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Air Quality Impact Assessment

Cairo International Airport, Terminal 3 Baseline studies

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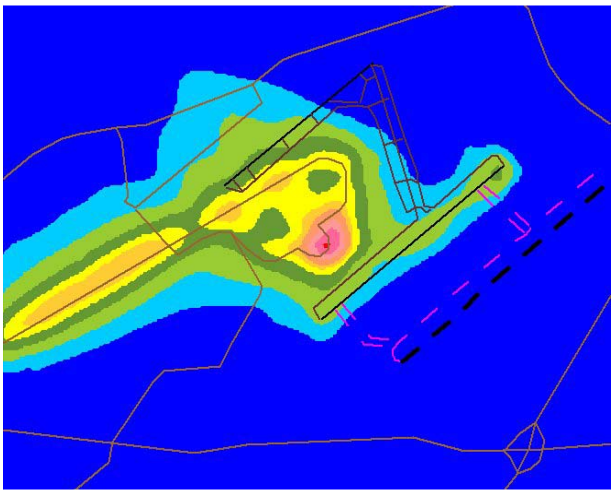

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Summary

The Norwegian Institute for Air Research (NILU) together with the Egyptian Environmental Affairs Agency (EEAA) has been requested by the Ministry of Civil Aviation to undertake an Environmental Impact Assessment (EIA) related to air pollution emitted from the different sources at a new air terminal at the Cairo Airport.

The first part of the study presents some of the baseline data, which have been collected for describing the present situation in the airport area. The main part of this study has been based upon measurement data on meteorology and air quality collected by the EIMP programme at EEAA. A special designed local field measurement programme was started in July 2003.

In a meeting with the Minister of Civil Aviation on 4 June 2003 representatives from EEAA and NILU were briefly informed about the plans for the new Terminal. Necessary input data were collected during the short project period available. Much of the requested information to perform an impact assessment was never made available. Several assumptions based on previous experience had to be made as a basis for the emission estimates.

The baseline study for identifying the present air quality have been based on measurements of meteorology and air quality as well as modelling of emissions and air pollution concentrations.

Measurements data collected by the EEAA programmes indicated that the air quality in the airport area is fair. The main problem is suspended particulate matter originating from traffic, open air burning and natural wind blown dust. Ozone concentrations may also during specific periods in the summer season exceed the limit values given in Law no. 4 of Egypt.

Calculations of emissions and concentrations of NO_X, CO, PM_{10} and HC (VOC) around the airport have been performed for 2002/03 and for future developments. The results indicated that the contribution from the airport on a local and regional scale is small. Close to the roads and in the maximum impact areas of the emissions from airport activities the additional contribution could reach up to 25 % of the existing concentration levels.

The NO_2 (NO_X) concentrations were closest to the air quality guidelines. Areas very close to the runways may experience concentrations due to the aircraft take off operations only, which are higher than the background concentrations measured in the airport area to day.

CO concentrations in some cases near the terminal building could reach levels exceeding the limit values.

Air Quality Impact Assessment
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1 Introduction

The Norwegian Institute for Air Research (NILU) together with the Egyptian Environmental Affairs Agency (EEAA) has been requested by the Ministry of Civil Aviation to undertake an Environmental Impact Assessment (EIA) related to air pollution emitted from the different sources at a new air terminal at the Cairo Airport. In a meeting with the Minister of Civil Aviation on 4 June 2003 representatives from EEAA and NILU were briefly informed about the plans for the new Terminal.

This report has concentrated on the existing environmental conditions based on measurements and modelling of the present activities at the airport.

1.1 Objectives and deadlines

The objectives of the study outlined below is to collect the necessary input data, perform dispersion modelling and present the future air quality as a result of the Cairo Airport New Terminal. An environmental impact assessment report related to air pollution will be presented before September 2003 provided all necessary input data have been collected and forwarded to NILU before Mid July 2003. Results of baseline studies and field measurements must be presented before 10 August 2003.

