average value of 37.39 mg/m^3(≒32 ppm at 20°C) of maximum concentrations at four points. These values are extremely high and are about three times as high as the environmental standard of Japan (10 ppm). NEAP (Attachment II-14) shows the average concentrations of CO in 1989 to 1993 and CO pollution is noticeable.

Table 3.7 Air Quality Level in Skopje for CO (1996)

No. of Measurement Sites	No. of Samples	Average Concentration (mg/m^3)	Minimum-Maximum (mg/m^3)	No. of Samples above the MPC*
4	165	10.38	0.00-37.39	125

Note) MPC: 3mg/m^3

Measuring sites are the following crossroads:

1: "Partizanski Odredi" - St. "Ruzveltova"

2: "Sv. Kliment Ohridski" - "Ivo Lola Rivar"

3: "Krste Misirkov" - "Goce Delchev"

4: "Kocho Racin" - "11 Oktomvri"

Source: IHP

f) Oxidant Concentration

According to the NEAP, from the beginning of 1993, concentrations of total oxidant (Ox) and ground ozone have been monitored 24-hour at Karpos IV (No.6) monitoring point. The NEAP published average values and maximum concentrations in 1993 and 1994 as statistical data which are shown in Table 3.8. The Ox environmental standard is 125μg/m^3 in maximum individual short-term concentration. The frequency of concentrations exceeding the standard value is high according to this data. According to a check made with the RHI, which compiled the data, the data were partially amended.

The statistical data indicates the following.

The statistical data are total Ox and uses 5%-KI solution as the absorption solution.

In 1994, the annual average concentration decreased as much as 112 μg/m^3. This indicates the characteristics of Skopje, which showed large variation over the time. (The concentration was specially high in 1993.)

The standard value of 125μg/m^3 is almost the same level as the environmental standard of 0.06ppm (1-hour value) as photochemical Ox of Japan. However, the data is an evaluation of total Ox and is influenced by NOx and is exceeded. It cannot be compared simply.

Table 3.8 Average and Maximum Concentrations of Ox

	1993	1994
Average Concentration (μg/m^3)	278	166
Monitoring Accomplishment Rate (%)	56	77
Maximum Concentration (μg/m^3)	669	433

As a future study task, it is recommended to redefine what should be the criteria (total Ox, photochemical Ox and ozone) for a standard and what should be done about the standard methods of monitoring. If photochemical Ox is the target, evaluation must be made after removing influence of NOx. Caution should also be exercised with variance of the influence factor of NOx by the potassium iodide solution concentration.

Total Ox = Photochemical Ox (O_3 + Peroxides) + Influence of NOx

In addition, Ox (O_3) concentration rises in day time. It is meaningful for Macedonian side to measure hourly value using automatic continuous monitoring equipment that is introduced by the Study. The Study Team suggested thinking about environmental standard of hourly value.

g) Monitored Value of Heavy Metal in Air at Main Intersections and Sampling Method (Data Book, Table D3.12)

<Pb>

The Pb concentration in air at intersections was monitored by two methods (two-hour sampling), namely, filter sampling and by directly absorbing in a solution and sampling it to evaluate the data. The results of this evaluation are shown in Attachment II-11 of the NEAP. Table 3.9 shows an excerpt of the evaluation.

Table 3.9 Two-hour Sampling Data of Pb

Intersection	Filtering Method (μg/m^3)	Absorption Solution Method (μg/m^3)	Filtering Method/Absorption Solution Method (%)
No.1	7.34	11.92	62
	11.76	18.76	63
No.3	1.13	7.65	15
	2.17	14.11	15
No.4	0.73	7.02	10
No.5	2.35	6.20	38
	1.71	7.12	24

The data by the solution absorption method show that the concentration variances are large depending on the sampling time and monitoring locations. However, generally, the range is 1 to 18μg/m^3 and average value is about 10μg/m^3. Compared with the concentration level of Japan of below 0.1μg/m^3, this concentration level is extremely high and non-leaded gasoline should be promoted.

In comparing the sampling methods, the former method had a far lower value and assuming that problems exist in filter sampling, thus pointing out the necessity of using the solution absorption method as a new criterion and standard method of monitoring. It is clear that the collection efficiency of the cellulose filters which were used, has a problem. The sampling method cannot be evaluated or conclusions from this method cannot be drawn only on the basis of this data.

For example, filters made of PTFE can collect particles smaller than the pore size at a high efficiency, because of the electrostatic effects. The collection efficiency of particulate increases over the sampling time. Generally, the air-flow resistance is small and the particulate collection efficiency is high with other glass and quartz filters compared with cellulose filters.

The sampling time and systems, particulate concentration level, filter type and other factors which influence the collection efficiency and factors which influence the analysis accuracy such as lead extraction method will be examined, and final evaluation will be proposed as a recommendation.

The use of the solution absorption method as an official method of monitoring is not denied. However, the standard value is provided by daily average values. Further, the optimum filter type should be examined. It will not be too late to decide on standard method of monitoring after making comparison and evaluation of the 24-hour sampling data.

<Cd>

The Cd concentration is also extremely high. The Cd concentration in areas in Japan generally noted for high concentration is about 0.003 μg/m^3.

It should be noted that this is most probably caused by dust flung up by running automobiles because the dust concentration is very high. (The concentration values exceed 120 μg/m^3, which is WHO standard, at every measuring point.) It is not clear if dust is TSP or PM10.

h) Dust Fall Concentration

According to the data (1996) of the IPH, the maximum concentration exceeded the standard (300mg/m^2/day≒9ton/km^2/month) in all months except February (Data Book, Table D3.13). The concentration level is high. However, the level is considered a general level in industrial zones and cities. The data fluctuates depending on the monitoring locations and must be evaluated after examining relationship of location between receptor and emission source.

According to the data (1990 to 1994) of the IPH, the maximum values in 10 measuring points among 11 exceed MPC, the minimum values are around 30 to 50 mg/m^2.

One characteristic of variation over the time of the air pollution concentration in Skopje is that the annual average value greatly fluctuates and is affected by meteorological conditions. Therefore, the current status cannot be evaluated using only data of 1996. However, using the ten-year data (1984 to 1994) of the NEAP shown in Attachment II-6, air pollution has been improved recently. Nevertheless, depending on the socio-economic trends, the situation may change in future and adequate measures are necessary.

i) Mining and Steel Company in Skopje and Environmental Influence

There are data of urban environmental influence by mining and steel company in Skopje for 18 years (1976 to 1993). (Ref. 3-1)

Ambient air quality is measured at the following two points for a long period of time.

Zelezarnica: An industrial zone in the city area. It is located 500m away from the emission source.

Singelic: An outside part of the industrial zone. It is located 3km away to south-east from the emission source.

Dust fall, heavy metal, SO_2 and BS are measured (Data Book, Tables D3.14 to D3.18 and Figures D3.13 to D3.16).

The concentration of dust fall at Zelezarnica had been low in 1988, when production of iron and steel were decreasing, to 1993. As to at Singelic, it is not clear.

The average values, which has been calculated at these points for 18 years are both 374 mg/m^2 per day.

At both measuring points, in some cases it can be seen that the concentrations exceed long lasting stagnant air pollution (L_{VCP}-L= 450 mg/m^2 per day) and short exceeding of pollution (L_{VCP}-S= 800 mg/m^2 per day).

By comparison between these two points, it can be seen that values of both Fe and Mn are higher at Zelezarnica, which is closer to the emission source, and they are largely influenced by the plants.

Variations of the annual average values of SO_2 and BS have been decreasing since 1990, except for that of 1993 at Singelic. It may be because they reflect declining production of iron and steel, and dust fall at Zelezarnica as well.

The followings are found out from the facts above.

- Fe and Mn concentration shows that dust fall has more influence on a closer place.

- It is because of the influence by other emission sources that there is scarcely any difference in quantities of dust fall between the two measuring points.
- The prevailing winds direction are W-NW and E-SE. It can be seen in the data that SO_2 and BS also affect Singelic.

3) Characteristics of Air Quality in the Other Major Cities

The data compiled by the NEAP, the RHI and the IPH were mainly used in making the analysis. Recently, the operating rates of the plants have been lowered greatly and air pollution has been improved compared with a short period of time in the past. The present status and evaluation of the pollutant concentration in ambient air in major cities are summarized below.

a) Veles

i) SO_2, BS and Dust Fall (Data Book, Tables D3.19 to D3.22 and Figure D3.17)

The total average value of SO_2 concentration is about twice as high as that of Skopje and seasonal variation of concentration in Skopje is not detected.
The level of average values of the maximum SO_2 concentration is almost the same as that of Skopje.
Seasonal variations of BS concentration are prominent in Skopje and the concentration is high during the heating season. In Veles, the total average value is the same level as Skopje, but the average of the maximum value is clearly low.
The maximum concentration of dust fall was recorded at Nova Nselba point and was 1,079 $mg/m^2/day$. This is slightly more than three times the standard.
At all measuring points, pH registered 5.9 to 7.7, the average value being about pH7.

During the period from 1984 to 1994, the concentration changes of SO_2 and BS had been surveyed in each year.
The survey results indicate the followings:

- By comparison among the measuring points the concentrations of SO_2 depend on the distance from the smelter and the closer to the smelter. On the other hand, the concentrations of BS are not influenced at such distance from the smelter.
- As for SO_2, the smelter is dominant and high concentrations are evidenced through the year.
- Maximum and 98 percentile of SO_2 show high concentrations at the northern monitoring point (No.4) and the southern point (No.5), which are far from the emission source. Even though the points far and away from the emission source can be influenced by weather conditions such as the atmospheric stability, the wind direction, wind speed and so on.

- The BS is mainly caused by automobiles and household heating.
- The concentrations of SO_2 exceed MPC at every point in many days and those of BS exceed MPC many times at the monitoring point (No.3).

ii) Heavy Metals into the Ambient Air (Data Book, Tables D3.23 to D3.25)

In the period from 1985 to 1986, the concentration of Pb, Zn and Cd in the ambient air was investigated at four monitoring points.
The concentrations of each heavy metal are highest at MMS (No.1) and there are some cases where the concentrations of Pb are high at TEKE (No.3) and BASINO SELO (No.4). At these three points, the concentrations of Pb exceed MPC ($0.7 \mu g/m^3$). Moreover, there is also a case where that of Cd exceeds MPC ($3 \mu g/m^3$) at TEKE (No.3). It can be seen that these points are broadly influenced by the smelter.

The contents of heavy metal in the dust fall and in the ambient air by areas are shown as an annual average value, from 1976 to 1985.
According to the data, compared with V. Ivankovci, which is a control area, heavy metal pollution is extreme in the urban area and Veles. The extent of pollution is around 10 to dozens of times as high as the control area.

b) Bitola (Data Book, Tables D3.26 and D3.27 and Figure D3.18)

The IPH in Bitola monitored dust fall at four points in 1996. Compared with Skopje and Veles, the dust fall concentration itself is considerably low and the standard is exceeded only in one case. Bitola MPGC, the largest coal mine and power station in Macedonia located 12 km northeast of the city.
The RHI has completed the survey results of the ambient air, investigated in the period from 1984 to 1994.
Although the average annual concentrations of SO_2 and BS are low, those of BS exceed MPC 18 to 42 days a year. On the other hand, those of SO_2 rarely exceed MPC. However, it is hard to say that these concentrations stand for Bitola, which is the largest city next to Skopje.

c) Tetovo (Data Book, Tables D3.28 to D3.31 and Figure D3.19)

The concentrations of BS exceed MPC many times a year, and those of SO_2, on the other hand, rarely exceed MPC in recent years.
The main emission sources are the metal chemical plant "Jugohrom Jegunovce" and pollution from heating facilities or equipment in the winter. Observing for the whole year, the concentration is higher on such a weather condition that temperature inversion occurs in the heating season in winter and it can be commonly seen in other cities.

d) Kumanovo

Dust fall was measured at four points in the city in 1996. There was only one case where the concentration of dust fall exceeded MPC (300 mg/m^2 per day) at a point in November 1996.

e) Shtip

Dust fall was measured at four points in the city in 1996. The annual average value of the concentrations of dust fall exceeded MPC and the quantities of dust fall are very large.
The maximum value was 1,176 mg/m^2 per day.

f) Prilep and Krushevo

Dust fall was measured at five points in Prilep and two points in Krushevo in 1996. Similarly to Shtip, the annual average value exceeded MPC and the measuring range of the quantities of dust fall was from 150 to 876 mg/m^2 per day in Krushevo.

4) Evaluation and Comparison on Air Quality in the Major Cities

The evaluation of air quality in the major cities is prepared for the measurement of 20 places in the Country. Table 3.10 shows the emission amount of the pollutants and the evaluation of air quality indicates in the major cities.
The major cities that are not listed in the table include Kumanovo, which is evaluated as xx-significant, and Berovo, Gevgelija, Resen, Shtip, which are evaluated as x-unsatisfactory.
Regarding these evaluations, heavy metal pollution is also added into the review. The Major cities that are evaluated to suffer from a serious impact are Skopje, Bitola and Veles.

