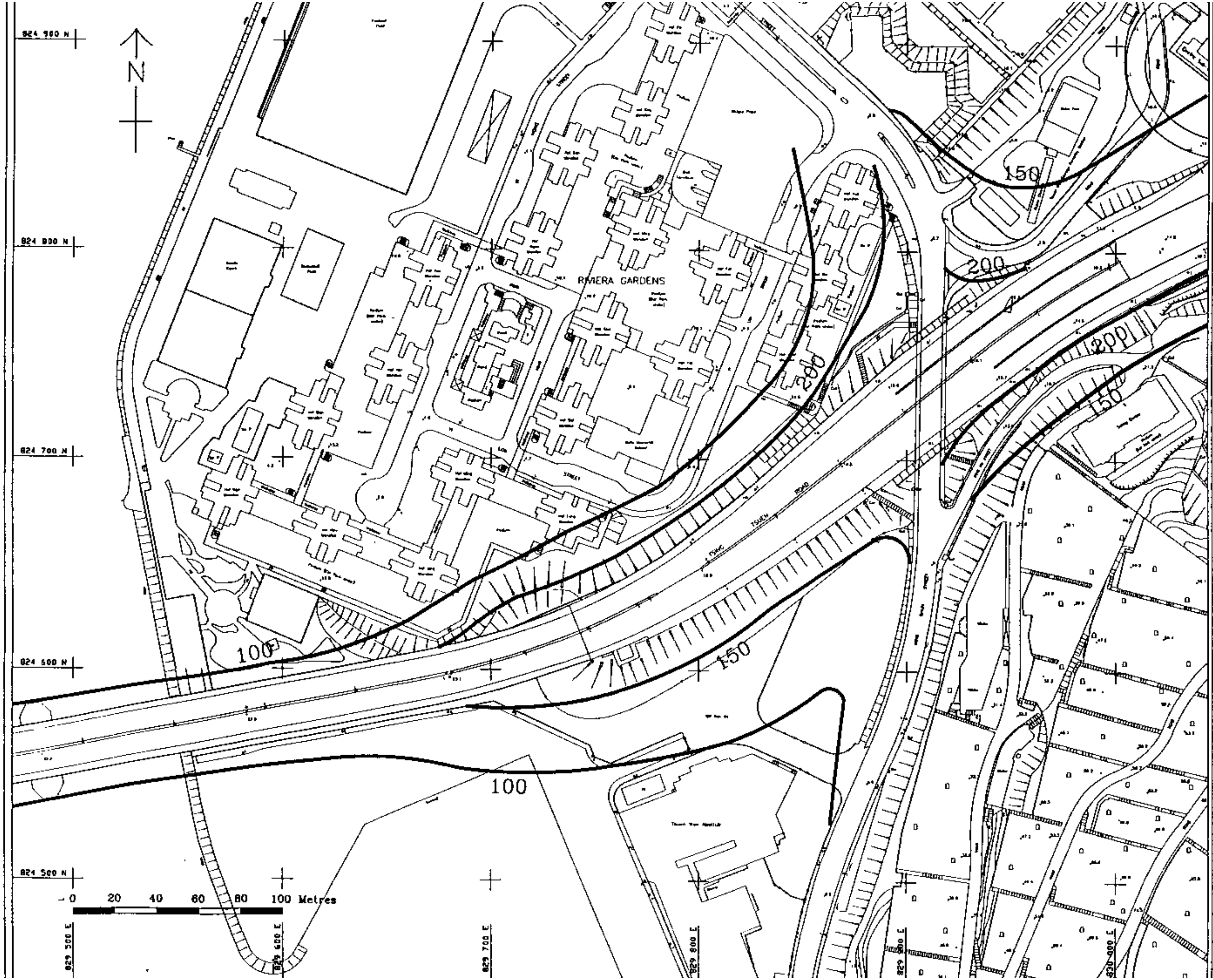
FIGURE NO. FIGURE 4-4

SCALE AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASUBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - UNMITIGATED

