Chapter 5

Development of simulation model and projection of long term ambient air concentration in GTA

5. Development of simulation model and projection of long term ambient air concentration in Greater Tehran Area

5.1 Development of simulation model

5.1.1 Basic model

The main role of dispersion model is to predict a future situation according to several scenarios and to evaluate effectiveness of countermeasures. The validation process under the current condition with optimized categorization/parameterization is important for confirmation of model performance. The total flow for the model development is summarized in the following chart.

At each step of the flow, the results obtained by the activities are utilized. For example, measured air quality data are analyzed in relation to the meteorological condition and utilized to set suitable categorization. Measurement at the target factories and statistical analyses on fuel consumption are utilized to set specifications of the stationary sources. For mobile sources, the emission factor is set based on the chassis-dynamo test. The traffic volume survey data are also combined with the existing data of TCTTS/TTTO.

It should be noted that main target of the model is to simulate the long term average concentration at area-representative points in order to grasp general features. Another suitable method should be adopted for special conditions described in 5.3.2.

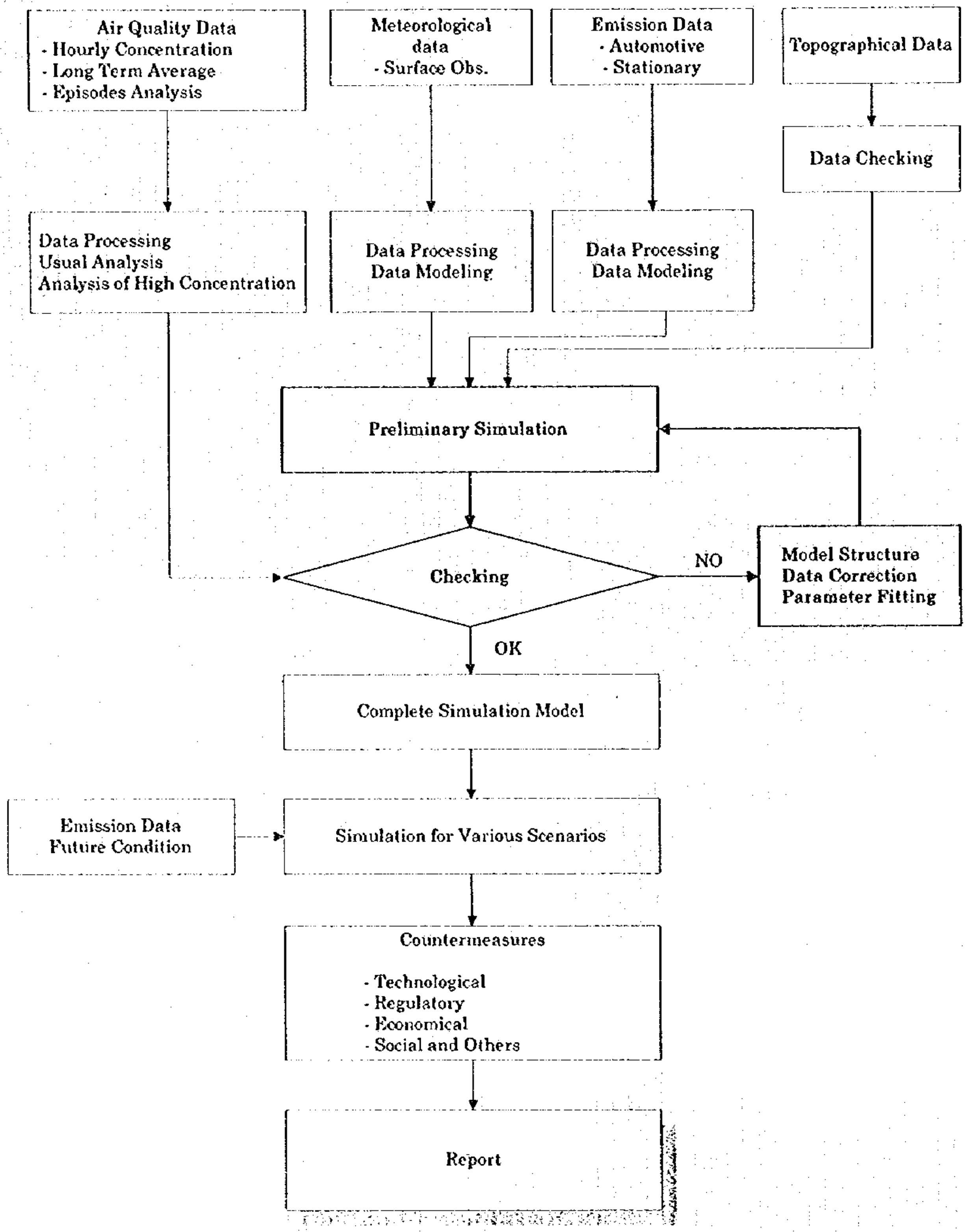


Fig.5.1.1-1 Total flow of the simulation

(1) formulation

The model is based on an approximation of Gaussian shaped plume formula shown below.

$$C(x,y,z)=\frac{q}{2\pi\sigma_y\sigma_z U}\exp(-\frac{y^2}{2\sigma_y^{\,2}})\left[\exp\left\{-\frac{(z-He)^2}{2\sigma_z^{\,2}}\right\}+\exp\left\{-\frac{(z+He)^2}{2\sigma_z^{\,2}}\right\}\right]$$

where

C: concentration at receptor

x,y,z :receptor position relative to the source

(x-downwind, y-lateral ,z-vertical)

q: source intensity

σ_y, σ_z: lateral and vertical diffusion parameter (function of x)

U: wind velocity

He: effective stack height

In calm condition, the following puff formula is adopted instead of the plume formula:

$$C(R,z)=\frac{q}{(2\pi)^{3/2}\gamma}\left[\frac{1}{R^2+\frac{\alpha^2}{\gamma^2}(He-z)^2}+\frac{1}{R^2+\frac{\alpha^2}{\gamma^2}(He+z)^2}\right]$$

where

R : horizontal distance ($R^2=x^2+y^2$)

α, γ : coefficient for σ_y,σ_z ($\sigma_y=\alpha t$, $\sigma_z=\gamma t$)

In case a temperature inversion layer exists, the pollutants are reflected on the top of inversion ("lid") and trapped below a lid.

To avoid diverging, we set a minimum distance for calculation. This value (10m) is automatically adopted if a source-receptor distance is smaller than it.

(2) Time periods

Whole day and year are divided into following eight (4x2) periods through the analyses on the variation of concentration and emission:

morning (7-9h), daytime (10-15h), evening(16-19h), nighttime(20-6h) non-heating season (April to October), heating season(November to March)

(3) Meteorological condition

Meteorological elements are categorized as following:

wind direction : 16 direction and calm

wind speed : 8 classes (0-0.4, 0.5-0.9, 1.0-1.9, 2.0-2.9, 3.0-3.9, 4.0-5.9, 6.0-7.9, 8.0- m/s)

stability : 10 classes (based on Pasquill-Gifford)

Table 5.1.1-1 Pasquill-Gifford classification

	solar radiation (kW/m2)				net radiation (kW/m2)		
wind speed	>=0.60	0.30 to 0.60	0.15 to 0.30	<0.15	>=-0.020	-0.020 to -0.010	<-0.40
<2 m/s	A	A-B	B	D	D	G	G
2 to 3	A-B	B	C	D	D	E	F
3 to 4	B	B-C	D	D	D	D	E
4 to 6	C	C-D	D	D	D	D	D
>=6	C	D	D	D	D	D	D

This calculation is based on the data of IRIMO, AQCC including results of field observation.

According to the meteorological analyses, suitable meteorological blocks to be assigned to each stack are set. Upper layer observation is utilized for setting of "lid" in addition to upper layer block setting. Modified stability classes, shifted to neutral side, are applied to the upper layer.

(4) Emission sources

Vehicles , large factories and commercial /household units are mainly considered as emission sources. Impact of airplanes is discussed in section 5.4.

1) vehicles

The vehicles on roads are treated as line sources.

The emission intensity (per unit length) is obtained as the product of emission factor of each vehicle and traffic volume. As for emission factors, the results of chassis-dynamo test including values in the international publications for references are adopted. Vehicles are divided into eight categories. For each of which, the emission factor is set as a function of traveling speed. Vehicle emission setting is summarized in section 4.4. Traffic volume settings are mainly based on TCTTS with utilization of the results of the survey and TTTO data in consideration of time variation and vehicle types. Estimated emissions are assigned to road links data prepared by TCTTS.

2)Large factories

Seventy-three large factories, four power plants and Tehran Refinery are treated as point sources.

In consideration of buoyant plume rise, an effective stack height (*He*) is adopted to each stack of the listed sources. *He* is obtained as the summation of actual height and plume rise Δh. Δh is calculated according to CONCAWE formula.

for windy condition:

$$\Delta h = 0.175 Q_h^{3/4} u^{-3/4}$$

and Briggs' formula for calm condition:

$$\Delta h = 0.175 Q_h^{1/4} (d\theta / dz)^{-3/8}$$

where

Qh: heat emission rate

u : wind speed at stack top

$d\theta / dz$: gradient of potential temperature

Diurnal and seasonal variation are set based on the information on operating hours.

3)commercial / household units

Small stationary sources, such as commercial offices or private houses, are not identified individually but treated as area sources.

An emission intensity is estimated on the basis of the statistics of districts in GTA. The total emissions from each district are summarized in section 4.5. Actually, some modifications to division of the districts are made with consideration on the district-wise size difference of small sources.

The assigned values are equally divided to all grids located in each district. The assignment to the District Boundaries (DB) are also assumed for each district.

The stack height of those area sources is generally assumed at 8 meters, though greater values are adopted for the central region of the city.

Diurnal and seasonal variations are set for each district according to information on variation of fuel consumption.

(5) Calculation

Contribution to the concentration by each source-receptor combination is calculated for each meteorological category defined by combination of the wind and stability class. These results are superposed for all the sources.

To obtain a long term average (annual value etc.), weight proportional to frequency of each category was used.

$$C_{annual} = \sum_{i,j,k} f_{ijk} C_{ijk} + C_b$$

where

C_{annual} : annual mean concentration

C_{ijk} : concentration for i-th wind direction, j-th wind speed class, k-th stability class

f_{ijk} : frequency of (i,j,k) meteorological condition (ratio to whole year)

C_b : background concentration (natural origin and unidentified sources)

5.1.2 Validation of the simulation model

The preliminary calculations were made before detailed setting in order to obtain a crude image and to validate model performance.

CO(carbon monoxide) was chosen as a target pollutant ;the diurnal variation was measured at 18 receptors (12 for horizontal and 6 for vertical) in the autumnal observation period, and was simulated. Points and results of the observation (October 10 and 11,1996) are shown in Figure5.1.2-1 and 5.1.2-2 respectively.

Meteorological data at the Aghdaciye station are adopted to all the sources and stability was set from solar radiation, net radiation and wind speed. Lid setting is based on the results of upper layer observation.

CO emission was assumed at 50g/km per any type of vehicle. The total traffic volume was set based on TCTTS data and their diurnal changes were assumed on the basis of the results of our field survey. (three types – the inside of the restricted area / the trunk road for commutation / the bypass to the suburbs). Daily total traffic volume was also corrected for the holiday case on the basis of the obtained weekday-holiday ratio. Estimated emissions were assigned to each link. Contributions of any other type of sources were neglected.

A day is divided into eight time periods.(0-3h,3-6h,....,21-24h) The meteorological and source conditions were analyzed with this categorization.

Figure 5.1.2-3 shows the comparison of the calculation with the observation at station 2, located in the northeast part of the city. A line with circles designates observed values and rectangles indicate calculated values. (hatched ones correspond to the non-lid case and non-hatched portions above it indicate increase due to lid effects. (for 0-9h,21-24h: lid height = 20m))

For October 10 , a two-peak diurnal pattern was simulated for the lid case while the morning peak was unclear for the non-lid case. Both results were overestimated in the evening. It may partly because the chosen day was Thursday and had different conditions from normal weekdays. The lid case overestimates in the morning of October 11, because only weaker inversion occurred existed in that morning. The simulated results follow the observation in the daytime but show overestimation in the evening.

Similar results were obtained at the other stations. Simulated diurnal patterns agree qualitatively with observation and show some characteristics of each station (e.g. relative high concentration at stations 4 and 7 in the morning of Oct.10). However the quantitative discrepancy, especially overestimation in the evening or nighttime, occurs at most stations.

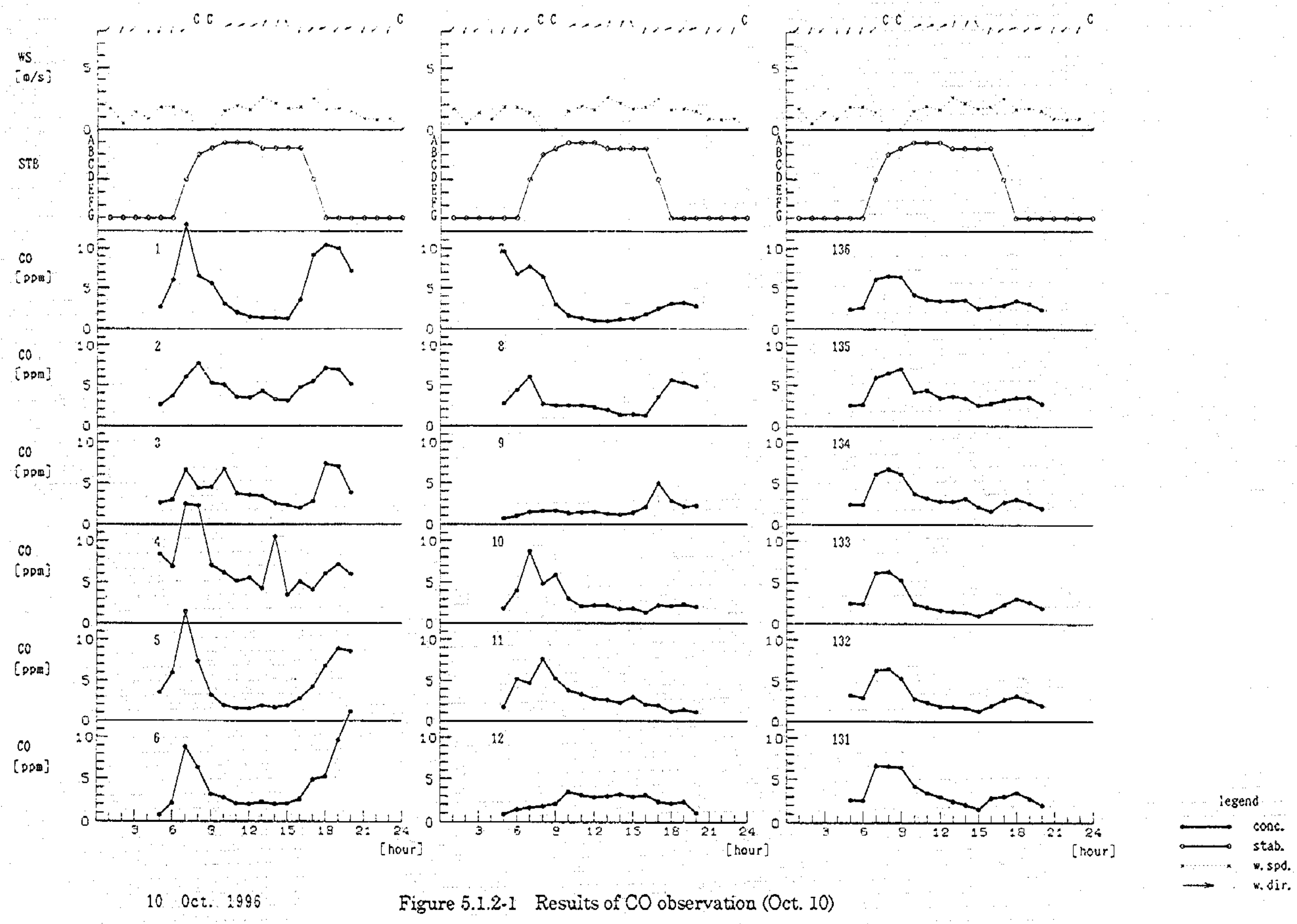
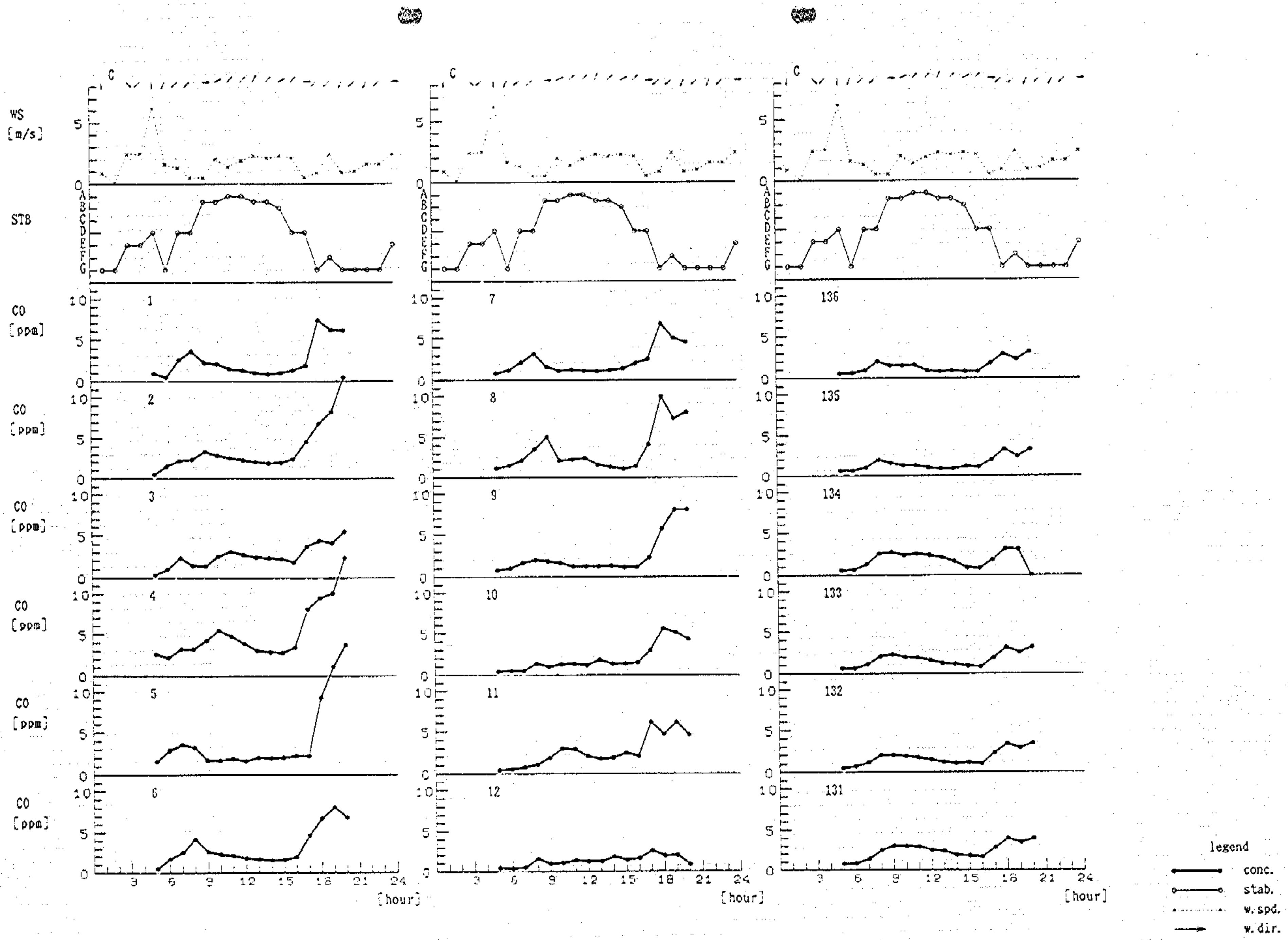
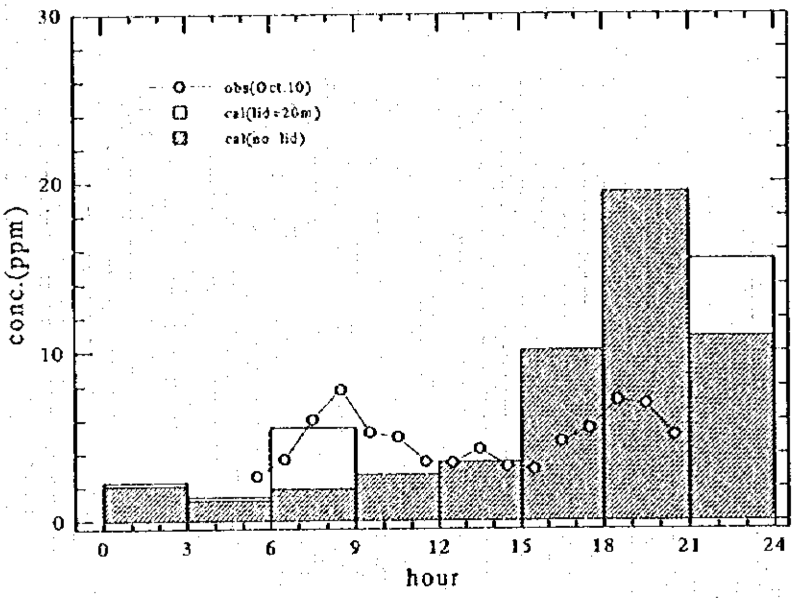


Figure 5.1.2-1 Results of CO observation (Oct. 10)



11 Oct. 1996

Figure 5.1.2-2 Results of CO observation (Oct. 11)



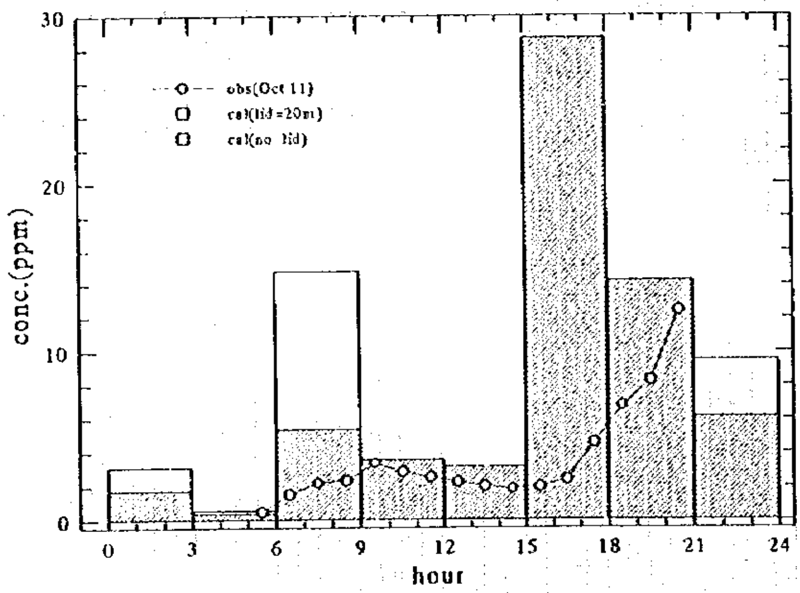


Figure 5.1.2-3 Comparison between calculated and observed values at station 2
(top: Oct.10, bottom:Oct.11)

5.2 Diffusion Potential

5.2.1 Concept

The "diffusion potential" is defined as an impact of the modeled emission source based on CDM(Climatological Dispersion Model). CDM is based on the formulation similar to the model described in section 5.1 and has a merit of easy handling. The characteristics of diffusion field can be clarified through comparison with the other areas.

5.2.2 International comparison

The meteorological data measured at Mehrabad Airport (1950-60) are applied to the model with some assumption on stability setting and the duration of calm.

(1) Elevated sources

Three type stacks are considered as elevated sources. The dimensions for the modeled stacks are as follows:

Table 5.2.2-1 Modeled Stacks

element	type		
	small	middle	large
stack height(m)	20	50	200
stack diameter(m)	0.5	3	7
gas emission rate(m^3N/h)	10000	25000	200000
gas temperature(C)	100	100	200
concentration at stack(ppm)	1000	1000	1000

The results are shown in the table below. The values of three Asian cities (Tokyo(Japan), Jakarta (Indonesia) , Dalian (China)) and Mexico City are also shown for comparison. Tehran has the lowest concentration for a small stack. For middle/large -sized stacks, Tehran's concentration is larger than those of Dalian and Tokyo but less than half of those of Jakarta and Mexico City.

Table 5.2.2-2 Concentration for Elevated Sources (unit : ppb)

city	type		
	small	middle	large
Tehran	2.67	0.95	4.08
Tokyo	4.22	0.62	1.04
Jakarta	4.44	2.15	11.89
Dalian	3.92	0.42	0.08
Mexico City	4.10	1.46	9.59

(2) Ground sources

A road link , shown in the following table, is assumed as an example of ground source.

Table 5.2.2-3 Modeled Link

element	specification
link length(m)	2
link direction	W-E
link height(m)	1.5
gas emission rate(m^3N/h)	1
initial spread(m)	3

The concentrations at surrounding 48 points (16 direction, distance from source: 20m,60m,100m) are calculated. The mean and maximum values among 16 directions are shown in the table below.

Tehran shows greater concentration (lower potential) than Tokyo and Dalian for the mean value. The maximum value however does not show a wide deviation from the mean for the Tehran case and is ranked in the lower concentration class except for a small source distance.

Table 5.2.2-4 Concentration for Ground Sources (unit : ppb)

source distance / city	20m		60m		100m	
	mean	maximum	mean	maximum	mean	maximum
Tehran	169.3	188.2(SW)	42.9	48.5(SW)	21.4	24.7(NE)
Tokyo	64.0	167.3(NNE)	21.8	66.0(NNE)	11.8	36.8(NNE)
Jakarta	453.1	504.8(N)	80.2	98.2(N)	31.9	41.4(N)
Dalian	50.8	99.1(S)	17.6	37.3(S)	9.4	20.4(S)
Mexico city	262.5	341.9(NE)	48.2	81.3(NE)	22.0	40.4(NE)

(3) Comments

Most of the emission sources in GTA are categorized as 'ground sources' or 'small stacks'. The result shows that the diffusion condition in Tehran is not bad for such sources. The actual high concentration accordingly implies excess of pollutant emission.

5.3 Consideration on pollution mechanism

5.3.1 Simulation of long term average concentration

As explained in section 5.1.1, the long term concentration is obtained as superposition of the concentration for each category with weight proportional to its frequency.

Fig.5.3.1-1(1) shows the annual concentration of CO, while (2) and (3) correspond to non-heating and heating season, respectively. All their simulations include both impacts of stationary sources and mobile sources (vehicles). The high concentration zone spreads through the center of the city to the north-south direction. The annual mean value exceeds 10 ppm in the Bazar area and the highway junction in the northern area (district 3). All maps by season show similar distribution, though the high concentration area expands in the heating season mainly due to meteorological conditions.

Fig.5.3.1-2(1) - (3) are the same with 5.3.1-1 but for SO_2. The annual map has some different features from one of CO. The concentration of several tens ppb is distributed over all districts except for the northernmost ones. The concentration over 100ppb covers district 19 in the heating season, while the high concentration area is limited in the southern part in the non-heating season.

Fig.5.3.1-3(1) - (3) are the same but for NOx. Location of the high concentration area resembles to one of CO. The areas with the concentration above 100ppb are located in Bazar , at the northern junction and at another traffic junction in the southern area. These areas expand in the heating season and cover several districts in the central area. Fig.5.3.1-4 is annual contour for NO2. The areas with concentration above 50ppb mostly correspond to ones with NOx value above 100ppb.

These obtained results are compared with the annual values measured at the two AQCC stations(Bazar and Fatemi, indicated by black circles) and at several stations of the other organizations. As the statistical periods of these data are different from the target year of the simulation, this comparison may not be exact but be enough for the model validation. The results are shown in Fig.5.3.1-5(1) - (3). As for CO, the calculations agree with the observed values. The distribution of SO_2 concentration is qualitatively well simulated but shows overestimation on the whole. As some of the statistics are based on the old data, they may show lower values than expected for the target year. All NOx concentrations are converted to NO_2 values, because only NO_2 is measured at some stations. The following conversion equation, obtained from all hourly data at Bazar station, is adopted:

$$[NO_2] = a * [NO_x]^b$$

The different values for a and b are used for each time period.

The characteristics of NO_2 are generally simulated with a slight underestimation.

Fig.5.3.1-6(1) - (3) are annual contours including only impacts of vehicles, while Fig. 5.3.1-7(1) - (3) about impacts of the stationary sources. The following features are derived from them:

1) Most of CO comes from vehicles and impacts of the stationary sources do not exceed 1 ppm anywhere in GTA.
2) The main SO_2 sources are the stationary sources. The vehicles, however, give a certain impact to the central area. (10-20ppb, around 1/5 of total impacts)
3) Contributions of the stationary sources and vehicles on the NOx concentration are generally even at most parts within 17 districts, though vehicles' impacts dominate at some grid points close to major roads such as highway junction areas.

5.3.2 Simulation for special conditions

(1) Fumigation and topographical effect

Fumigation occurs when the strongly stable layer, such as a temperature inversion, lies over the unstable surface layer. Emitted pollutants are captured and diffused in this surface layer and cause high concentration.

As for the GTA case, these effects can be basically considered with stability modification or lid setting in the model.

If these phenomena occur over the complex terrain, wind and diffusion field are substantially affected by topography and can be simulated with neither the usual Gaussian formula nor its modification. To consider such a topographical effect, the following methods are adopted: 1) the wind tunnel experiment ,2) the mass consistent model, and 3) the random walk model.

The wind tunnel experiment uses a scaled model of the actual field. The equivalent
meteorological conditions should be carefully set in consideration of the laws of similarity in the hydrodynamic equations.

The concept of mass consistent model is modification of a given wind field using Lagrange's method of undetermined multipliers. The continuity equation acts as a constraint and division of total modification between horizontal and vertical components is set as a function of stability. Emitted puffs are advected by the modified wind field and simultaneously diffused.

The random walk model is used to be combined with a simulation model of wind field. Particle positions at the following time step are obtained with a probability due to turbulent motion. In this model, many imaginary particles are released and advected by summation of the mean wind component and turbulent one expressed by the random function. If a particle is located inside a topography, its location and the vector of motion are corrected in consideration of their reflection on the surface.