Table 3.10 Air Emissions in Municipalities (1993)

(kg/hr)

Municipality	SO_2	NOx	CO	CO_2	Dust	Pollution Level
Skopje	3.692	1.00	1.00	42.678	0.154	xxx
Bitola	9.540	0.01	0.13	562.920	0.500	xxx
Veles	0.757	0.11	0.11	18.355	2.674	xxx
Gostivar	0.040	0.35	0.35	12.338	0.018	x
Delchevo	0.003	-	-	-	-	-
Kavadarci	0.040	0.03	0.03	1.846	-	x
Ohrid	0.001	0.08	0.08	1.631	-	xx
Krushevo	-	-	-	0.078	-	-
Negotino	0.060	0.02	0.02	1.915	-	x
Strumica	0.005	-	-	-	-	x
Kratovo	0.009	0.01	0.01	1.235	-	-
Tetovo	0.281	0.01	0.01	22.055	3.040	xx
Kriva Palanka	-	-	-	-	0.075	x
Prilep	-	-	-	-	0.635	xx
Struga	-	0.39	0.39	1.620	-	-
Kichevo	0.870	0.10	0.10	145.800	0.156	xx
Kochani	-	-	-	-	0.425	x
Sveti Nikole	0.002	-	-	0.220	-	-
Macedonia	15.720	3.00	3.00	812.691	8.666	-

Note) Pollution levels: x- unsatisfactory xx- significant xxx- critical

Source: NEAP

(4) Overview of Emission Sources in the Major Cities

Results of the survey are summarized briefly as follows:

- Most of large-scale factories install dust collector while medium and small scale factories rarely install it. But the toxic gas treatment facility with high efficiency is not installed in most of factories and the pollution prevention measures are therefore insufficient.
- The major fuel in use in Macedonia is heavy oil except thermal power stations and dependence on natural gas and diesel oil is limited. The usage of coal for household heating is less than 10 %.
- Based on the result of the analysis of questionnaire, net operation rate of factories was 30 to 40%, i.e. 153 factories.

1) Overview of Air Emission in Skopje

a) Environmental Protection Measures

Field surveys were conducted concerning some of the major emission source facilities.
Central heating plants, iron and steel mills, cement plants and other plants are installed with

dust collecting equipment for flue duct emissions. However, almost all emission source facilities are not installed with dust collecting equipment. Except for those installed in some establishment of iron works, any full-scale toxic gas removal equipment is not installed entirely.

Other problems include the low chimneys. For high stacks, the concentration of emission gases near the ground can be reduced due to diffusion by the atmosphere. In the case of high stacks, depending on meteorological conditions, release of air emission by upper portions of the temperature layers can be expected. The present state of environmental protection measures is not sufficient. This tendency was found true throughout Macedonia.

b) Fuels Used and Operating Ratio

The fuel burnt in various emission source facilities in Skopje is mostly heavy oil. The consumption of coal and gases was found to be little.

For individual household heating, firewood and electric heaters are mainly used. Coal is used less than 10% of the total and natural gas is not used.

The operating ratios of emission source facilities in the plants are 50% or lower. Roughly 20% of all the plants were found operating at below 33% operation ratio.

c) Overview of Major Emission Sources

i) Heating Plant "Toplificacija"

The central heating plant "Toplificacija" was built in 1965, employs about 400 employees and has five plants in the city (one plant is effectively shut down). The plant is a gigantic pollution source with a total heat capacity of 600 MWth equivalent to about eight boilers with evaporation of 100 t/h. The plant supplies heat to 41,000 households in residential districts of 2.6 km^2 and to commercial districts of 1.3 km^2. Heat is supplied mainly to buildings such as apartment buildings (60%) and government and municipal offices (21%). Most of the heat supply for these consumers is provided from two plants in Istok (East) and Zapad (West). These two plants have five or six boilers with a capacity of 40 to 60 MWth/unit each. The boilers have rotary burners.

The plants have converted heavy oil with a sulfur content of 3 to 3.5% with good quality heavy oil having a nominal sulfur content of about 1% (value actually measured by the Study Team: about 1.4%) to reduce SO_2 emissions. The plants have low stacks. The Istok plant, which is the largest, has a stack about 65m high. A cyclone for exhaust gas is equipped at this plant, but desulfurization equipment is not equipped.

Heat is supplied only during the heating season and the plants are not operated in other seasons. Process steam for factories are not supplied. In 1997 season, the plants consumed 73,000t of fuels.

NEAP proposes the fuel conversion to natural gas in heating plants. As a trial, eight million m^3 of natural gas (10% of the total production) was consumed beginning in March 1998. 22% of the total fuel used during the heating season from October 1998 to March 1999 was expected to be natural gas. The fuel conversion to natural gas will be promoted in future.

ii) Iron & Steel Company

The iron and steel mill "Iron & Steel" was built in 1967 and employs about 3,000 employees. Now, it is being divided into four companies and is undergoing privatization. It uses pig iron and scrap as raw materials. It manufactures plates, medium-thickness plates, sheets and other steel plates and sheets (1,200,000 ton/year in capacity), steel sheets such as color steel sheets as construction materials and coated steel sheets (240,000 ton/year in capacity), ferro-alloys mixed with zinc, manganese (50,000 ton/year in capacity), wires and other products.
Five electric furnaces with 40,000 ton/year capacity are installed, burning heavy oil as an auxiliary fuel. As for environmental protection measures, bag filters are installed as dust collecting equipment.
Moreover, RZ "Topilnica" Co. ferro-manganese and silica-manganese smelting plants and "Balkamstil" low temperature milling plants that conduct deoxidizing process are the only plant that have installed harmful emission gases removal facilities. Such facilities are not installed in other plants.
In the smelting plant, a wet gas removal closed system (made in Poland) is being installed, thus reducing the emission of SO_2, NOx and allowing Mn precipitates to be collected. Moreover, large quantities of the emitted CO gas is being collected and a part of the steam boiler fuel is being used.
The acidic gases from the deoxidizing process can be completely removed by scrubing it with alkali, but special processes are not being employed in pollution source facilities, for example, boilers. At the time of the field survey, the operating ratio of these furnaces was below 30%.

iii) Leather Factory "Godel"

The leather factory "Godel" was built in 1945 and employs 1,200 employees. It produces 50 ton per day of leather. The factory is installed with three 6-ton boilers and one 12.5-ton boiler for heating and processing. These boilers burn heavy oil. Beside this, the 12.5-ton boiler for gas combustion was built in 1997, but is still standing by with a supply of gas.
In future, heavy oil burners for old boilers will be replaced with gas burners, if gas is provided. About 9 to 15 ton per day of heavy oil and 50,000 Nm^3 per day of natural gas will be used. The height of the stacks is 15m. According to the person in charge of the boiler, depending on where the heavy oil is bought and the lot, there may be variation in the properties, but due to the excellent devices (burners are made in Germany), troubles do not occur.

iv) Chemical Plant "OHIS"

The chemical plant "OHIS" manufactures plastics, polyvinyl chloride, polyacrylic fiber and other plastics in its electrochemical plant. Heavy oil is used to supply heat to the plant. This chemical plant and the leather factory in c) are scheduled to convert their energy source to natural gas in the near future. However, as in the central heating plant in a), the measures devised in the future must be given intense scrutiny.

v) Cement Factory "USJE"

The cement factory "USJE" is the largest cement plant in Macedonia, the production rate of the rotary kiln is 150,000 ton/year. The fuel used is 70% coal and 30% heavy oil. The plant is heading towards privatization and is currently holding talks with foreign enterprises.
Dust and NOx are normally monitored in one week and they are kept within the standard emission values. People in charge of the environmental protection work have mentioned that being in touch with foreign enterprises, aids in the learning more about control of emission. However, Skopje admits that "USJE" is a gigantic dust emission source and it bears hopes of introducing new filter technologies. It is extremely important to devise measurement for environmental protection.
In this plant, there are many emission sources such as the rotary kilns and the mills with around 10 stacks.

vi) Area Sources

As area sources, the contribution of firewood and stoves (individual heating) burnt in residential houses to air pollution is large and has become a major focus in monitoring surveys in the past in Eastern Europe. Under the weak-wind stagnant meteorological conditions (stagnation) during winter, these sources may cause great health damage.

vii) Mobile Sources

Among all registered vehicles, there are a wide variety of passenger cars from highly polluting cars manufactured in the former East European block to the latest-model cars manufactured in Western Europe and Japan.
A periodic vehicle inspection system is not enforced in Macedonia and many vehicles have incomplete combustion. Roughly 40% of all vehicles including public transportation vehicles in the Country are concentrated in Skopje and the level of air pollution in Skopje caused by mobile emission sources is estimated to be very high.

2) Present State of the Stationary Sources in Skopje

a) Total of Data from Stationary Sources

According to the Register of Polluters in Skopje prepared by Mining Institute from Skopje in 1996, there are 153 objects potential polluters (33% are industrial objects and the rest are not industrial) with 543 emitters (35.4% from industry). It was found that there were a very few objects having filters for treating the exhaust gases. The total volume of exhaust gases from whole registered emitters is 32,329,451 Nm^3/h. The amount of CO is calculated to be 11,414.7 kg/24h, SO_2 of 11,394.9 kg/24h, NOx of 4,948 kg/24h and dust of 2,042 kg/24h. The volume of exhaust gases and the presence of CO, SO_2, NOx and dust for the territory of the city of Skopje and communities in Skopje are given in Table 3.11.

Table 3.11 Emission of Exhaust Gases in Communities and City of Skopje for 24 h (1996)

Community	Vol. Flow, in $Nm^3/24h$	Emission of CO, in kg/24h	Emission of SO_2, in kg/24h	Emission of NOx, in kg/24h	Emission of Dust, in kg/24h
Cair	1,873,059	10,001.0	106.4	639.8	-
Karpos	1,384,391	597.9	1,446.3	645.3	-
Center	605,683	106.9	346.2	214.9	-
Gazi Baba	4,881,887	283.9	5,962.0	2,449.0	-
Kisela Voda	23,584,431	425.0	3,534.0	999.0	2,042.0
Skopje	32,329,451	11,414.7	11,394.9	4,948.0	2,042.0

b) Emitters

The information and data about investigated objects and emitters are given in Data Book, Table D3.32.

Major emission sources in Skopje which exhaust gas rate exceeds 10,000 m^3/h are shown below, 14 types and 16 facilities:

① Porc. Factory IGM
② Central Heating Plant, WEST, EAST and 11 Oktomvri
③ Clinic Center
④ Beer Co. Pivara
⑤ Pharmaceutic Co. Alkaloid
⑥ Paper Co. Komuna
⑦ Textile Fact. Mak. Rakotvorbi

⑧ Leader Co. Kozara
⑨ Petrol Refinery OKTA
⑩ Iron & Steel Co.
⑪ Electric Co. Rade Koncar
⑫ Ceramic Fac. IGM Partizan
⑬ Cement Factory
⑭ Chemical Co. OHIS

①, both west and east of ②, ⑨, ⑩, ⑪, ⑫, ⑬ and ⑭ are especially large emission sources with emission rate more than 50,000 m^3/h.

c) Types of Companies - Emitters of Pollution

Emitters of pollution in each area by types, numbers, working years and consumption of fuels are shown in Data Book, Tables D3.33 to D3.41.
Putting the information together, the general findings are listed below:

- Industry occupied one third of the total number of facilities of stationary source.
- Gazi Baba and Cair areas have many facilities of stationary source and emitters.
- There are many old combustion facilities. Close to 80% facilities of the whole have been working over ten years.
- Small combustion facilities can be seen to be a lot. Approximately half of emitters are less than 1MW and more than 80% are from 1 to 50 MW.
- Most of the fuels used are liquid.
- Almost 200 emission facilities have working capacities from 33 to 50% and almost 90 facilities have those of less than 33%.
- The amount of emitted CO is largest in industry, and that of SO_2 and NOx is largest in Energetic.

3) Central Heating Plants in Skopje

Distribution network is 170 km long from the central heating plants in Skopje.
According to the existing data and data obtained during the visit of the direction of central heating plants in Skopje, following facts are found.

There is the central heating system comprising of five heating plants in Skopje.
Table 3.12 shows the emission of central heating plant which is now under operation.
A scheme of the city central heating network is given in Figure 3.14 and schemes of the each heating plant are in Data Book, Figures D3.20 to D3.23.

The periodical measurements of air emission are performed by own department or by the institutions working on emission measurements (RHI, Mining Institute, IEZ). There are some data of air emission that performed in March 1995 for different emitters of heating plant East, West and 11 Oktomvri.

These data are shown in Data Book, Tables D3.42 to D3.50.