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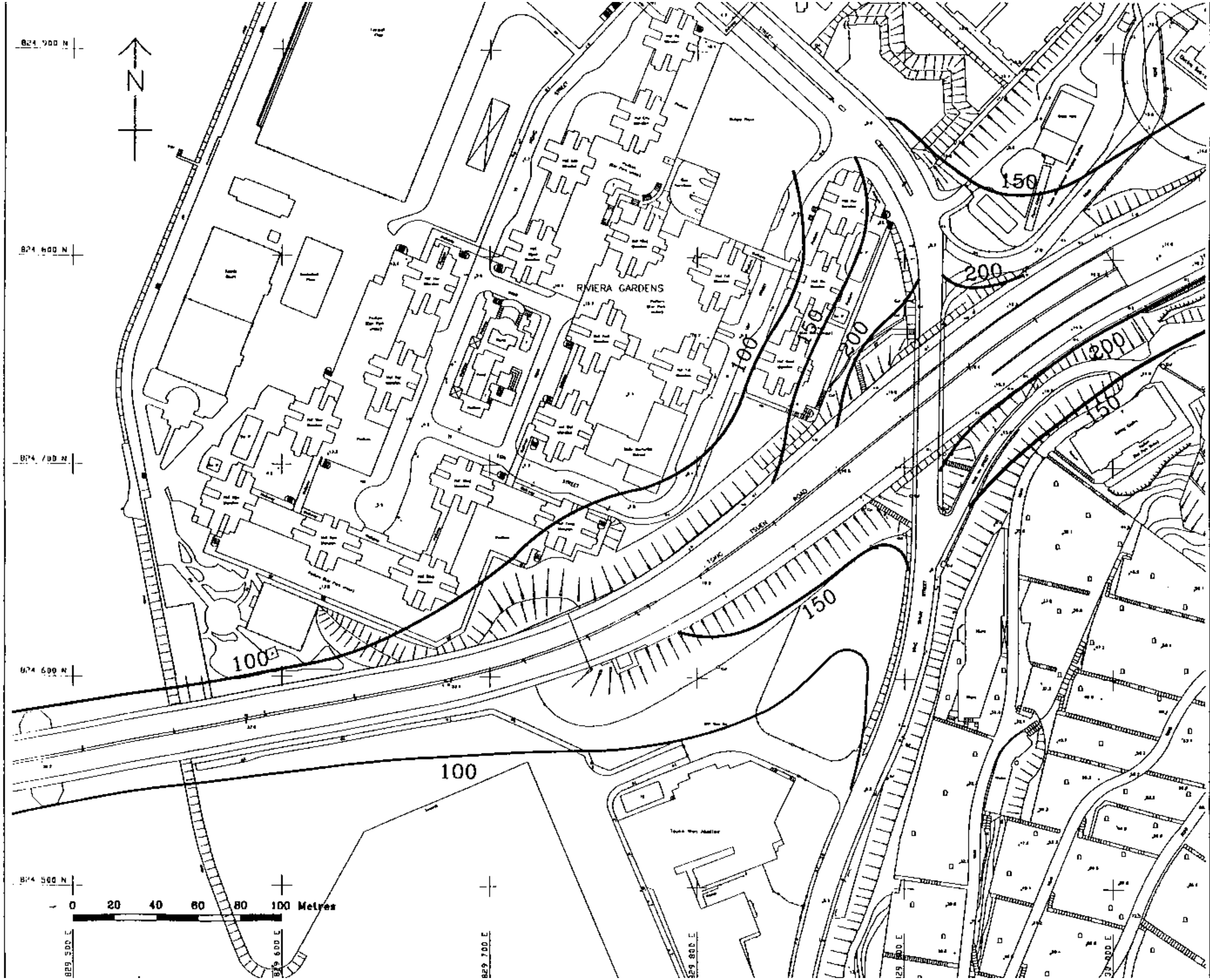
FIGURE.NO. FIGURE 4-5

SCALE AS SHOWN

Maunsell



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - MITIGATED

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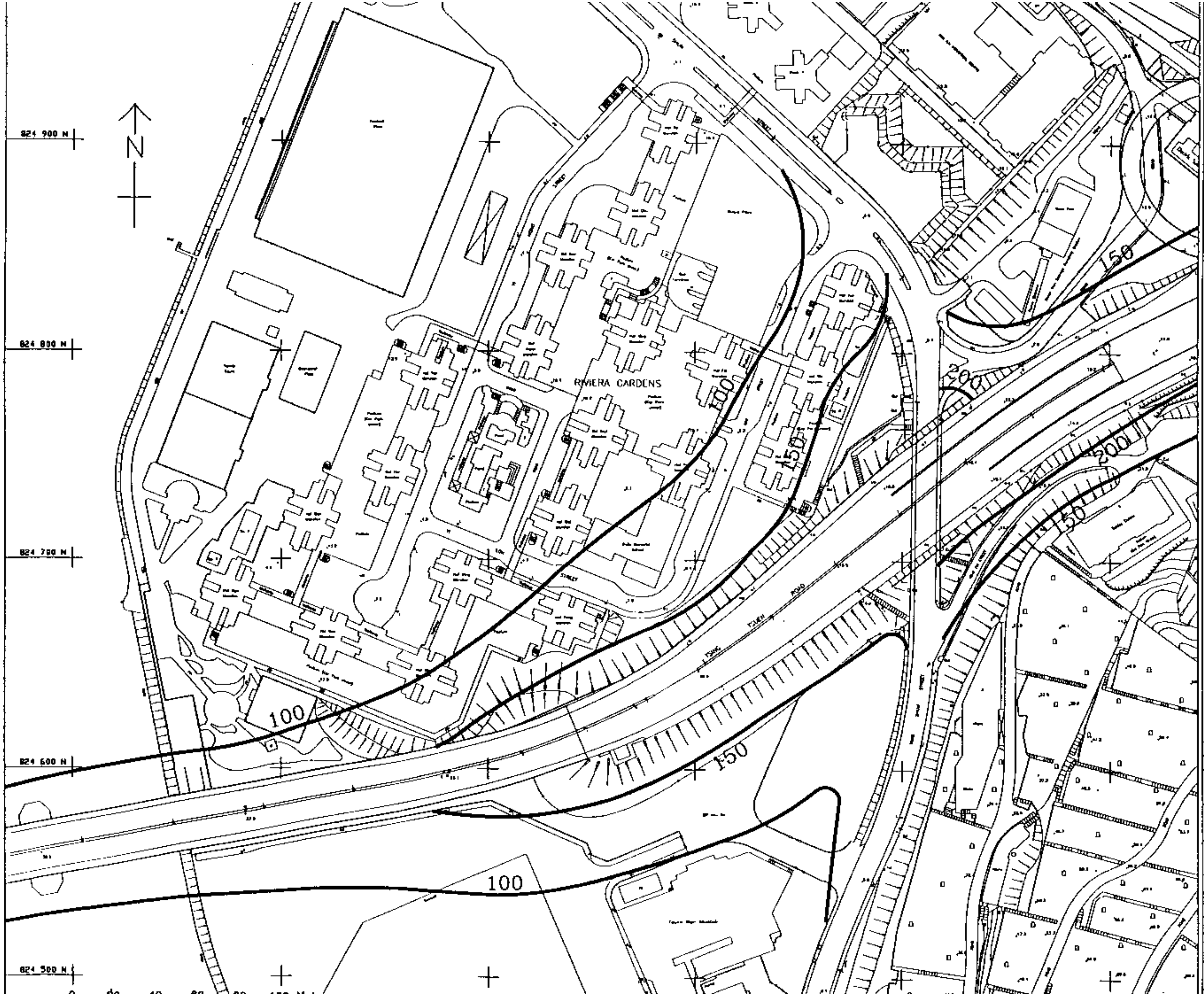
FIGURE NO. FIGURE 4-6