(2) Effect of the buildings

The wind field around high buildings shows complicated feature. A building modifies air flows both horizontally and vertically and also creates a cavity region extended to 2 to 3 times of Hb (Hb: a characteristic height of the building) in a downwind side. A wake region follows it and extends to more than 10 Hb downwind distance. The effect of wake can be included by some modification on the diffusion parameters(σy, σz) or the effective stack height (He). The air flow in the cavity region is, however, both highly turbulent and generally recirculating and thus can be expressed by neither the Gaussian type model nor its modification. If many buildings whose size are different exist in the target area, a flow pattern will become much more complicated due to the combined effect of each building.

To simulate such a situation, the models directly based on Navier-Stokes' equation, e.g. LES(Large Eddy Simulation) or 'k- ε model', should be adopted. The wind tunnel experiment and the random walk model, already explained, will also give informative results.

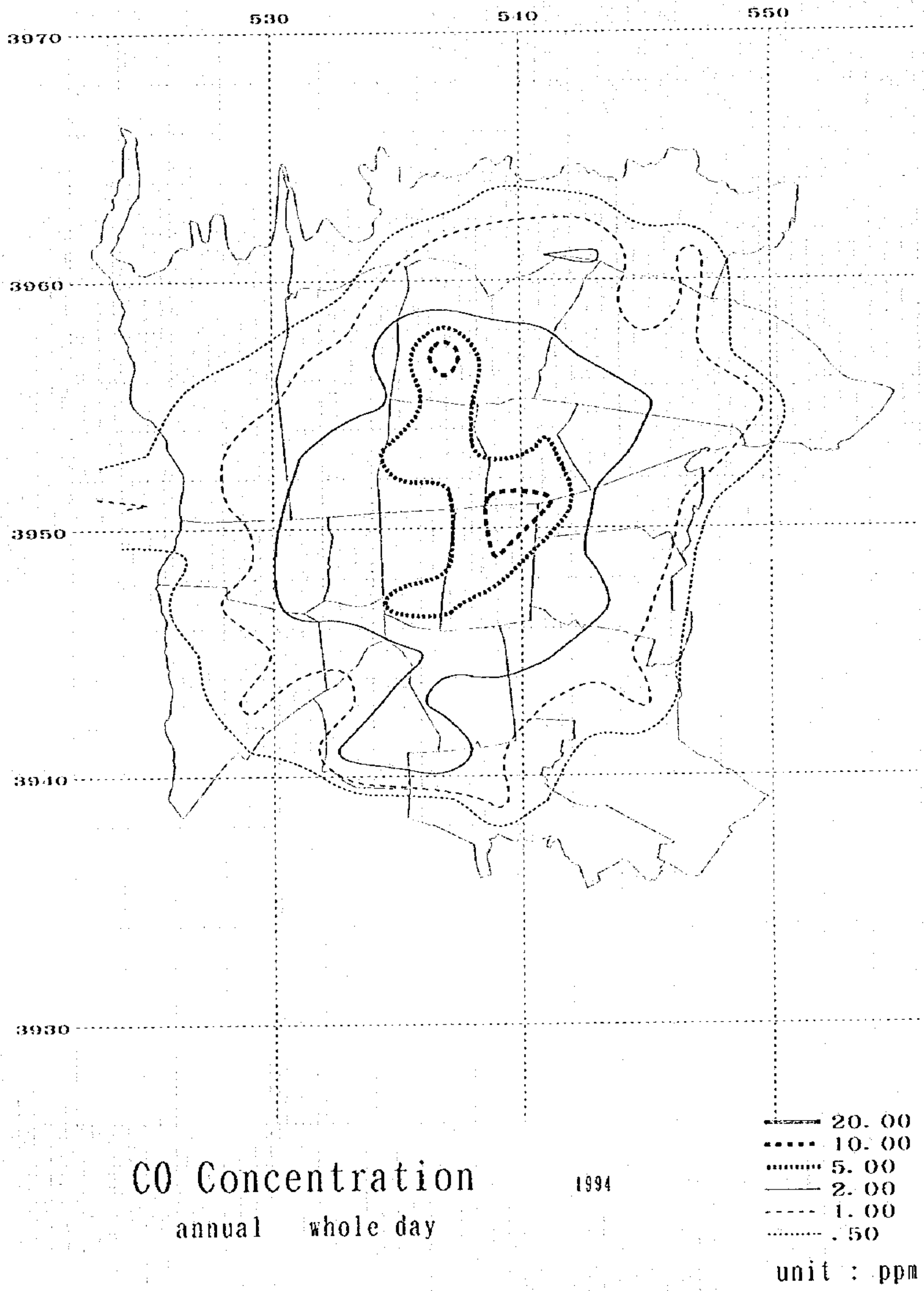


Figure 5.3.1-1 (1) CO concentration (annual , whole day)

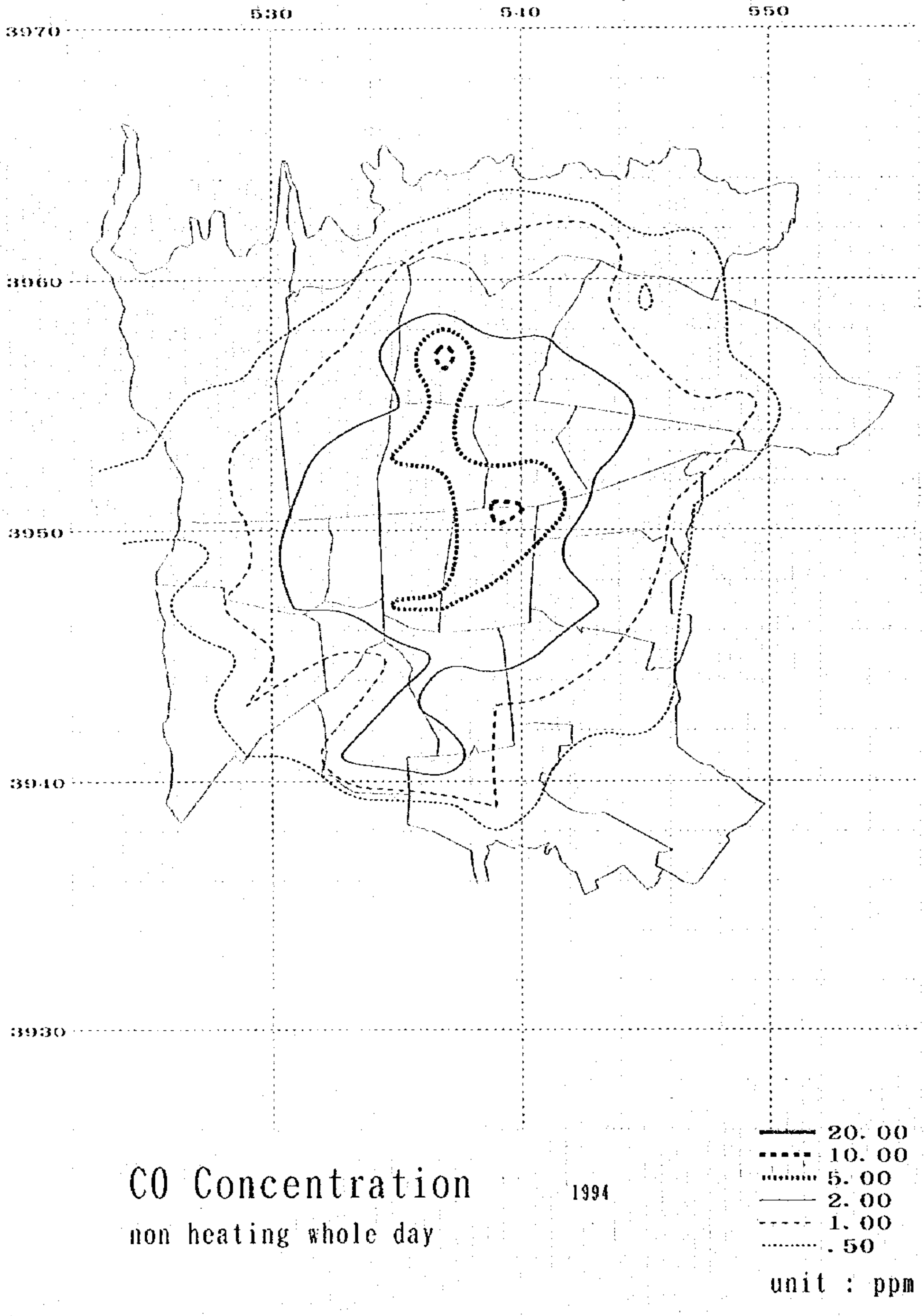


Figure 5.3.1-1 (2) CO concentration (non-heating , whole day)

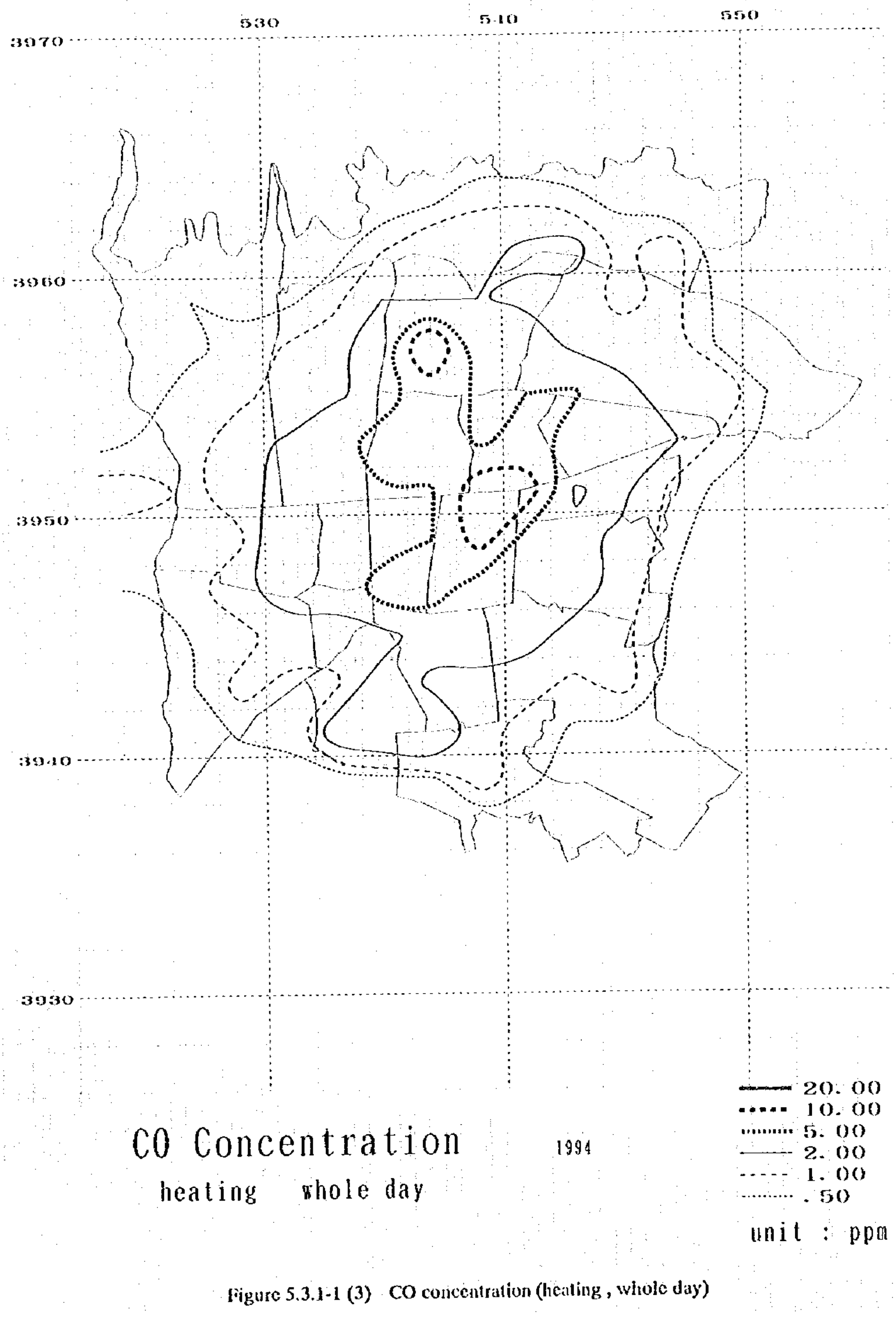


Figure 5.3.1-1 (3) CO concentration (heating, whole day)

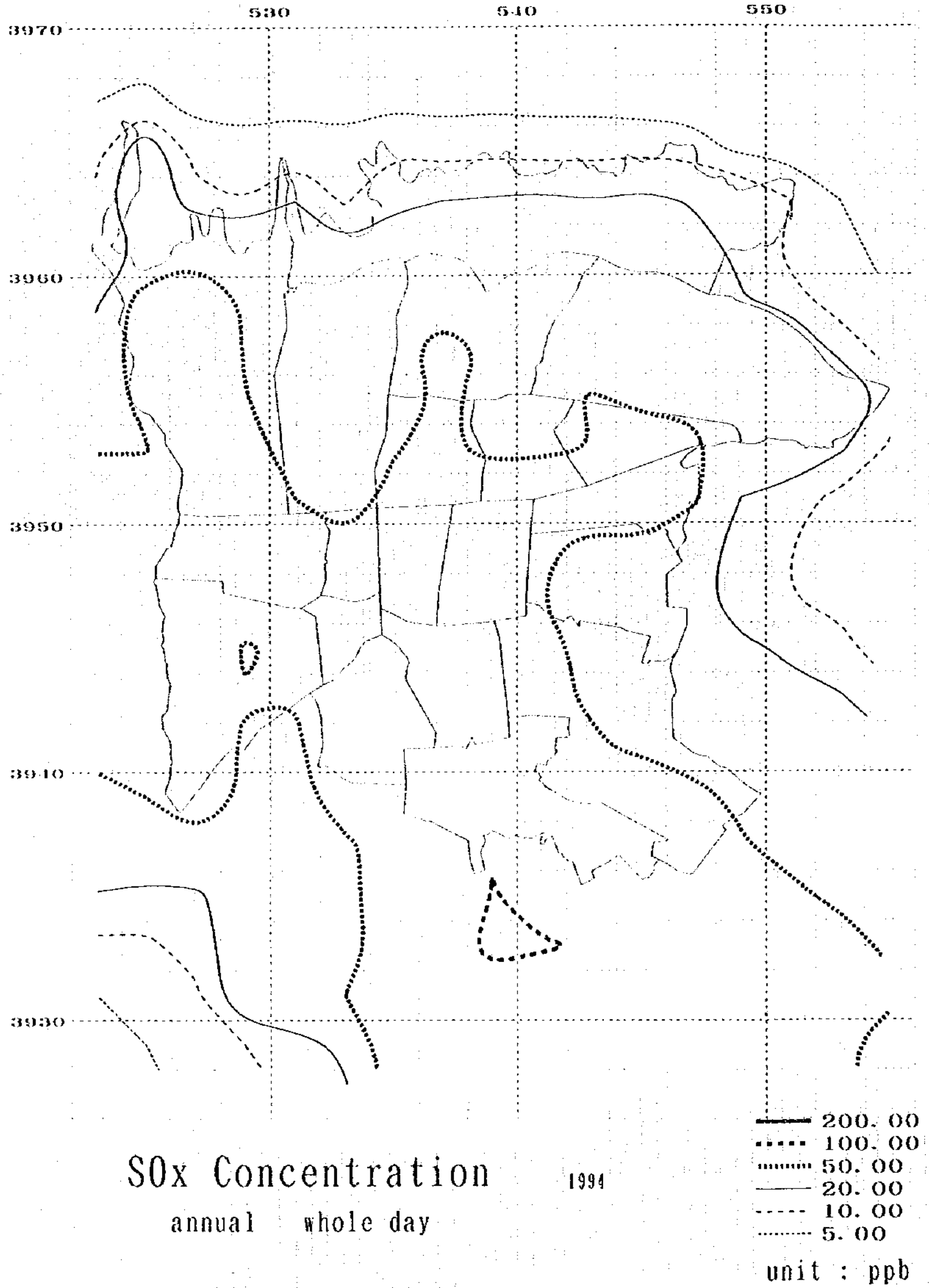


Figure 5.3.1-2 (1) SO_2 concentration (annual, whole day)

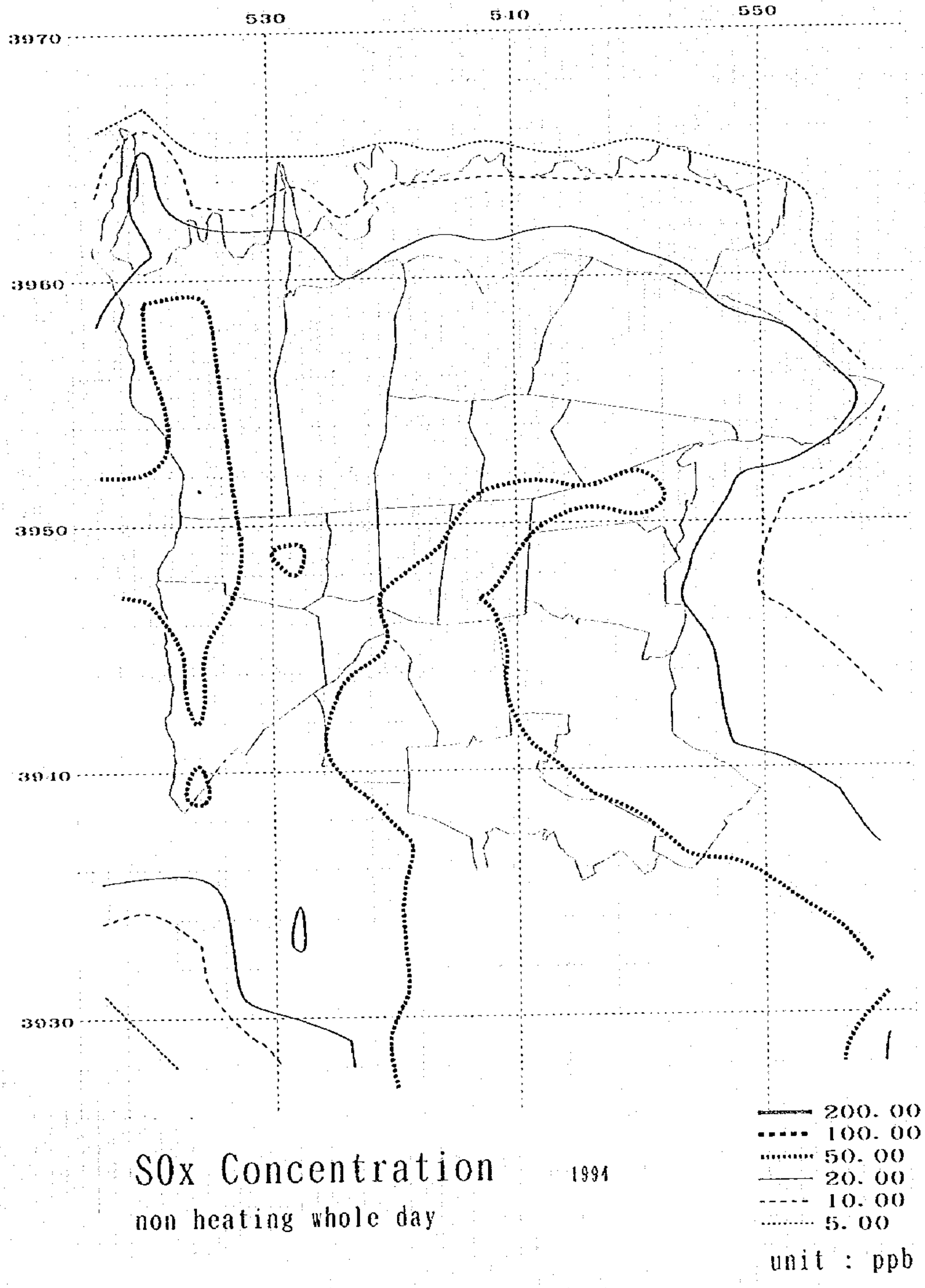


Figure 5.3.1-2 (2) SO_2 concentration (non-heating, whole day)

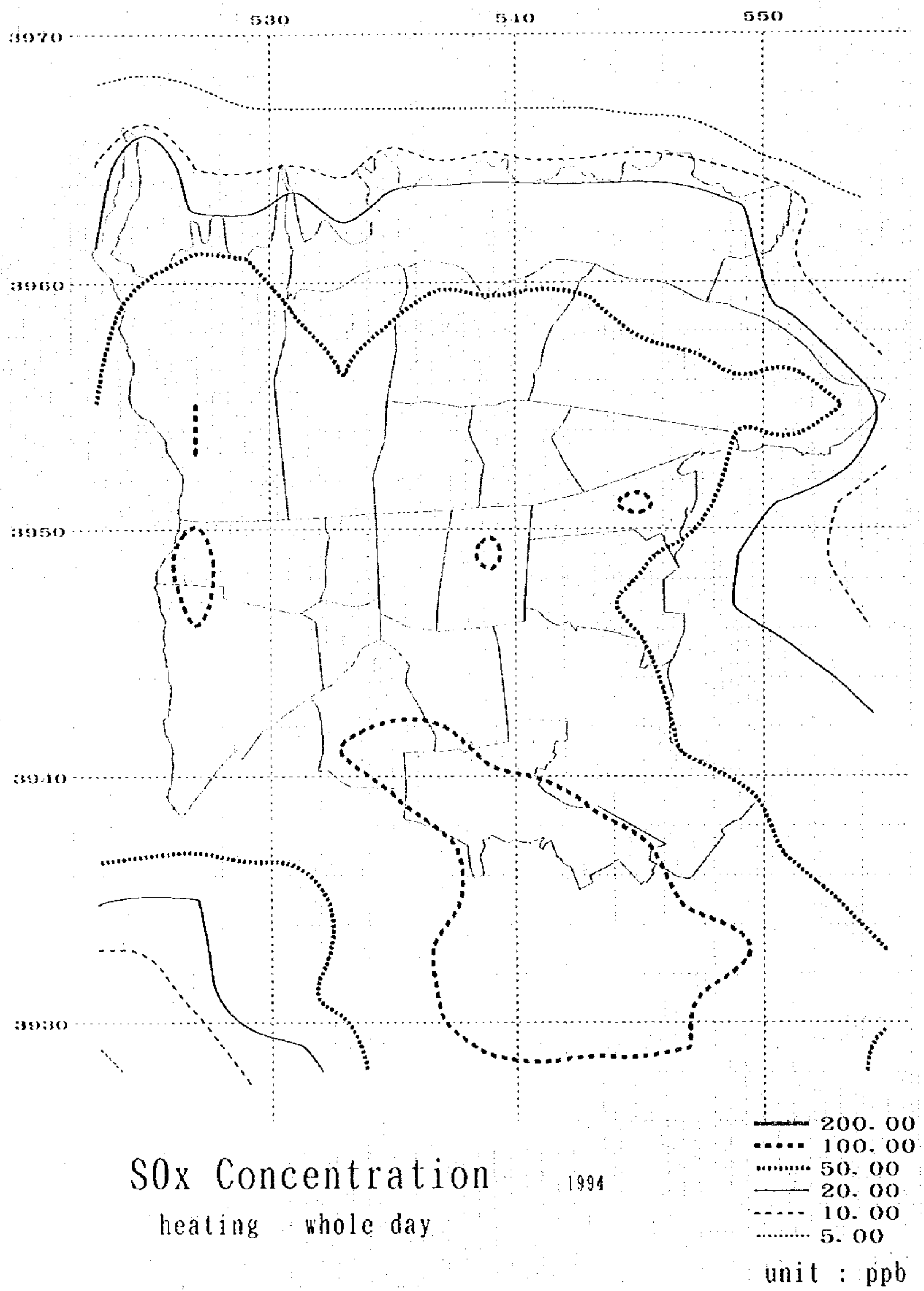


Figure 5.3.1-2 (3) SO_2 concentration (heating , whole day)

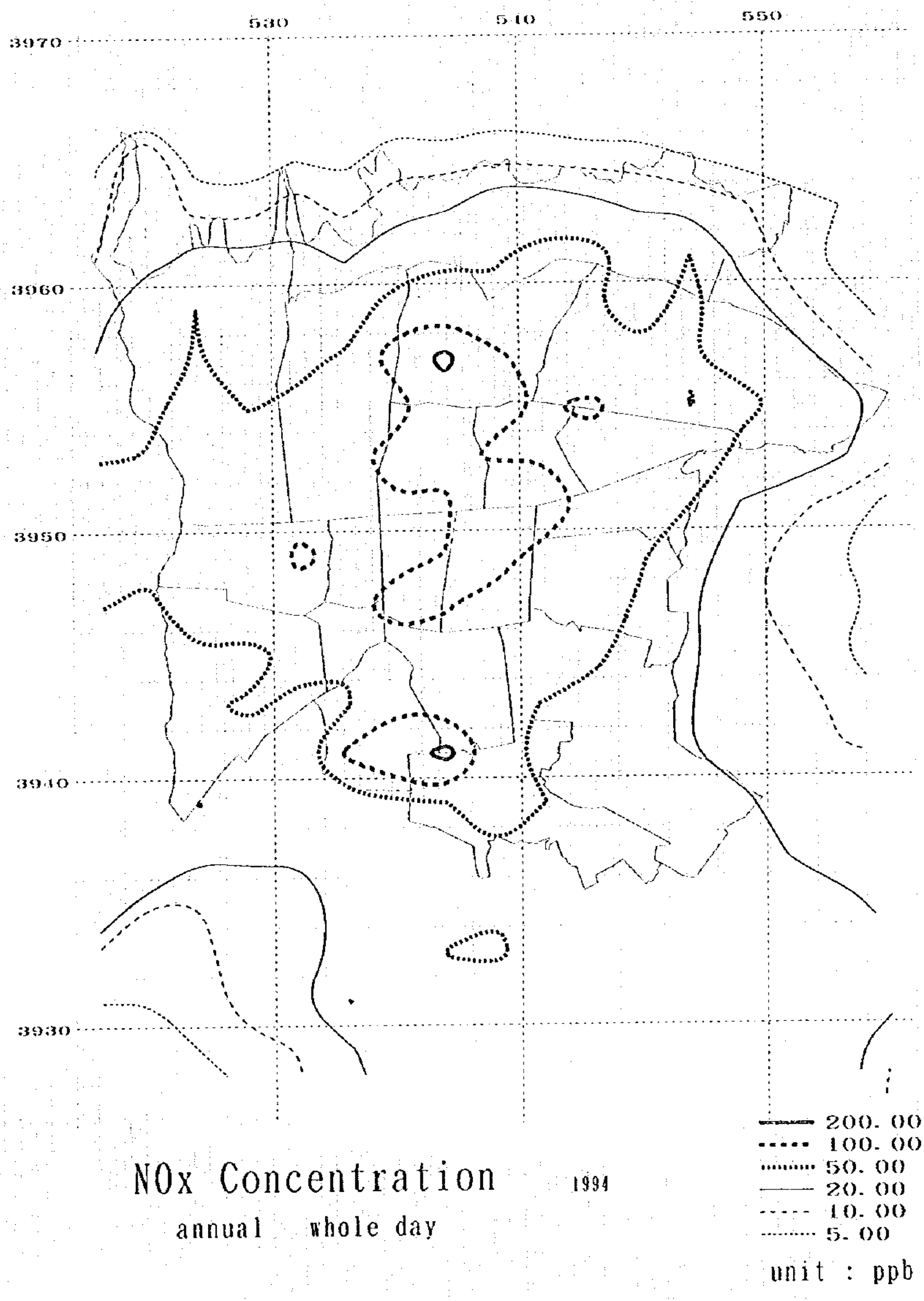


Figure 5.3.1-3 (1) NOx concentration (annual , whole day)

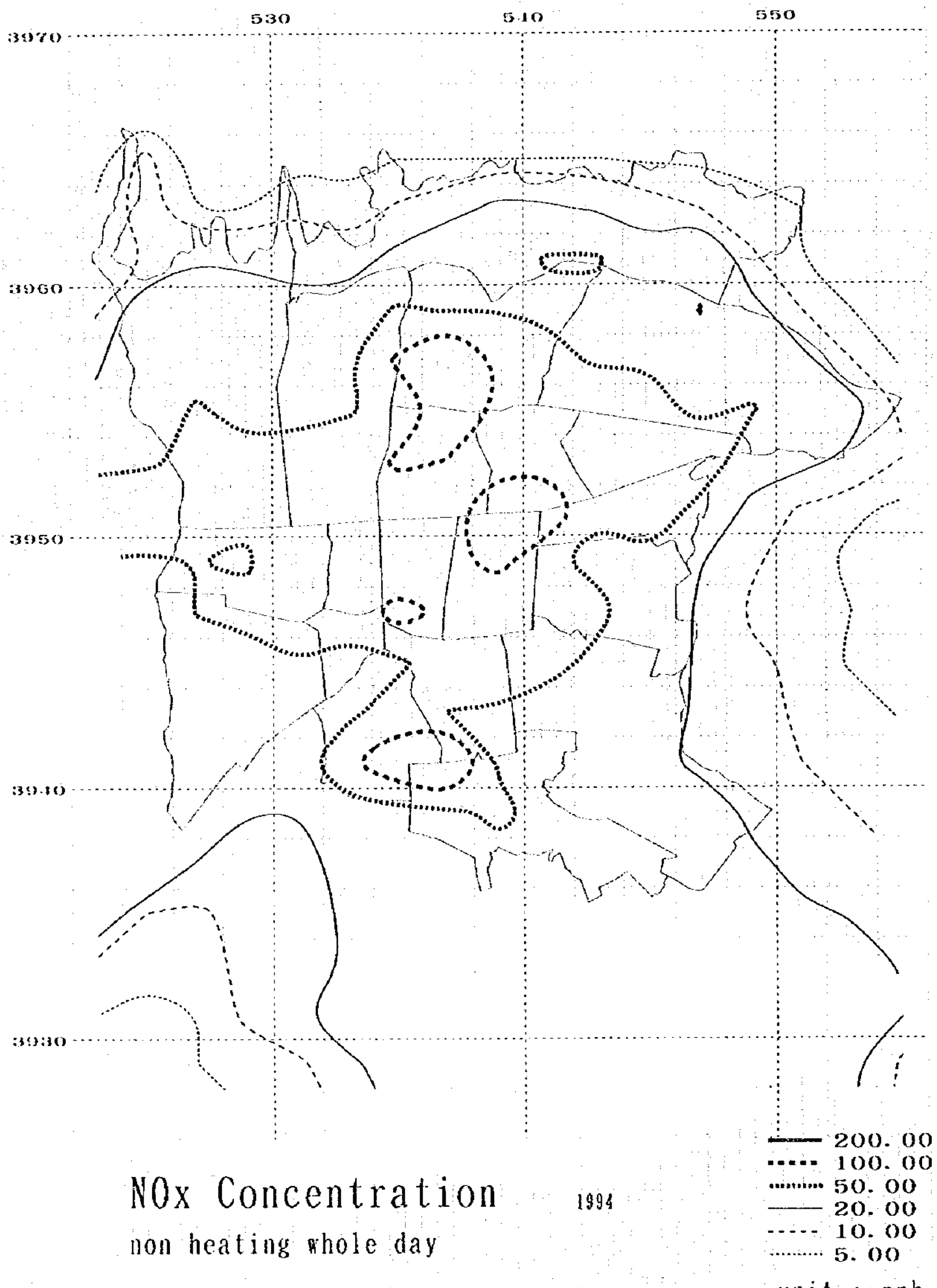


Figure 5.3.1-3 (2) NOx concentration (non-heating, whole day)