Table 3.12 Emission from the Central Heating Plants

Heating Plant	Vol. Flow Waste Gases (Nm^3/h)	Vol. Flow Waste Gases ($Nm^3/24h$)	CO (kg/24h)	SO_2 (kg/24h)	NOx (kg/24h)
EAST	304,597	2,456,522	108.56	2,790.39	1,390.12
WEST	137,367	1,102,640	34.54	1,277.17	594.53
11 Oktomvri	26,748	208,978	1.96	226.76	96.54
Park	5,031	44,256	0.71	52.82	26.36
Total	473,743	3,812,396	145.77	4,347.12	2,107.55

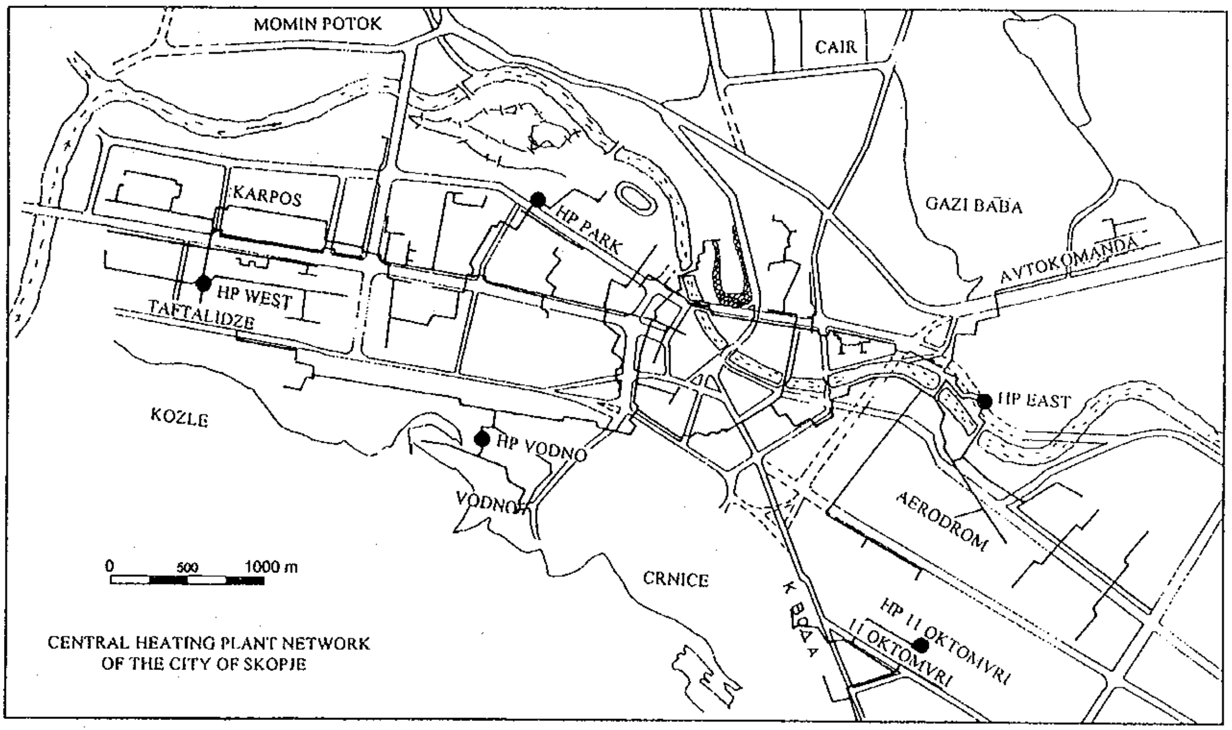

Figure 3.14 Central Heating Plant Network

4) Overview of Air Emission in the Major Cities

a) Veles

Veles is located in a basin. Even though the northern side of it is open, the city is in a topographically poor location for metal smelting and other industries.

The MHK "Zletovo" metal smelting plant as the center of the stationary emission source is located about 1km northwest from the center of the city in the same basin and is smelting zinc and lead. As byproducts, cadmium, chromium and sulfuric acid are produced. The factory was built in 1964 and employs 1,600 employees. The plant was producing 67,000 ton of zinc and 33,000 ton of lead per year. However, in recent years, due to the obsolescence of production equipment, production fell to 42,000 ton of zinc and 19,000 ton of lead per year in 1995, 30 to 40% decrease compared with full-production time.

Coke, imported from Poland, Ukrine and other countries, is used as the fuel (55,000 to 65,000 ton per year). For emission control, electric precipitators, bag filters, cyclones, wet flue gas desulfurization facilities and other facilities and systems are used. However, removal efficiency is poor and soil contamination, farm produce pollution and livestock contamination caused by this smelting plant have become serious problems (Data Book, Tables D3.51 to D3.54 and Figure D3.24).

Coke which is stacked in an open coal yard and slag storage places have become an emission source of dust. Much dust is generated when a strong wind blows.

Environmental pollution does not stop with the atmosphere. Surface underground water pollution from the slag storage places are becoming serious problems. A drainage disposal project supported by the Overseas Economic Cooperation Fund of Japan (OECF) is under way. Plans for environmental protection are being considered by the agreement with MOE.

b) Tetovo

Air temperature inversions occur in this region during winter up to an altitude of 1,000m. Normally, these inversions cause fogs (Average 34 days per year). The duration of sunshine is shortest (1,876 hours per year on average) and the precipitation is largest in the country during winter (annual average precipitation is 784 mm). These meteorological conditions are one of the deciding factors for concentration of air pollutant in Tetovo.

Stationary emission sources include a textile factory at one end of the city and a metal chemical plant "JUGOHROM" emitting chromium in Jegunovce Village which is located in the northern part of the valley, more than 10 km distant from the city.

Exhaust gases are emitted from its stacks without any prior treatment. Particles containing heavy metals precipitate in the neighborhoods of the metal chemical factory. Under peculiar meteorological conditions, NO_2, SO_2 and other gaseous substances affect not only the entire region of Tetovo, but also regions as far as valleys in the northwestern part of Skopje.

Exhaust gases from the metal chemical factory are emitted not only from low stacks, but also from the entire factory buildings themselves. The residents living in adjoining residential districts are exposed directly to exhaust gases emitted by this factory. The factory widely affects not only the adjoining residential districts, but also down the valleys.

This area has farmland, which has the soil of the highest quality in Macedonia, suitable for producing vegetables. A survey of influence to humans by soil contamination due to air fallout and by secondary pollution of river water and underground water is urgently needed.

c) Bitola

The main wind directions in Bitola are from the north and south. The average duration of sunshine per year is 2,344 hours. The temperature inversion phenomenon, which affects the surface concentration of ambient air quality is frequently present. Fogs occur 21 days per year on average.

Stationary emission sources include the "Bitola MPGC" coal mining and thermal power station (225 MW x 3 units, two 250 m stacks) which is the largest coal mining and power station in Macedonia located 12 km northeast of the city. There are 2,500 staff working in the coal mines and thermal power station.

In the summer, almost all electric power is supplied by hydraulic power generation, thus, this plant has a minimum load.

At present, desulfurization and denitration facility are not installed in the plant. The emissions from this plant affect a wide area. Because of the tall stacks, pollution caused by air emission is considered not to be as great as that widely believed. Nevertheless, the morbidity of respiratory system diseases caused by coal dust is high in Biljanik Village as well as the dispersal of ashes from the coal ash storage piles. The same is true for other places which are located quite near to the coal yard. Damage to health is extensive. The situation is serious.

According to monitoring results of ambient air quality (preliminary survey report), there is a regular trend for SO_2 and BS behaviors which show a high concentration during the heating season. At present, the BS concentration often exceeds the standard value. Even though the SO_2 concentration is generally below standard values, this monitoring data was obtained in an industrial zone around the city and do not represent a typical value for the city.

d) Kavadarci

Kavadarci is located further downstream of the Vardar River than Veles and is similar to Veles in both topography and meteorological conditions.

The ferro-alloy factory "FENIMAK" and its waste disposal yard are located nearby. The dust removal devices operate poorly. Stacks were emitting reddish brown smoke.

The main components of the dust are iron, nickel and silicon. The dust is affecting nearby environments. A solution is needed. The operating conditions of the thermal power station "TEC NEGOTINO" on the east bank of the Vardar River could not be confirmed.

5) Traffic Condition and Emission Volume of Toxic Compound

Traffic is the main source of air pollution. Automobiles are the only means of transport. Old and superannuated buses are used for public transport. Most of passenger cars also are old and superannuated. This in turn aggravates air pollution due to NOx, CO, VOC and TSP (Data Book, Tables D3.55 to D3.57).
Table 3.13 shows the registered numbers for each type of vehicle.
To add, although the definition of conditions necessary for calculating emission volume is provided for by the NEAP, in terms of emission volume calculation, the calculation of emission is based on the experiences of other nations. Therefore, revisions should be made and added to such data whenever new ideas or new monitored data are available.

Table 3.13 Registered Numbers Based on Type of Vehicles (1993)

	Types of Vehicle						
	Motor-cycles	Cars	Buses	Commercial Vehicles	Special Vehicles	Tractors and Working Vehicles	Trailers
In the R. Macedonia (total)	3003	289979	2921	20104	6563	6648	7624
Private Sector (No.)	2893	275339	366	10402	1357	5019	2541
Percents (%)	96.3	94.9	12.5	51.7	20.7	75.5	33.3
In Skopje	709	110332	1242	7457	1888	383	1327
% from Total Vehicles	23.6	38.0	42.5	37.0	28.7	5.7	17.4

Source: NEAP

3.1.5 Selection of the Model City and its Bases

Skopje city, the capital of the Macedonia, was selected as the model city through a number of consultation with the concerned personnel of the Macedonian side concerning analyses of the present status of air pollution and characteristics of emission sources.

- Skopje city, the center of socio-economy and industries of the Macedonia, suffers from most serious air pollution due to heating during winter because of its topographical and meteorological conditions and also due to automobiles and plant emission gases.

- Automatic continuous monitoring stations owned by metal smelting plant were set in two points in Veles. However, only British samplers unable to cope with emergencies were used in Skopje.

- Veles, Tetovo and Bitola etc. expect a great effect based on the countermeasures in factories which take a leading part. Skopje needs to be covered with overall countermeasures. It is required to construct monitoring system earlier in order to examine the measures.

Discussions were taken place as to whether or not to include Veles city, which had serious air pollution problems as in Skopje, as a model city. However, Veles being 40 km away from Skopje, had different emission source conditions of pollutants. As a result, Veles was not included as a model city. It was decided to take up Veles in recommendations on the construction of a nation-wide air quality monitoring network.

3.2 Determination of Sites for Air Quality Monitoring Station

3.2.1 Distribution Survey of Air Quality in Wide Area

(1) Concentration Distributions of SO_2 and NO_2

1) Survey Method

A total of 100 monitoring points were selected using an 1 km mesh as a reference mesh to evaluate the concentration distribution in the entire Skopje. Simplified samplers were installed at these monitoring points.
The monitoring points were selected based on topographical condition, density of dwelling houses and existing data and information as a reference. At 16 of these 100 monitoring points, simplified samplers were installed near the existing monitoring points of existing samplers for cross-check between these two types of samplers.
Figure 3.15 shows the locations where the simplified samplers were installed.
The locations of the sampling points are shown in Data Book, Table D3.58.
All monitoring points were surveyed and set by the Counterpart teams of the RHI and the IPH and by the Study Team.

a) Sampling period: November 10 to 20, 1997
24-hour sampling
(Replaced between 7:00 a. m. and 7:00 a. m. every day)
b) Number of sampling times: 10 times
c) Monitoring items: SO_2, NO_2
d) Sampling method:
Filter paper moistened with an absorption solution was mounted inside the simplified

sampler. The filter paper was replaced every 24-hour. Replace time for the filter paper at all the points was simultaneous, with the replacement of the absorption solution for the existing samplers was set 7:00 a.m. to 7:00 a.m. every day. The filters were sealed after sampling and were brought to the laboratory of the RHI every morning.

e) Analytical method:

Filters were extracted using distilled water and were used for analysis of SO_2 and NO_2.