SCALE AS SHOWN

Maunsell



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 24-HOUR AVERAGE RSP CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - UNMITIGATED

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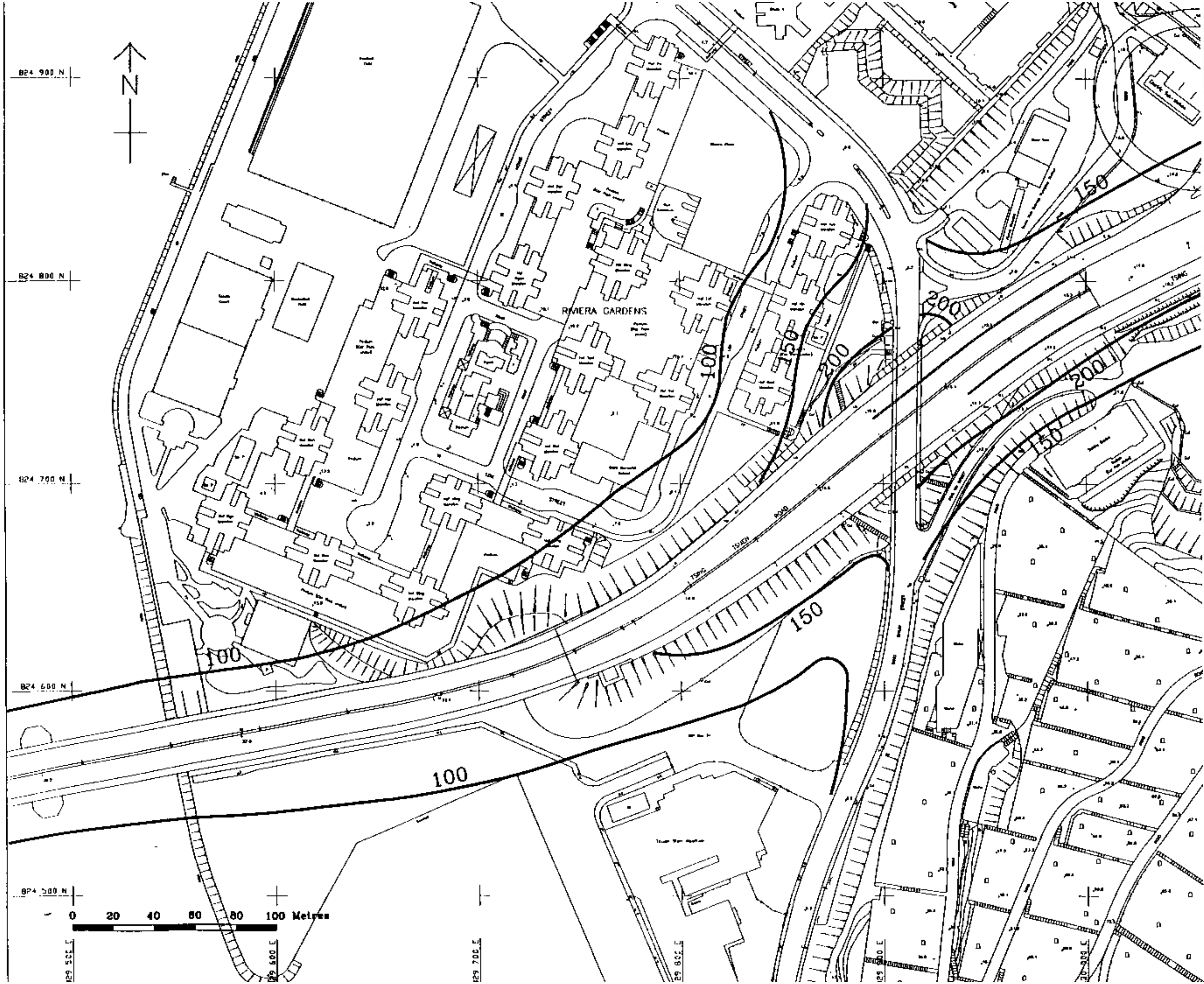
FIGURE NO. FIGURE 4-7

SCALE AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 24-HOUR AVERAGE RSP CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - MITIGATED