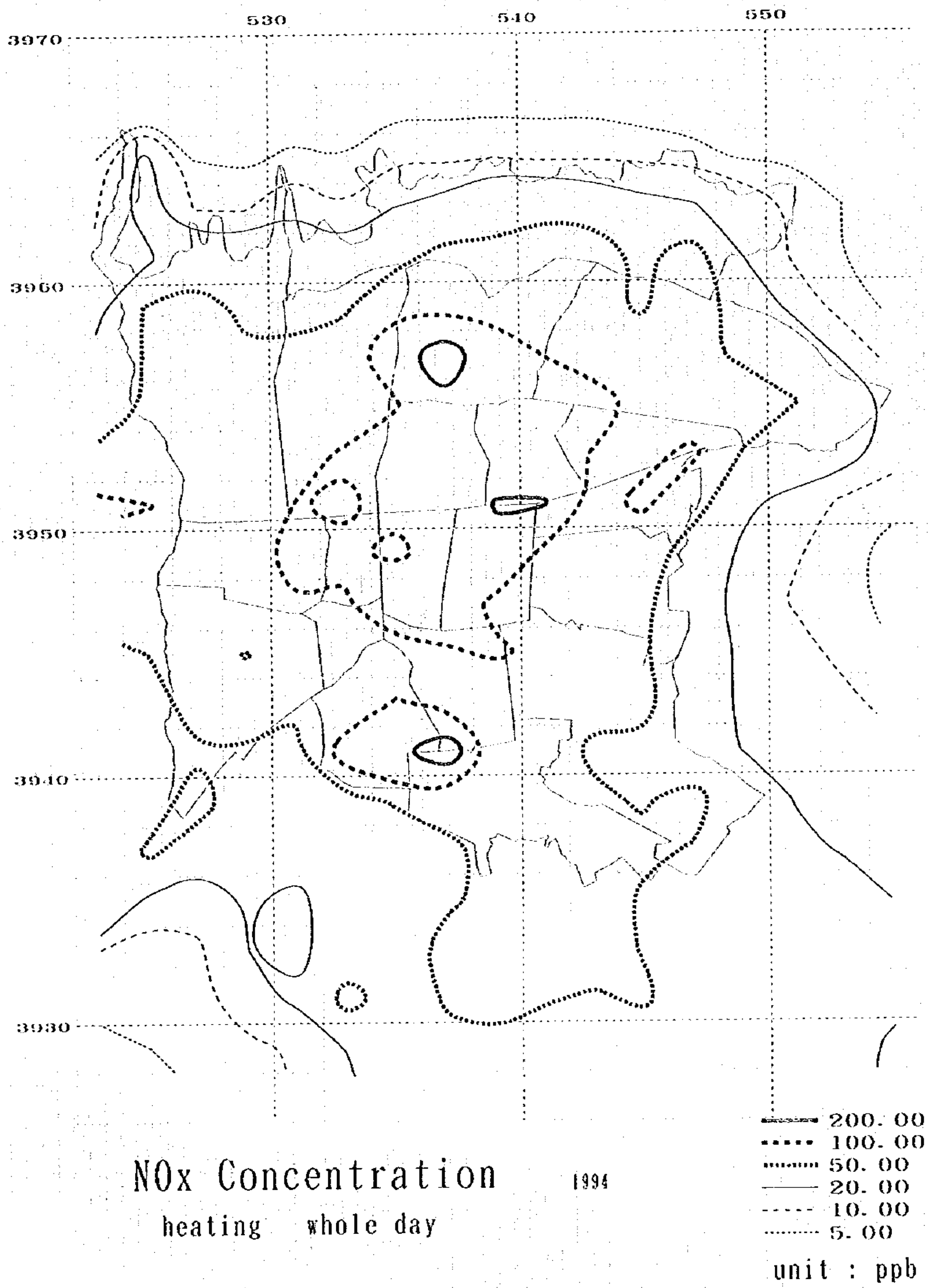


Figure 5.3.1-3 (3) NOx concentration (heating , whole day)

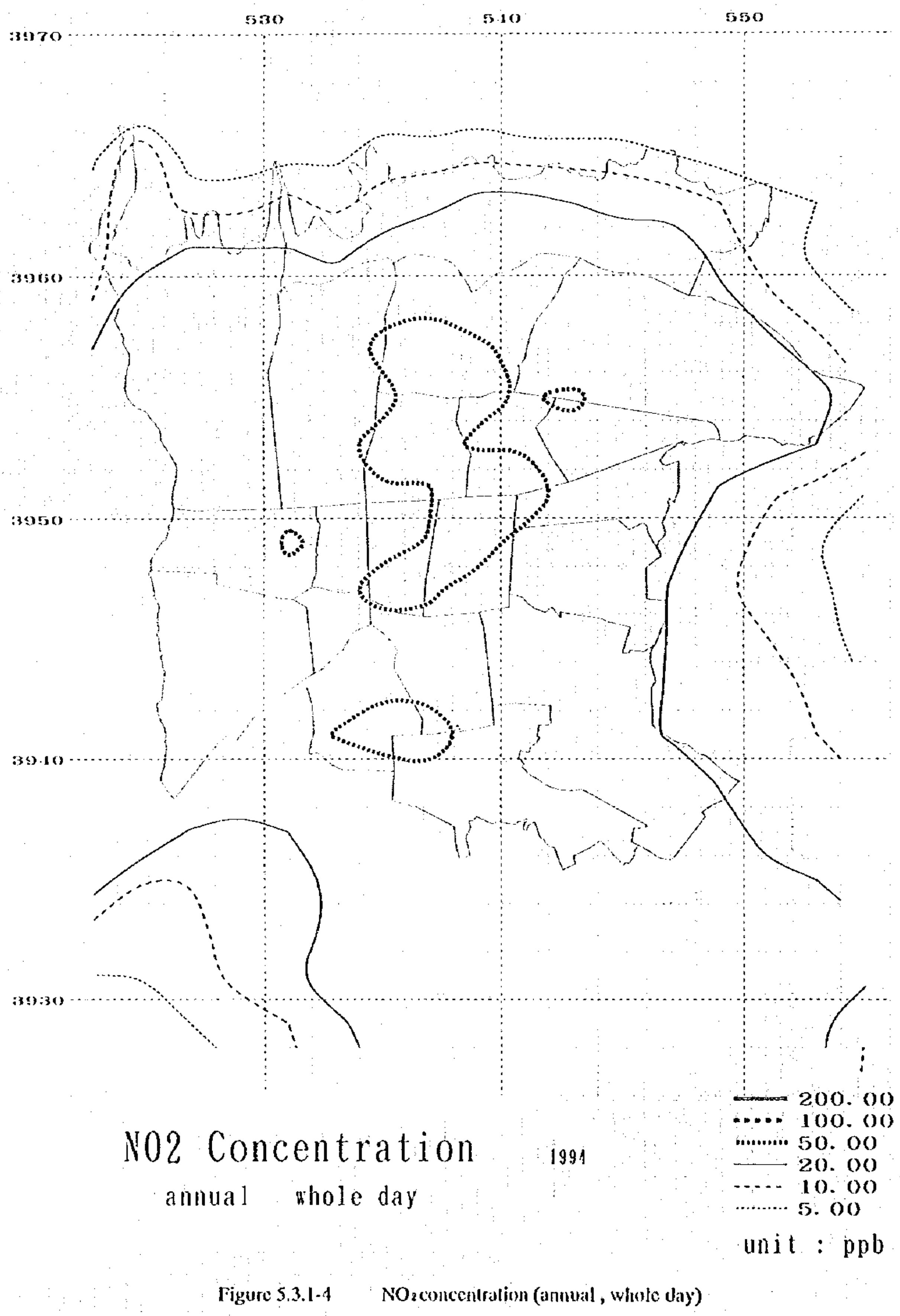
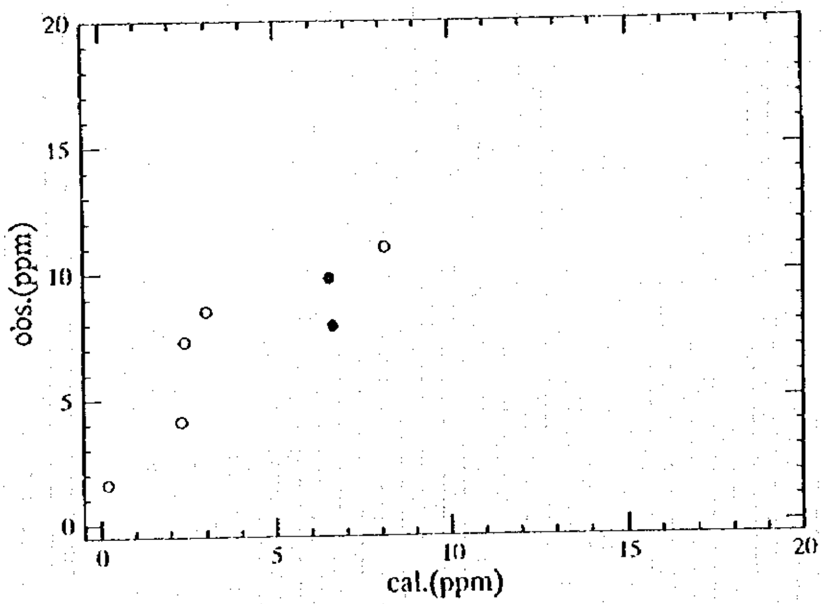
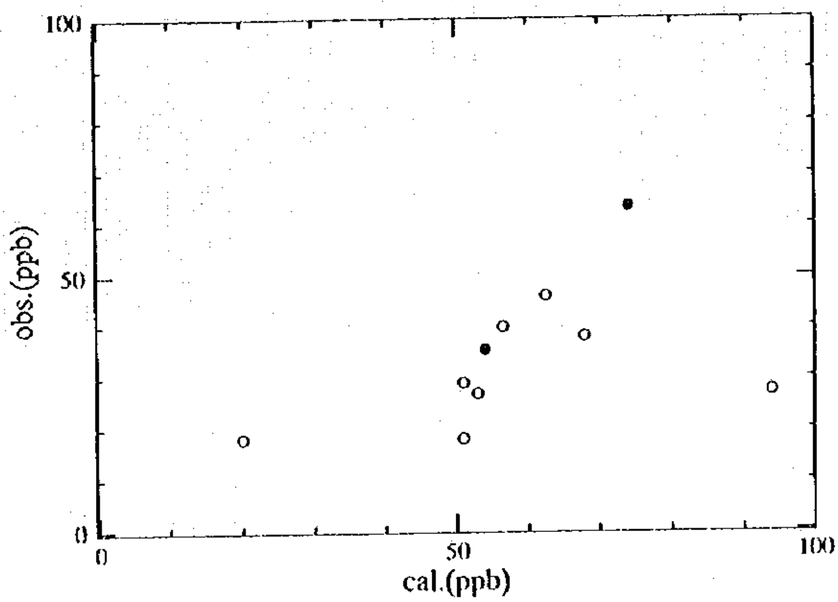


Figure 5.3.1-4 NO_2 concentration (annual, whole day)

(1) CO



(2)SO_2



(3)NO_2

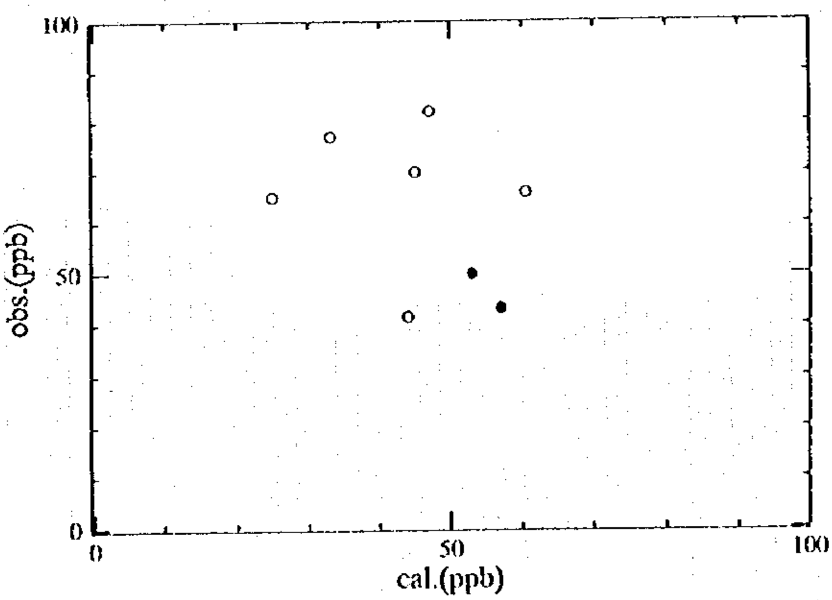


Figure 5.3.1-5 Comparison between calculation and observation

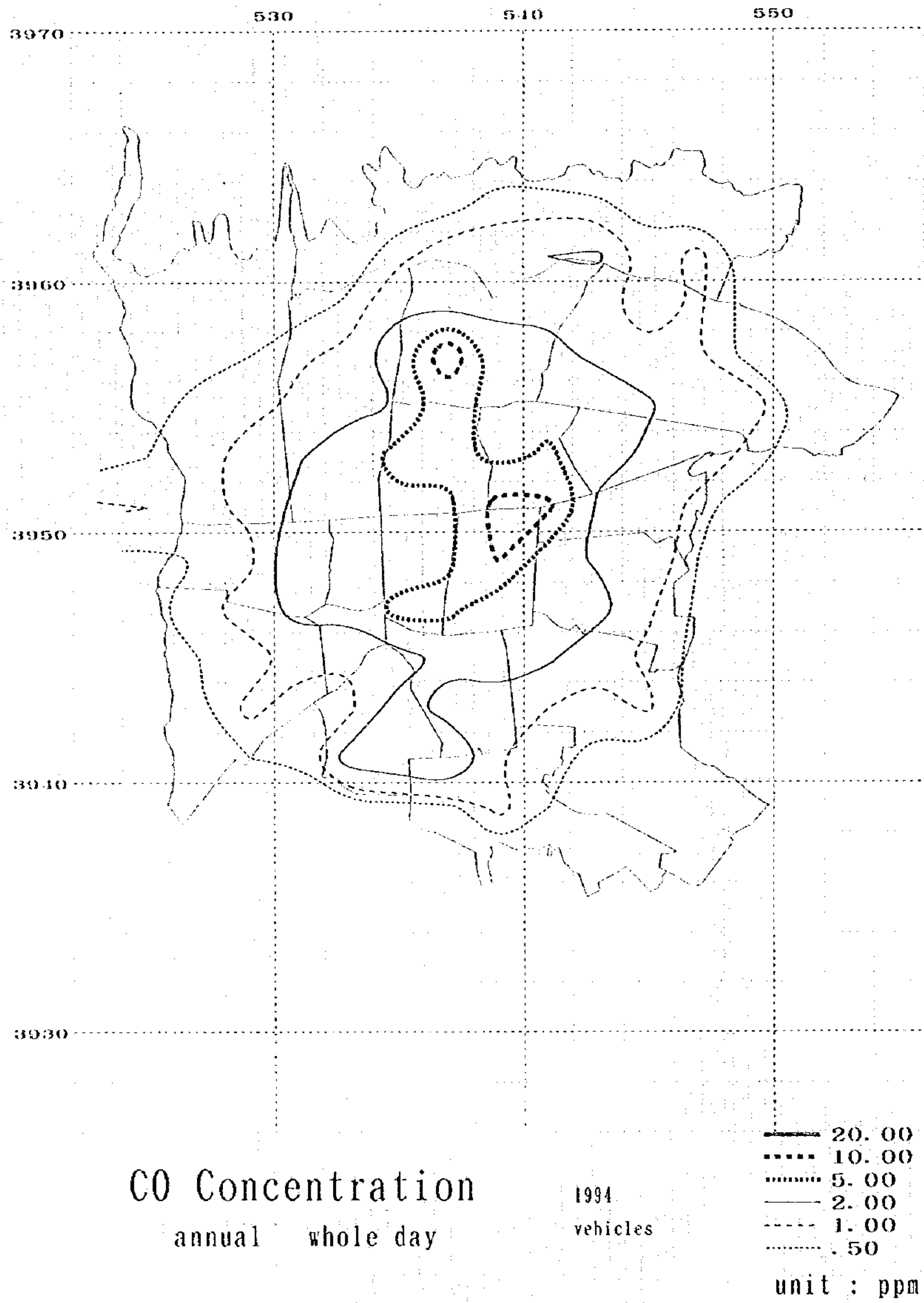
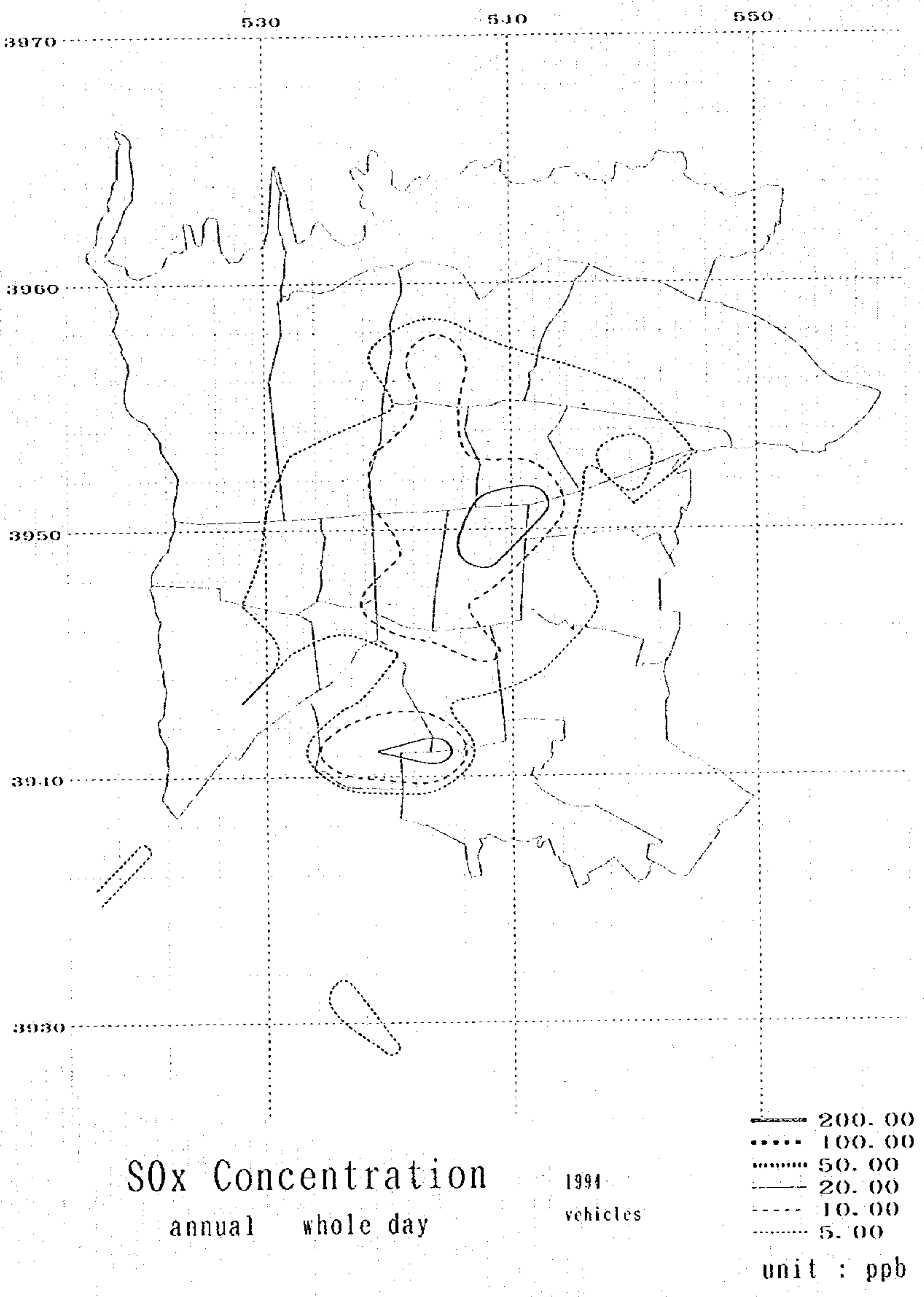


Figure 5.3.1-6 (1) CO concentration (vehicles)



SOx Concentration

annual whole day

1994

vehicles

Figure 5.3.1-6 (2) SO_2 concentration (vehicles)

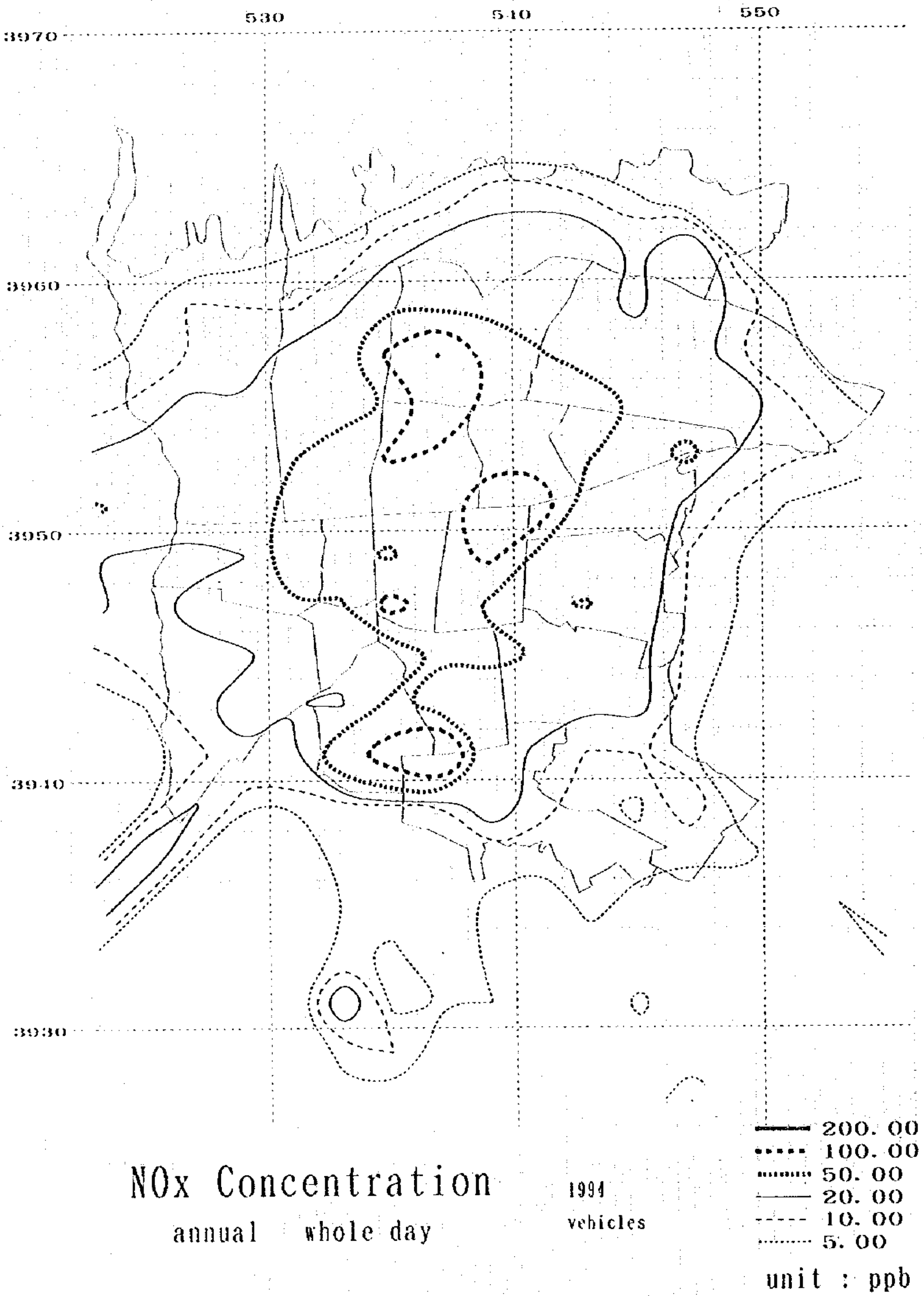


Figure 5.3.1-6 (3) NOx concentration (vehicles)

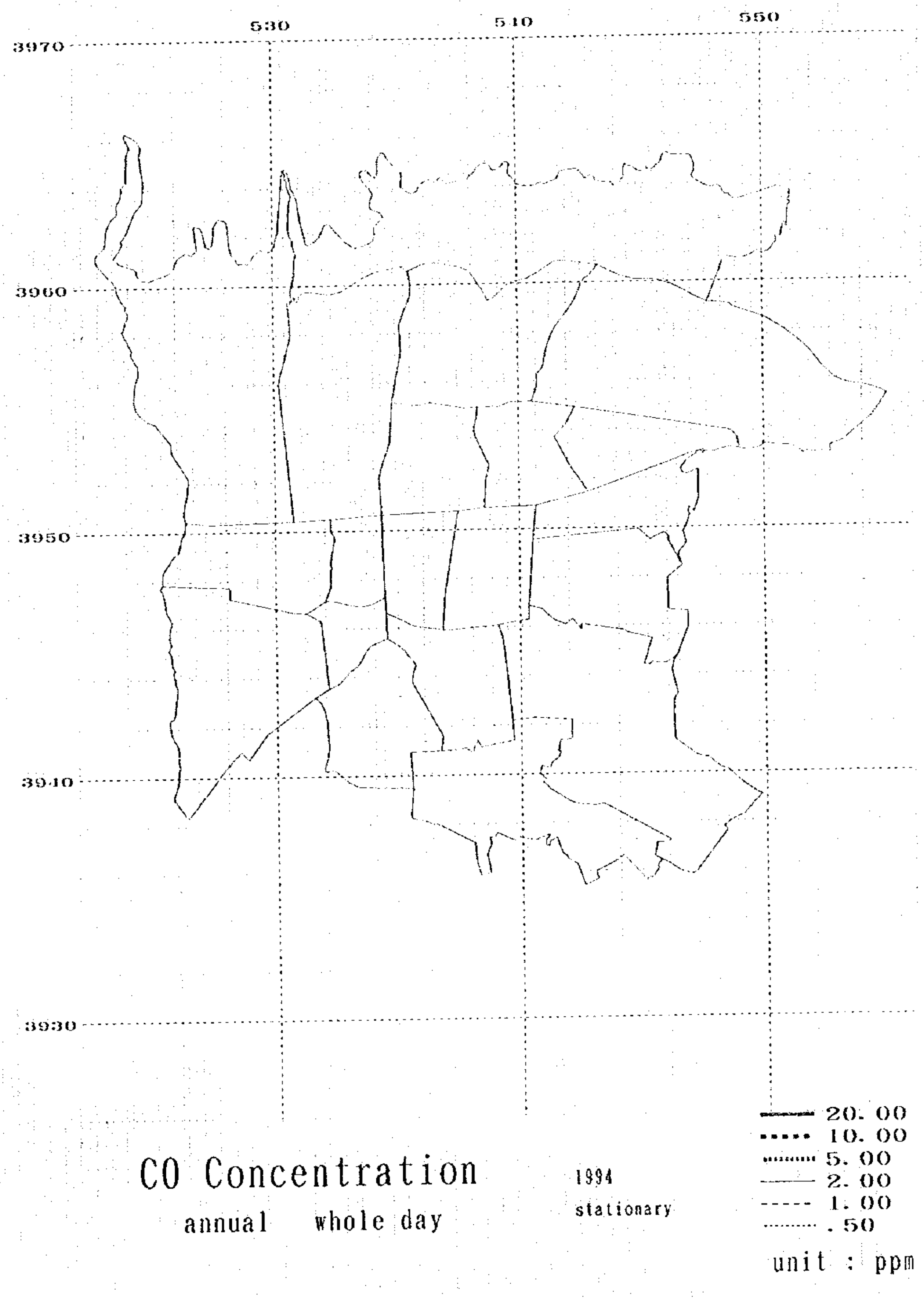


Figure 5.3.1-7 (1) CO concentration (stationary sources)