SO_2: Absorptiometry (Pararosaniline method)

NO_2: Absorptiometry (Saltzman method)

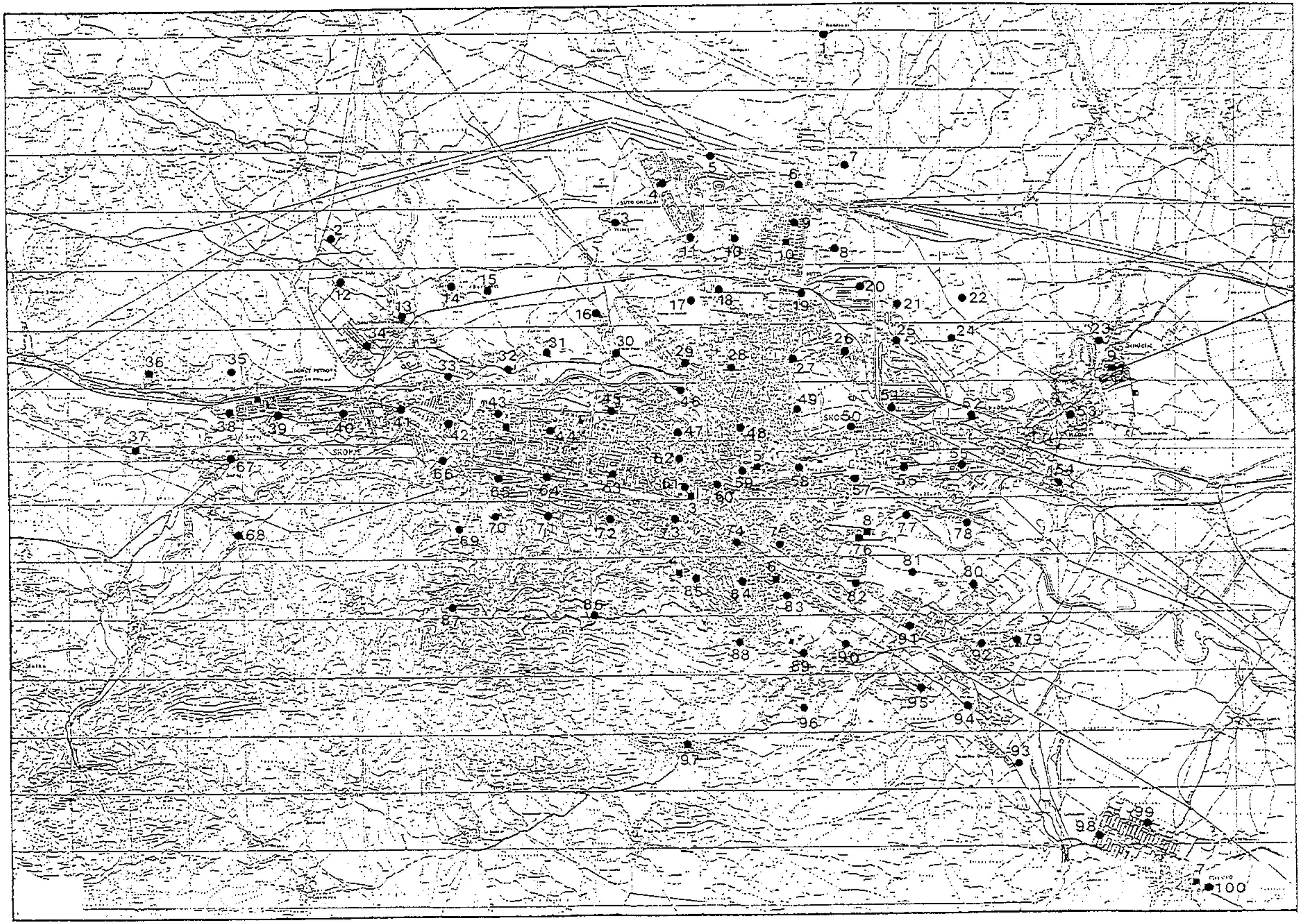

Figure 3.15 The Location Map of the Simplified Samplers

<Monitoring Principle of Simplified Sampler>

The simplified sampler uses the principle of gas molecule diffusion and is almost immune to impacts by winds. This method cannot monitor continuously, deriving data with time values as in automatic continuous monitoring equipment. However, the monitoring cost of the simplified sampling is relatively low and monitoring can be performed easily. Therefore, it can be installed in locations and can monitor average concentrations in fixed time periods simultaneously.
Monitoring examples using simplified samplers include surveys of concentration on automobile roads and personal exposure monitoring wearing them. Simplified samplers for long-and short-term use are available. Short-term samplers were used in this Study.
Figure 3.16 shows the outline of simplified sampler.

Passive Sampler Assembly: order of assembly in each of the two chambers of the sampler, starting at the inner position and progressing outward to the diffuser end cap, is as follows:

1. PTFE Disk
2. PTFE Ring
3. Stainless Screen
4. Coated Collection Filter
5. Stainless Screen
6. Diffuser End Cap

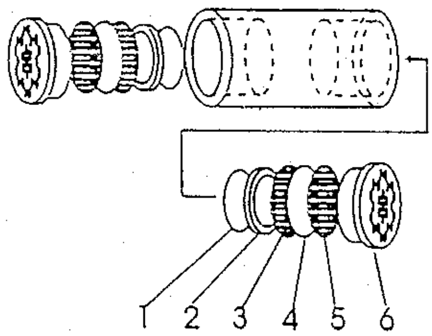

Figure 3.16 Outline of Simplified Sampler

2) Results of Monitoring

The monitoring results of SO_2 and NO_2 are shown in Data Book, Tables D3.59 and D3.60.
Figures 3.17 and 3.18 show the wide-area concentration distributions of SO_2 and NO_2 in the entire area of Skopje (Data Book, Figures D3.25 and D3.26).
Concentration distribution diagrams were prepared for average values of the entire cases of NO_2, of the three cases of SO_2, namely, RUN-2, RUN-3 and RUN-9, and of the entire cases of SO_2 and NO_2. The three cases selected for SO_2 showed relatively high concentrations during the period. According to a large number of literature descriptions, even if

concentration is low, NOx is known to show a high correlation with automatic continuous monitoring equipment and is high in reliability. On the other hand, for SO_2 the sampling period must be extended to enhance accuracy when the concentration level is low. According to the results of the monitoring survey, the concentration was lower than anticipated in all cases and the three cases which showed relatively high-concentrations among all the cases were selected. Generally, the following observation can be made from the wide-area concentration distribution diagrams of SO_2 and NO_2:

- As far as the overall concentration levels are concerned, cases of windy days (RUN-4), and days affected by rainfall (RUN-5 and RUN-6) registered low concentrations compared to the other cases.
- According to the data of the individual cases, specially high-concentrations were not recorded with NO_2, except for RUN-1, 2 and 10 with concentrations exceeding $100\mu g/m^3$. The reference value of $80\mu g/m^3$ was exceeded only in some areas. None of the points exceeded the reference SO_2 value ($150\mu g/m^3$).
- In the NO_2 concentration distribution, the central part of the city showed high concentrations, while high concentrations were also recorded locally in some suburban areas.
- As in RUN-2 and RUN-3, the SO_2 concentration distribution showed a high concentration level in the suburbs, rather than in urban areas, differing from the distribution pattern with NO_2.
- Some areas in the mountains on the southern part of the urban area also showed high SO_2 concentrations. Summarizing the above, the impact of mobile sources (vehicles) and area emission sources are large with NO_2. Impacts by other stationary sources added to SO_2.

The primary purpose of the wide concentration distribution survey using simplified samplers is to grasp air quality concentration distribution in all of Skopje and to set up four AQM stations properly. However, another purpose for the Study Team carried out technical transfer of this survey method through cooperative research with the Counterpart.
The method of the simplified sampler is known to the Macedonian side as the alkali filter paper method or Toliethanolamine (TEA) filter paper method, but this is the first time for Macedonia to make complete use of a sampler that is highly accurate and applies the theory of molecule spread.
The simplified sampler that the Study has introduced and the survey methods are useful for grasping a wide concentration distribution for a given period at a low cost. The Macedonian side has already started utilizing it for other research. It is very significant for the Study Team to have already realized some part of the purpose of the Study.
It is expected that the Macedonian side will positively utilize the simplified monitoring method for variety of studies.