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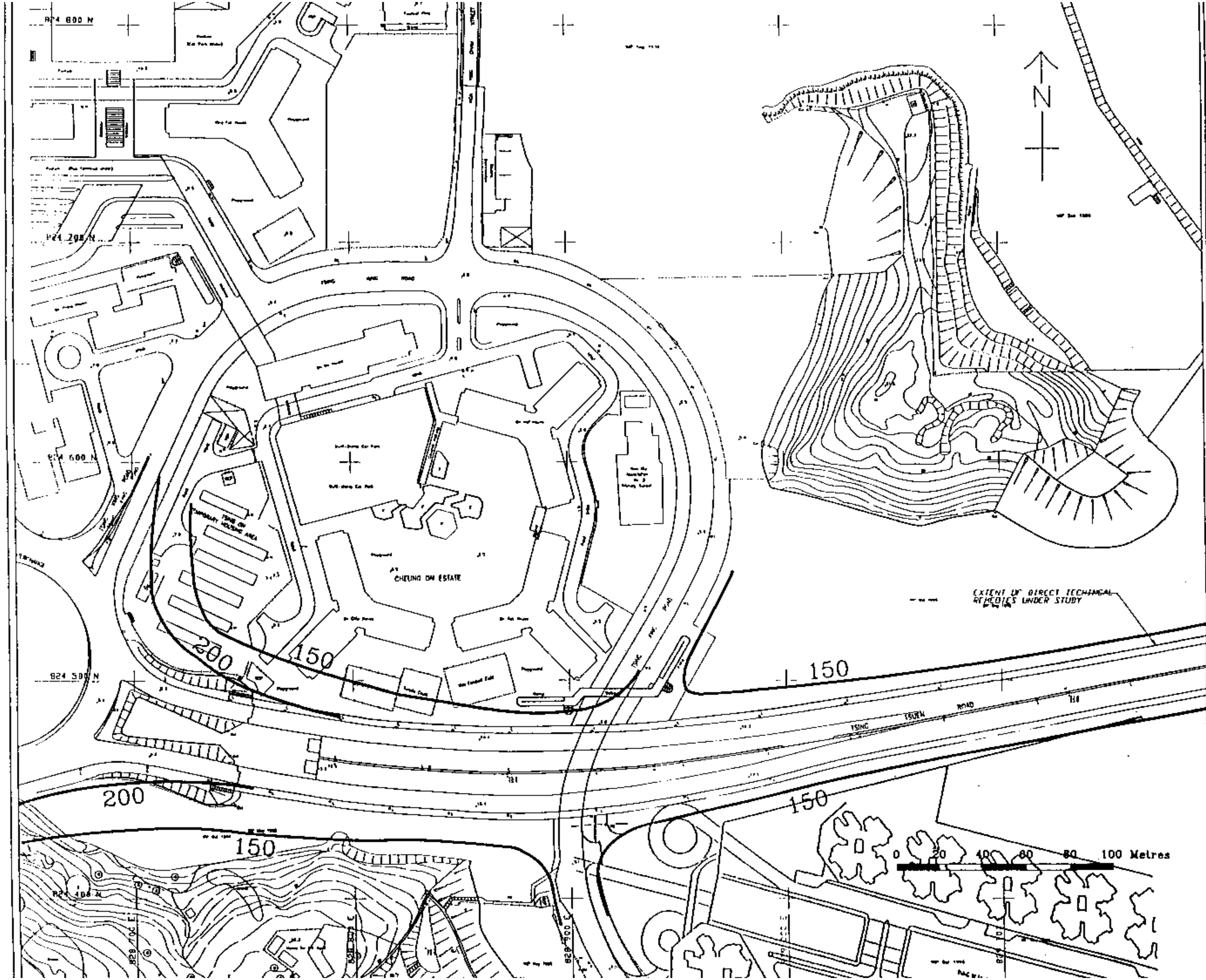
FIGURE NO.
圖表編號 FIGURE 4-8

SCALE
比例 AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATION ($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - UNMITIGATED

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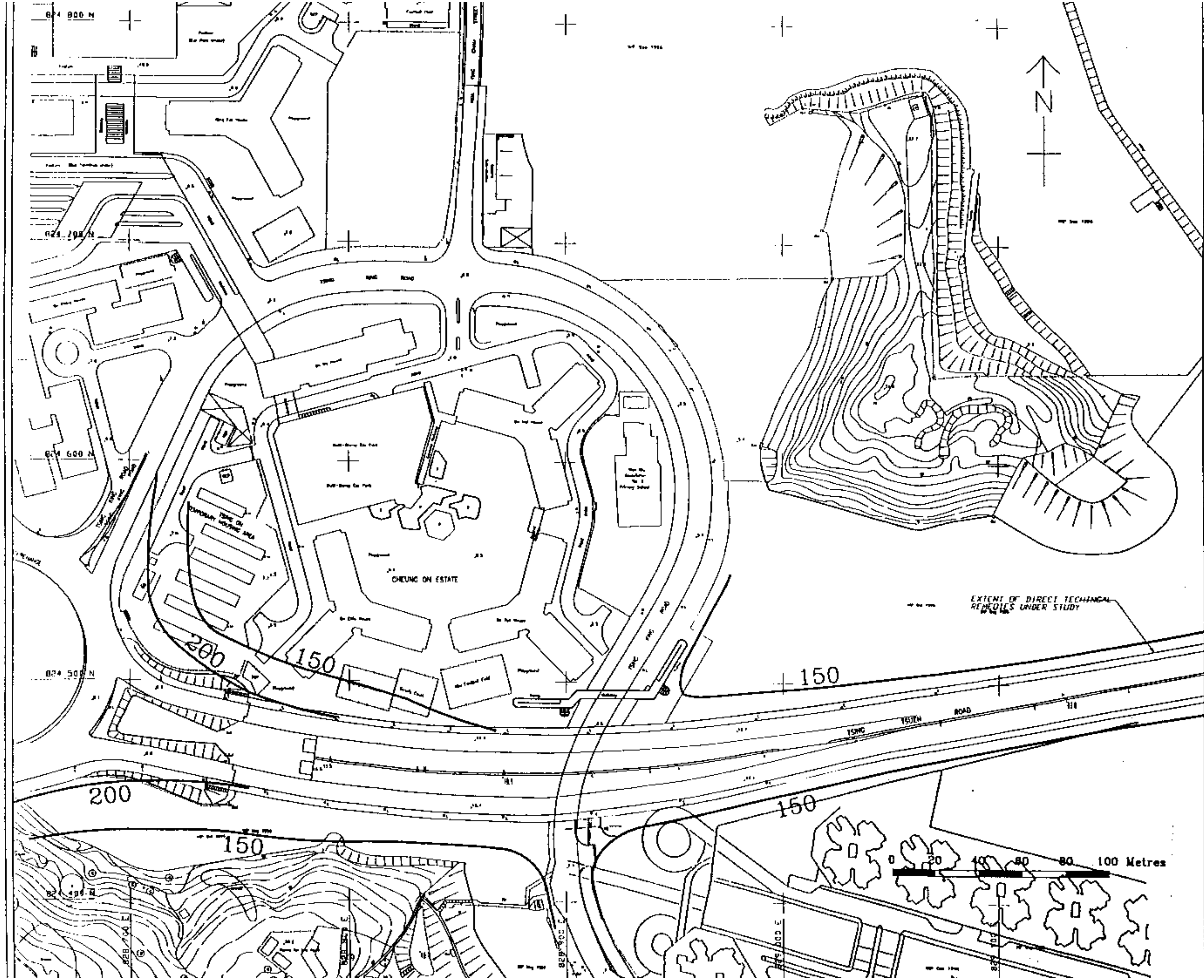
FIGURE NO. FIGURE 4-9