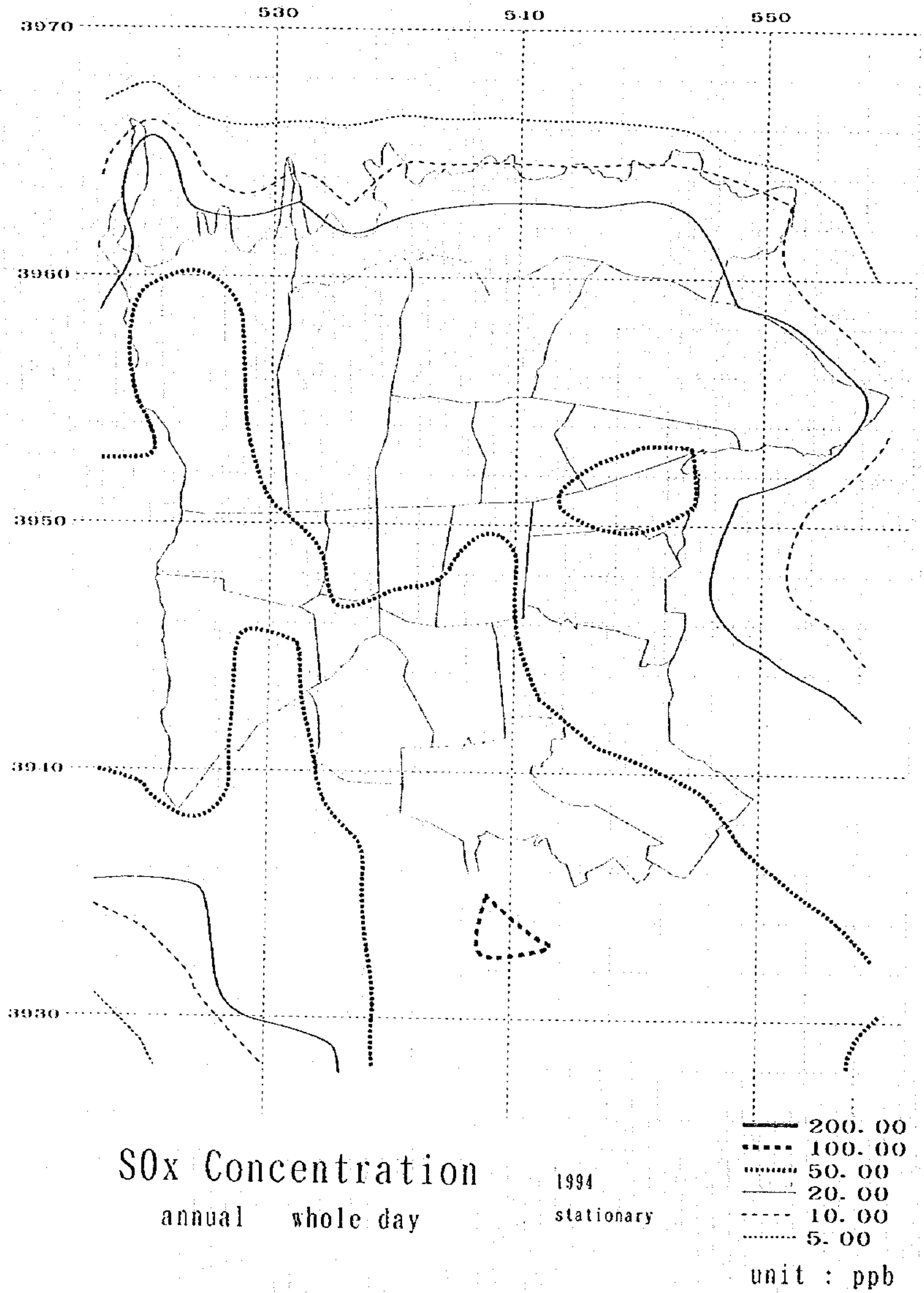


Figure 5.3.1-7 (2) SO_2 concentration (stationary sources)

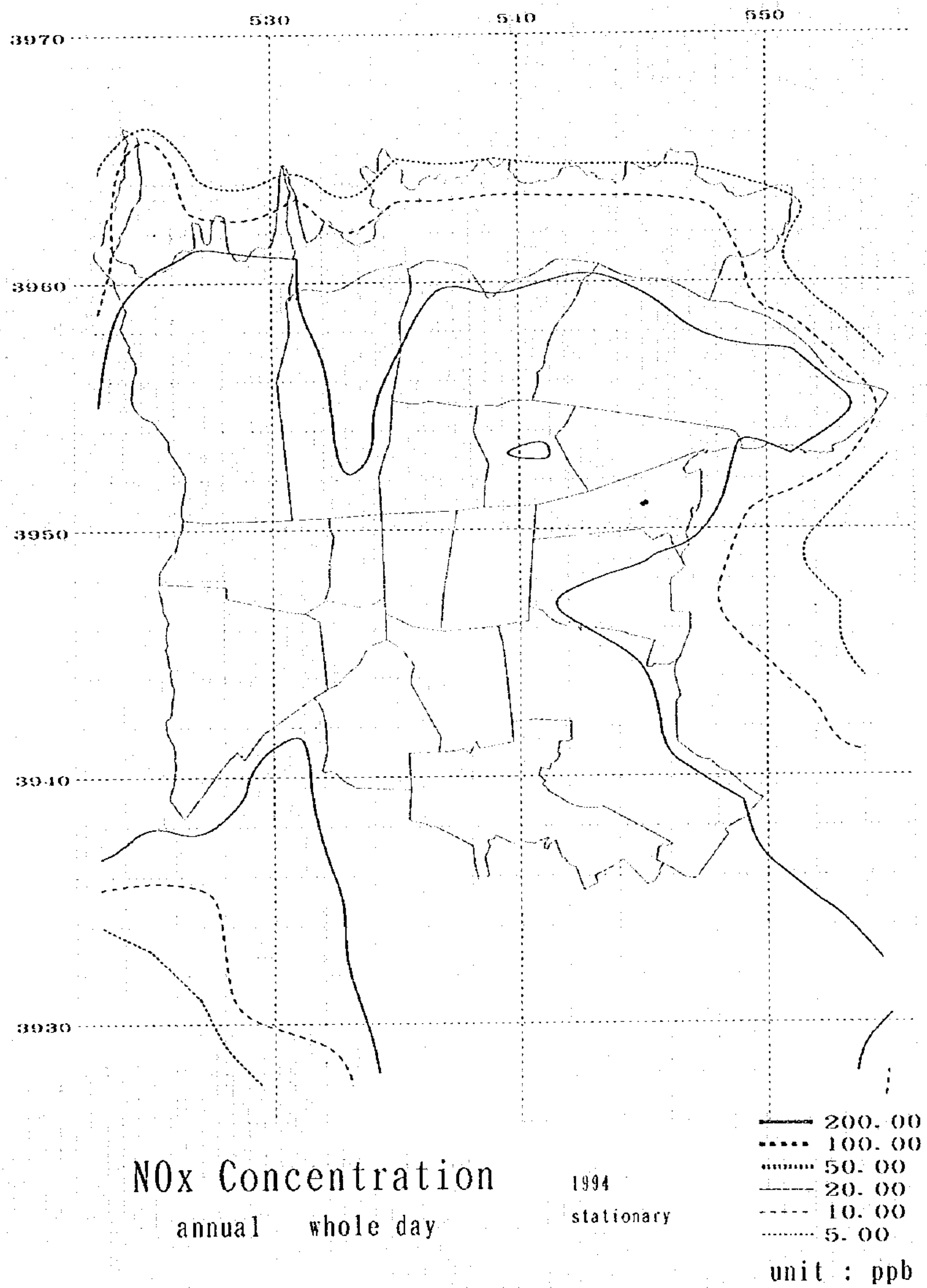


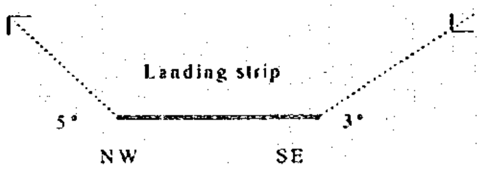
Figure 5.3.1-7 (3) NOx concentration (stationary sources)

5. 4 Simulation for Airport

5.4.1 Model structure

To estimate the impact of the airport, a model similar to one explained in section 5.1 and the same categorization for meteorological condition are adopted.

The contribution of the airplanes which depart from or arrive at the Mehrabad Airport will be also estimated. Emission is assigned to the landing strip and the flight route extended to both sides of the strip up to 1000m height. Airplanes are assumed to approach from the southwest and to take off and ascend toward the northwest. (See the figure below.)



Total contribution is expressed as a summation of those three line sources and area sources extended around the landing strip.

The frequency of flights for each aircraft type is set based on the number of weekly flights for each carrier company. Table 5.4.1-1 shows the weekly number of flights for each aircraft type and total number is 428. These aircraft types are re-categorized into eleven types with the engine specifications.

Table 5.4.1-1 Weekly frequency of flights

type	A-300	A-306	A-310	A-312	A-320					
number	80	15	10	4	2					
type	B-707	B-727	B-72S	B-734	B-737	B-747	B-74F	B-74L	B-763	B-767
number	10	20	49	2	35	16	3	2	2	3
type	TU-134	TU-154	F-100	MD-11						
number	5	51	118	1						

The emission factor is assigned for each engine type and each step in landing-take off (LTO) cycles. The duration of each step is: 4.0sec(approach), 26.0sec(idling), 0.8sec(take off) and 1.6sec(ascending). But they are slightly different in the case of the F-100 type. The emission amount by step and element is summarized as Table 5.4.1-2. In actual calculation, emissions during the idling step are equally divided into three area sources. For diurnal variation setting, the same intensity is assumed except for the nighttime category. The stack height for idling or take off is set at 10meter.

Table 5.4.1-2 Total emission from airplanes

step/element	CO	SOx	NOx
approach	0.63	0.45	4.79
idling	182.15	0.97	3.94
take off	0.34	0.29	10.18
climb	1.18	0.50	13.31

unit: m^3N/hour

5.4.2 Evaluation of air pollution around Mehrabad Airport

Figures 5.4.1-2(1) - (3) indicate the annual concentration of CO, SO_2 and NOx respectively. The values at the center of the airport and its surrounding grids are summarized in Table 5.4.2-1. The impacts of other sources (stationary / vehicles) in this area (calculated in section 5.3) are also shown for comparison. Generally speaking, the impacts of airplanes are one tenth or less of those of other sources.

Table 5.4.2-1 Impacts at the airport area

	air planes		stationary	vehicles
	center	surroundings		
CO (ppm)	0.08	0.01	0	0.4-3.2
SO2 (ppb)	0.7	0.1	60	2-4
NOx (ppb)	10.3	0.1-0.7	40	10-60

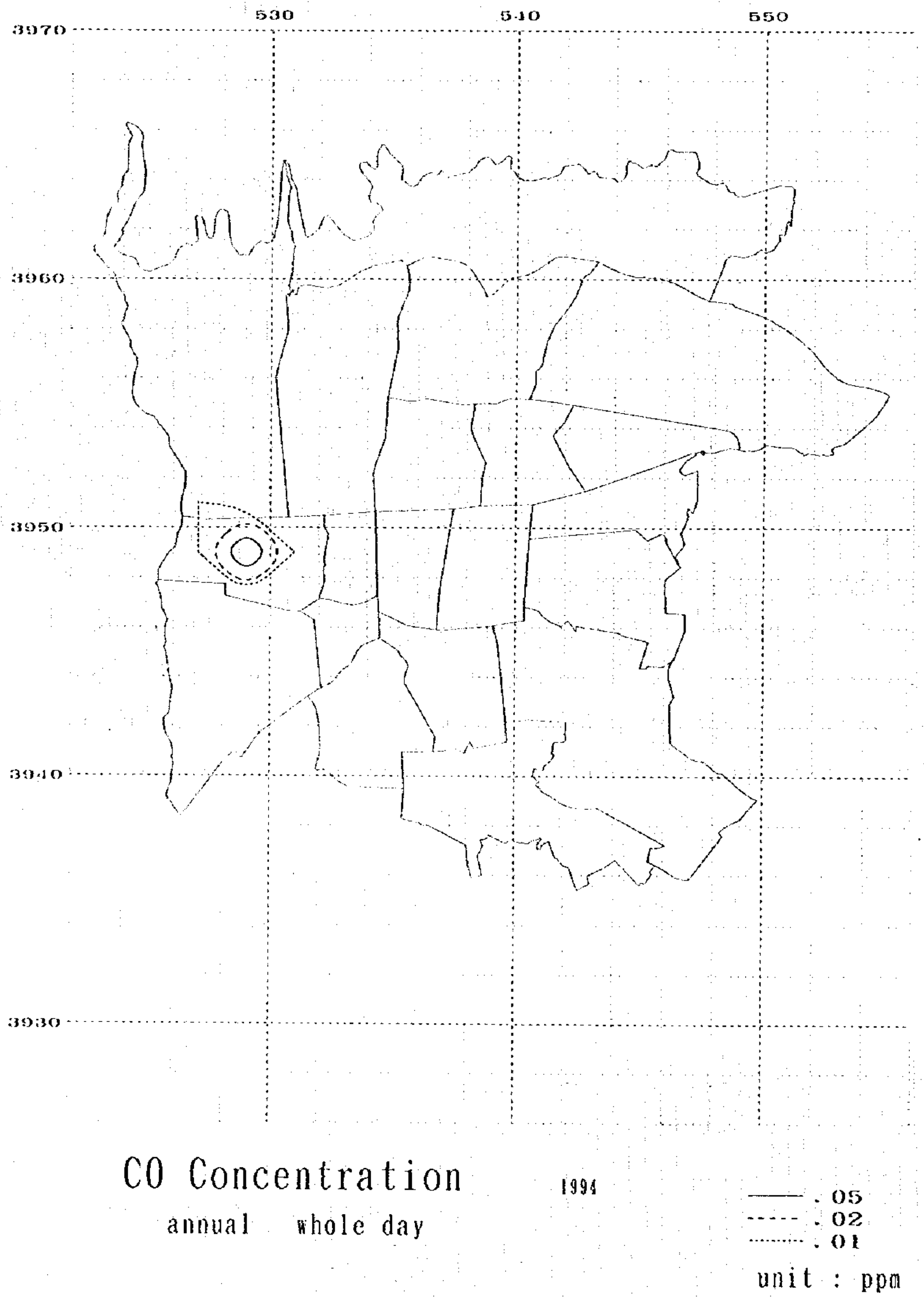


Figure 5.4.2-1 (1) CO concentration (airplanes)

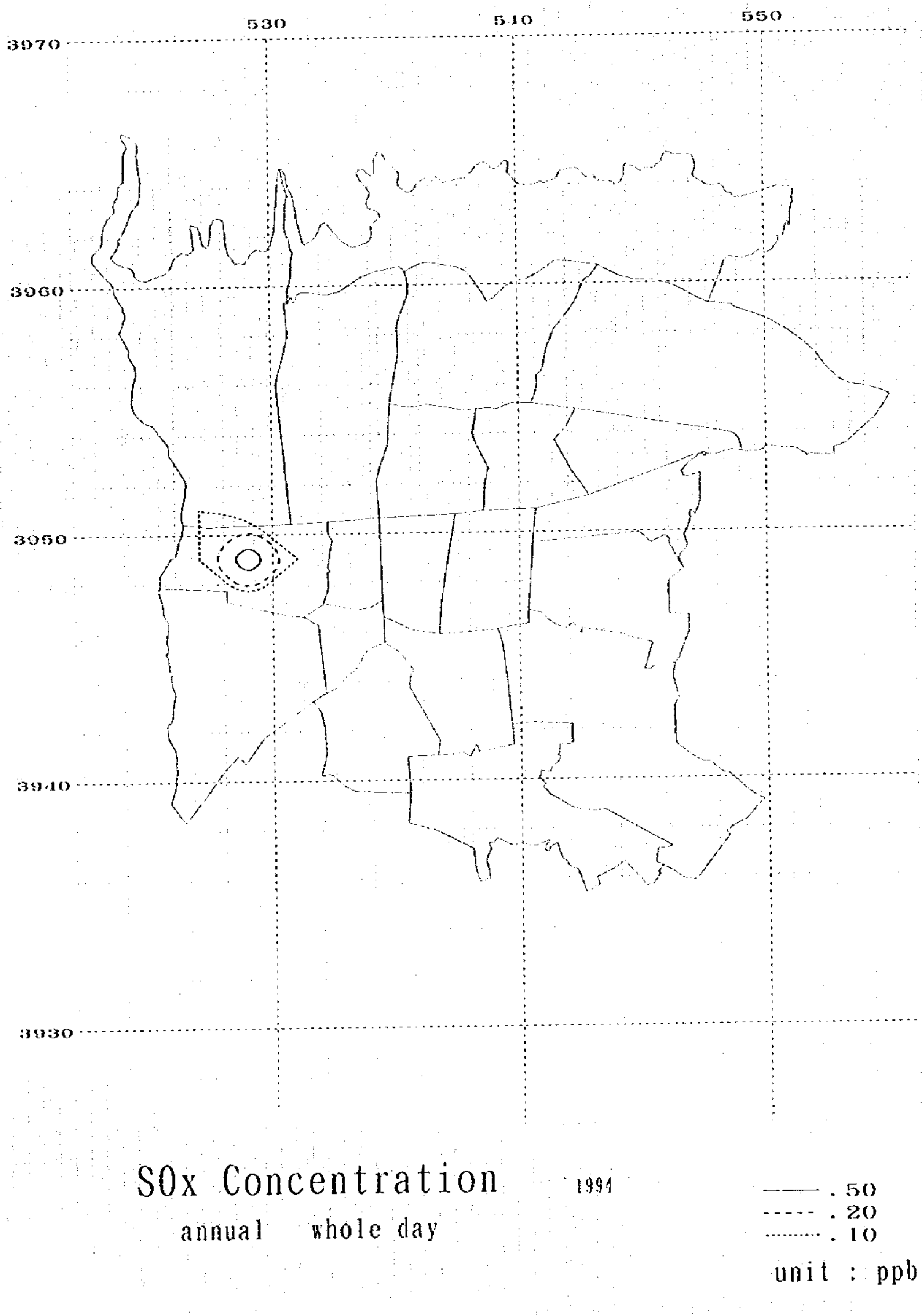


Figure 5.4.2-1 (2) SO_2 concentration (airplanes)

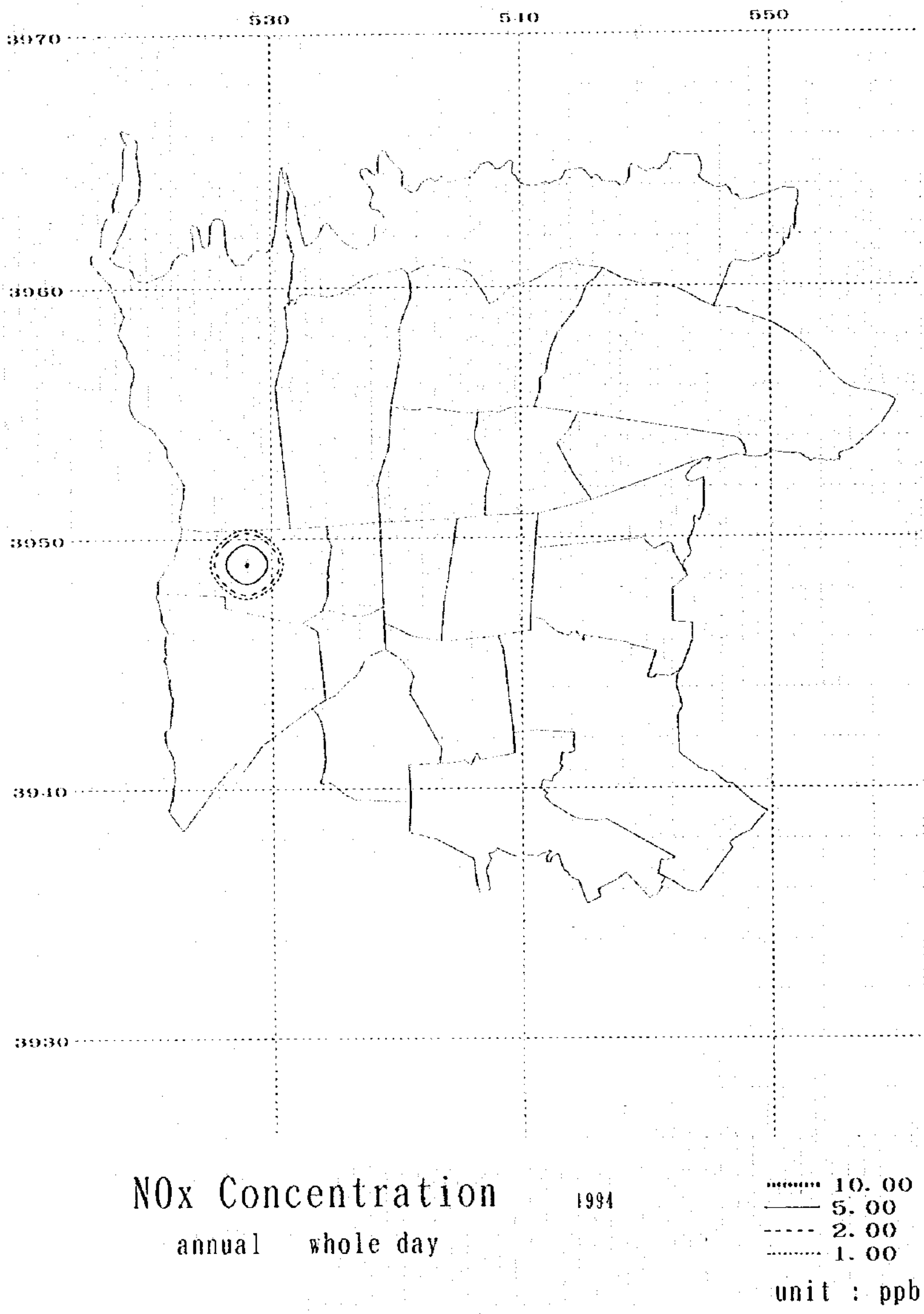


Figure 5.4.2-1 (3) NOx concentration (airplanes)

5.5 Prediction in future condition

5.5.1 Future scenarios in the year 2010.

The meteorological condition is assumed to be the same with present situations.

Future emission from vehicles is calculated on the basis of predicted traffic volume and assumed future emission factors. The traffic volume predictions are based on TCTTS's results for two scenarios; one is 'do nothing' (1994 network meeting 2001 demand) and the other is 'existing + funded' (existing and funded network meeting 2001 demand). The change of the traffic volume from the year 2001 to 2010 is estimated on the values between 1994 and 2001. Two scenarios for emission factor changes are 'do nothing' (same as present) and 'best' (including full countermeasures for emission reduction).

Future conditions of stationary sources are considered to have the following three scenarios. In 'do nothing' the amount of pollutants is assumed to increase in proportion to the economic growth rate. 'Best' is based on the schedule of the pollution reduction plan and 'common' is the intermediate reduction between 'do nothing' and 'best'. All of them are targets for the year 2010. See section 6.3 for detailed description of these scenarios.

The calculation settings are summarized in Table 5.5.1-1. 'do nothing' scenarios is the worst combination ,i.e. 'do nothing' for both of stationary and mobile sources. On the contrary, 'best' scenario includes all effects of countermeasures. The estimated emission amounts are shown in Table 5.5.1-2. Their ratio to the present values is also indicated for reference.

Table 5.5.1-1 Future setting for calculation

scenario	stationary sources	mobile	sources
		traffic volume	emission factor
do nothing	do nothing	do nothing	same as present
common	common	existing and funded	reduced
best	best	existing and funded	reduced

Table 5.5.1-2 Present and future emission amount

unit : ton/year

1994 (present)

	mobile	stationary	total
CO	826806	51421	878227
	94.1%	5.9%	100.0%
SOx	8340	253981	262321
	3.2%	96.8%	100.0%
NOx	39610	95571	135181
	29.3%	70.7%	100.0%

2010 (future)

		mobile	/1994	stationary	/1994	total	/1994
CO	do nothing	1378748	*1.668*	51421	*1.000*	1430169	*1.628*
		96.4%		3.6%		100.0%	
	common	336158	*0.407*	51421	*1.000*	387579	*0.441*
		86.7%		13.3%		100.0%	
	best	336158	*0.407*	51421	*1.000*	387579	*0.441*
		86.7%		13.3%		100.0%	
SOx	do nothing	11017	*1.321*	524585	*2.065*	535602	*2.042*
		2.1%		97.9%		100.0%	
	common	5084	*0.610*	286237	*1.127*	291321	*1.111*
		1.7%		98.3%		100.0%	
	best	5084	*0.610*	83902	*0.330*	88986	*0.339*
		5.7%		94.3%		100.0%	
NOx	do nothing	53931	*1.362*	188220	*1.969*	242151	*1.791*
		22.3%		77.7%		100.0%	
	common	33143	*0.837*	146396	*1.532*	179539	*1.328*
		18.5%		81.5%		100.0%	
	best	33143	*0.837*	109304	*1.144*	142447	*1.054*
		23.3%		76.7%		100.0%	

note

percentage: component ratio to total emission
italic: ratio to value of year 1994
The CO emission from stationaly sources is assumed to be the same with present situations.

5.5.2 Simulation based on the future scenarios.

Fig.5.5.2-1 (1)-(3) are simulated annual concentrations in 'do nothing' case. Fig.5.5.2-2 (1)-(3) and Fig. 5.5.2-3 (1)-(3) are same but for 'common' and 'best' case, respectively.

(1) CO

In 'do nothing' case, the maximum CO concentration increases to 25.8 ppm from 14.4 ppm (present value), while it decreases to 4.3 ppm in 'best' case. In 'best', the area whose concentration is over 2 ppm can be seen only at some junctions and city center. The shape of the contours differs from those of present (1994) or 'do nothing' due to the effect of the included road network plans.

(2) SO_2

In 'do nothing', the maximum SO_2 doubles from 104 ppb (present value) to 209 ppb, while it is reduced to 39 ppb for 'best'. In both cases, their maximum values appear in the industrialized southern area and the concentrations in twenty districts are around a half of them.

(3) NOx and NO2

The maximum NOx increases from 232 ppb (present value) to 348 ppb in 'do nothing' while it slightly decreases to 160 ppb in 'best'. In 'do nothing', more than half of twenty districts is covered with 100ppb contours. In 'best', 100ppb contours cover only small part and the annual concentration of most part of the city is the value between 40-70ppb.

Using the conversion formula , NO2 concentrations are mostly a half of NOx. Then in 'best' case no values of the concentration exceed 50ppb except for in some small areas.

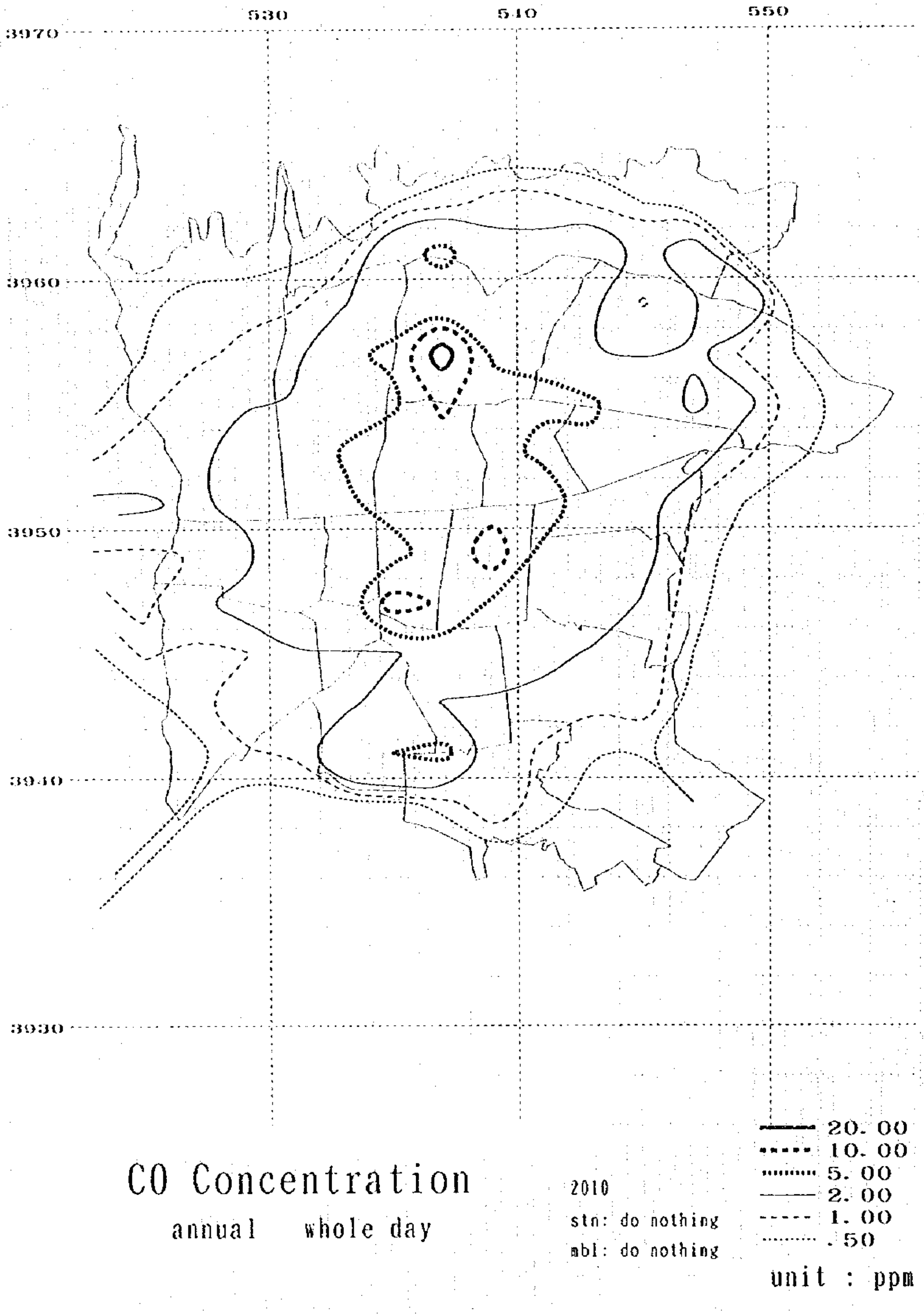


Figure 5.5.2-1 (1) Future CO concentration (do nothing , annual, whole day)