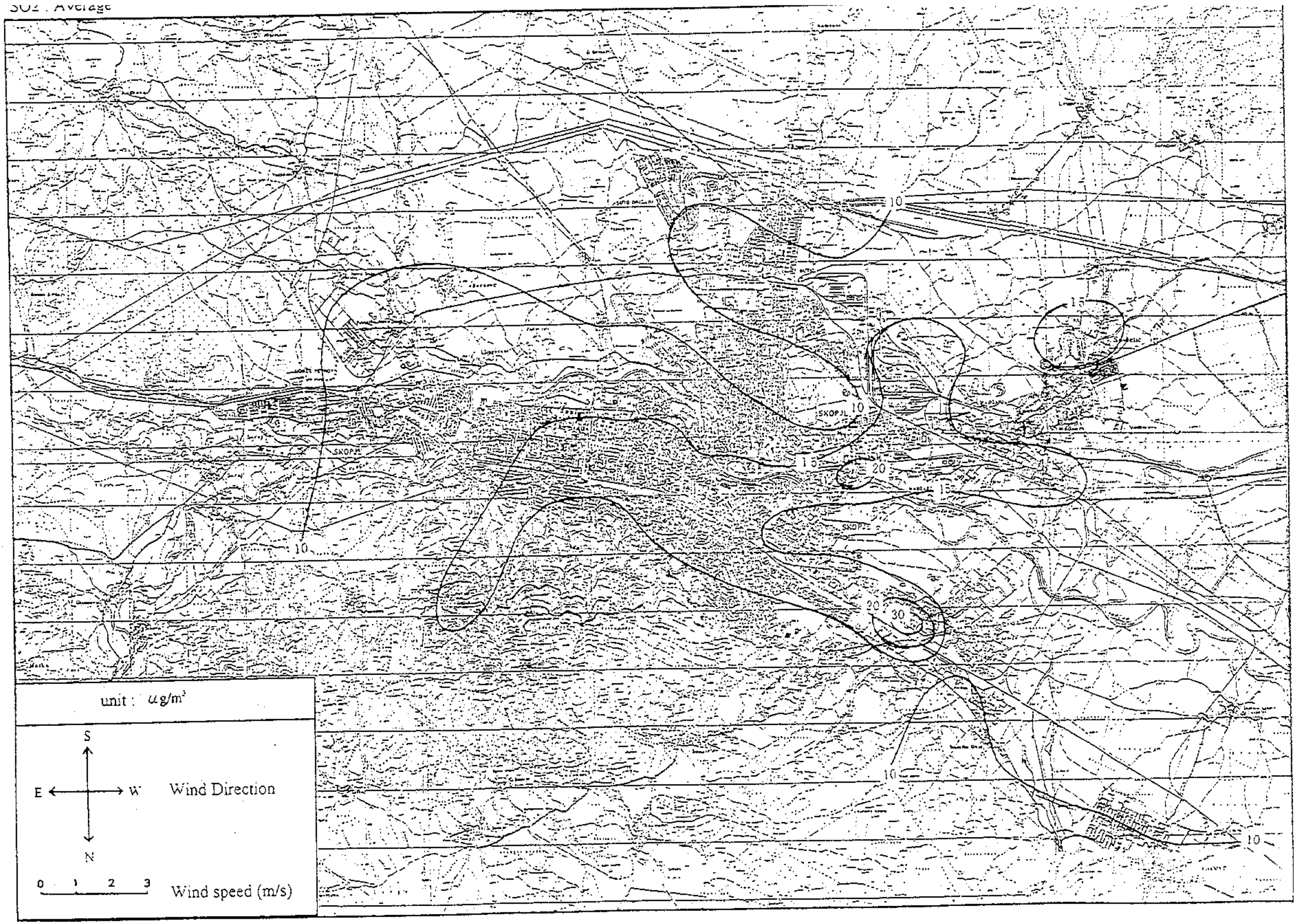

Figure 3.17 (1) The Concentration Distributions of SO_2

SO2 : Run-2

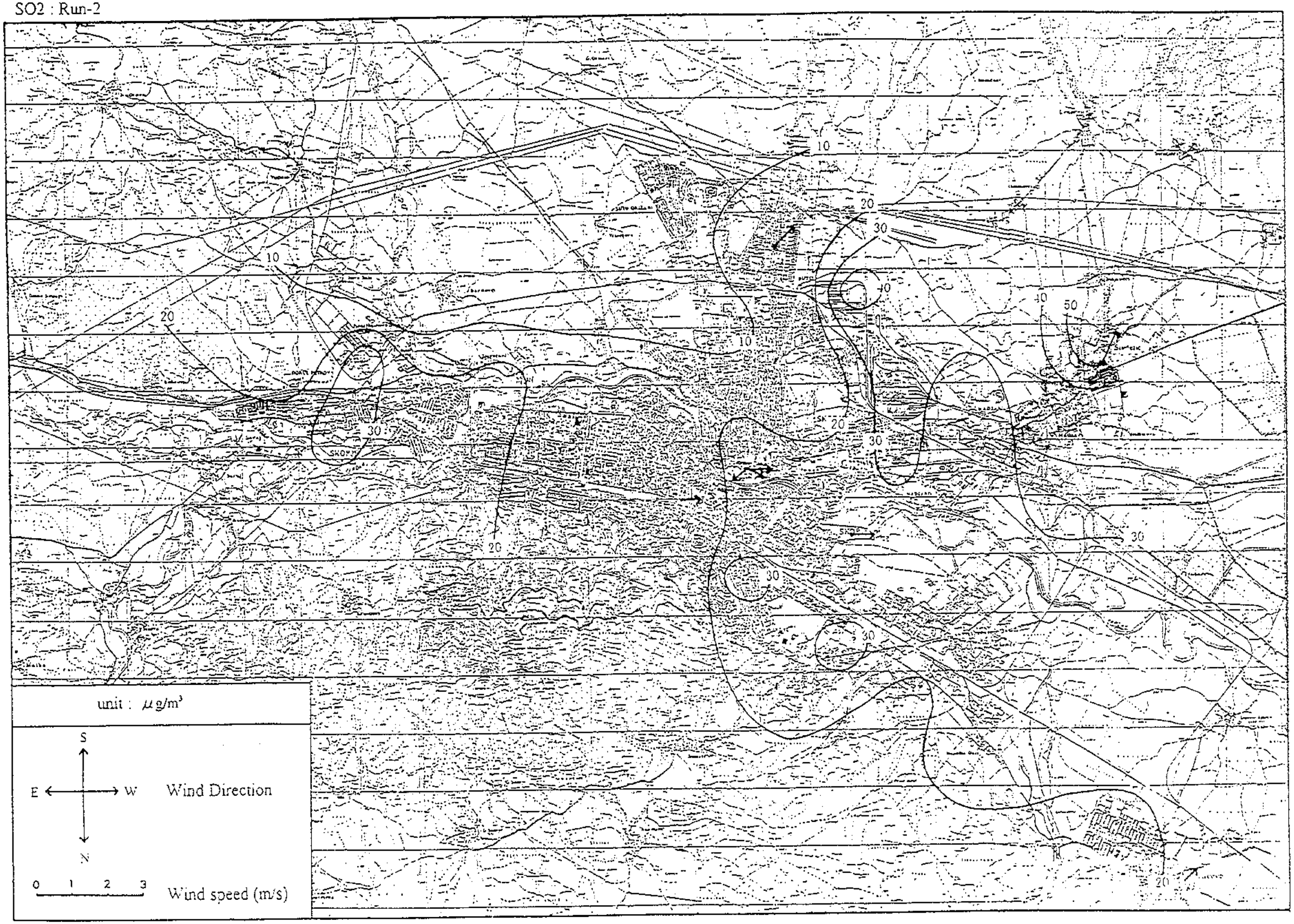

Figure 3.17 (2) The Concentration Distributions of SO_2

NO2 : Average

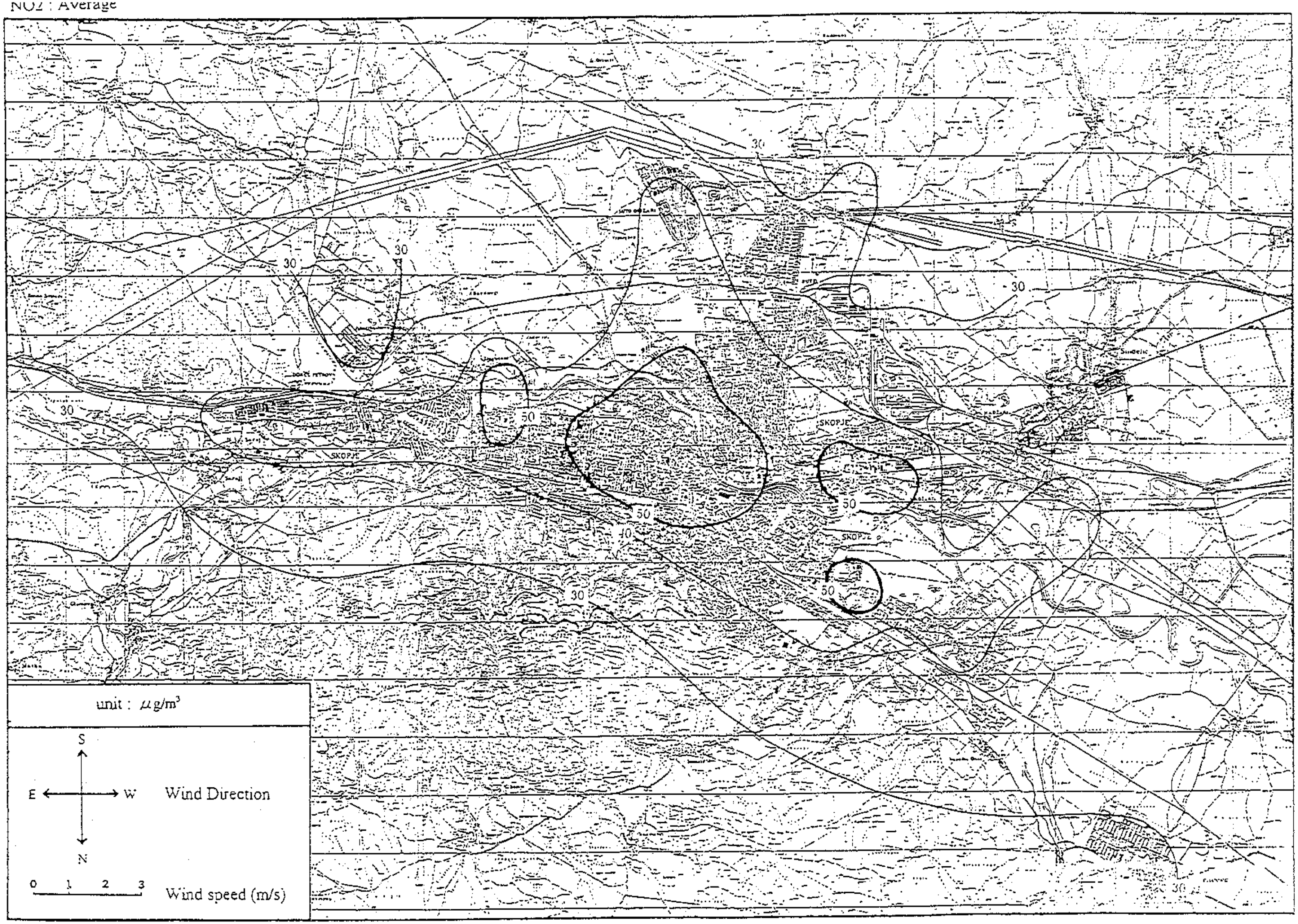

Figure 3.18 (1) The Concentration Distributions of NO2

4.1.4 Survey of Mobile Sources

(1) Traffic Volume and Speed

1) Location

Mobile source survey was performed in two days: weekday and holiday for 24 hours at 75 points (five areas with 15 intersections/area). Locations of those points are shown on a map of the city of Skopje (Figure 4.10).
The list of each monitoring point is listed in Data book, Table D4.51.

2) Period of the Survey

Weekday: 7:00 a.m., April 22 to 7:00 a.m., April 23, 1998 (Wednesday to Thursday)
Holiday: 7:00 a.m., April 25 to 7:00 a.m., April 26, 1998 (Saturday to Sunday)

3) Survey Methods

a) 24-hour traffic volumes in two, three or four direction at each location were counted in each hour by five types of vehicles: passenger car, small truck, large truck, bus and trailer.
b) Driving speed was measured by stopwatch for 10 vehicles at each point in each hour at 50 points.

4) Results

In the survey, wide-scale examinations were carried out on the traffic volume of the whole of Skopje region. Through the survey, better understanding of the traffic conditions in Skopje was obtained.
According to the results of the survey, there are significant differences in the variation patterns of the hourly traffic volumes between that of normal weekday and holidays.

The traffic volume for weekdays shows an increase after 7:00 in the morning and this increase in traffic volume continues until midday, after which, it continues to decrease from midnight to sunrise. On the other hand, the traffic volume for holidays, was found to peak at around 0:00 p. m. and 11:00 p. m., reflecting a distribution pattern consisting of two peak times.
The reason for this could be due to the fact that during holidays, people mostly revolve around leisure and private activities as compared to economic activities on weekdays. Although the daytime traffic volume for weekdays is higher than that for weekends, the

difference is not significant.
As for the traffic volume during peak hours, the number of vehicles along major roadways was calculated to be from 3,000 to 8,000 vehicles per hour. There were also cases whereby the number of vehicles at cross-junctions were found to exceed 100,000 vehicles.
For example, at measuring point No. 46 the number of vehicles passed in 24 hours on weekday is about 110,000 and during holiday about 95,000. The number of buses (using diesel) at some points is very large (on some crossroads over 5000).
As for the types of vehicles along major roadways, passenger car is the largest in number, followed by bus, small and large truck. When comparing weekdays with holidays, it is observed that more buses are found on weekdays.
On some measuring points the speed of vehicles was found to be very high: more than the limit of 60 km/h.
Table 4.30 and Figure 4.11 as well as Table 4.31 and Figure 4.12 give examples of the traffic volume survey for holidays and weekdays. The results in detail are shown in Data Book, Table D4.52 and Figure D4.27. The results of driving speed measurement are in Data Book, Table D4.53 and Figure D4.28.

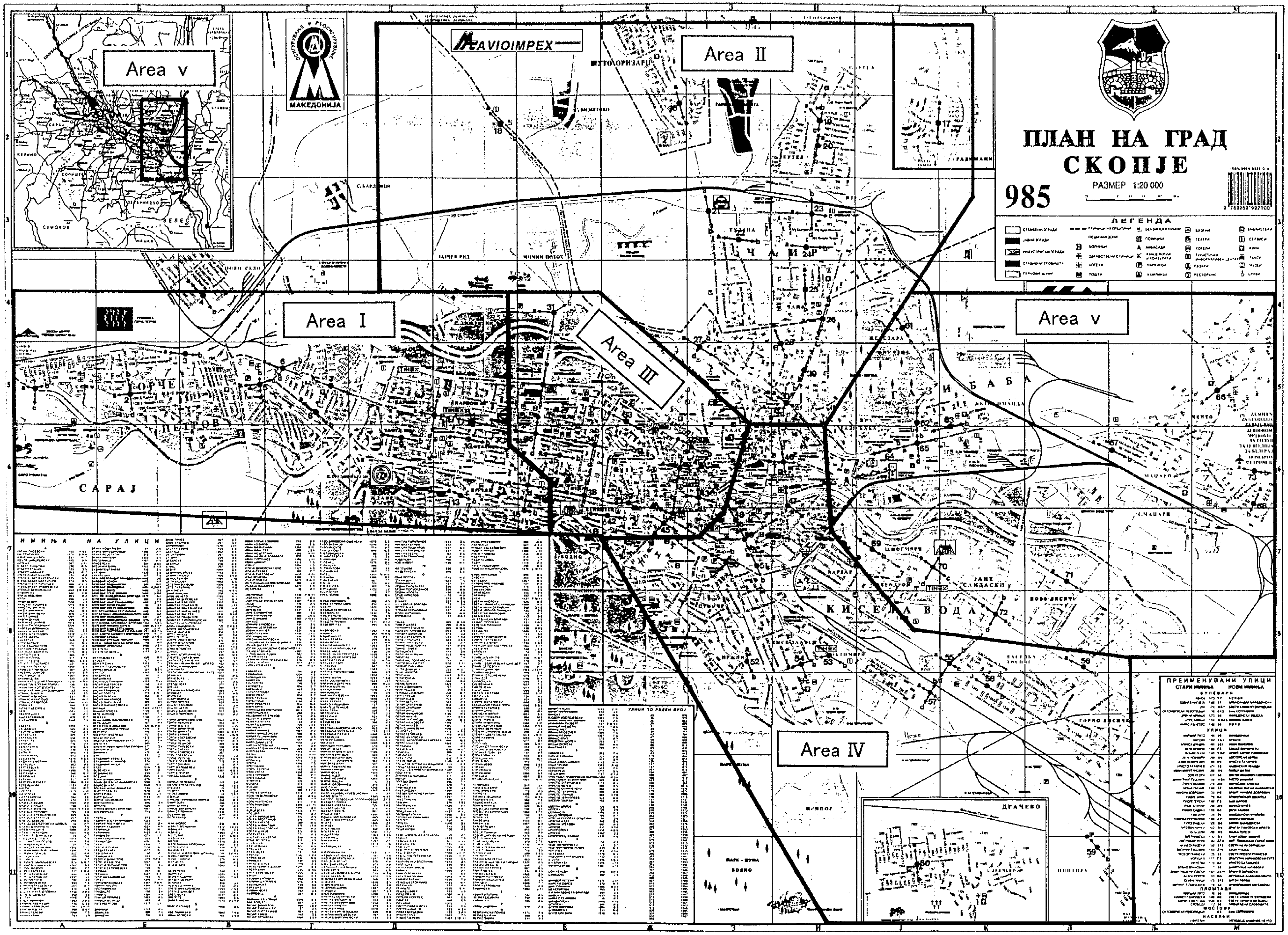

Figure 4.10 The Location Map on the Measuring Points for Traffic Volume Measurements