SCALE AS SHOWN

Maunsell



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 1-HOUR AVERAGE NO_2 CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - MITIGATED

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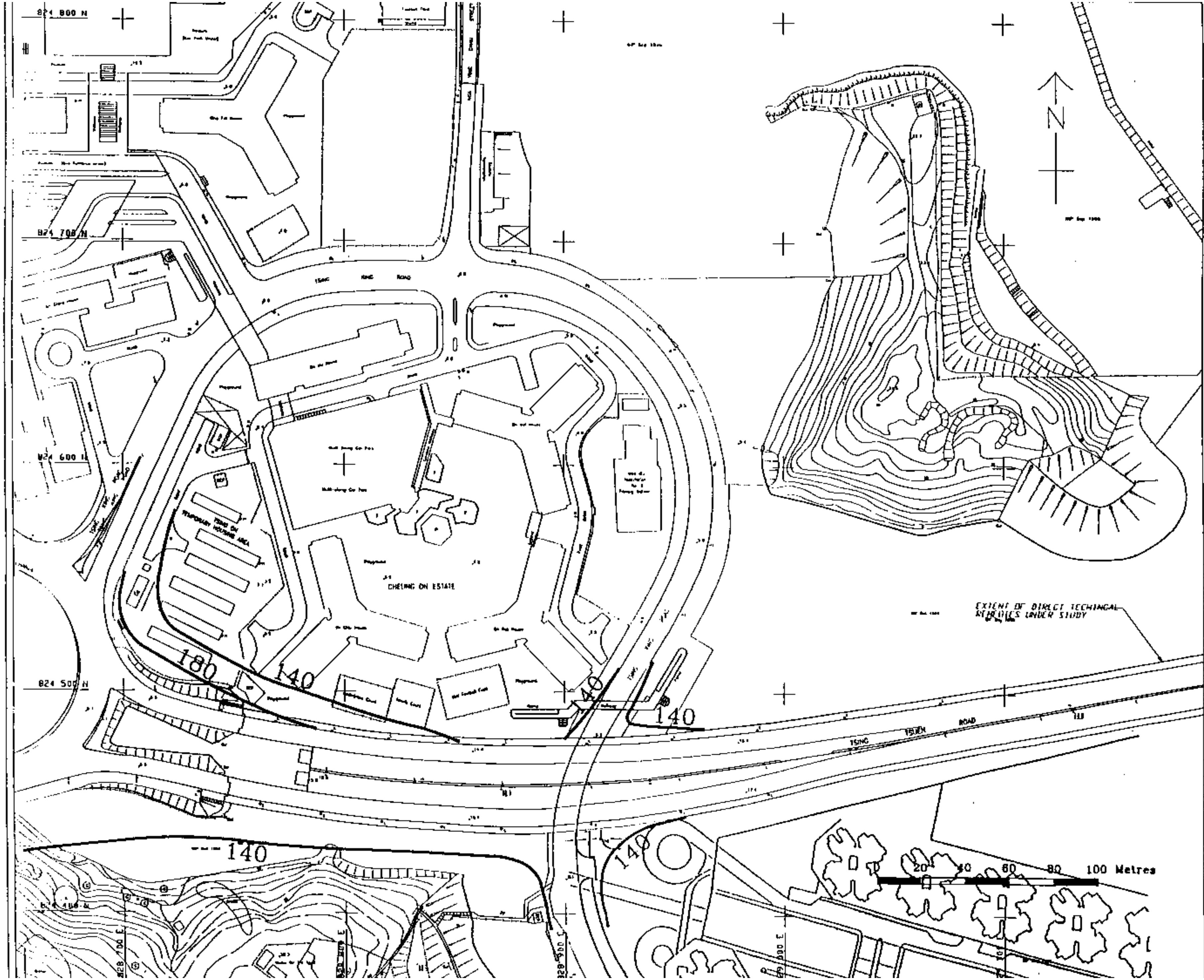
FIGURE NO. 圖紙編號 FIGURE 4-10