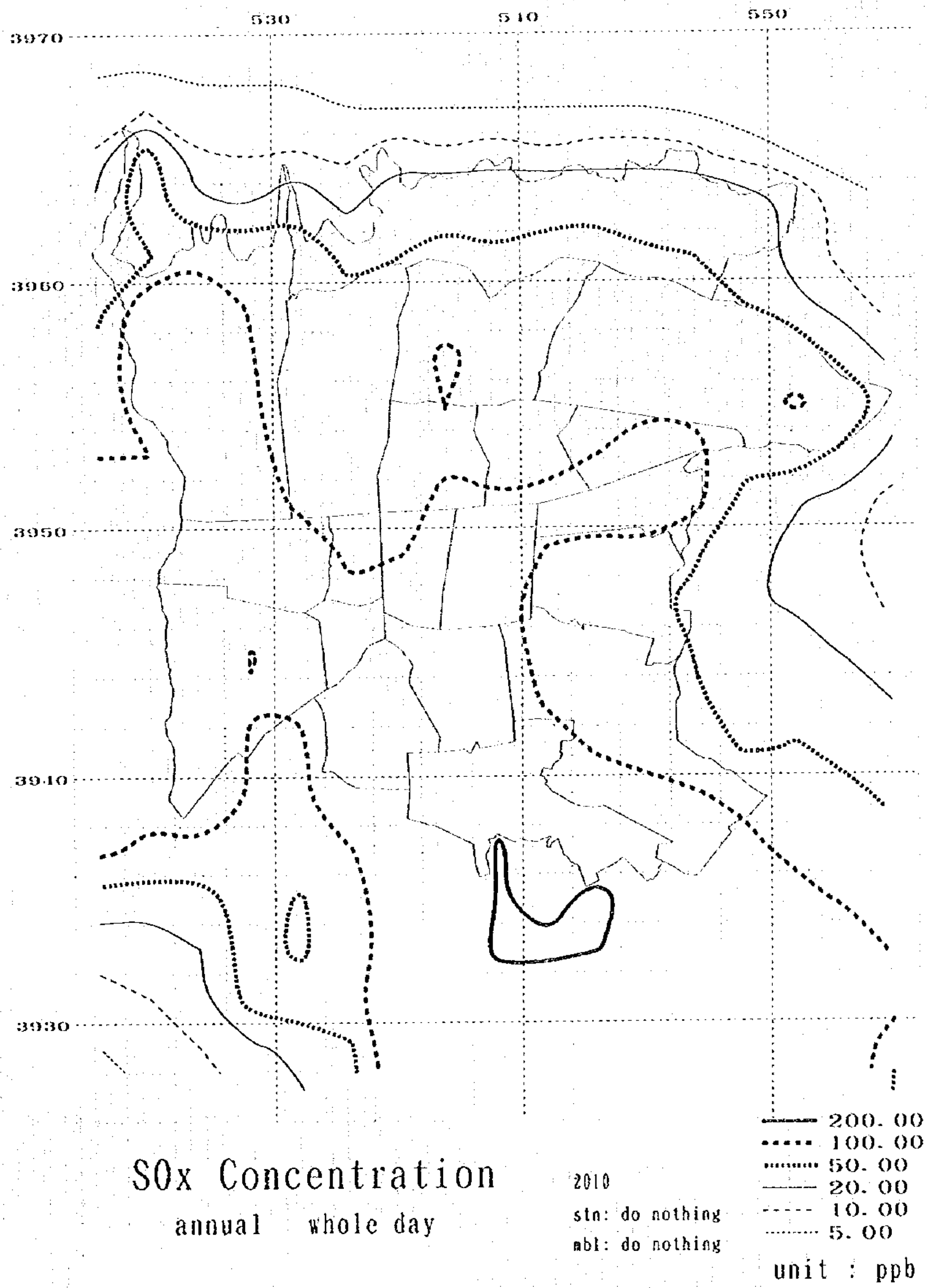


Figure 5.5.2-1 (2) Future SO_2 concentration (do nothing, annual, whole day)

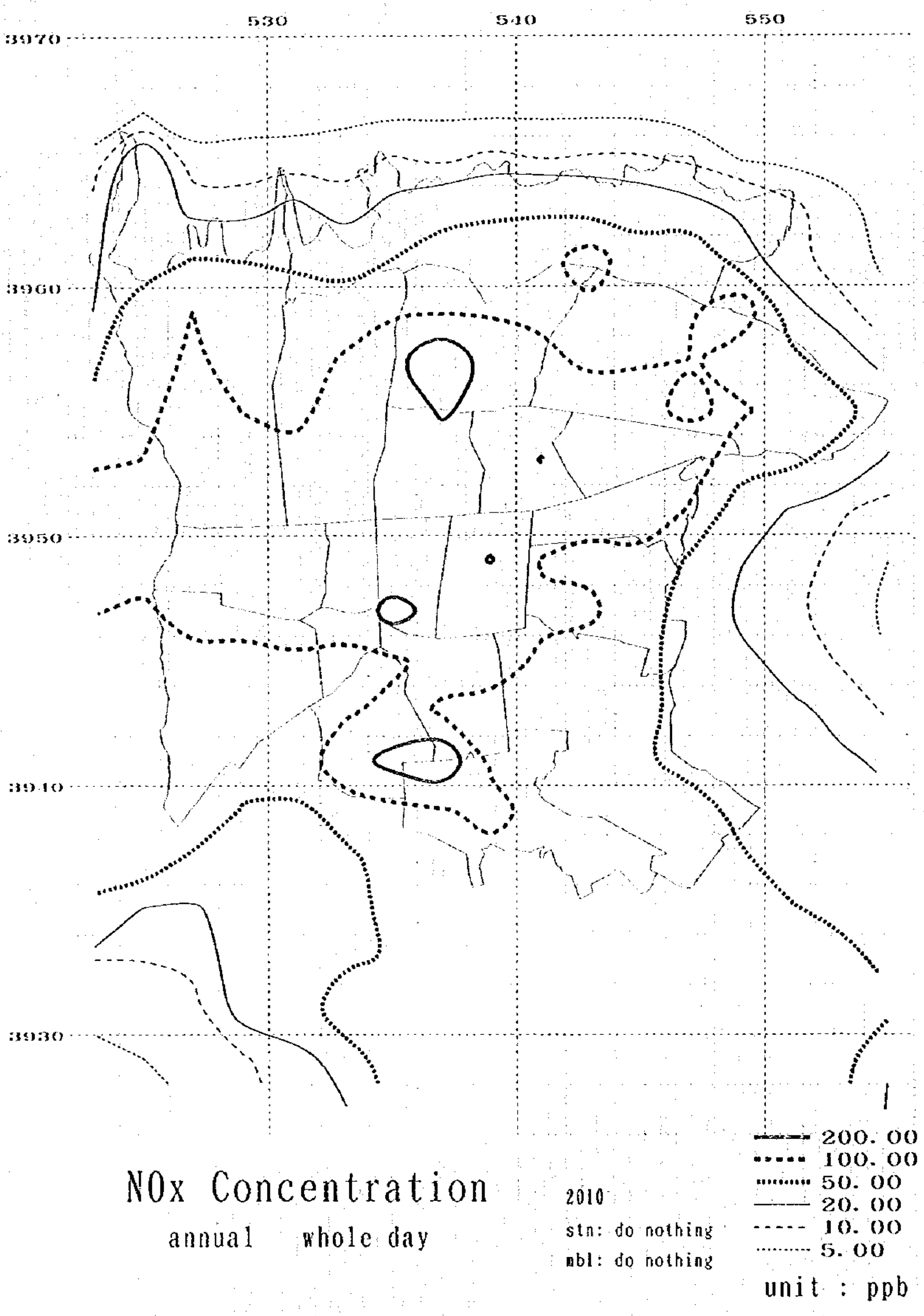


Figure 5.5.2-1 (3) Future NOx concentration (do nothing, annual, whole day)

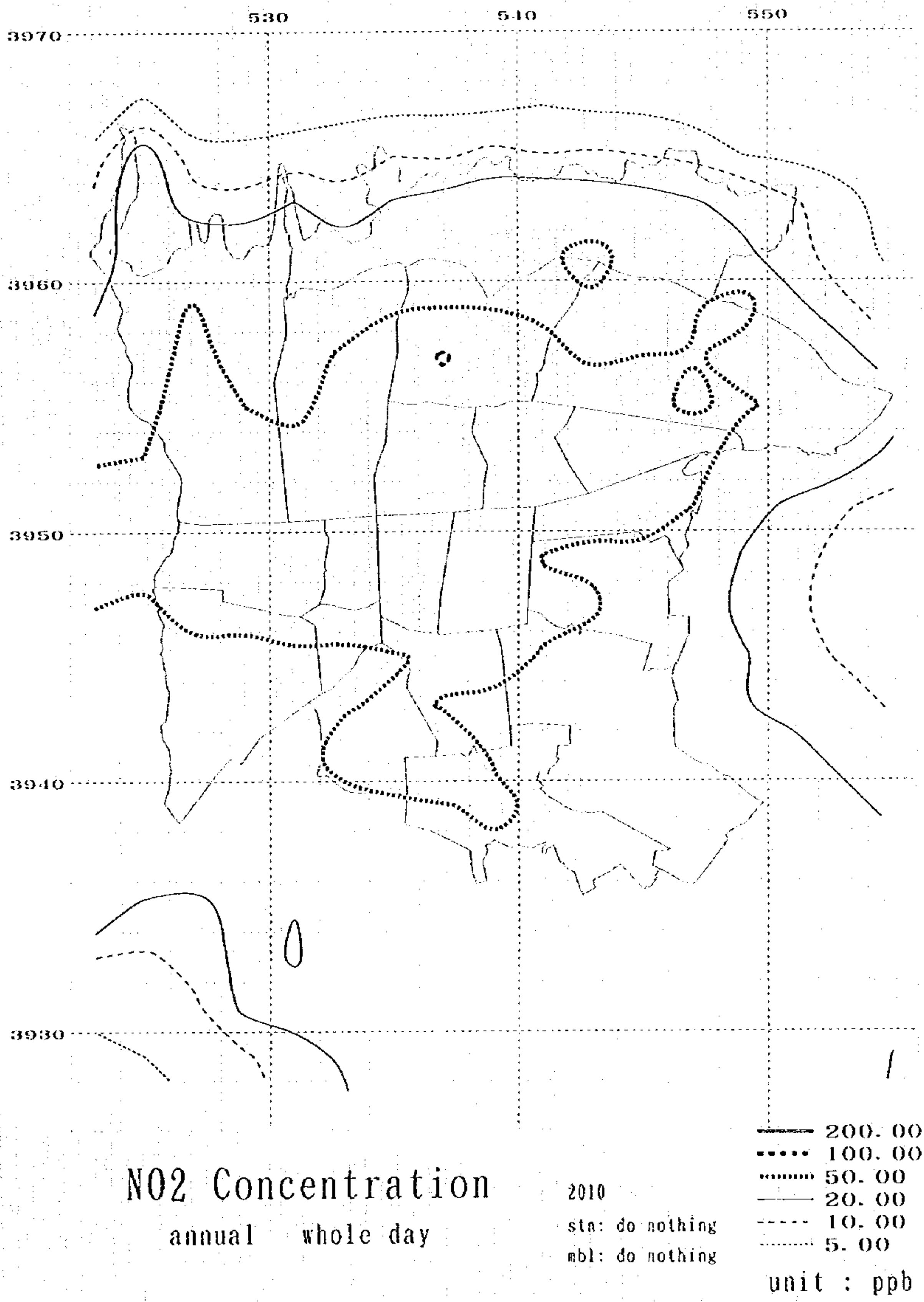


Figure 5.5.2-1 (4) Future NO_2 concentration (do nothing, annual, whole day)

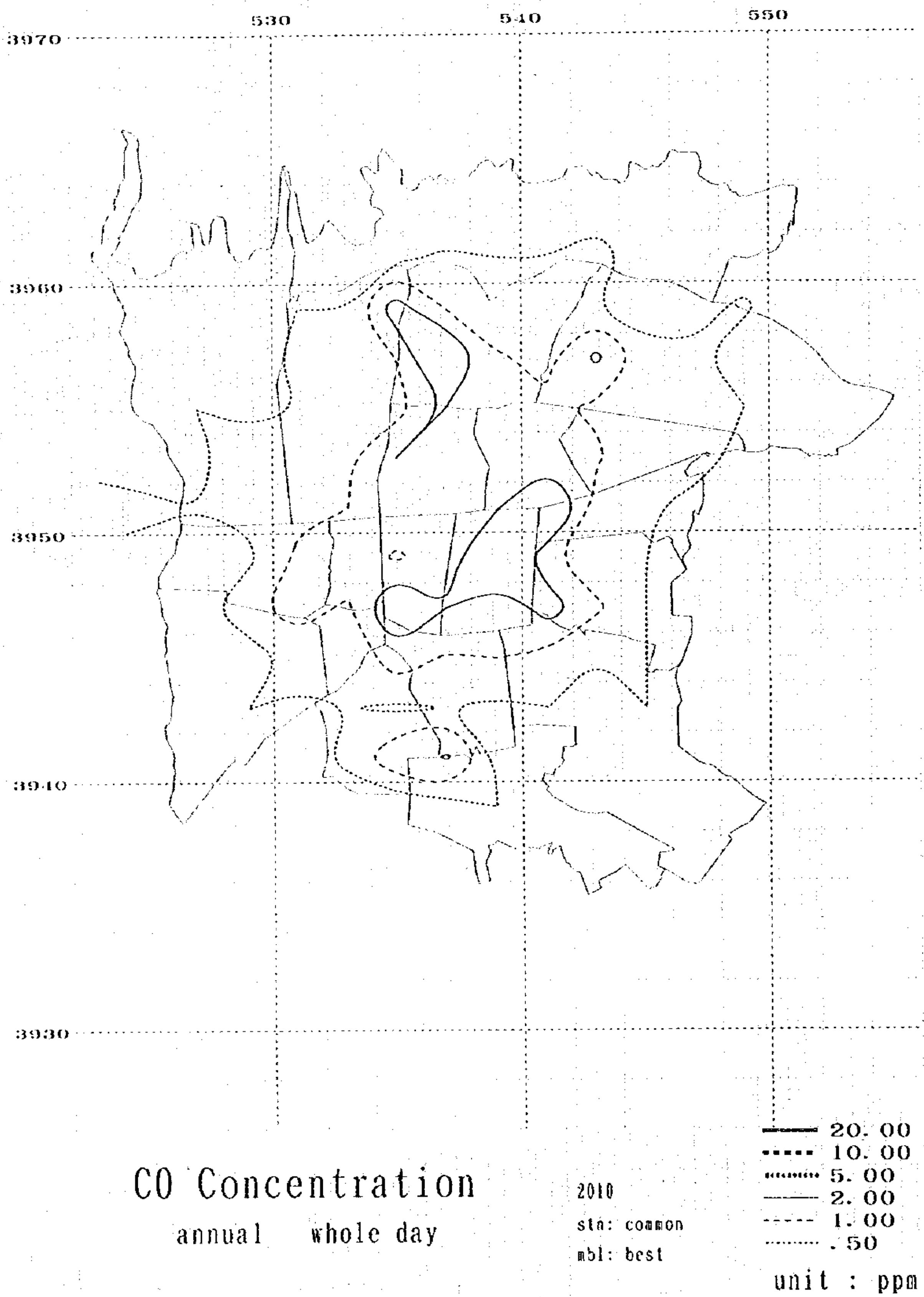


Figure 5.5.2-2 (1) Future CO concentration (common, annual, whole day)

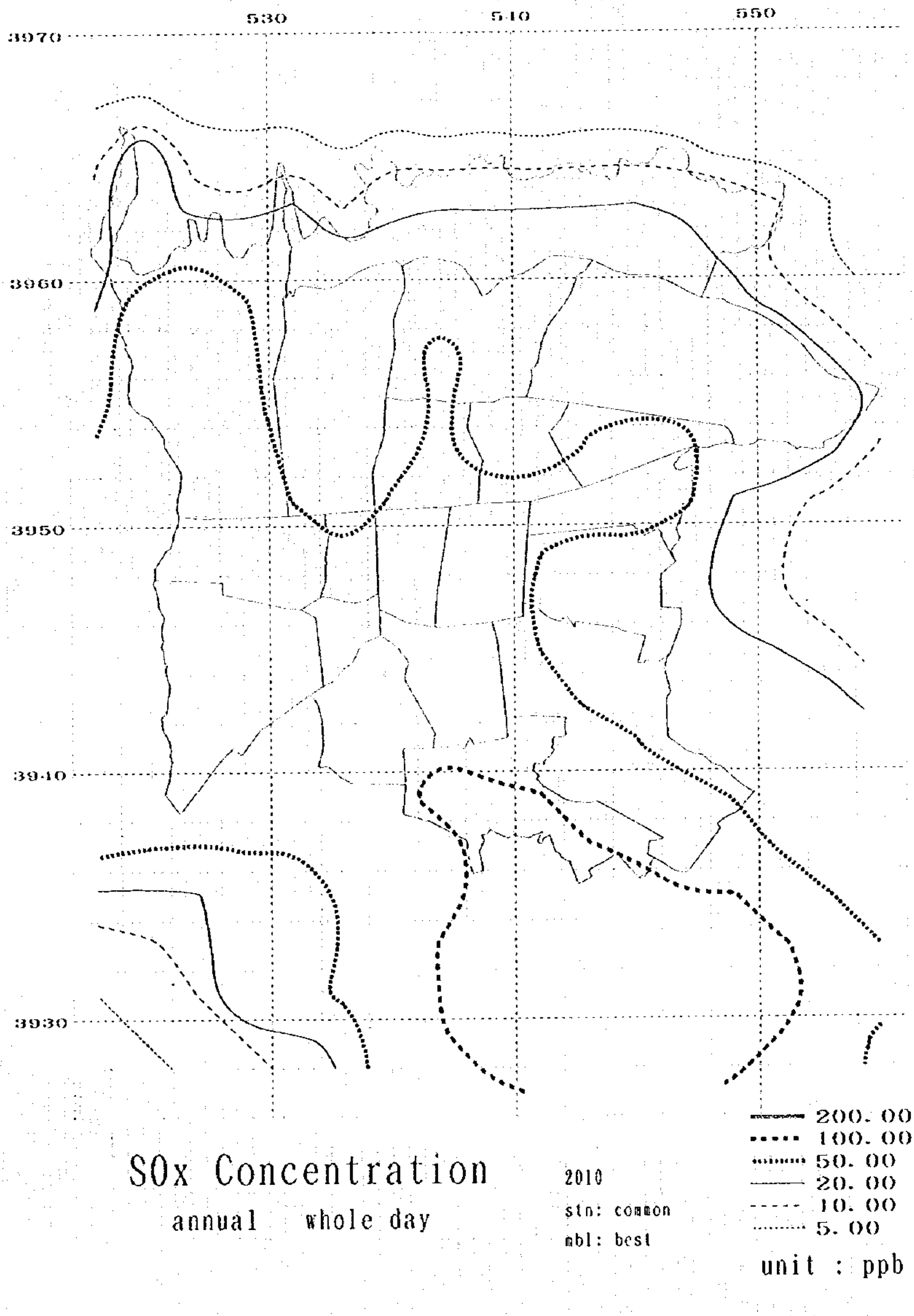


Figure 5.5.2-2 (2) Future SO_2 concentration (common, annual, whole day)

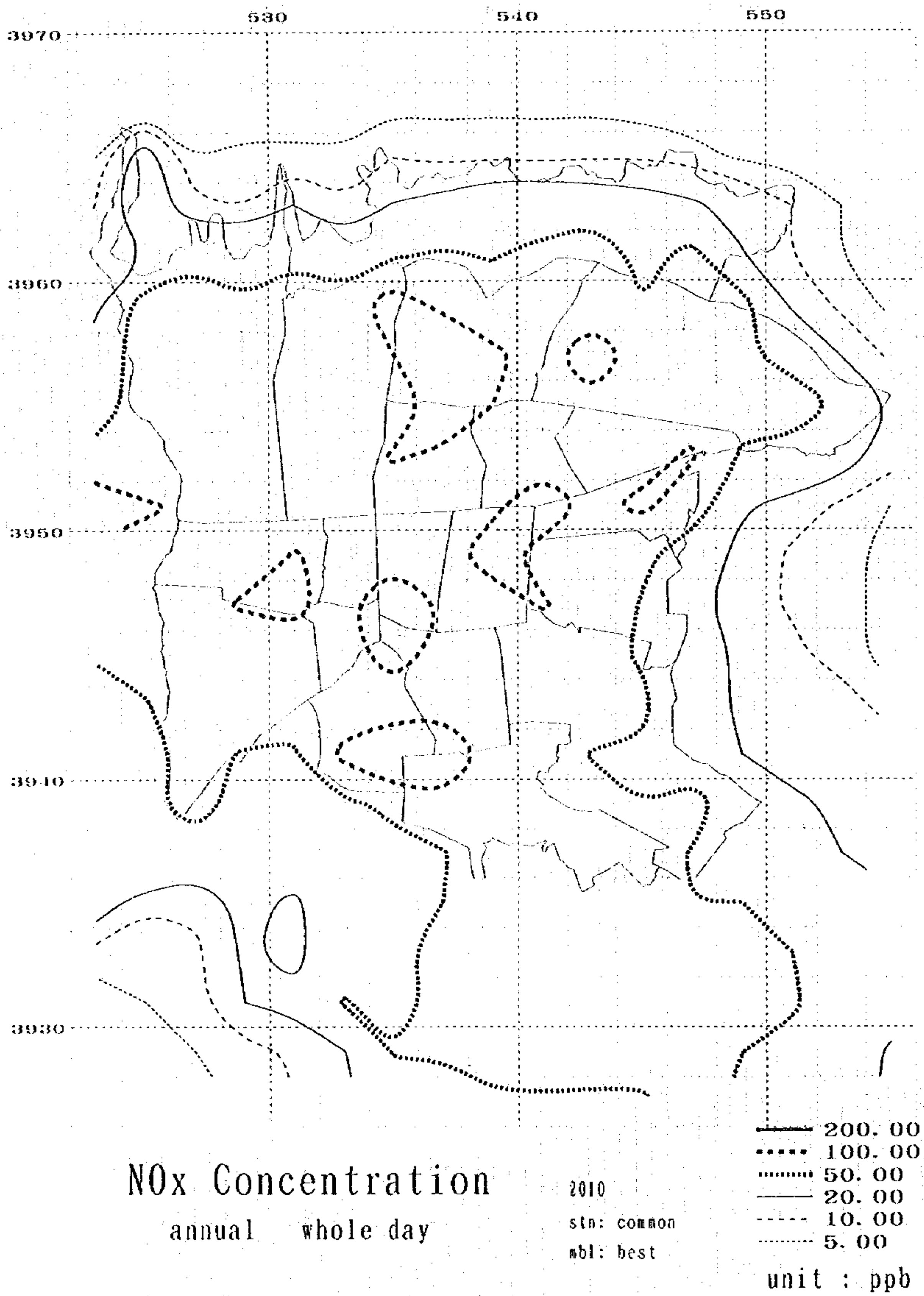


Figure 5.5.2-2 (3) Future NOx concentration (common, annual, whole day)

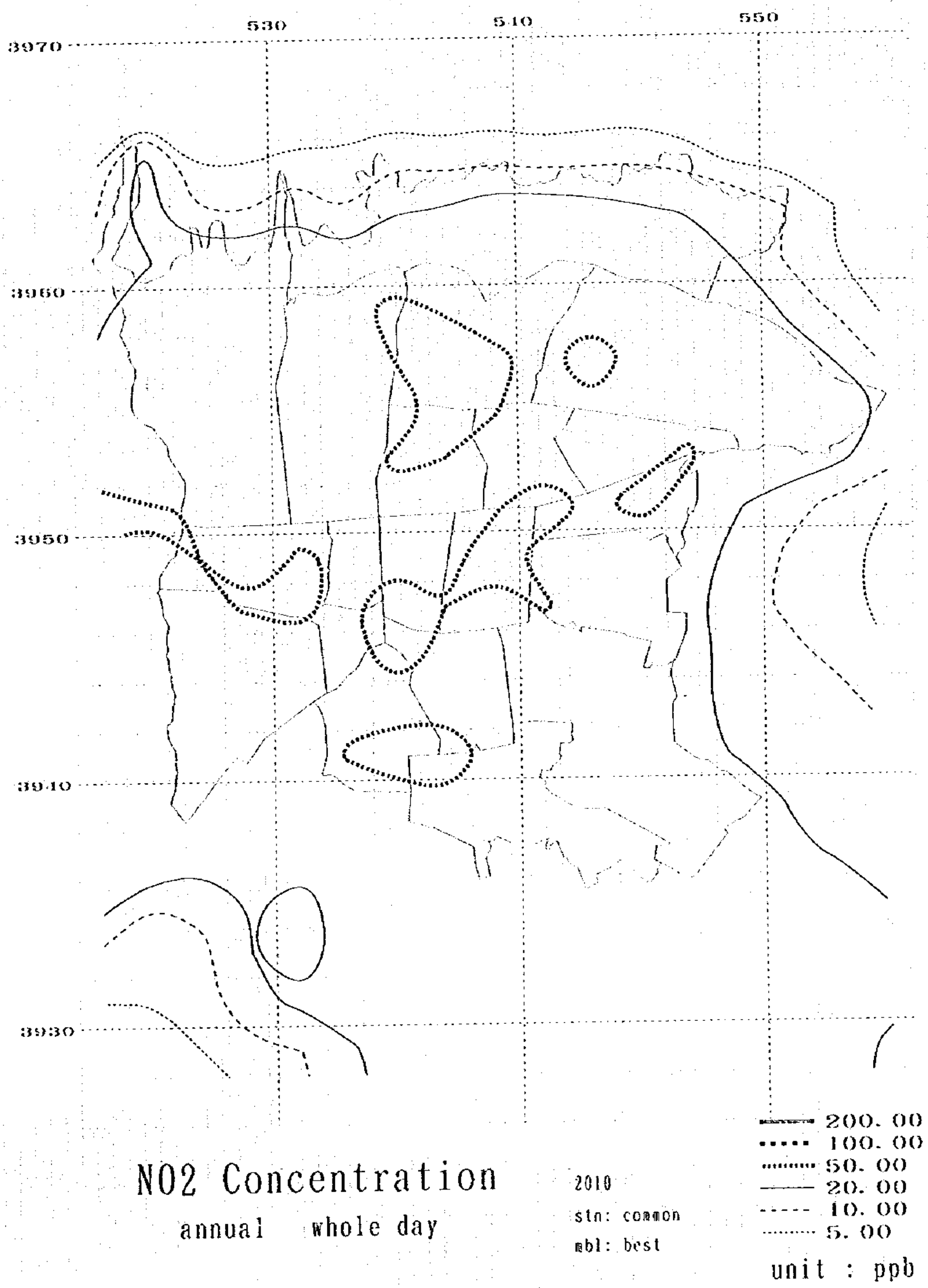


Figure 5.5.2-2 (4) Future NO_2 concentration (common, annual, whole day)

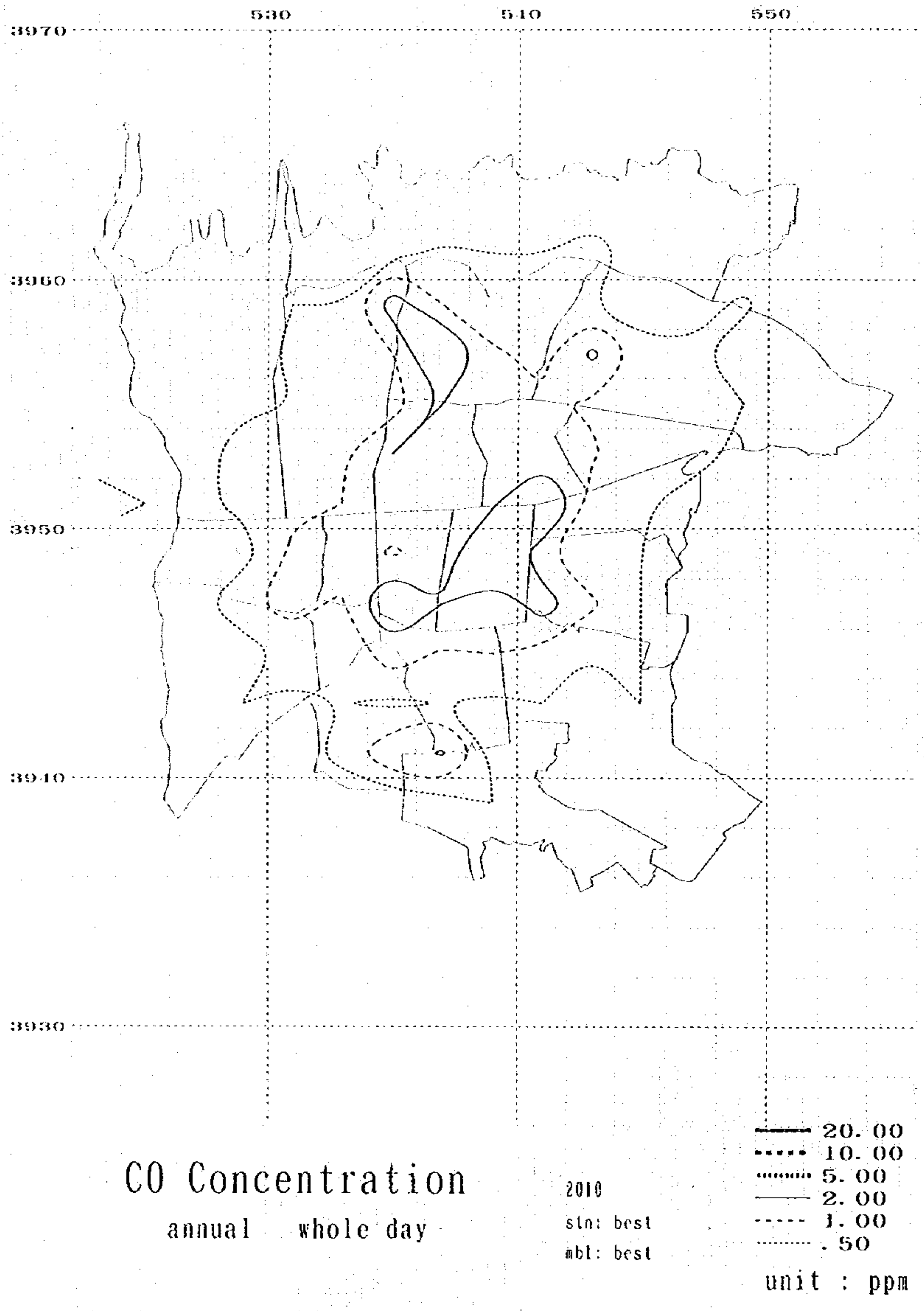


Figure 5.5.2-3 (1) Future CO concentration (best, annual, whole day)