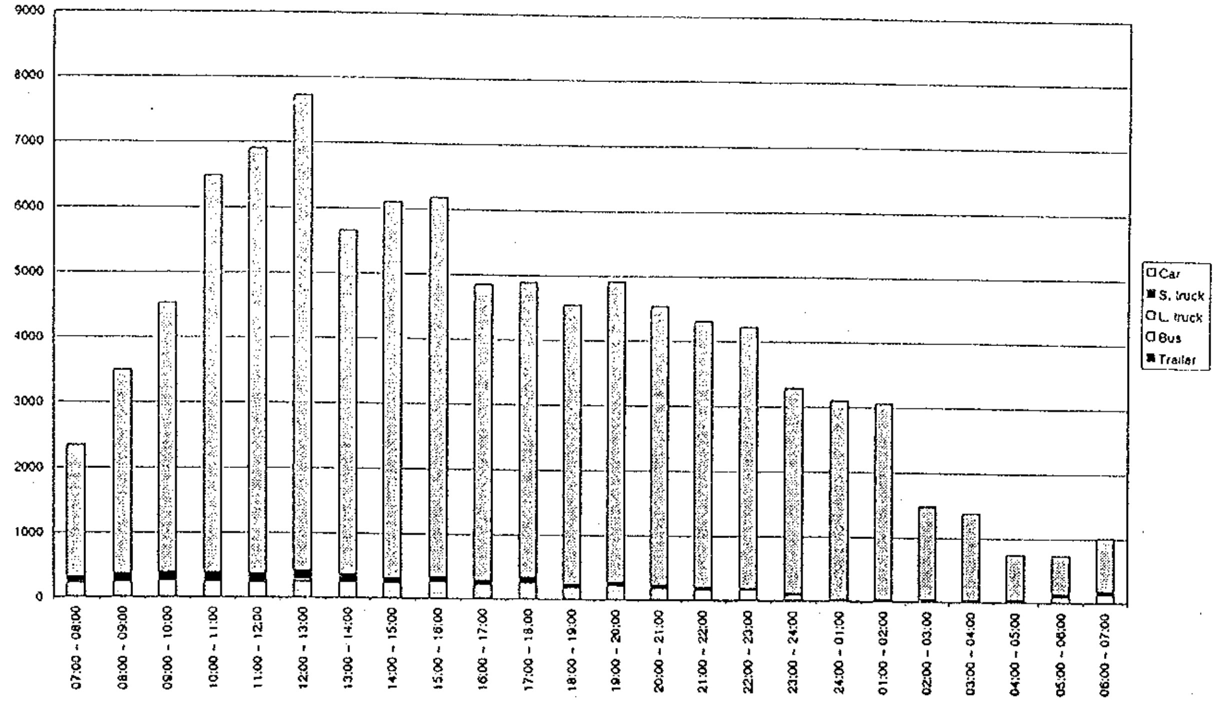

Figure 4.11 Hourly Traffic Volume by Vehicle Type – Measuring Point 46
(Holiday: April 25 to 26, 1998)

Table 4.30 Hourly Traffic Volume by Direction and Vehicle Type – Measuring Point 46
(Holiday: April 25 to 26, 1998)

time	No. 46 a						No. 46 b						No. 46 c						No. 46 d						Total for No. 46					
	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total
07:00 ~ 08:00	568	15	7	67	0	657	367	8	5	73	0	453	497	17	5	21	1	541	604	19	12	53	0	688	2036	59	29	214	1	2339
08:00 ~ 09:00	937	23	17	49	0	1026	649	21	7	89	0	766	663	13	7	23	0	706	889	23	8	79	0	999	3138	80	39	240	0	3497
09:00 ~ 10:00	1008	20	8	47	0	1083	933	24	5	84	0	1046	1011	27	5	45	3	1091	1191	24	5	81	0	1301	4143	95	23	257	3	4521
10:00 ~ 11:00	1617	23	7	51	1	1699	1360	35	8	96	3	1502	1304	37	1	20	0	1362	1813	19	8	75	0	1915	6094	114	24	242	4	6478
11:00 ~ 12:00	2040	23	11	52	0	2126	1361	37	16	92	0	1506	1287	16	7	23	1	1334	1848	15	5	69	0	1937	6536	91	39	236	1	6903
12:00 ~ 13:00	2269	36	21	56	0	2382	1483	21	15	85	0	1604	1581	19	5	35	0	1640	1973	29	12	77	0	2091	7306	105	53	253	0	7717
13:00 ~ 14:00	1887	15	4	44	3	1953	1309	12	8	91	0	1420	145	27	8	28	1	209	1956	24	11	83	0	2074	5297	78	31	246	4	5656
14:00 ~ 15:00	1568	13	5	47	0	1633	1336	20	1	97	0	1454	1197	16	1	37	0	1251	1689	13	3	53	0	1758	5790	62	10	234	0	6096
15:00 ~ 16:00	1571	8	1	47	0	1627	1451	19	3	100	1	1574	1229	19	5	39	0	1292	1600	4	5	72	0	1681	5851	50	14	258	1	6174
16:00 ~ 17:00	1233	8	3	43	0	1287	1051	17	0	75	0	1143	972	16	1	43	0	1032	1316	7	7	59	0	1389	4572	48	11	220	0	4851
17:00 ~ 18:00	1244	8	0	61	1	1314	892	25	5	85	1	1008	961	13	1	45	0	1020	1457	17	7	61	0	1542	4554	63	13	252	2	4884
18:00 ~ 19:00	876	3	0	36	0	915	1124	11	1	77	1	1214	328	5	3	27	0	363	1493	11	3	47	0	1554	4321	30	7	187	1	4546
19:00 ~ 20:00	1463	11	1	33	0	1508	1003	4	3	75	0	1085	659	7	1	37	0	704	1520	12	3	77	0	1612	4645	34	8	222	0	4909
20:00 ~ 21:00	1216	3	0	41	0	1260	903	1	0	61	0	965	757	8	0	17	0	782	1440	24	3	63	0	1530	4316	36	3	182	0	4537
21:00 ~ 22:00	1316	1	0	28	0	1345	915	3	1	53	0	972	641	3	1	21	0	666	1240	19	5	60	0	1324	4112	26	7	162	0	4307
22:00 ~ 23:00	1351	1	1	28	0	1381	889	1	0	63	0	953	631	0	0	17	0	648	1160	17	5	55	0	1237	4031	19	6	163	0	4219
23:00 ~ 24:00	907	0	0	15	0	922	845	3	3	21	0	872	663	3	1	12	0	679	760	8	0	43	0	811	3175	14	4	91	0	3284
24:00 ~ 01:00	753	0	0	1	0	754	803	1	0	1	0	805	721	1	0	1	0	723	787	1	0	23	0	811	3064	3	0	26	0	3093
01:00 ~ 02:00	725	1	0	0	0	726	859	0	3	1	0	863	759	5	0	1	0	765	680	1	4	19	0	704	3023	7	7	21	0	3058
02:00 ~ 03:00	360	0	0	4	0	364	413	0	7	0	0	420	300	0	0	1	0	301	373	8	1	9	0	391	1446	8	8	14	0	1476
03:00 ~ 04:00	300	1	0	1	0	302	328	1	1	1	0	331	412	3	1	0	0	416	316	5	1	7	0	329	1356	10	3	9	0	1378
04:00 ~ 05:00	181	0	0	5	0	186	215	3	1	4	0	223	187	5	0	3	0	195	137	3	0	4	0	144	720	11	1	16	0	748
05:00 ~ 06:00	96	1	0	12	0	109	116	1	0	33	0	150	183	7	0	7	0	197	217	20	0	44	0	281	612	29	0	96	0	737
06:00 ~ 07:00	135	1	0	25	0	161	203	9	0	36	0	248	243	7	0	24	0	274	263	15	1	52	0	331	844	32	1	137	0	1014
Total	25621	115	56	793	5	26720	20806	277	33	1393	6	22577	17631	274	53	527	6	18491	24722	338	109	1245	0	28434	90982	1104	341	3978	17	96422

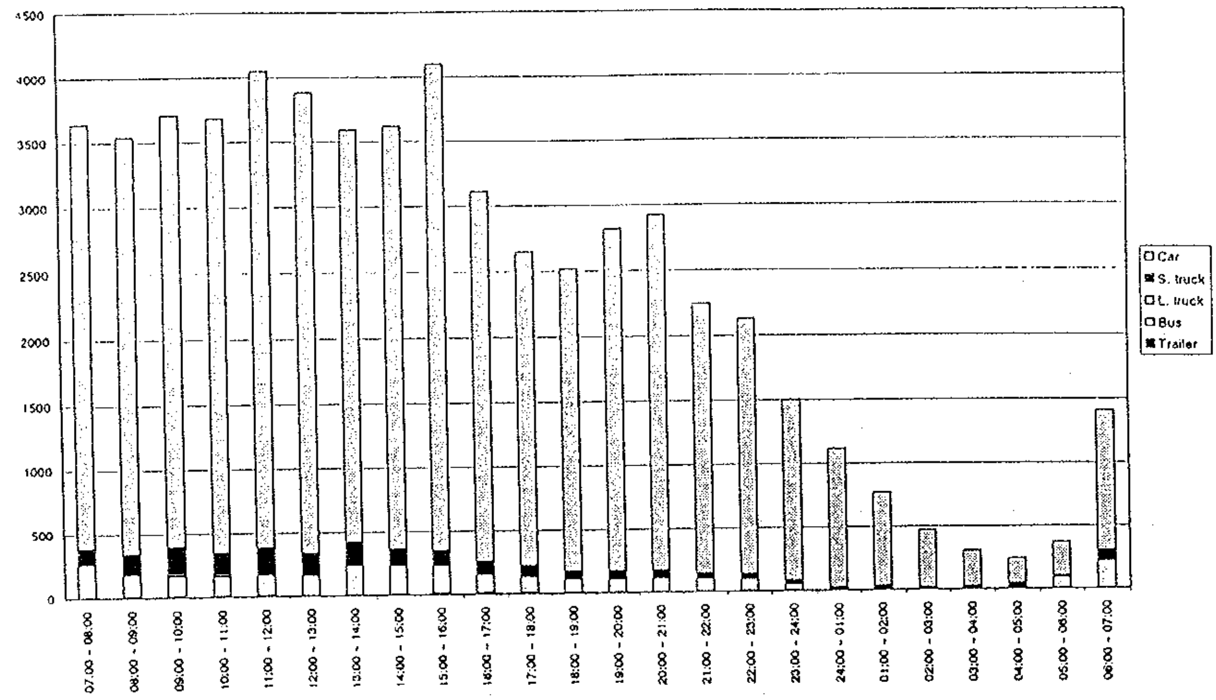

Figure 4.12 Hourly Traffic Volume by Vehicle Type – Measuring Point 49
(Weekday: April 22 to 23, 1998)

Table 4.31 Hourly Traffic Volume by Direction and Vehicle Type – Measuring Point 49
(Weekday: April 22 to 23, 1998)

time	No. 49 a						No. 49 b						No. 49 c						No. 49 d						Total for No. 49					
	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total	car	s. t.	l. t.	bus	trailer	total
07:00 - 08:00	1000	24	0	104	0	1128	863	33	0	95	0	991	536	29	8	27	0	600	865	21	3	32	0	921	3264	107	11	258	0	3640
08:00 - 09:00	913	49	0	73	0	1035	859	48	5	68	0	980	512	21	5	15	0	553	923	19	5	21	1	969	3207	137	15	177	1	3537
09:00 - 10:00	987	60	1	71	0	1119	947	65	7	56	3	1078	544	40	5	16	0	605	841	32	11	21	0	905	3319	197	24	164	3	3707
10:00 - 11:00	973	49	0	68	0	1090	979	52	13	56	0	1100	575	20	3	16	0	614	821	32	5	19	3	880	3348	153	21	159	3	3684
11:00 - 12:00	1080	73	1	65	0	1219	1068	51	9	60	0	1188	657	39	3	13	1	713	861	33	5	24	3	926	3666	196	18	162	4	4046
12:00 - 13:00	1120	53	3	65	0	1241	940	45	7	57	0	1049	569	24	4	19	0	616	924	31	0	19	0	974	3553	153	14	160	0	3880
13:00 - 14:00	1007	41	0	95	0	1143	801	36	4	79	0	920	628	45	3	25	0	701	743	41	4	37	0	825	3179	163	11	236	0	3589
14:00 - 15:00	933	17	0	89	0	1039	925	44	4	85	0	1058	609	24	5	29	0	667	800	21	3	27	1	852	3267	106	12	230	1	3616
15:00 - 16:00	933	5	0	96	0	1034	1025	35	5	68	1	1134	797	33	7	28	0	865	1009	20	4	33	0	1066	3764	93	16	225	1	4099
16:00 - 17:00	700	9	0	57	0	766	784	32	3	52	1	872	535	21	3	15	0	574	843	20	12	25	0	900	2862	82	18	149	1	3112
17:00 - 18:00	680	9	0	51	0	740	703	28	5	48	1	785	445	17	4	13	0	479	605	19	1	19	0	644	2433	73	10	131	1	2648
18:00 - 19:00	813	4	0	47	0	864	647	23	1	40	0	711	408	19	1	11	0	439	481	8	1	13	0	503	2349	54	3	111	0	2517
19:00 - 20:00	893	15	0	48	0	956	761	20	1	39	0	821	431	12	1	9	0	453	571	5	1	12	0	589	2656	52	3	108	0	2819
20:00 - 21:00	880	11	0	41	0	932	760	13	0	41	0	814	511	16	1	13	0	541	605	11	1	16	0	633	2756	51	2	111	0	2920
21:00 - 22:00	693	8	0	40	0	741	573	9	0	45	0	627	325	7	3	5	0	340	520	5	0	15	0	540	2111	29	3	105	0	2248
22:00 - 23:00	720	9	4	43	0	776	495	3	0	33	0	531	329	15	1	9	0	354	456	1	4	9	0	470	2000	28	9	94	0	2131
23:00 - 24:00	520	5	0	21	0	546	403	3	0	19	0	425	275	9	4	3	0	291	228	1	1	8	0	238	1426	18	5	51	0	1500
24:00 - 01:00	467	3	0	0	0	470	339	3	0	3	0	345	185	4	1	1	0	191	103	1	0	1	0	105	1094	11	1	5	0	1111
01:00 - 02:00	280	3	1	1	0	285	239	0	8	0	0	247	161	1	7	0	0	169	64	1	0	1	0	66	744	5	16	2	0	767
02:00 - 03:00	160	0	0	1	0	161	152	0	4	0	0	156	91	0	0	1	0	92	56	0	0	3	0	59	459	0	4	5	0	468
03:00 - 04:00	107	4	0	1	0	112	97	3	0	0	0	100	49	1	1	3	0	54	27	5	0	1	0	33	280	13	1	5	0	299
04:00 - 05:00	53	1	0	1	0	55	44	5	0	1	0	50	37	3	0	3	0	43	67	13	0	13	0	93	201	22	0	18	0	241
05:00 - 06:00	40	1	0	36	0	77	64	0	0	17	0	81	77	5	1	16	0	99	84	4	0	20	0	108	265	10	1	89	0	365
06:00 - 07:00	373	17	0	88	0	478	255	13	4	69	0	341	171	20	3	32	0	226	320	16	0	28	0	364	1119	66	7	217	0	1409
Total	16325	470	10	1202	0	18007	14723	564	80	1031	6	16404	9457	425	74	322	1	10279	12817	360	61	417	8	13663	53322	1819	225	2972	15	58353