SCALE 比例 AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

PREDICTED 24-HOUR AVERAGE RSP CONCENTRATION($\mu g/m^3$) CONTOURS AT 1.5M ABOVE GROUND - UNMITIGATED

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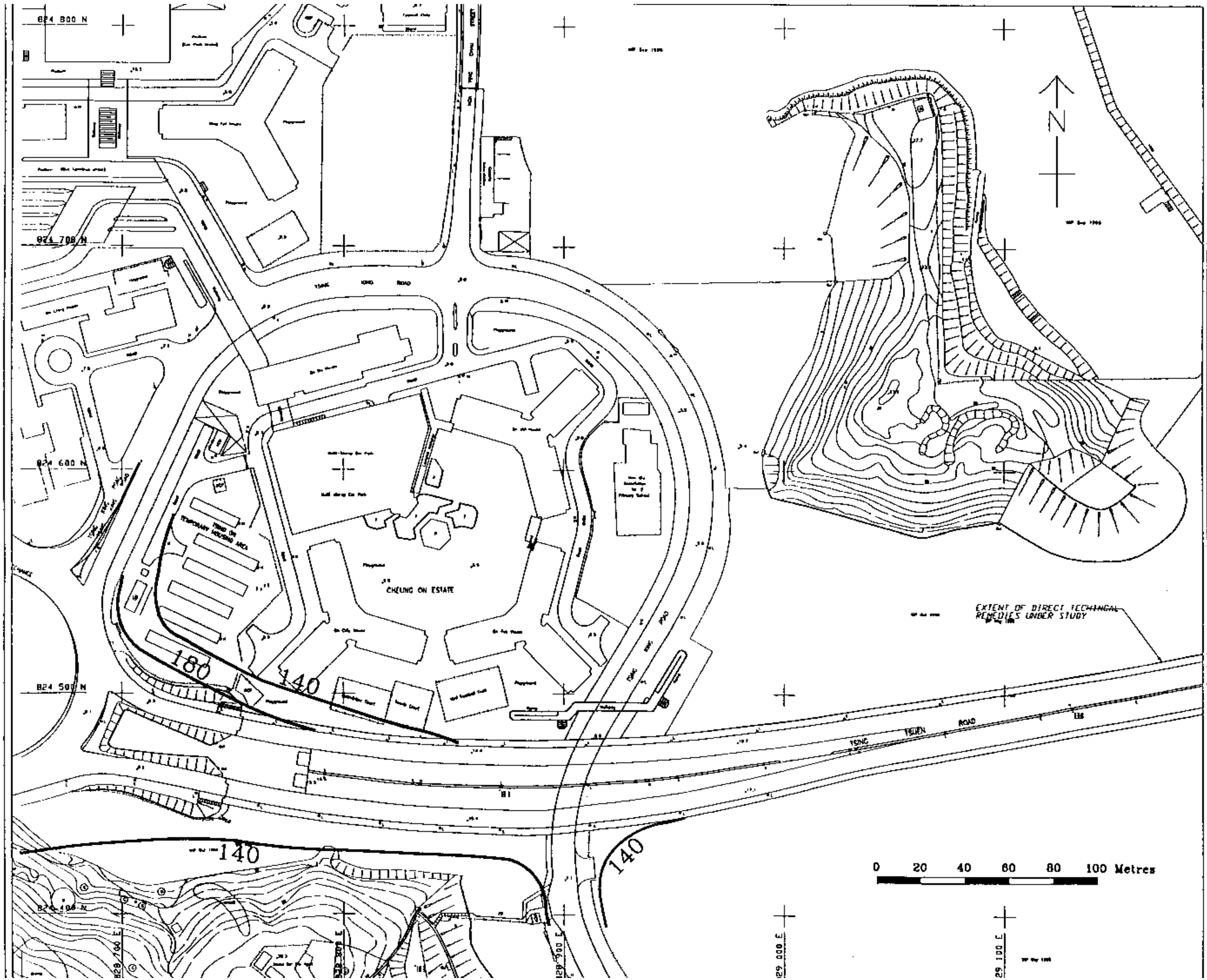
茂盛(亞洲)工程顧問有限公司

FIGURE NO. 圖表編號 FIGURE 4-11

SCALE 比例 AS SHOWN



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

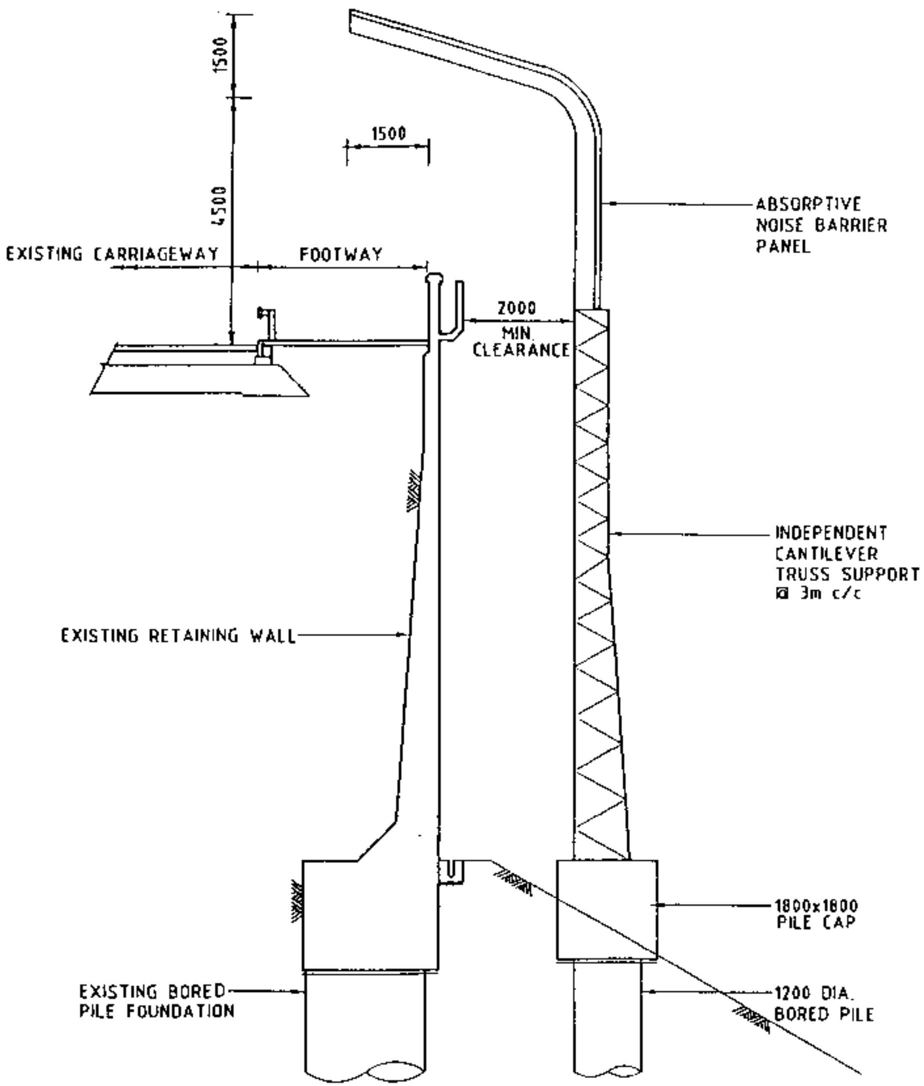
PREDICTED 24-HOUR AVERAGE RSP CONCENTRATION(μg/m3) CONTOURS AT 1.5M ABOVE GROUND - MITIGATED