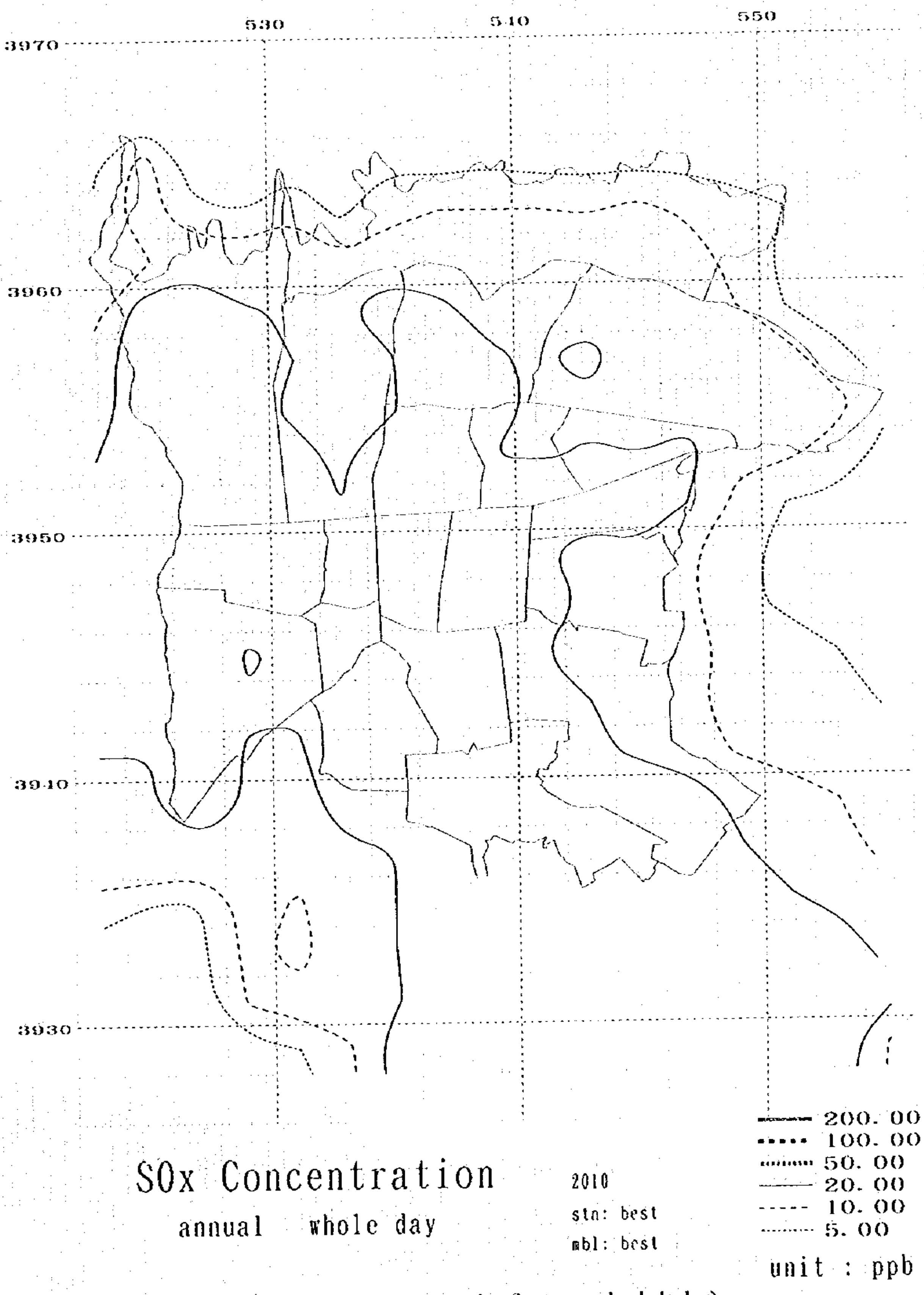


Figure 5.5.2-3 (2) Future SO_2 concentration (best, annual, whole day)

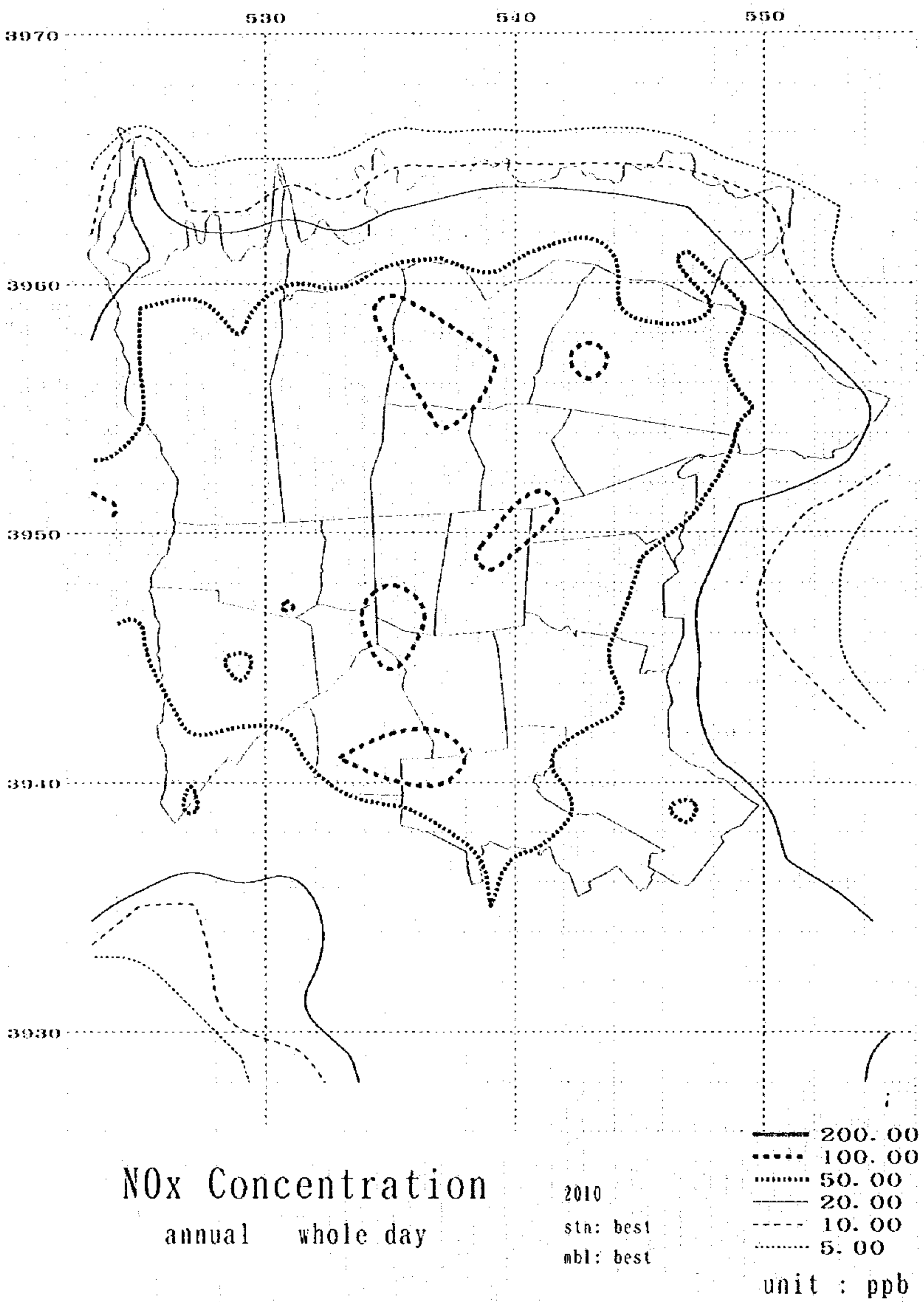


Figure 5.5.2-3 (3) Future NOx concentration (best, annual, whole day)

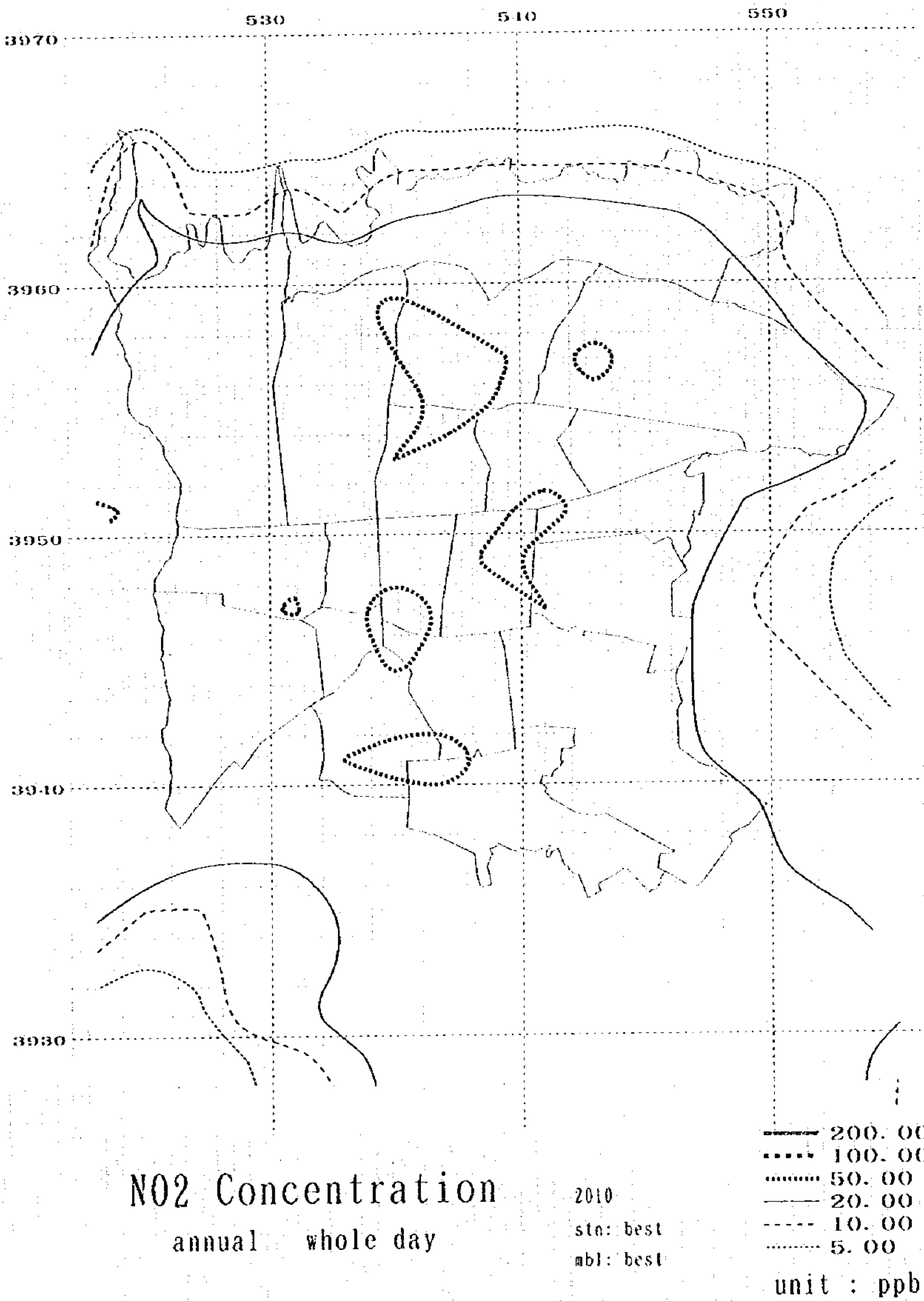


Figure 5.5.2-3 (4) Future NO_2 concentration (best, annual, whole day)

5.6 Necessities of reduction of pollutants and their amount to be reduced

5.6.1 Necessities of emission reduction of pollutants

The calculated values are compared with several standards of air quality in order to judge the situation of GTA. (Also refer to section 4.2 for the standards and the observed values.)

The conversion of the standard values is needed for some case due to the difference of target period. Pressure effect should also be considered because Tehran's average (880hPa, 17℃) is different from normal condition (1013hPa, 20℃).

(1) CO

As the WHO guideline provides only values for short term averages (8-hour, 1-hour, 30 and 15 minutes), they can not be compared directly with the annual value. Generally speaking, however, the annual standards correspond to half of the daily standards and daily ones to about half of the 8 hour averages. Thus WHO standard of 10 mg/m3 (about 9 ppm in normal condition) for 8 hour average may be converted to 2.5 ppm for the annual value of Tehran. (It is also supported by the Hungarian annual standard (2 ppm).) The calculated maximum value (14.4 ppm, present) reaches five times of this standard and the concentrations exceed 3 ppm in 6% of the whole calculation area.

(2) SO_2

The WHO standard of 0.06mg/m3 for the annual average (about 23 ppb in normal condition) is converted to 26ppb due to pressure effect. The calculated maximum value (104 ppb, present) is four times of this level and the concentration exceeds 25 ppb in 80% of the whole calculation area.

(2) NO_2

As in the case of CO, WHO sets 0.15mg/m3 (78 ppb in normal condition, 90 ppb in Tehran) as a daily standard but does not specify annual value. The same discussion made about CO and settings in several countries imply that suitable annual standard is around 45 ppb. The calculated maximum value of NOx (232 ppb, present) is converted to around 75 ppb of NO_2 using the empirical formula described in 5.3.1. The area where

NO2 concentration exceeds 50 ppb occupies 4 % of the whole, but most of them are below 60 ppb. Compared with CO and SO_2, NO_2 pollution is less serious in GTA.

5.6.2 Determination of reduction amount of pollutants

In the light of the analyses in 5.6.1 , the required amount of reduction can be determined as follows. The results based on the scenarios are also mentioned:

(1) CO

The CO emission should be reduced to a quarter of the present level in order to satisfy the environmental standard in the whole area. At least, reduction to a half is required for mobile sources in the central districts or at major highway junctions.

If 'best' scenario explained in 5.5 is realized, CO concentration can attain the required level based on the environmental standard except for few singular points such as highway junction.

(2) SO_2

Excess of SO_2 also causes some serious problems. Though the SO_2 contour map does not have as sharp a peak as CO, the average concentration exceeds the standard by far, i.e. most parts of 20 districts are located inside of the 20 ppb contour. To satisfy the environmental standard, the emission must be reduced to one third of, at most to a half of the present.

Based on the result of the 'best' scenario, the required level is attained except for few small areas close to the industrialized areas or the road junctions.

(3) NO_2

As mentioned in section 5.6.1, NO_2 pollution level is relatively close to the upper limit of the standard and the concentration can be reduced to an acceptable level on account of a certain emission control. A careful choice of countermeasures, however, is required because the NO-NO_2 equilibrium widely varies responding to external conditions and countermeasures to reduce other pollutants have a possibility accompanied by increase in NOx emission.

'Best' scenario brings the required level into the area except for little small area along highways or major roads.

5.6.3 Effects of Air Pollution on Human Health

Effects of air pollution on human health reported in a lot of papers are reviewed comprehensively in "Air Pollution (3rd ed.)" edited by A.C.Stern, and published by Academic Press in 1976. Helpful information for the target setting of pollutant reduction concerning the effect on human health are quoted from the book and other papers, and they are summarized below.

(1) Effects of Gaseous Pollutants

① Sulfur Dioxide

Sulfur dioxide is nearly completely absorbed during quiet breathing in the nose and the upper airway (trachea) because it is very soluble. Sulfur dioxide and other stimuli given to the upper airway produces increased airway resistance in the lung via the vagal nerve. Sulfur dioxide is synergistic in combination with smoke. Together they affect the respiratory tracts and about 1% of the population encounter bronchial spasms at the concentration of between 300 and 500 $\mu g/m^3$ (about 0.12 - 0.19ppm). During the 1952 London smog, the extra deaths of 4000 people in one week and additional 8000 in the following three months were attributed to the combination of sulfur dioxide and smoke. A number of experimental investigations show the unusually severe impairment of lung functions with exposures to between 2 and 5 ppm or in some cases, the development of a moderately severe attack of asthma in an otherwise healthy subject with no recent history of asthma. The effects at low concentrations include the distasteful odor, detectable at about 0.5ppm. At slightly higher concentrations, the irritating effects lead to increased airway resistance. Chronic cough and mucus secretion may result from repeated exposures, although most of the exposures to which these effects appear to be related are probably not due to sulfur dioxide alone.

As epidemiological evidence, the excess occurrences of chronic respiratory symptoms in the populations of Port Kembla with the great exposure of sulfur dioxide released by smelters in the neighborhood are documented by the study in Australia. This study seems to represent predominant effects of sulfur dioxide. Other epidemiological studies that appear to reflect effects of sulfur dioxide are most likely due to its interactive effects with other pollutants.

Another effect of SO_2 on lichens begins at $40\mu g/m^3$ (about 0.015ppm). It does not correlate with the health effects on human, however, should be known.

② Ozone and Other Oxidants

Ozone is produced by photochemical reactions involving hydrocarbons from car exhausts and nitrogen oxides and it becomes an irritant to eyes, throat and lungs. It can be formed in photochemical smog. However, ozone itself is not thought to be the eye irritating ingredient in photochemical pollution. The exact substances that cause eye irritation are still not defined. They are now thought to include formaldehyde, acrolein, peroxybenzoyl nitrate, and peroxyacryl nitrate. The respiratory effects of photochemical pollution, some of which can be produced by the amount of ozone present, are thought to be aggravated by these other substances.

Dictionary of Environmental Science and Technology (1996) said that Individuals vary considerably in their response to ozone. Sensitive people experience temporary breathing difficulties if they take vigorous outdoor exercise when the ozone concentrations are at or above about $160\mu g/m^3$ (about 0.08ppm). In terms of lung function, people who suffer from asthma or other respiratory disorders are not more likely to be sensitive to ozone than other members of population.

At the concentration of about 0.3ppm with exposures of a few minutes, the irritating effects of ozone are detected (Young *et al.*, 1963). These are readily detected at half a part per million by most individuals and may be detected at the lower concentrations by some (Daldez,1928, Flury and Zernik, 1931, and Goldsmith and Nadel, 1969). The irritation includes a sense of dryness of the throat. Under normal conditions of breathing through the nose, the irritation occurs in the respiratory tract but does not affect the gas-exchanging part of the lung seriously. However, if the ventilation rate is sufficiently high and mouth breathing occurs, the mechanisms of scrubbing the incoming air to remove the relatively in soluble gas are inefficient and the ozone may reach the deeper part of the lung. A more severe effect of ozone exposure is alteration in the airway resistance. Remmers and Balchum (1965) and Ury and Hexter (1969) are examined impairment of respiratory function in a population of patients with established chronic respiratory disease at Los Angels, County Hospital. There is a statistically significant association between the photochemical oxidant and airway resistance which is a valid indicator of the severity of the respiratory disease. Los Angels residents with chronic respiratory disease report aggravation during periods of photochemical pollution. Schoettlin and Landau (1961) indicated that there was statistically significant excess of asthma attacks on days when the peak oxidant, which measured by the potassium iodide method, was greater than 0.25ppm. This corresponds during the days actually measured to an hourly average of 0.20ppm.

The most characteristic toxic effect of relatively high-level ozone exposure is pulmonary edema (Mueller and Hitchcock, 1969), which implies a leakage of fluid into the gas-exchanging parts of the lung. Pulmonary edema, if severe, can be disabling and fatal.

③ Carbon Monoxide

Carbon monoxide is not irritating, but it affects the human body after taken in. Affinity of carbon monoxide for hemoglobin(Hb) is about 210 times of oxygen. As a result of increase of carboxyhemoglobin, that is the hemoglobin combined with carbon monoxide, transportation of oxygen to the tissues in the body is hindered and tissues suffer from oxygen starvation. Furthermore, carbon monoxide taken into the body reacts or is combined with the materials in a living body causing, for example, symptoms of poisoning in the central nervous system and enzymatic action.

Stewart *et al.* (1974) discussed the effect of carbon monoxide from community air based on the obtained blood samples from persons who appeared at various blood banks in a number of urban areas in the United States. The fact obtained by the study showing that urban populations have carboxyhemoglobin levels so much above the expected background level suggesting that there is a systematic contribution from pollution. The serious harmful influences of low concentration carbon monoxide intake over a long period appear especially on the people living on highland above 5,000 feet

(2,400m) or the people who have chronic heart diseases, pulmonary troubles, or anemia. Particularly, it gives a fatal damage to the people being suffered from acute heart attack or cerebral hemorrhage. High altitude (that is to say low pressure) makes the CO effect greater. It is reported that the CO concentration of 25ppm is dangerous for the people at 1500 – 2000m. The study in this field, how the effect changes depending on the altitude or chronic disease, has not advanced so much. However, in the case of GTA, its altitude should be taken into consideration in planning air pollution control.

Effects of CO on the human health have tended to be discussed on the assumption that the concentration is constant. As for the urban CO pollution, however, discussions should be made on the effect on human by fluctuating CO, because the main source of CO pollution in the city is the exhaust gas of vehicles. Variation patterns of the CO concentration by week or by season show the similarity with those of mortality from disease of respiratory or circulatory organs. Rhythm of exposure to CO for each person is formed by the combination of the environmental CO pollution in the residential area, in the commuting car, in the office or workroom, and smoking. Effects on human under the expcsure to high concentration exhausted gas fluctuation in the short cycle are dependent on the absorption degree of CO, existence of other influence except formation of carboxyhemoglobin, the synergistic effect of CO and other ingredients of exhaust gas. In the case a person is exposed to the comparatively high concentration CO, about 44% of the intake CO is assimilated.

④ Nitrogen Dioxide and Other Nitrogen Oxides

Among the seven oxides of nitrogen known to exist in the ambient air, nitric oxide (NO) and nitrogen dioxide (NO_2) are the only gas thought to affect human health. Nitric oxide is readily oxidized to nitrogen dioxide, and until now there are no data showing that nitric oxide at the levels encountered in the ambient air is a health hazard. This oxidation may occur in the atmosphere or in the membranes and tissues lining the airways.

It seems to be difficult to prove and specify the effect of nitrogen oxides on human health, though a lot of efforts have been made to clarify the effect and some of them were rewarded with good results. Both nitric oxide and nitrogen dioxide, if transferred across the lung-blood barrier, can produce inactive forms of hemoglobin, the most important of which is called methemoglobin, which is not able to carry oxygen because it is an oxide of hemoglobin. Studies undertaken in Los Angeles by Goldsmith and Shearer (1975) indicated that methemoglobin levels in school children and in commuting adults have ranged up to 5.2% and among groups of commuters average between 2.0 and 2.5%. This is higher than the 1% that had previously been thought normal. In one series of studies of nitrogen dioxide as a community pollutant in Tennessee by Shy *et al.* and Pearlman *et al.*, adverse effects of pollutant on both adult and childhood respiratory illness and pulmonary function as well as acute lower respiratory illness in children living near TNT plants emitting nitrogen dioxide were reported. A WHO Task Group on Environmental Health Criteria for Oxides of Nitrogen concluded that a nitrogen dioxide concentration of 0.5ppm was established to be the lowest level at which adverse effects, due to short-term exposure, can be expected to occur. A maximum one-hour exposure of 0.10 – 0.17ppm, no more frequently once a month, was felt to be consistent with protection of the public health.

⑤ Hydrocarbon Vapors

Some of the hydrocarbon vapors in the atmosphere have health implications. Among the aldehydes of importance are formaldehyde and acrolein, both potent irritants. Effects of formaldehyde are primarily irritating. It is thought to be a major contributor to the eye and respiratory irritation of photochemical smog. Benzene was a popularly used solvent, but its industrial use is now restricted because sufficient exposure to it interferes with the formation of red blood cells in the bone marrow. Leukemia occurs in some individuals with long-term occupational exposures. The range in which any hazardous effects have been observed in occupationally exposed workers has its lower bound between 5 and 25 ppm, which is two orders of magnitudes greater than the reported air pollution concentrations. However, considering the alterations in chromosomes from lymphocytes in persons who recovered from occupational exposure to benzene, we should treat any exposure as a serious matter.

(2) Effects of Suspended Particulate Matter

Imai(1997) reviews studies on the effects of suspended particulate matter for human health concerning a new target of air pollution policy as follows:

Recent epidemiological studies show that suspended particulate matters are more hazardous for human health than gas components such as SO_x and NO_x. PM10, especially ultra fine particles are inhaled deep into the lung and cause the respiratory troubles. Ambient air with high level PM10 may increase the number of daily deaths in inhabitants especially in aged persons having chronic obstructive lung diseases. PM10 level is related to the incidence of respiratory symptoms such as chronic cough or wheeze, and to the aggravation of infant asthma and bronchitis in the polluted region. The level of total suspended particulate over $80 \mu g/m^3$ reduces vital lung capacity obviously, and some reports warn that the effect on the cardio pulmonary function is detectable even at the concentration levels below the environmental standard. Up to the present, the main interest of studies is in the black smoke less than $2 \mu m$ from oil combustion in the industrial and urban areas. However, PM10 from the steel mill industry, which consists mainly of iron, also showed the same effects on inhabitant's health. It suggests that any particulate matter, regardless of its component, may be hazardous for respiratory organs. A study on the long term effects of air pollution showed that a lower survival curve was expected in inhabitants of the most polluted cities as compared with those of the least polluted cities, and that the death rate was correlated with particulate and sulfate levels in the ambient air.

(3) Chronic disease caused by air pollution

① Bronchitis and emphysema

Sufficient exposure to air pollution of various types is a likely causal factor in chronic bronchitis and a suspected one in emphysema. The accumulating epidemiological evidence satisfies at least some of the criteria of proof of causal relationship between air pollution and chronic bronchitis. Although air pollution is certainly neither the only cause, nor perhaps even the major initiating cause, it is almost certainly a promoting or aggravating factor of serious chronic lung disease. In the Los

Angels, air pollution is a suspected causal factor of increased cough and sputum in older workers and a likely cause of impairment of pulmonary function for persons with chronic respiratory conditions. Moreover, there is suggestive evidence that populations of cigarette smokers are particularly susceptible to air pollution aggravation of their bronchitis. There is as yet too little evidence for any firm conclusion concerning a causal relationship of community air pollution and emphysema. However, air pollution should be considered a suggested causal factor in emphysema.

② Asthma

Pollens are almost certainly a causal factor in some cases of asthma. Other materials may, as community air pollutants, be causal factors in certain locations. Generalized community air pollution is a suggested causal factor, but only for a small proportion of all adult asthma patients. Photochemical pollution is a likely causal factor in aggravation of asthma, in a portion of adult asthmatic patients. Sulfate aerosols are a suggested causal factor. Hyperreactivity of the airway caused by pollutants is likely to be an important mechanism in air pollution aggravated asthma.

③ Respiratory cancer

Most of the relevant epidemiological studies show an association between urban residence and increased risk of lung cancer. In Norway, the death rates for cancer of the respiratory system are more than three times greater for urban males than for rural males, with a smaller excess for females (Norwegian Cancer Society, 1964). In New York State, excluding New York City, the age-adjusted lung cancer rate is twice as high in urban portions of metropolitan areas as in rural parts of nonmetropolitan areas. In Iowa, the urban-rural gradient is nearly threefold.

However, air pollution remains a "suggested" explanation for the urban excess of lung cancer. Whether it is true or not, there is the important practical consideration, that is, control of soot, suspended particulate matters, and products of incomplete combustion are most important among the most urgent goals of air pollution control, without regard for the interpretations of pollution and cancer data.

④ Cardiovascular disease

There are three possible mechanisms by which air pollution may affect the cardiovascular system on a long term basis. The first and the most important is associated with the role of carbon monoxide. The second is the effect of cadmium on cardiovascular disease, in particular on cardiovascular renal disease. The third effect depends on the interaction of the respiratory effects of pollution and the cardiovascular system. If there is respiratory irritation with coughing, the resulting internal pulmonary pressure increases. Chronic respiratory disease, particularly where extensive fibrosis or loss of lung tissue occurs, tends to be associated with cor pulmonale, or heart disease secondary to lung disease. Among populations with an increased frequency of chronic respiratory conditions, it is likely that secondary heart disease will be found.

⑤ Hematological reactions

The effect of carbon monoxide in interfering with the oxygen transport function of the blood has been shown in cigarette smokers to affect the number of red blood cells produced. However, there is no evidence indicating that such an effect occurs as the result of community air pollution. Similarly, there is no evidence of hematological effects from community exposure to levels of lead resulting from motor vehicle exhaust.

Kapalin (1970) summarized findings on blood changes in groups of children living in clean areas as opposed to those in areas polluted by smoke and sulfur dioxide. Children from the polluted town have statistically significant higher red cell counts and lower average cell volume than children from the clean town. There are no differences between the hematocrit and the total amount of hemoglobin levels among these communities. He also showed that there is a decrease in the rate of skeletal growth of children in the more polluted towns. Because it is difficult to estimate the amount and type of pollution that quantitatively produces such effects, it is difficult to interpret these results. However, there is no doubt as to their nature.

⑥ Chemical mutation

A suggestive link between photochemical pollution and possible lethal mutations was reported by Lewis *et al.* (1967) in male mice exposed to irradiated auto exhaust during the full length of spermatogenetic cycle. As for human, Mertz *et al.*(1975) have shown that ozone exposure led to detectable increased frequency of mutations in lymphocytes. Increased neonatal mortality was noted in mice born in irradiated automotive exhaust atmospheres containing commonly measured levels of photochemical pollutants. Male mice exposed during the spermatogenetic cycle to irradiated exhaust containing ambient concentrations of pollutants sired fewer and smaller litters per mating, and had more neonatal deaths than among litters living in clean air, suggesting lethal mutations (Lewis *et al.*, 1967). Furthermore, male infertility and increased early infant mortality have been described in mice exposed to irradiated auto exhaust, suggesting damage to chromosomes by simulated photochemical pollution. Human males exposed to mutagenic pollutants might be expected to be fathers of children with an increase of genetically conditioned abnormalities.

(4) Evaluation of air pollution in Tehran based on the WHO air quality guidelines
The original concentrations in this table in $\mu g/m^3$ are converted into the values in ppm under the conditions of both the sea level (25℃, 1013hPa) and Tehran (20℃, 880hPa).