(2) Air Quality Impact Analysis of Mobile Sources Along Major Roadways

The distance attenuation of concentration of NOx (NO and NO_2) was surveyed by the simplified sampler and portable vane direction anemometer in order to understand the characteristics of NOx pollution by mobile emission along major roadways in Skopje.

1) Location

Determination of the concentration of NO and NOx was performed by the simplified sampler at six measuring points:

For two directions:

No. 11: Bul. Partizanski odredi (Karpos III)

No. 64: Bul. Aleksandar Makedonski (Hotel Continental)

For four directions:

No. 40: Bul. Partizanski odredi - Bul. Sv. Kliment Ohridski

No. 44: Bul. Makedonija - Bul. Sv. Kliment Ohridski

No. 46: Bul. Krste Misirkov - Bul. Goce Delcev

No. 49: Bul. Koco Racin - Bul. 11 Oktomvri

2) Period of the Survey

Weekday: 7:00 a.m., April 22 to 7:00 a.m., April 23, 1998 (Wednesday to Thursday)

Holiday: 7:00 a.m., April 25 to 7:00 a.m., April 26, 1998 (Saturday to Sunday)

3) Survey Method

a) Attenuation from four main intersections (20 points/intersections) were at 0, 20, 50, 100 and 150 m and for two cross sections (10 points/cross section) were at 0, 10, 20, 40 and 100 m.

b) Wind direction and speed measurements by portable wind vane anemometer two times per day on three and five points.

4) Results

Results from the NO, NO_2 and NOx determinations on six measuring points in each direction on different attenuation are shown in Data Book, Table D4.54.

Wind direction and speed measurements by portable wind vane anemometer are shown in Data Book, Table D4.55.

The declining concentrations of NO_2 and NOx in accordance with the distance from edges and intersections on roads are shown in Figure 4.13, and Figure D4.29 in Data Book.

The distribution of NOx shows high concentrations on almost all measuring points.

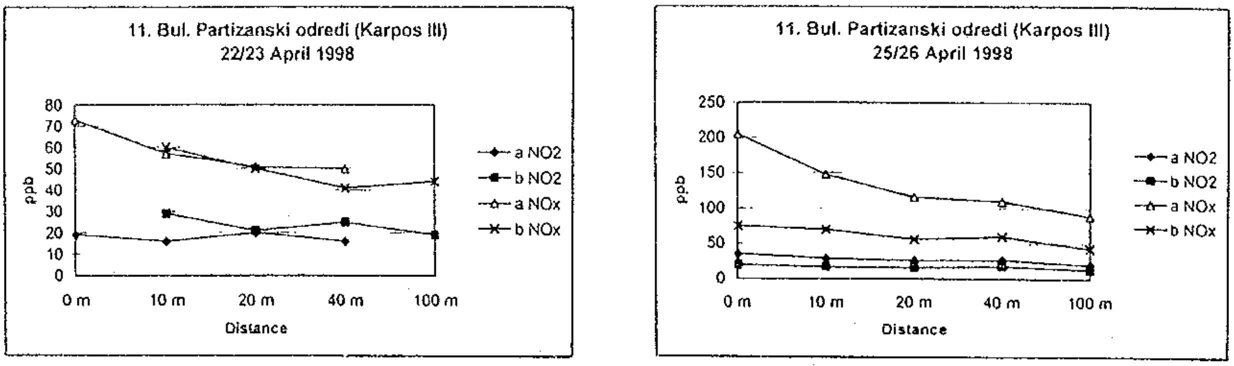

Figure 4.13 Attenuation of Concentrations of NO_2 and NOx by Distance

4.2 Evaluation of the AQM and Existing Data

4.2.1 Evaluation of the Data

(1) General

As is known from the result of this study, the air pollution of Skopje is extremely serious particularly in winter. The Government of Macedonia has been carrying out various pollution abatement programs to overcome this problem, but has faced difficulties. For example, monitoring performed conventionally with existing samplers is not enough to immediately cope with an increase in the air pollution concentration, etc..

Introduction of the AQM system as planned has enabled a real-time understanding of the fluctuation of the concentration over time, thereby assisting the Macedonian Counterpart to achieve its objectives. These objectives include the understanding of the current status of air pollution and implementation of the appropriate countermeasures, development of the monitoring system to serve for review of the counter-measures, as well as development and implementation of regulatory laws, and promotion of the appropriate environmental management aimed at entry in the EU market.

Monitoring with the existing samplers offered only the daily average, and days were required to obtain the results. Consequently, no effective countermeasure was possible and time-dependent fluctuations could not be determined. On the other hand, the AQM system has the advantage and is thus highly valued as a solution to the above-indicated drawbacks when introduced.

(2) Evaluation

Evaluation of the accuracy of the data obtained through monitoring is dependent on whether or not the following points are properly taken into account.
In order to acquire accurate data, the monitoring equipment needs to be incorporated in the traceability system. In addition, the steps involved in the measurement and operation must be minimized to eliminate possible causes of errors. The monitoring system must be maintained thoroughly as a whole, including the screening of measured data.

Evaluation of the data obtained with the AQM system is as follows.

- The monitoring equipment for gaseous materials (SO_2, etc.) is calibrated automatically every day using a standard gas, thereby guaranteeing a degree of traceability basically equivalent to that in Europe and the USA; and
- The SPM meter directly measures the weight of the SPM of 10 μm or less sampled on a filter paper as changes in the frequency, minimizing the intervening error factors.

In this way, the data obtained with the AQM system can be considered as highly reliable if the system is maintained properly. On the other hand, the existing sampler has the following demerits:

- The SO_2 concentration is determined by means of a manual analysis with the prepared standard solution. Many steps are necessary until the data is obtained, resulting in the possibility of hardware and human errors.
- In the case of black smoke, dust collected on the filter paper is measured in the form of scattered light. Consequently, the data obtained refers to the relative concentration, that is to say, the mass is not measured directly. Moreover, the black smoke uses dust as a target and is basically different from the SPM meter. Proper attention must be given to these facts during the evaluation of the data.

When the monitored data is compared between the current case with the existing samplers and the AQM system, the latter is considered to offer a higher degree of accuracy with less error factors. However, the AQM system does not always give accurate results and may indicate the wrong data due to noise and other factors if the maintenance is not sufficient. On the other hand, the monitoring system with the existing samplers may offer the highly accurate data if proper attention is given to error factors.

The method for determining the suitability of the monitoring data was detailed in the previous paragraph "Validation of the Monitoring Data". The essential points, from a different viewpoint, are summarized below:

a) The comparison with the concentration level at other locations
b) The comparison of fluctuation of the concentration among different components
c) The study of the relationship between the concentration and the meteorological conditions
d) A cross check among monitoring equipment and different monitoring methods
e) Study of the error factors when the data is considered to be incorrect

Concerning a) through c), the central station can conduct the check with ease. It is necessary to screen of the data to exclude any abnormal values. In cases other than a) through c), and when the monitoring data is considered to be abnormal, however, such data should not be excluded readily if the cause of the error can not be explained rationally.

Methods for evaluating the accuracy of the data may specifically include a cross-check of equipment employing multiple monitoring methods by using the standard gas, monitoring of the environmental atmospheric quality concentration through parallel operation of the equipment, etc..

As the cross check results of the existing samplers with the standard SO_2 gas point out, there are various error factors including the error among laboratories. It also became evident that proper consideration of these factors ensured satisfactory data.

The past and future data of existing samplers can be used for analysis examining thoroughly the results of various cross-check obtained from this Study.

4.2.2 Method of Data Processing and its Reporting

Automatic continuous monitoring has become possible in Skopje. In order to announce data publicly, validation and evaluation of the monitoring data before hand are necessary.

(1) Validation of the Monitoring Data

To obtain a high credibility of measured value, smooth operation of both measuring system and telemeter system is essential. It is also important to maintain the performance of measuring equipment by careful maintenance system that involves both some cost and labor works. However, even with enough maintenance and control, the occurrence of transmission error due to abnormal noise at recording is still unavoidable. Thus the assurance check of measured value is also necessitated to maintain a high level of credibility.

1) Contents of Definition Work

The data collected in monitoring center is not only applicable as hourly or daily data but also needs to be statistically processed required for each. It is summed up as monthly or yearly data after checking and correcting the abnormal values. It is desirable that the measured values of the year concerned should be published as "National Air Pollution Report (tentative name)" after having been published by each municipality.

a) Daily Confirmation of Measured Value

Daily confirmation is the most basic work, not only making tables using measured data collected by on-line system as hourly data but also verifying the normality of monitoring data collected by processing such as comparing them with reference data set up in each measuring item in advance. On-line data sent to the monitoring center has to be recorded together as a list with message of maintenance and trouble condition of measurement instrument. It is an essential work to maintain and control those integrated data and information with the aim of promoting measures of environmental control.

b) Confirmation of Measured Values

Confirmation of measured values is a work to check the validity of measured values by comparing collected values with various information such as reports on maintenance and control execution. Generally, it is often carried out in the step of creating monthly report. The process starts from checking up the measured values collected in monitoring center with those by each measurer in monitoring stations. In many cases, each measured value in 24-hour the day concerned is checked up once a week or once in ten days in every month. As there are so many values to be checked, it is also recommended to compare various message signals added in the measured values and pick out the values which should be checked especially.

c) Data Screening

Data screening is a work to detect abnormal values, judging from measured values accumulated in the past. The criteria data should be decided after having appreciated fully the distribution of calculation value properties such as hourly value, daily mean value and monthly mean value as well as their relations with various statistics, using the past data as base data. Methods of data screening are shown below.

i) Method of Using Defined Data Obtained by the Station Concerned in the Past

Screening of defined data as the judging value of each measuring item can be done by setting up the upper and lower limit values.
Since the values measured continuously are strongly related to the previous and following values in general, screening can be done by setting up the variational upper limit value as the judgment value.

ii) Method of Using Change Volume of Measured Values

It is a method of using periodic change property of measured values, and the changing quantity usually seems to be periodical, related to month or season. Therefore, screening can be done by setting up a certain period when the values hardly change after a certain time, or when they continue simply increasing or decreasing.

iii) Method of Using Other Items in the Same Station or Same Items of the Adjacent Station

As many patterns of the time change among measured items or adjacent stations have a fixed tendency, screening can be done by setting up the judgment value based on it.
It is possible for experienced engineers to screen those data manually if the quantity is small, but a lot of labors are required if the volume is big. Accordingly, at present, the realization of better efficiency and standardizing is being planned by computerizing a part of data screening.