MAUNSELL CONSULTANTS ASIA LTD.

FIGURE NO. FIGURE 4-12

SCALE AS SHOWN

APPENDIX A



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

CROSS-SECTION OF INVERTED-L SHAPED NOISE BARRIER

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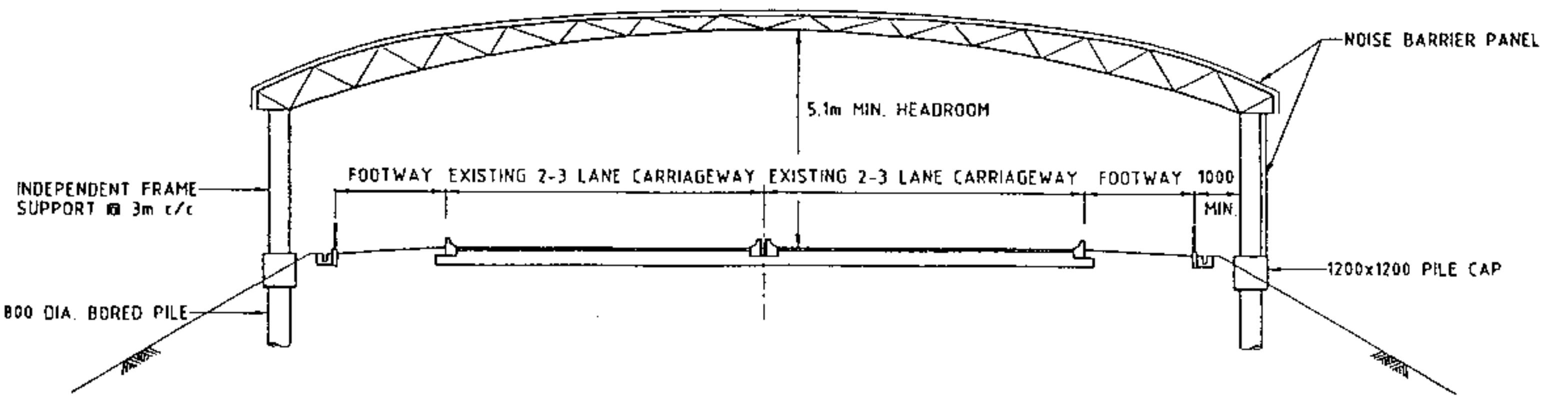
FIGURE NO: FIGURE A1

SCALE: N. T. S.



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

CROSS-SECTION OF PARTIAL ENCLOSURE (TYPE 1) (SHEET 1 OF 2)

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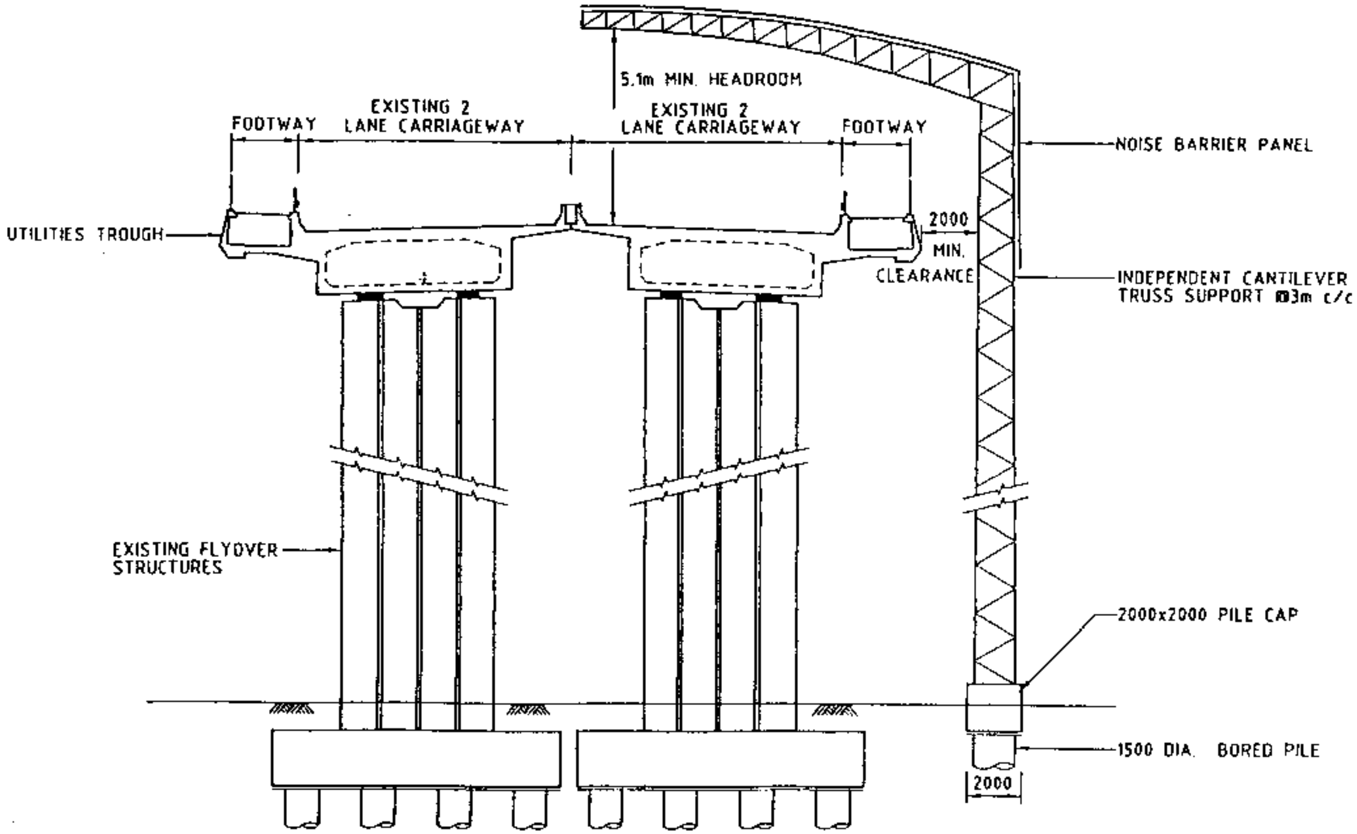
FIGURE NO: FIGURE A2