Air quality guidelines and standards are established by WHO and nations for the purpose of prevention of harmful effects on human health and welfare. The standards and guidelines are determined for some different adoption. Annual mean guidelines and standards are designed to protect the population from regular exposure to high levels of pollution. By ensuring that the mean daily concentrations remain lower than that, long-term chronic effects on health are minimized. There is also a need to control acute effects which result when abnormally high levels of pollution persist for short periods. Therefore, short-term guidelines and standards place limits on pollutant concentrations over periods ranging from 10 minutes to 24 hours. Typically, 1-hour, 8-hour and 24-hour averaging times are used in short-term guidelines and standards. Table 5.6.3-1 gives the extracted data of the WHO air quality guideline to be used for evaluation of the air pollution effect on human health of population in Tehran. The original concentrations in this table in $\mu g/m^3$ are converted into the values in ppm under the conditions of both the sea level (25℃, 1013hPa) and Tehran (20℃, 880hPa).

Table 5.6.3-1 WHO air quality guideline (extracted)

Pollutant	Time-weighted average (μgm^{-3})	Converted value[2] (ppm, sea level)	Converted value[3] (ppm, Tehran)	Averaging time
Sulfur dioxide[a,b]	350	0.14	0.151	1 hour
	100 – 150[1]	0.04 – 0.06	0.043 – 0.065	24 hours
	40 – 60[1]	0.015 – 0.023	0.017 – 0.026	1 year
Carbon monoxide[a,c]	30	26	30	1 hour
	10	9	10	8 hours
Nitrogen Dioxide[a,d]	400	0.21	0.241	1 hour
	150	0.08	0.09	24 hours
Ozone[a,e]	150 – 200	0.08 – 0.10	0.087 – 0.115	1 hour
	100 – 120	0.05 – 0.06	0.058 – 0.069	8 hours
PM10	70[1]	-	-	24 hours

Note; 1 Combined value of SO_2/SPM guideline

2 Conversion into ppm is made on the basis of 25℃, 1atm (1013hPa).

3 Conversion into ppm is made on the basis of 20℃, 880hPa.

Sources; [a](WHO, 1987) [b](WHO, 1979a) [c](WHO, 1979b)

[d](WHO, 1977) [e](WHO, 1978)

It is important to evaluate the actual pollution level in Tehran from the point of view of the effect on human health. Fig. 5.6.3-1 ~ Fig. 5.6.3-5 are the diurnal variation of pollutant concentrations for the extracted serious air pollution examples monitored at Bazar and Fatemi. These are 1 hour average data available for comparison with the WHO guideline of 1 hour time weighted average.

① Sulfur dioxide

Sulfur dioxide concentrations show the extremely high level at Bazar. The daily maximum SO_2 concentration on November 30, 1995 at Bazar is 345ppb that is 2.3 times as large as the WHO guideline (0.15ppm) for the 1 hour average. The high concentration exceeding the guideline is observed in the morning and the night, and such high level persists for 6 – 16 hours in these cases.

② Ozone

Ozone concentrations at Bazar also exceed the guideline (0.08 - 0.10ppm) for 4 – 5 hours in the afternoon. Especially, maximum concentration on July 24, 1996 at Bazar is 150ppb that also exceeds the WHO guideline (87-115ppb). The irritating effect of ozone may be detected at such concentration.

③ Carbon monoxide

Concentrations of carbon monoxide both at Bazar and Fatemi are considerably high. The guideline is 30ppm, while the daily maximum of each examples exceeds 70ppm, especially the peak concentration on September 16, 1996 at Fatemi indicates 93ppm that is 3.1 times as large as the WHO guideline. In addition, as mentioned before, the effect of carbon monoxide on humans is emphasized on highland. Consequently, the concentration level at present is thought to be very harmful for health of population in view of the altitude of Tehran.

④ Nitrogen dioxide

Nitrogen dioxide pollution is not so serious in comparison with other pollutants. The concentration levels at Bazar are lower than the guideline (0.2ppm).

⑤ PM10

As the averaging time for the PM10 guideline is 24 hours, the 1 hour averaged data at Bazar cannot be compared with the guideline value. The daily average of PM10 concentration on July 9, 1996 at Bazar is $192\mu g/m^3$ that is 2.7 times as large as the WHO guideline for 24 hours($70\mu g/m^3$).

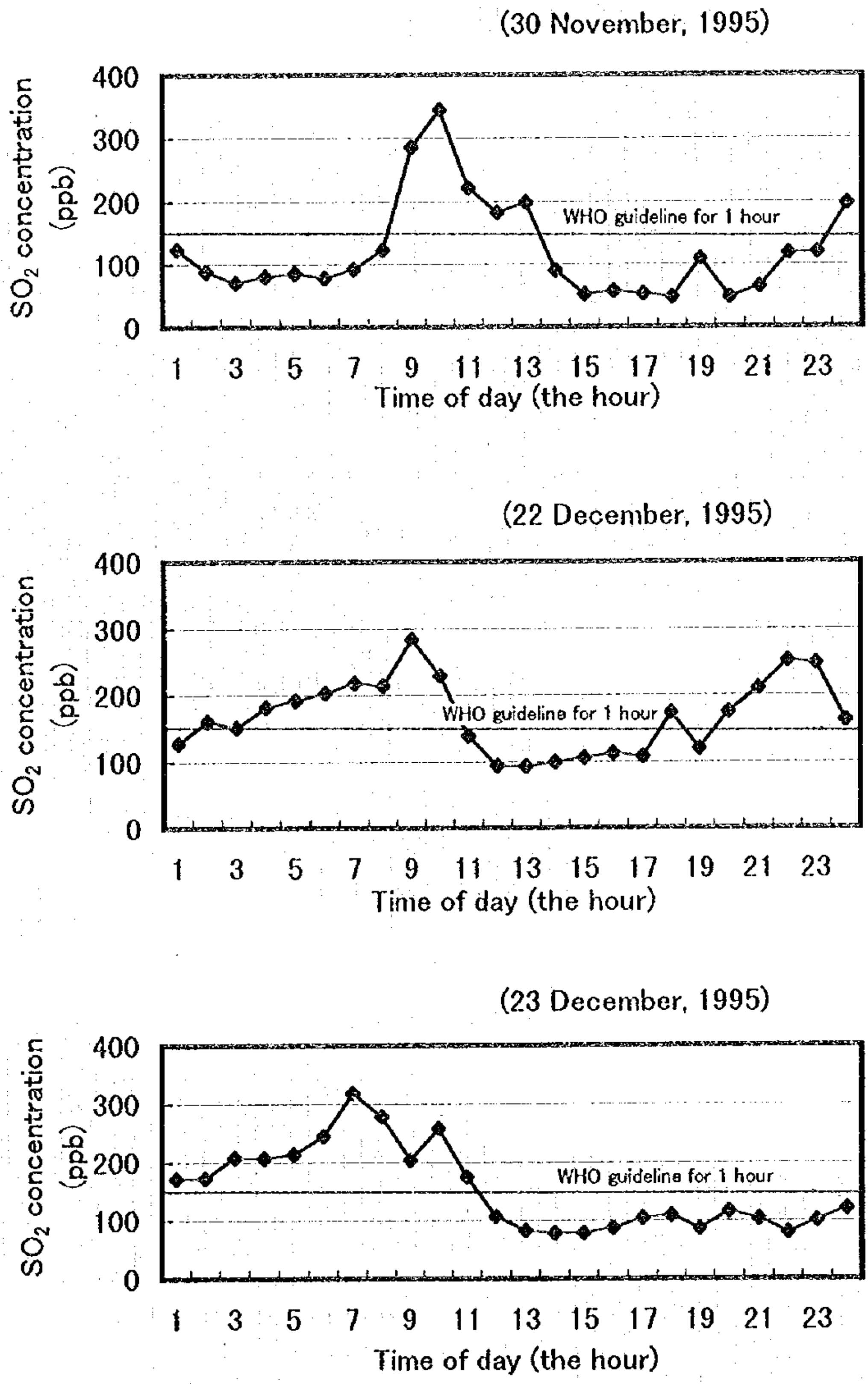


Fig.5.6.3-1 Diurnal variation of SO_2 concentration during serious pollution at Bazar.

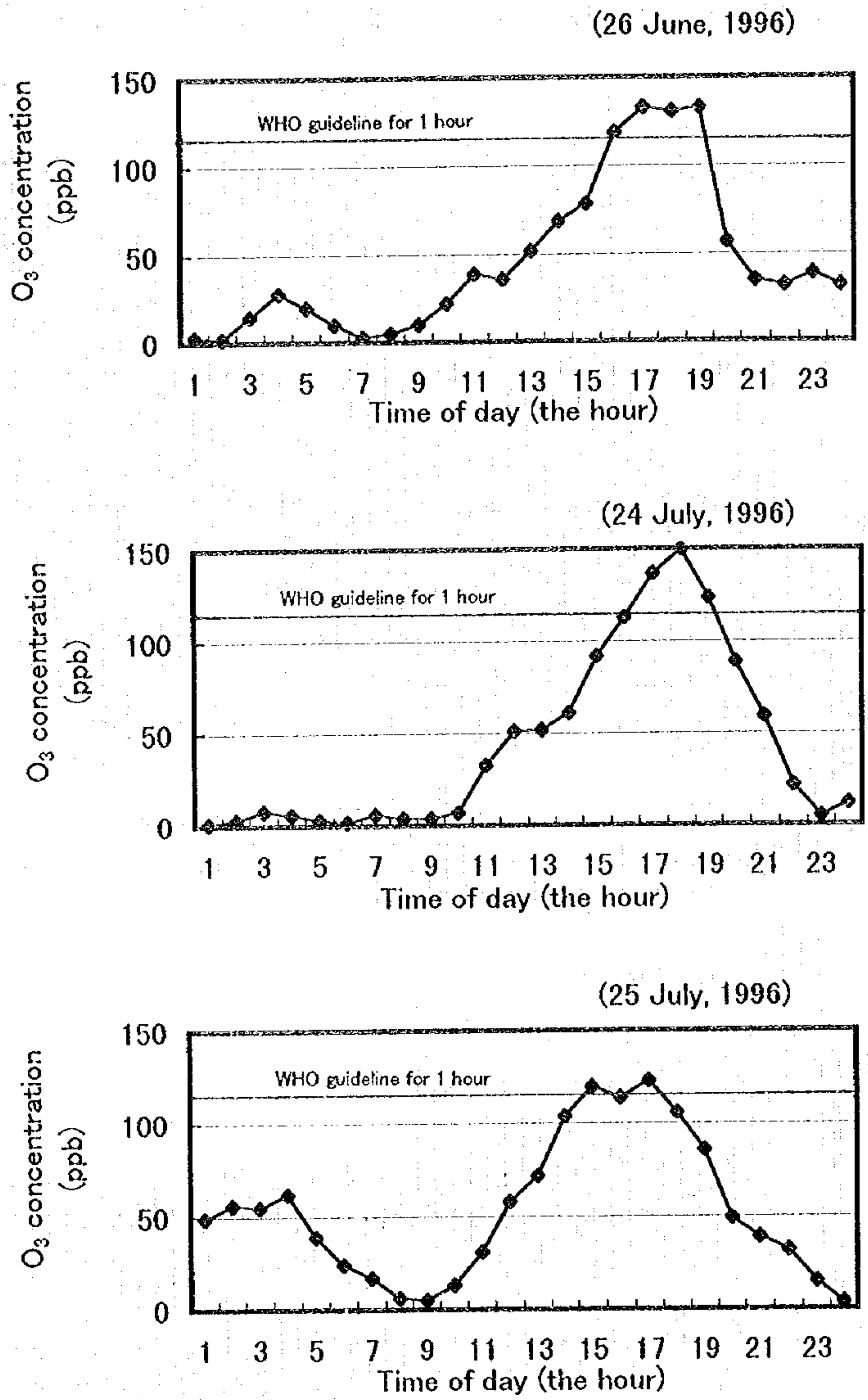
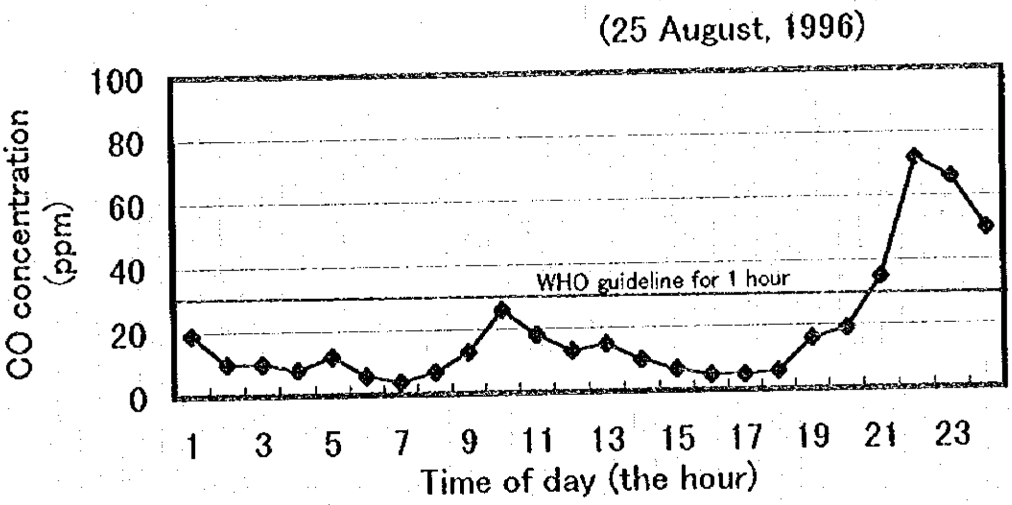
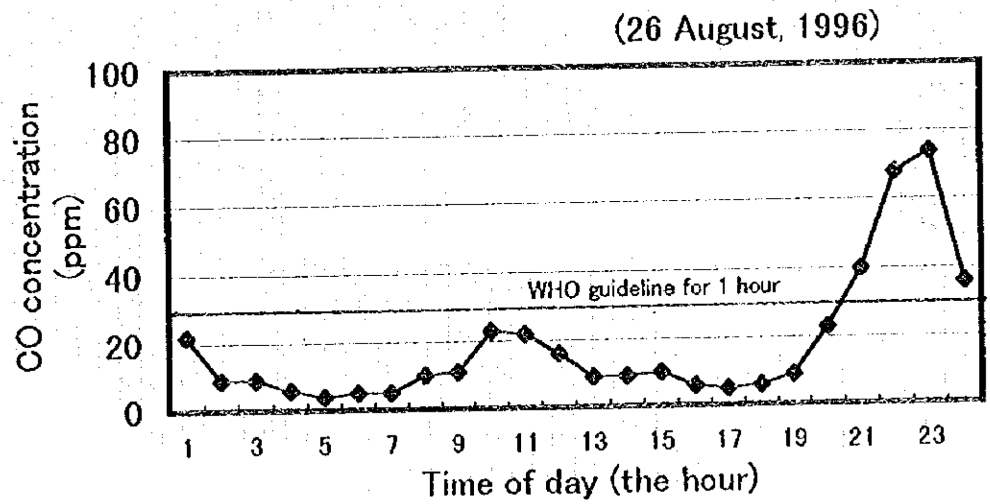


Fig.5.6.3-2 Diurnal variation of O_3 concentration during serious pollution at Bazar.





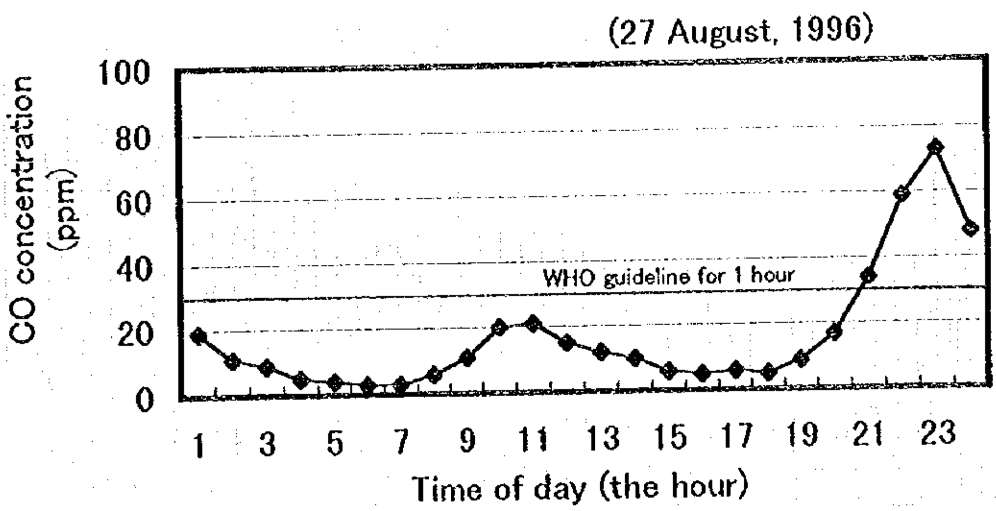
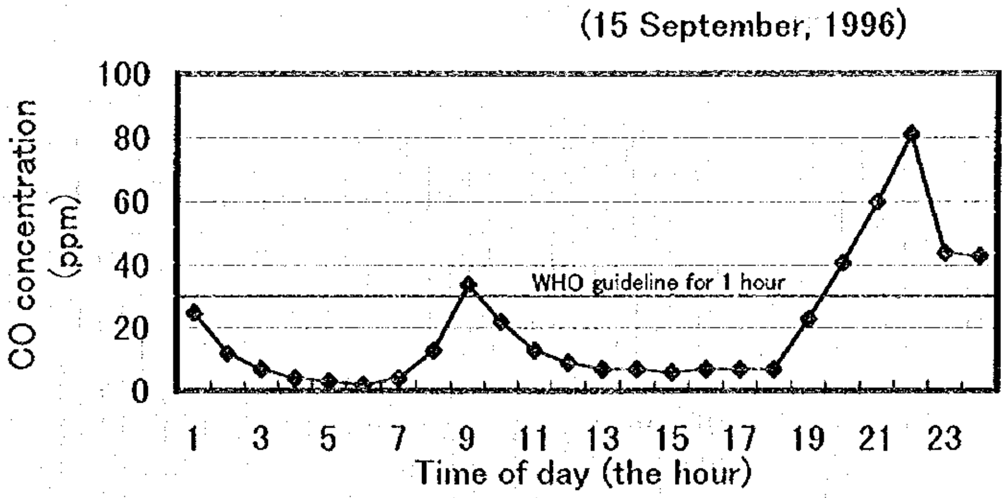
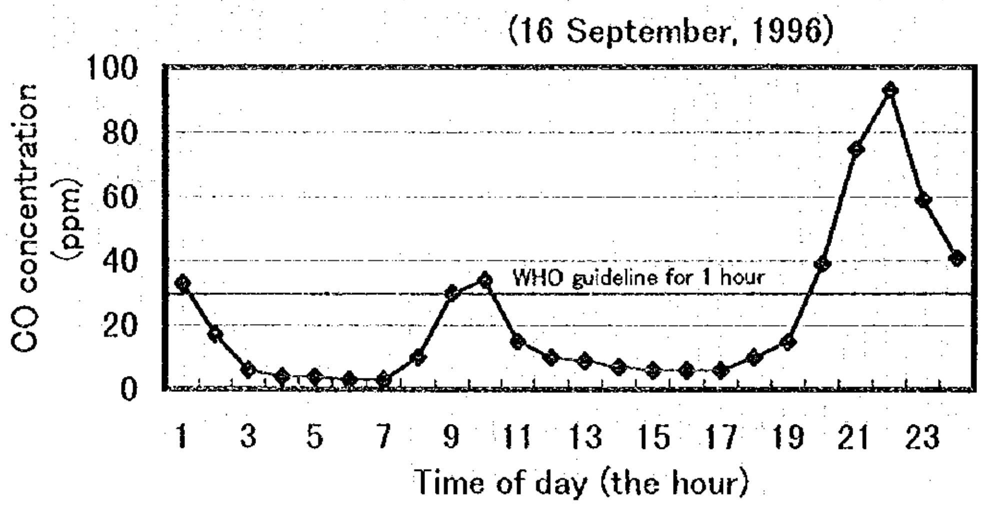


Fig.5.6.3-3(1) Diurnal variation of CO concentration during serious pollution at Bazar.





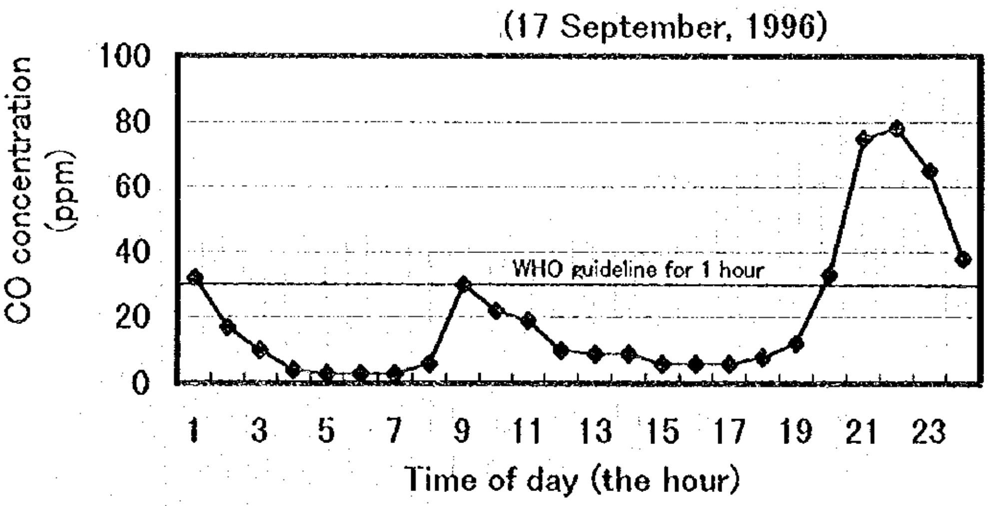


Fig.5.6.3-3(2) Diurnal variation of CO concentration during serious pollution at Fatemi.

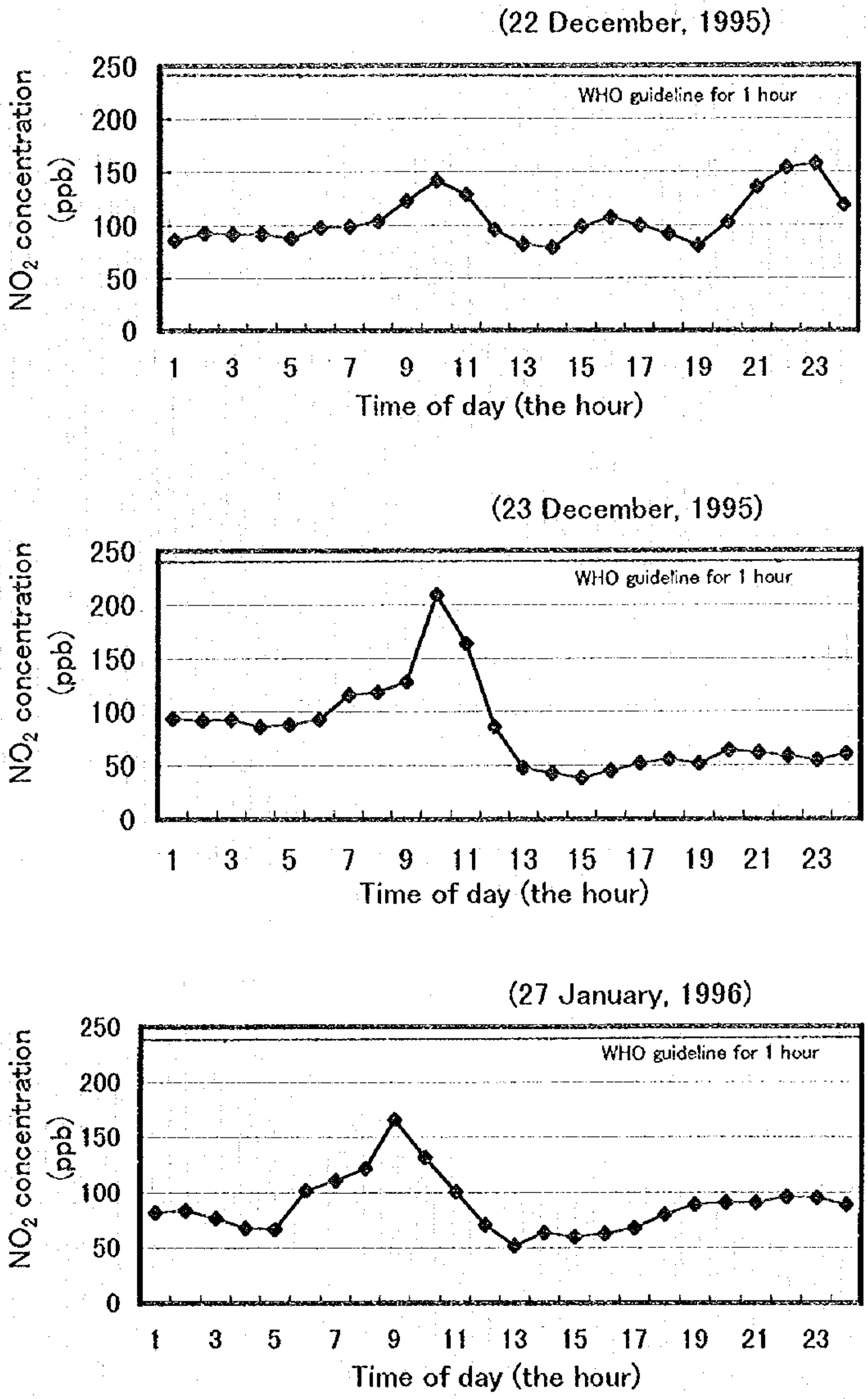


Fig.5.6.3-4 Diurnal variation of NO_2 concentration during serious pollution at Bazar.

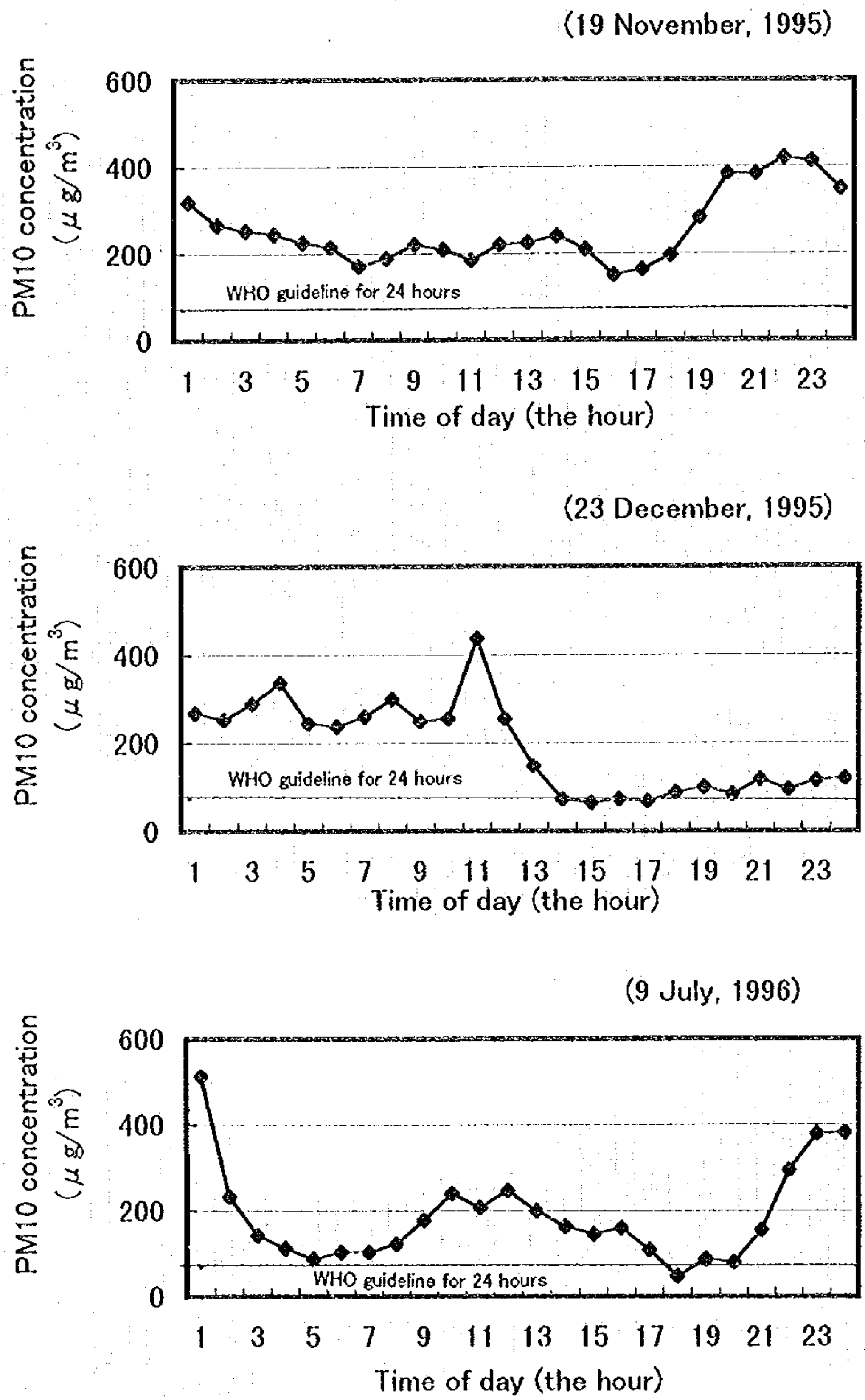


Fig.5.6.3-5 Diurnal variation of PM10 concentration during serious pollution at Bazar.

References of 5.6.3

Daldez, M.J. (1928): *Quart. J. Pharmacol.* 1, 99-100.

Flury, F. and F. Zernik (1931): "Schadliche Gase Dampfe, Nebel, Rauch- und Staubarten." Springer-Verlag, Berlin, Federal Republic of Germany and New York.

Goldsmith, J.R. and J.A. Nadel (1969): *J. Air Pollut. Contr. Ass.* 19, 329-330.

Goldsmith, J.R., S.M. Rokaw, and L.A. Shearer (1975): *Int. J. Epidemiol.* 4, 207-212.

Iwai, K. (1997): Recent studies on the effects of suspended particulate matter for human health – A review for a new air control target –, *J. Jpn. Soc. Atmos. Environ.* 32, 323-330.

Kapalin, V. (1979): in "Collection of Scientific Reports of the Institute of Hygiene," pp.782.

Ustav. Hygiena, Prague, Czechoslovakia.

Lewis, T.R., F.G. Heuter, ,K.A. Busch (1967): *Arch. Envion. Health,* 15, 26-35.

Mertz, T.,M. Bender, H.D. Kerr, T.J. Kulle (1975): *Mutat. Res.* 31, 299-302.