2) Judging and Processing of Abnormal Values

It is necessary to retrieve abnormal values and correct extracted values to accurate ones for keeping the reliability of measured values to be a fixed standard. It is called an abnormal value processing. Basically, an effort should be made to collect measured value as much as possible.
As for the values extracted as abnormal one, they are needed to be searched their causes. It is required to set up unified judging criteria to loose or modify those measured values in each cause so that they may be executed the processing of no correcting, correcting or missing.
If all the abnormal values are dealt with as unknown one, the information volume of measured data is decreased and the values cannot be used effectively. Therefore, "Processing criteria of unknown value" is required to be set. The processing criteria is the standard to judge whether the cause of abnormal value obtained every hour by measurement is in the allowance range of accuracy and whether the modification is available in principle or not. It should be set in accordance with technical standard of measurement in presence

and the purpose of measurement. After having set it up, it is also desirable to improve the contents according to the improvement of technology and the change in purposes of measured values.

The examples of judging and processing of abnormal values are described as follows.

a) Abnormality of Measuring Equipment

When the failure of the equipment is evident, all the measured values are considered to be unknown. However, those values would be modified as the measured data in such cases; sensitivity change is recognized in correcting, zero drift is recognized, abnormality is found in calculation device and modification available in principle, etc..

b) Abnormality of Telemeter System

When abnormal values are collected by data logger or telemeter system, they would be applied as measured value if it is clear that they were caused from collecting or recording errors, and if the normal measured values are confirmed on the recording chart.

c) Abnormality by External Causes

The measured values that had been directly influenced by local occurrence sources such as bonfires, burning trashes, parking cars or fire accidents are considered to be valid in principle. However, they may become "unknown values" if the cause is only a temporary one which is regarded as a very limited local pollution.

d) Others

When unnatural measured values appear and its cause is unclear, they are regarded as effective values in principle. However, a note should be put with each unnatural value.

(2) Reporting

1) Outline of the Software for Data Processing

The telemeter system installed in Skopje and the data processing software are outlined below. Details are provided in paragraph 6.2.6 (p.6-33).

The atmospheric quality and meteorological data taken at each AQM station (slave station) and other information from the monitoring equipment are recorded in the data logger and transmitted to the central station (master station) via modem by the radio telemeter.

The transmitted data is continuously recorded. This data-base is automatically processed by means of a computer processing system functioning in accordance with the previous setting of the user and displayed or printed as required.
Each AQM data is transmitted to the public information system by the radio telemeter for display of the atmospheric pollution concentration.

Figure 6.5 (p.6-35) of paragraph 6.2.6 shows the conceptual view of the whole of the data acquisition and processing system.

a) Data Acquisition Software of the Central Station
The data acquisition software of the central station consists mainly of two software modules as follows:

- Communication of information with each monitoring station for the purpose of recording the data as a database
- Various data processing according to the purpose

Specific features of the data processing software can be summarized as follows:

- Various functions, including preparation of reports (daily, monthly, etc.) of atmosphere quality concentration and meteorological data, time-course fluctuation diagram, statistical analysis and graphical representation (tables and figures) of data, etc., allowing the user to set these functions properly.
- Data acquisition with a function which enables the transfer of the recorded database to other spreadsheet programs (Excel and others)
- Software interface, which enables conversion of the data into the international database format for utilization of the user as required.

Other software features include the remote calibration of atmospheric quality monitoring equipment of each station and the function which confirms the calibration record and caution message.

b) Data Logger of the AQM Station

The data logger of AQM station records and stores data as the database for each station while transmitting the hour-value data to the data acquisition software of the central station each time communication is made with the central station. Similar to the case of data acquisition, the data logger can also transfer the database to Excel and other programs in addition to providing a display of the recorded data according to the user setting.
The data logger has the software function which records the calibration information and

various warning messages from each monitoring equipment and display them as required. This is transmitted to the data acquisition software of the central station, similar to the case of data transmission.

c) Software of the Public Information System

The software of the public information system is designed mainly for data indication on public information displays. Data indication of street displays for each station can be varied freely as required by the user to indicate the current concentration and its fluctuation by means of various figures, etc.. The monitoring items to be displayed and the figure display interval can be changed by the software.

2) Preparation of Reporting

Atmospheric quality and meteorological data obtained from the AQM station by this study is recorded by the data acquisition software of the central station for processing and subsequent preparation of the report in the form of various tables and figures. These reports are prepared daily, weekly, monthly and yearly, and in arbitrary intervals (every season, etc.). The major content of the report is as follows:

- Statistical processing report; average, maximum, minimum, 50%, 98%, and 99.9% value
- Table of frequency of appearance by wind direction and by wind speed class
- Chart of the hourly, daily and monthly averages of fluctuation (comparison between locations and items, etc.)
- Wind rose
- Bar chart representation of data, etc.

For reference, the daily and monthly reports are shown Tables 4.32 and 4.33. Note that the wind rose is shown in paragraph 4.1.1 (p. 4-1) and other processing data (tables and figures) are shown in Data Book, Figures D4.1 to D4.8 and Table D4.2.

Table 4.32 Example of Daily Report

Station: GAZIBABA
Report: Ministerstvo za zivotna sredina
1998/10/28 – Daily

DT Gb Dec.28.98	CO	NO	NO2	NOx	SO2	SPM	TEMP	HUMI	WDIR	WSPEED
	ppm	ppb	ppb	ppb	ppb	ug/m3	C	%	deg	m/s
00:00	5.1	19.8	60.3	80.2	64.0	463.8	-11.7	87.3	73.5	1.5
01:00	4.2	24.1	59.7	83.9	90.9	409.0	-12.0	87.7	79.8	0.9
02:00	3.4	8.9	52.6	61.5	90.4	337.1	-12.1	87.6	76.1	1.0
03:00	2.5	1.0	36.7	37.8	65.3	252.8	-12.3	87.3	76.3	0.5
04:00	3.0	3.3	45.4	48.7	65.4	272.7	-12.5	86.0	82.8	0.9
05:00	2.8	2.7	39.8	42.5	65.4	244.5	-13.4	85.4	83.5	1.1
06:00	2.2	0.3	27.9	28.2	56.8	254.3	-13.3	86.3	72.8	0.9
07:00	3.3	9.1	41.5	50.7	62.5	348.5	-12.4	87.0	112.7	0.4
08:00	3.3	51.4	48.9	100.4	59.9	351.6	-12.1	87.4	111.7	0.9
09:00	3.0	34.3	45.3	79.7	115.1	322.0	-12.1	86.6	156.7	0.7
10:00	3.2	68.1	53.9	122.1	90.2	367.4	-11.3	86.5	87.4	0.4
11:00	3.5	62.0	59.0	121.1	77.8	404.0	-10.9	86.6	121.9	0.7
12:00	3.4	66.7	64.6	131.4	170.5	436.7	-10.4	86.9	133.3	1.0
13:00	5.5	71.3	75.3	146.6	168.4	476.9	-9.5	87.1	135.0	1.0
14:00	5.2	41.0	71.5	112.6	122.4	451.2	-10.0	86.9	122.5	1.8
15:00	3.6	32.6	74.8	107.4	97.7	453.4	-10.1	87.2	125.7	1.4
16:00	4.6	56.7	88.8	145.6	109.2	489.8	-10.1	87.0	124.6	0.5
17:00	5.4	47.0	63.3	110.3	96.5	529.7	-10.3	86.9	94.8	0.6
18:00	5.2	18.9	16.4	35.4	104.4	564.9	-11.3	86.5	101.3	1.0
19:00	5.2	68.0	68.5	136.6	111.8	545.4	-11.8	86.5	87.3	1.1
20:00	4.8	59.0	70.9	130.0	142.9	464.7	-12.0	85.9	125.7	0.8
21:00	4.5	46.7	66.6	113.4	113.9	433.8	-12.0	85.6	115.0	0.6
22:00	4.7	52.6	66.9	119.5	138.4	434.4	-12.1	85.4	100.6	0.3
23:00	4.9	62.2	66.6	128.8	137.2	474.3	-11.8	85.4	101.9	0.6
Average	4.0	37.8	56.9	94.8	100.7	407.6	-11.6	86.6	104.3	0.9
Minimum	2.2	0.3	16.4	28.2	56.8	244.5	-13.4	85.4	72.8	0.3
Maximum	5.5	71.3	88.8	146.6	170.5	564.9	0.0	87.7	156.7	1.8
Recovery(%)	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Recovery)	24	24	24	24	24	24	24	24	24	24
50 perc.	3.6	41.0	59.7	107.4	96.5	433.8	-12.0	86.6	101.3	0.9
98 perc.	5.5	71.3	88.8	146.6	170.5	564.9	-9.5	87.7	156.7	1.8
99 perc.	5.5	71.3	88.8	146.6	170.5	564.9	-9.5	87.7	156.7	1.8
Stdev.	1.0	24.7	16.6	38.2	33.6	93.2	1.0	0.7	23.2	0.3

Table 4.33 Example of Monthly Report

Station: CENTAR
Report: Ministerstvo za zivotna sredina
1998/10/01 - Monthly

	CO	NO	NO2	SO2	SPM	TEMP	HUMI	WDIR	SPEE
	mg/m3	ug/m3	ug/m3	ug/m3	ug/m3	C	%	deg	m/s
1998/10/01	2.9	79.1	41.7	88.8	107.0	16.3	69.6	219.7	0.9
1998/10/02	3.2	69.7	57.2	133.1	111.5	15.9	78.1	242.5	0.9
1998/10/03	2.2	39.1	40.0	67.9	46.5	16.0	88.7	241.9	1.0
1998/10/04	1.7	39.3	24.8	76.2	57.4	15.9	73.0	264.5	1.4
1998/10/05	2.9	85.8	37.5	121.9	99.2	14.5	76.6	220.9	0.9
1998/10/06	3.4	95.0	46.8	157.9	107.9	16.2	74.5	225.2	0.8
1998/10/07	4.1	113.9	47.8	153.8	113.3	16.3	84.3	245.4	0.8
1998/10/08	3.0	71.1	41.1	117.8	72.3	17.2	81.2	171.1	1.3
1998/10/09	3.0	77.1	41.0	125.9	82.8	17.4	77.1	203.4	0.9
1998/10/10	3.7	99.9	44.9	117.6	118.7	16.3	84.6	218.4	0.7
1998/10/11	3.1	90.3	35.0	144.4	113.5	17.4	77.7	227.1	0.9
1998/10/12	2.5	64.5	29.4	162.4	87.8	17.3	81.2	220.9	0.7
1998/10/13	1.9	40.0	26.4	216.7	30.0	12.3	81.9	283.8	2.2
1998/10/14	1.4	28.9	25.6	128.9	42.9	10.9	59.0	293.8	2.0
1998/10/15	2.2	64.1	33.8	52.5	65.9	11.4	57.9	268.1	2.0
1998/10/16	3.3	111.0	59.6	145.9	134.2	11.4	71.4	222.6	1.0
1998/10/17	3.7	140.1	35.0	205.1	114.1	11.4	83.5	227.0	0.8
1998/10/18	3.8	133.9	40.6	164.4	107.6	11.5	85.5	235.4	0.7
1998/10/19	3.8	128.7	45.6	223.8	161.6	11.6	85.3	222.1	0.8
1998/10/20	4.4	137.4	52.9	239.1	121.2	13.1	83.6	251.0	0.7
1998/10/21	2.0	49.6	32.0	142.8	63.1	10.7	72.4	290.3	1.8
1998/10/22	3.2	118.0	42.0	197.7	124.4	9.7	79.3	231.7	0.9
1998/10/23	3.6	121.1	44.2	198.2	127.3	10.2	84.2	258.1	0.9
1998/10/24	3.6	130.8	35.1	121.0	148.5	8.7	85.6	222.7	0.7
1998/10/25	3.0	90.9	38.9	123.8	136.2	10.7	80.7	226.5	0.8
1998/10/26	3.1	60.4	46.5	52.8	67.2	12.0	84.1	264.6	1.4
1998/10/27	2.4	68.4	41.1	54.6	58.1	10.6	54.1	289.8	1.9
1998/10/28	3.5	117.4	52.5	120.8	108.2	6.5	71.1	229.4	0.9
1998/10/29	5.0	171.7	72.6	171.2	146.8	8.3	72.6	237.7	0.8
1998/10/30	3.4	100.4	49.9	75.3	85.7	9.8	66.4	245.4	1.4
1998/10/31	2.3	78.3	47.7	100.0	79.0	8.0	74.0	205.0	1.1
Minimum:	0.0	0.0	0.0	2.7	0.2	1.5	33.7	88.0	0.2
Maximum:	13.2	530.8	143.3	682.6	279.6	23.6	96.6	323.3	4.7
Average:	3.1	90.8	42.2	136.2	98.1	12.8	76.7	238.9	1.1
ecovery%:	100%	100%	100%	99%	100%	100%	100%	100%	100%
Recovery:	744	744	744	737	744	744	744	744	744
50 perc.:	2.3	59.8	38.7	116.4	91.2	12.7	80.1	267.0	0.9
98 perc.:	8.6	298.7	95.9	413.5	203.5	22.0	94.8	313.9	3.0
99.9 per.:	12.6	460.8	122.9	678.9	276.6	23.6	96.2	323.0	4.1
Std:	2.2	83.1	24.0	92.5	53.1	4.4	14.9	63.4	0.6