SCALE



ENVIRONMENTAL PROTECTION DEPARTMENT

FEASIBILITY STUDY FOR PROVIDING NOISE MITIGATION MEASURES ON EXISTING FLYOVERS

CROSS-SECTION OF PARTIAL ENCLOSURE (TYPE II) (SHEET 2 OF 2)

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FIGURE NO. FIGURE A2

SCALE

APPENDIX B

CALINE4: CALIFORNIA LINE SOURCE DISPERSION MODEL
JUNE 1989 VERSION
PAGE 1

JOB: Retroactive: AP LEI CHAU (UN-mitigrated)
RUN: 11 (WORST CASE ANGLE)
POLLUTANT: NO2

I. SITE VARIABLES

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

NOX VARIABLES

NO2= .05 PPM   NO= .07 PPM   O3= .03 PPM   KR= .004 1/SEC

II. LINK VARIABLES

LINK DESCRIPTION	X1	Y1	X2	Y2	TYPE	VPH	EF (G/MI)	H (M)	W (M)
A. 2A	34419	11636	34373	11630	AG	180	9.39	.0	13.0
B. 2B	34373	11630	34310	11627	AG	180	9.39	.0	13.0
C. 3	34313	11400	34310	11514	AG	690	9.02	.0	14.0
D. 4A	34310	11514	34255	11529	AG	160	4.07	.0	14.0
E. 4B	34255	11529	34231	11604	AG	160	4.07	.0	14.0
F. 4C	34231	11604	34138	11603	AG	160	4.07	.0	14.0
G. 5	34310	11514	34309	11626	AG	840	8.23	.0	16.0
H. 6	34310	11618	34250	11654	AG	940	8.55	.0	18.0
I. 7A	34491	11860	34404	11775	BG	2480	7.30	18.0	24.0
J. 7B	34404	11775	34361	11754	BG	2480	7.30	18.0	24.0
K. 7C	34361	11754	34316	11732	AG	2480	7.30	.0	24.0
L. 7D	34316	11732	34283	11693	AG	2480	7.30	.0	24.0
M. 7E	34283	11693	34250	11654	AG	2480	7.30	.0	24.0
N. 8A	34250	11654	34222	11641	AG	2020	7.04	.0	24.0
O. 8B	34222	11641	34133	11645	AG	2020	7.04	.0	24.0
P. 8C	34133	11645	34041	11612	AG	2020	7.04	.0	24.0
Q. 8D	34041	11612	33948	11556	AG	2020	7.04	.0	24.0
R. 8E	33948	11556	33884	11546	AG	2020	7.04	.0	24.0
S. 8F	33884	11546	33808	11574	AG	2020	7.04	.0	24.0
T. 9	34214	11752	34167	11734	AG	110	6.95	.0	16.0
U. 0A	34214	11752	34232	11706	AG	95	5.90	.0	16.0
V. 0B	34232	11706	34184	11689	AG	95	5.90	.0	16.0
W. 0C	34184	11689	34167	11734	AG	95	5.90	.0	16.0
X. 11	34167	11734	33883	11627	AG	230	6.65	.0	16.0

III. RECEPTOR LOCATIONS

RECEPTOR	X	Y	Z
1. HA	34353	11730	2.0
2. HM	34288	11674	2.0
3. SO	34270	11596	5.0
4. CO	34179	11592	5.0
5. FM	34117	11678	5.0
6. BK	34213	11662	2.0
7. FP	34296	11740	2.0

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. HA	255.	.11	.00	.00	.00	.00	.00	.00	.00	.00
2. HM	251.	.14	.00	.00	.00	.00	.00	.00	.00	.01
3. SO	358.	.08	.00	.00	.00	.00	.00	.00	.00	.01
4. CO	47.	.09	.00	.00	.00	.00	.00	.01	.00	.00
5. FM	127.	.08	.00	.00	.00	.00	.00	.00	.00	.00
6. BK	109.	.11	.00	.00	.00	.00	.00	.00	.00	.02
7. FP	182.	.11	.00	.00	.00	.00	.00	.00	.01	.01