Mueller, P.K. and M. Hitchcock (1969): *J. Air Pollut. Contr. Ass.* 19, 670-676.

Pearlman, M.E., J.R. Finklea, J.P. Creason, C.M. Shy, M.M. Young, and R. Horton (1971):

Pediatrics 47, 391-398.

Remmers, J.E. and O.J. Balchum (1965): "Effects of Los Angels Urban Air Pollution Upon

Respiratory Function of Emphysematous Patients. The Effect of the Microenvironment on Patients with Chronic Respiratory Disease." Air Pollution Control Association, Pittsburgh, Pennsylvania.

Schoettlin, C.E. and E. Landau (1961): *Pub. Health Rep.* 76, 545-548.

Shy, C., J.P. Creason, M.E.Pearlman, K.E. McClain, F.B. Benson, and M.M. Young (1970):

J. Air Pollut. Contr. Ass. 20, 539-545.

Stewart, R.D., E.D. Baretta, L.R. Platte, E.B. Stewart, J.H. Kalbfleisch, B. Van Yserloo, and A.A. Rimm (1974): *J. Amer. Med. Ass.* 229, 1187-1195.

The Cancer Registry of Norway (1964): "Cancer Registration in Norway." Norwegian

Cancer Society, Oslo, Norway.

Ury, H.K. and A.C. Hexter (1969): *Arch. Environ. Health* 18, 473-480.

WHO (1977): *Oxides of nitrogen*, Environmental Health Criteria 4, World Health Organization, Geneva.

WHO (1978): *Photochemical oxidants*, Environmental Health Criteria 7, World Health Organization, Geneva.

WHO (1979 a): *Sulfur oxides and suspended particulate matter*, Environmental Health Criteria 8, World Health Organization, Geneva.

WHO (1979 b): *Carbon monoxide*, Environmental Health Criteria 13, World Health Organization, Geneva.

WHO (1987): *Air quality guidelines for Europe*, WHO Regional Publications, European Series NO.23, World Health Organization, Regional Office for Europe, Copenhagen.

Young, W.A., D.B. Shaw, and D.V. Bates (1963): *Arch. Environ. Health* 7, 337-340.

Chapter 6

Countermeasure for air pollution in the GTA

6. Countermeasure for air pollution in the GTA

6.1 Framework of countermeasure for air pollution in the GTA

6.1.1 Proposed framework for air pollution in the GTA

As reviewed and analyzed in the previous chapters, the present situation of air pollution in GTA is in severe conditions. About 71% of the pollution is being caused by vehicular emissions and about 29% by stationary sources including households. The status will become worse in the year 2010, when the yearly average concentration of CO, NOx, SO_2 and SPM in the ambient air will reach 26ppm, 0.3ppm, 0.2ppm and 200$\mu g/m^3$ respectively.

Therefore, improvement of environmental management systems of the government, a high-aged structure in vehicle fleets, energy saving among industries and individuals as well as technology development in industry are urgently required to promote in the Municipality and the Central government.

In addition to the above, economic policy measures addressing fuel price and foreign exchange rate system and import restrictions are to be analyzed in view of their decisive impacts to the air pollution conditions in the GTA, these causes, however, are beyond the scope of this Report, which only deals with organizational, institutional and technological measures for reduction of air pollution.

The measures for air pollution reduction in the GTA are classified into three categories; (1)establishment of environmental management systems in the central government and MOT, (2)measures targeting vehicular emission sources and (3)measures targeting stationary sources as shown in Fig 6.1.1-1.

Based on the results of analytical and simulation in the previous chapters, all the proposed measures were studied and evaluated and summarized in Table 6.1.1-1 concerning management systems, vehicles, stationary sources, commercial and households and public awareness which will lead to improvement based on the organizational and institutional and technological viewpoint.

Naturally, these countermeasures are not achieved only by MOT, almost all of which should be supported by the Central government.

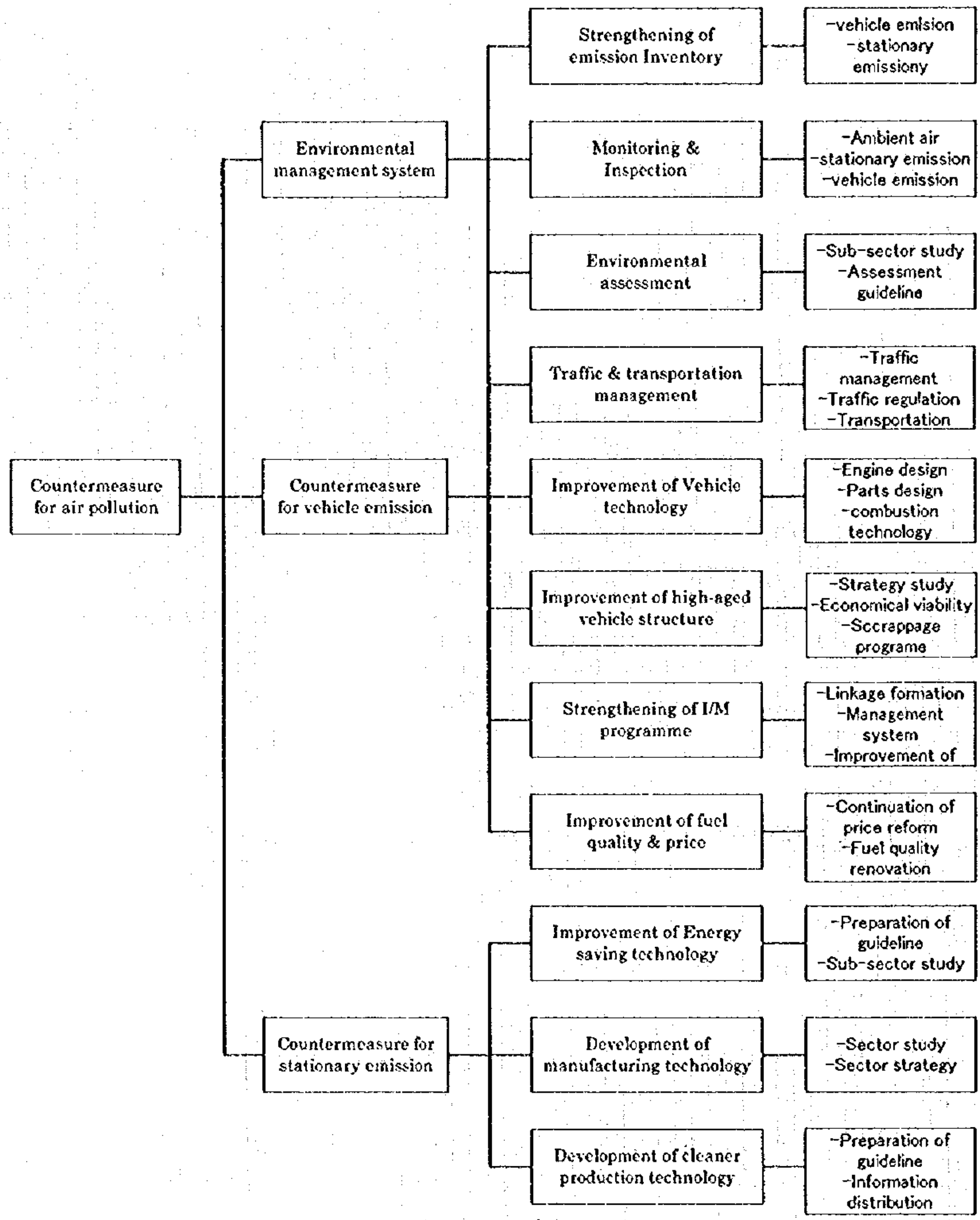


Fig. 6.1.1-1 Countermeasure for air pollution reduction in GTA

Table 6.1.1-1 List of Countermeasure for Air Pollution Control for Greater Tehran Area

No.	Countermeasure	Component of the countermeasure	
		Organizational and institutional measure (Org)	Technical measure for improvement (Tech)
1	Policy & Management		
1-1.	Environmental management		
1-1-1.	Establishment of inventory system	All inventory data base is to be compiled for emissions sources for vehicle and stationary sector (Long and short term foreign expert shall be invited)	
1-1-2.	Environment assessment	Environment impact assessment is to be introduced prior to construction of facilities to cause environmental pollution	
1-1-3.	Ambient air monitoring system	All ambient air monitoring activities on any level are to be integrated to form database for policies making purposes (long and short term foreign expert shall be co-operated)	
1-1-4.	Man-power development	All measures to contribute to the man-power development including overseas technical cooperation is to be planned	
1-2.	Institutionalization		
1-2-1.	National environment center	Advisory service activities for environmental policy making including research and development in air pollution, waste water, industrial & municipal waste, food, forestry and biodiversities, underground water pollution is to be promoted and *	*national environment center is to be established
		Numbers of staff; ca. 200	
1-2-2.	Municipal environment research and promotion Center	Upgrading of AQCC; strengthening of assessment, monitoring, research, engineering and implementation plan. engineer and researcher; ca. 100	
1-2-3.	Expert certification system	Certification of 1) environment engineer, 2) inspection analyst, 3) combustion engineer, 4) monitoring analyst etc. shall be planned and promoted under the Central government	
1-2-4.	Re-organization of air pollution related activities in MOT	Present AQCC, TTTO, TCTTS, TTCC, TVTIB and ORSUITO etc. are to be reorganed to contribute an establishment of municipal environmental management system	

2	Monitoring		
2-1.	Ambient air monitoring system		
2-1-1.	Expansion of monitoring stations		1) New installation of 10 stations including ambient(7) and road side stations(3), 2) telemeter center (overseas technical cooperation and grant shall be utilized)
2-1-2.	Man-power development	Especially activities and specialist for 1) analytical instrument, 2) ambient monitoring instrument and 3) emission measurement instrument shall be strengthened in relation to the 2-1-1 above.	
2-2.	Emission sources		
2-2-1.	Mobile I/M system		Linkages among certification/registration/inspection/maintenance activities shall be improved and strengthened (overseas technical cooperation and grant shall be utilized)
2-2-2.	Strengthening of inspection activities in the stationary emission sources		Inspection and monitoring activities in the emissions sources including 1) enforcement of installation of monitoring instrument 2) assignment of one registered analyst shall be promoted
2-2-3.	Guideline for emission reduction amount	Shall be planned through 1) establishment of committee, 2) working group, 3) guide line, 4) dissemination and training (Short term foreign expert shall be received)	
2-2-4.	Improvement of regional inspection lab.		Inspection laboratories under the ORSUITO shall be improved including central inspection lab and at least four district inspection laboratories (overseas technical cooperation and grant shall be utilized)
3	Vehicular sources		
3-1.	Urban Transport and Traffic measure		
3-1-1.	Enhancement of public transport system	Sub-way, bus, troulley bus and other mass transport system shall be expanded	
3-1-2.	Increasing parking area and facilities	Public and private parking facilities is to be expanded at measured junction	
3-1-3.	Modification of road structure	Junction and sideways etc. to contribute to the transportation and traffic efficiency are to be expanded	
3-2.	Traffic management system		
3-2-1.	Improvement of traffic control	Present restricted area, staggered, parking, bus operation and share system are to be totally improved	
3-2-2.	Improvement of traffic control system	Expansion of traffic signal and their control system be planned	
3-2-3.	Improvement of traffic efficiency	All measures for reduction of traffic stream shall be executed	
3-2-4.	Strengthening of vehicle inspection system		Inspection capacity is to be expanded including modification of contents of inspection item and procedure. (Overseas technical cooperation and grant shall be utilized)
3-2-5.	Strengthening of traffic regulation incd'g license	Present traffic regulation and driver license system are to be reformed	
3-2-6.	Incentive for low-emission vehicle	All measure to introduce low-emission vehicle shall be developed	
3-2-7.	Enforcement of emission standard	Stepwise enforcement of emission standard is to be planned and implemented	
3-2-8.	Scrappage program	Stepwise retirement program of high-aged vehicles is to be planned through elaboration of retirement master plan (Integrated overseas cooperation shall be promoted)	
3-2-9.	Improvement of maintenance shop		System renovation and improvement of maintenance facilities and man-power development (Overseas technical cooperation and grant shall be utilized)

3-2-10.	Establishment of I/M training course		Training center to contribute for man-power development of technicians for I/M system is be executed (Overseas technical cooperation and grant shall be utilized)
3-2-11.	Establishment of vehicle engineering center		Engineering center aiming improvement of in-use engine for emission reduction in engineering and repairment technology (Overseas technical cooperation and grant shall be utilized)
3-2-12.	Technical cooperation project		Promotion of receiving of overseas experts and training abroad including joint research etc. for all technical aspect is to be planned and executed
3-3.	Strengthening of vehicle technology		
3-3-1.	Improvement of car engine		Engine and peripherals design and manufacturing technology is to be developed through execution of plant renovation survey
3-3-2.	Improvement of main parts of car manufacture		Vehicle part manufacturing technology is to be developed (Overseas technical cooperation and grant shall be utilized)
3-3-3.	Introduction of catalytic converter		Catalytic oxidation converter is to be developed and mounted (Joint research project shall be promoted)
3-3-4.	Improvement of car maintenance system	Vehicle maintenance system is to be improved and strengthened in relation to the inspection system	
3-3-5.	man-power development of I/M system	All measure for development of man-power in I/M system are to be planned	
3-3-6.	Promotion of international cooperation	Receiving and dispatching of expert or joint research project are to be expanded	
3-4.	Improvement of fuel		
3-4-1.	Improvement of fuel quality		Higher octane rating and gasoline with lower volatility and up-grading of quality to international level
3-4-2.	Desulfurization of diesel oil		Covering whole consumption of diesel oil in GTA
3-4-3.	Discontinuation of leaded gasoline	Discontinuation of lead and necessary countermeasure	
3-4-4.	Construction of oxygenated fuel additive plant		New RFG manufacturing and distribution system of it
3-4-5.	Expansion of LPG/LNG vehicle	Conversion to LPG/LNG shall be expanded	
3-4-6	Fuel Price reform	Fuel price reform is to be expanded gradually to international level up to 2010	
3-5.	Promotion of public awareness		
3-5-1.	Promotion of public awareness activities	Public awareness activities is to be strengthened in central and Municipality level	
3-5-2.	Public campaign for emission reduction	Activities in central and Municipality level shall be strengthened including clean fuel purchase	
3-5-3.	Expansion of public transportation	Utilization of public transportation instead of passenger car shall be strongly campaigned	

4	Stationary source		
4-1.	Master planning and policy making		
4-1-1.	Investigation of present status of sub-sector		Investigation study for major polluted manufacturing sector are to be conducted (Overseas technical cooperation and grant shall be utilized)
4-1-2.	master planning and feasibility study		According to the above study, master plan for reduction of pollutants including guide line, are to be prepared with feasibility study (Overseas technical cooperation and grant shall be utilized)
4-2.	Action plan for execution		
4-2-1.	Motivation of energy saving	Energy saving project and implementation program shall be conducted under the government's support	
4-2-2.	Motivation for investment of emission reduction	Provision of miscellaneous assistance to investment projects	
4-3.	Dissemination of information on cleaner production technology.		Preparation of cleaner production technology and dissemination to the entrepreneur and introduction of training system (Overseas technical cooperation and grant shall be utilized)
4-4.	Improvement of combustion technology	Low cost measures for improvement of burner, and combustion control system etc.	
4-5.	Implementation of pollutant reduction measure		
4-5-1.	Construction of model plant for de-sulfurization of flue gas		Dissemination of information on emission reduction technology through construction of model plant (Overseas technical cooperation and grant shall be utilized)
4-5-2.	Construction of model combustion boiler		Dissemination of technology and information through construction of model boiler (Overseas technical cooperation and grant shall be utilized)
4-5-3.	Improvement of burner		Burner and control unit distribution project to medium scale industries (Overseas technical cooperation and grant shall be utilized)
5	Residential & Commercial		
5-1.	Standization of household heater		Improvement of heat efficiency including incomplete combustion
5-2.	Standardization of household cooking range		Popularly observed apparatus shall be inspected and be standardized
6	Environmental education and Public awareness		
6-1.	Strengthening of environmental public awareness		Environmental publicity including pollutant reduction campaign through media is to be made
6-2.	Motivation of cleaner fuel utilization	Benefit provision to pollution free fuel users	
6-3.	Expansion of media campaign		To be introduced for vehicle emission especially for retirement of high-aged vehicles and popularization of public transport media

6.1.2 Management system reform required

Among the miscellaneous countermeasures for reduction of the air pollution in GTA, the first priority should be the establishment of management systems in the Central Government and MOT. As discussed in the previous Chapters, though environmental management is being implemented by both organizations , it is still neither fully institutionalized nor adequately supervised for prevention of air pollution.

Therefore, intensive development of environmental management systems in the Central Government and MOT Is be required in the following respects;

Countermeasures for air pollution reduction in the GTA are classified into three categories: establishment of environmental management systems in the central government and MOT , measures targeting vehicular emission sources and those targeting stationary sources;

(1) Establishment of environmental management system in central government and MOT

In the central government and municipalities, preparation of an emission inventory, monitoring and inspection activities, and environmental law/regulation including environmental audit systems as shown in Fig.6.1.1-1 are needed for reduction of air pollution in GTA, which will be explained as followings:

1) Organization of environmental management
2) Plan of environmental law and regulation
3) Analysis of air pollution of mobile & stationary emissions which is designed to facilitate policy making
4) Study of international environmental management systems
5) Establishment of environment management systems
6)Regional & wide area monitoring systems including meteorological observation
7) Establishment of systems for monitoring and inspection of emission sources
8) Establishment of inventory systems
9) Improvement and research in analytical technology concerning air polluting substances
10) Preparation of emission reduction guidelines
11) Research in impacts on health and economic loss due to air pollution

12) Supporting activities for the private sector for reduction of air pollution
13) Research and development in energy conservation
14) Man-power development in the environment protection
15) Promotion of technical cooperation with foreign countries

(2) Management of Vehicular sources

As management systems for vehicular emissions reduction needs a wide range of activities by the central government and municipality, the following role of these organizations needs to be clarified.

1) Monitoring of transportation and traffic volume in the GTA
2) Improvement of traffic regulations and monitoring of traffic conditions
3) Execution of vehicle inspection & maintenance program
4) Determination of traveling modes and operation of chassis dynamo tests
5) Expansion of vehicle maintenance capacity
6) Improvement in vehicle manufacturing technology
7) Research and development of vehicle emissions reduction technology targeted for in-use vehicles
8) Research and development in urban planning
9) National innovation programs for vehicle fuels
10) Research and development in energy economy
11) Promotion and coordination of introduction of foreign technology for emission reduction

(3) Management of stationary sources

At this moment in GTA, removal or relocation of factories is being implemented according to the Clean City 80 plan, and there are not so many huge stationary emission sources excluding in the southern area in GTA, but in consideration of future economic development, it is projected that light industries such as agro-based food, plastic and packaging as well as mechatronic industries will increase, so, it is recommended to prepare future increase of stationary emissions in view of present situation of stationary emission.

1) Improvement of an emissions inventory system
2) Improvement of monitoring and inspection systems
3) Preparation of air pollution reduction guidelines through a manufacturing sector

study including promotion of development of industrial technology

4) Promotion of activities for dissemination of technology and information to the manufacturing sector on saving of energy including cleaner production technologies prevailing overseas
5) Improvement of combustion technology and promotion of importing technology and related equipment
6) Development of man-power relating to the above environment key technology and management
7) Dissemination and demonstration of model facilities for air pollution control technology
8) Rehabilitation of a regional inspection laboratory in GTA
9) Enforcement of emission standard regulations for flue gas
10) Promotion of technical cooperation with overseas organizations

Among these environmental activities, urgent, essential and strategic countermeasures for reduction of air pollution are proposed as shown in Table 6.1.1-1.

6.1.3 Strengthening of institutionalization

In order to set up environmental activities for air pollution prevention, cross-sectoral issues need to be addressed. Therefore, an integrated and institutionalized system needs to be established under the joint responsibilities of the Central government and municipality targeting several sectors.

In Iran, there is neither national or municipal environmental research institute which is found in many other countries, nor a national environmental management system to be implemented by not only the central government and regional states but by individuals or enterprises. There are few laws/regulations, except those for the ambient air quality, for protection of environment and conservation of natural resources.

Provision of such organizations and systems needs to form a fundamental starting point for promotion of environmental activity, without which, any plan or implementation of measure based on a single viewpoint would ineffective.

As reviewed in the previous chapters, huge volume of emission of CO in GTA is the outcomes of the high-aged vehicle structure. It would be difficult to replace a large number of aged vehicles in GTA without promotion of integrated strategies combined with complete maintenance, vehicle inspection systems, development of maintenance technology, replacement of vehicle parts, improvement of public transportation means and traffic management systems. Also would be needed measures for discouraging peoples' reliance on high aged vehicles including reconsideration of present low prices of fuels and other strategies for earlier retirement of high aged vehicles.

From this view point, the roles of the central government and municipality including the demarcation between them are listed in Table 6.1.3-1.

Table 6.1.3-1 Strengthening of Institutionalization

No.	Environmental activities	Role of Central government	Role of MOT
1.	Organization of environmental management		
1.1.	Plan of environmental law and regulation	Leadership and coordination of necessary working groups in view of national benefit	Expressing of opinion on their feasibility and acceptance
1.2.	Analysis of present air pollution status of vehicle & stationary sources to contribute policy making	Integrated evaluation of national benefit and leader ship and coordination of working groups and supervision of each sub-sector especially emission sector	key function shall be performed in analysis of ambient air, road-side and stationary sources
1.3.	Study of international environmental management system	In connection with IBRD, WHO and ISO etc including participation of international seminars etc.	Especially study of role of Municipality in recent urban development
1.4.	Establishment of environment management system	In national and regional levels	Especially demarcation of the government is to be proposed
1.5.	Regional & wide area monitoring systems including meteorological observation	Demarcation of all ministries and MOT is required and wide-area monitoring is under responsibility of central government	Monitoring of MOT is to be done by MOT
1.6.	Establishment of monitoring & inspection for emission sources	All inspection activities excluding law/regulation are to be done by MOT	Enforcement of regional administrative regulation is to be accepted
1.7.	Establishment of inventory system	Inventory system is to be implemented nation wide	Improvement and strengthening of the system
1.8.	Improvement and research in analytical technology on air polluting substances	National activities are to be cooperated by Universities and public research institutions	Dispatching of staff to working group for technology development
1.9.	Preparation of emission reduction guidelines	Prior to determination of emission regulations, acceptability of sub-sector is to be carefully considered in line with manufacturing	Survey of present emission status in stationary and vehicle fleet and evaluation of vehicle regulation
1.10.	Research in health impacts and economic loss due to air pollution	Mortality and morbidity evaluation is to be extended	Ambient air status is to be issued
1.11.	Supporting activities to private sector for reduction of air pollution	Integrated pollution reduction supporting system including fuel price, quality of fuel, supply of vehicle parts and investment etc. is to be elaborated	Public transport services and maintenance of vehicle are to be expanded
1.12.	Research and development in energy conservation in Iran	National level energy research is to be organized and promoted	Public awareness is to be promoted
1.13.	Man-power development in the environment protection	Man-power development in management, monitoring, inspection, engine, converter, traffic control, combustion technology, cleaner technology etc.	Especially in management, monitoring, inspection, engine, converter, etc.
1.14.	Promotion of technical cooperation with foreign countries	Integrated environmental center on national or municipality level is required and to be promoted	DTT shall be strengthened

No.	Environmental activities	Role of Central government	Role of MOT
2.	Management of Vehicular sources	Responsible for new vehicle and fuel	Responsible for transportation and traffic including in-use vehicle
2.1.	Monitoring of transportation and traffic volume in the GTA		Data base for periodical survey
2.2.	Improvement of traffic regulation and monitoring of traffic condition	Approval of proposal through SCEP	monitoring through traffic control center
2.3.	Execution of vehicle inspection	Policy making and supporting for vehicle parts in I/M program	Expansion of present I/M program
2.4.	Determination of traveling mode and operation of chassie-dynamo test	Development and improvement of new vehicle and emission control	Especially for traveling mode and expansion of chassie-dynamo test
2.5.	Expansion of vehicle maintenance capacity	Support of national vehicle maintenance training center etc.	Integrated linkages with vehicle inspection system required
2.6.	Improvement of vehicle manufacturing technology	Cooperation with foreign technology suppliers and reform of import policy	
2.7.	Research and development of vehicle emission reduction technology targeting for in-use vehicle	Support of technology development through national manufacturing company	R/D in converter, improvement of carburetor including maintenance technology for oxidation
2.8.	Research and development in urban planning	Cross-sectoral urban planning guideline is to be developed	Integrated urban planning function is to be developed
2.9.	National innovation program for vehicle fuel	Improvement of gasoline, desufurization of diesel oil, manufacturing of MTBE, expansion of LPG distribution station including revision of fuel price are to be studied	Feasibility study report for fuel improvement is to be urgently proposed for decision maker
2.10.	Research and development in energy economy	Research and development especially in manufacturing and transportation sector is to be developed	
2.11.	Promotion and coordination of introduction of foreign technology for emission reduction	Experts in renovation of in-use parts and cooperation for new vehicle design are to be invited	Experts for emission reduction technology for in-use vehicle, , maintenance, vehicle data base are to be invited

No.	Environmental activities	Role of Central government	Role of MOT
3	Management of stationary sources	Government policy for industrial development and relocation plan including improvement of production efficiency etc.	Monitoring and inspection including environmental assessment
3.1.	Improvement of emission inventory system	Official anouncement of disclosure of inventory data including necessities of environmental pollution control and management	Compulsory inventory survey is to be conducted annually
3.2.	Improvement of monitoring and inspection system	Early determination of compulsory and monthly inspection and reporting including emission standard enforcement	Expansion and improvement of central inspection center including district laboratories
3.3.	Preparation of air pollution reduction guideline through manufacturing sector study including promotion of development of industrial technology	Coordination and supervision of execution of sector study by responsible ministries	Participation in working group as an adviser for verification of achievement of emission reduction
3.4.	Promotion of activities for dissemination of technology and information to manufacturing sub-sector on saving of energy including cleaner production technology which are prevailing internationally	Coordination and supervision including supporting of ministerial working group	Participation in working group as an adviser for verification of achievement of emission reduction
3.5.	Improvement of combustion technology and promotion of import of overseas technology and related equipment	Government policy through sub-sector study required	
3.6.	Development of man-power relating to the above environment key technology and management	Plan of man-power development required through establishment of master plan	
3.7.	Dissemination and demonstration of model facilities for air pollution technology	Most polluted sub-sector shall be selected among refinery, power station and chemical industries(MOO, MOE, MOI)	Participation in the selection stages
3.8.	Rehabilitation of regional inspection laboratory in GTA	Standard and specification are to be authorized by the central government	Master plan of rehabilitation project with phased schedule
3.9.	Promotion of enforcement of emission standard and regulation for flue gas	Followed by sub-sector study and reviewal of national policy	Practical advisory experiences is to be submitted
3.10	Promotion of technical cooperation with overseas organizations	Especially, in the fields of refinery, power station and cement industries	Especially, in the fields of inspection and laboratory management

6.1.4 Basic concept of city planning for air pollution abatement

This part of report discusses the urban structure that will help prevent air pollution.

Urban redevelopment should be planned so that air pollution will be minimized. For this aim, the urban structure should assure, first, minimum discharge of pollutants and, second, their minimum stagnation. Another effective measure is to plant as many trees as possible to form a green belt that will purify the air. For this purpose, urban planning should be promoted including urban redevelopment and rearrangement of transportation networks as well as improvement of urban facilities needed for these measures.

(1) Area for public facilities

The urban structure of the central part of Tehran at present needs considerable redevelopment from the viewpoint of air pollution prevention. An essential policy for reduction of urban air pollution is not only to reduce pollutant discharge volume but to facilitate diffusion of air stream by locating sufficient open spaces near pollutant discharging spots.

In central Tehran, an effective policy for providing open spaces for environmental protection is exemplified by minimizing land spaces needed for buildings of central government offices by construction of high-rise building, by joint use of a building by more than one ministries and agencies, or by promoting relocation of organizations like schools that do not need to stay in the central city. The spaces to be generated by such measures would facilitate smooth air stream. Furthermore, congestion of vehicle traffics to be caused by centralization of buildings and other facilities should be reduced by improving road, synchronizing traffic signals and making other efforts for forming better transportation systems as well as by shifts to better vehicle use practices emphasizing maximum use of public transportation means (including more use of improved park-and-rides and circuit buses).

(2) Commercial area

Energy conservation should be promoted through provision of district air conditioning and fuel switchover in consideration of environmental protection such as more use of natural gas should be promoted so that less air pollutant will be generated. Furthermore, freight distribution facilities should be improved and expanded, meeting increasing demand for freight moving vehicle traffics and diversifying physical distribution modes.

Also desirable in a commercial district would be collective relocation of stores matching to their currently occupying spaces as well as their joint operations so that commercial spaces will be restructured, air stream will be made smoother and polluted air will be diffused because of open spaces to be generated.

(3) Residential area

Essential requirement are to supply urban type housing (condominiums and high-rise houses) which absorb increasing population in future envisaged by the Master Plan and to provide housing conditions consistent with future supply-demand conditions.

(4) Green belt

Being the core of green area of a city, a green belt is essential as a shelter from a disaster and as a base of relief activities like prevention of spread of fire and rehabilitation.

While Tehran has a number of city parks, more medium/small scale parks and district parks should be provided in the vicinity of high-rise/joint offices and residential area in order to buffer air pollution.

(5) Relocation

For effective and steady environmental improvement such as promotion of relocation of polluting industries and construction of industrial estates, a factory relocation program should be drawn up based on the following central concepts:

① The impact of relocated factories on neighborhood environment should be studied in advance covering siting conditions of the industrial estate to be built, operational conditions of factories to be relocated and other pertinent information so that environmental impact of relocated factories will not increase total impact.

② Distance between relocated factories and employees' residences should be minimized so that employees' commuting to such factories will not cause traffic congestion.

③ The factory relocation program should incorporate new technologies for elimination and reduction of pollution on the basis of overall examination of energy conservation policies, disposal of industrial wastes, well-planned siting of waste water treatment facilities, natural resources recycling and other relevant factors, so that air conditioning of an entire industrial estate will be made efficient by and fuels will be replaced by more environmental-friendly ones.