1.2 Scope of work

The scope of work has included several tasks, which had to be undertaken with very short deadlines. These tasks were:

1. Collect maps and GIS information
2. Emission data, background information
3. Meteorological data, from EIMP and Supplementary local measurements
4. Background air quality Cairo, EIMP
5. Baseline measurements
6. Emission modelling and complete inventory
7. Dispersion modelling
8. Air quality assessment and reporting
9. Workshop, presentation and training

2 New Terminal, Airport location and Sources

2.1 The new Terminal

A new terminal complex (TB3) has been designed for the Cairo International Airport. Functionally it has been integrated with the existing terminal building

TB2. The combined terminals are dimensioned to accommodate a capacity of 9 million international and 5 million domestic passengers per annum. Reservations are made for the ultimate capacity of 50 million. Included in the project are the related aprons, taxiways, access roads, elevated roads, fuel supply system, loading bridges, drainage, airfield lighting and all other systems.

Figure 1: The Terminal 3 layout for the new Cairo Airport.

2.2 Location and prevailing winds

The Airport location northeast of Greater Cairo area is considered good location from the air quality point of view. The prevailing wind direction over the greater Cairo area is from around north. At the airport area north-north-westerly winds are totally dominating in the summer season, while southerly and westerly winds are also present in the winter, bringing pollution from the airport away from the city (see Appendix B). Most often the airport area up will be upwind from the major air pollution sources in Cairo. The area will thus be fairly clean compared to the high concentrations frequently observed in Cairo.

2.3 Sources and compounds

The main sources of air pollution will come from aircraft engines, surface vehicles of all kinds, ground support systems, power plants, fuel tank areas, fire training activities and refuelling activities. The main air pollutant compounds acting as the most important indicators for air pollution in the surrounding areas will be:

Nitrogen oxides (NO_x, and especially nitrogen dioxide NO_2), are mainly emitted from road traffic, aircrafts and power production. Most of the emissions from cars will be as NO, while 5 to 20 % may be emitted as NO_2. The ratio NO/NO_2 from aircrafts is not easily available. However, NO will be oxidised to NO_2 by the presence of ozone. It is thus necessary to have some information about background ozone concentrations.

$NO + O_3 \rightarrow NO_2 + O_2$

Sulphur dioxide (SO_2), from power plants, waste burning, fires and diesel vehicles. SO_2 is assumed to represent a insignificant problem in the airport area. Only limited estimates have been undertaken.

Hydrocarbons (HCs) consisting of different subgroups of different compounds such as benzene, toluene and xylene (BTX) and volatile organic compound (VOC). Measurements are often undertaken as NMHC (non-methane hydrocarbons). The HC pollutants are normally a complex mixture of gases and aerosols from evaporation areas and releases of unburned fuels from aircraft engines (parafines), or car engines (mostly diesel). These emissions as well as releases from fuel storage areas and fuelling areas may be sources of odours. The largest emissions will occur in the taxing areas and around the terminal buildings.

Particulate matter (indicator PM_{10}, particles with diameter < 10 µm), from diesel vehicles and general activities, burning and transport. Suspended particles is the term for particles found in the air, including dust, dirt, soot, smoke, and liquid droplets. Particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or smoke. Others are so small that individually they can only be detected with an electron microscope.

Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, tilled fields, unpaved roads, stone crushing, and burning of wood.

Combustion in air craft and car engines normally creates fine particles less than 10 µm in diameter (PM_{10}) or less than 2,5 µm ($PM_{2,5}$). These small particles may cause health impacts. At take off we often see a black cloud of unburned hydrocarbons, creating small particles; soot or black smoke. For some engines the ICAO standards give a “smoke number”. However this can hardly be related to emission rates in kg/h.

Carbon Monoxide (CO) is a colourless, odourless gas that is formed when carbon in fuel is not burned completely. It is a component of motor vehicle exhaust, which contributes about 56 percent of all CO emissions nationwide. CO is also emitted from aircrafts during taxing and idling. Traffic emissions of CO will increase in the terminal area as a result of low speeds and long periods of idling.

Carbon Dioxide (CO_2), from all burning of fossil fuels, only a global problem.

3 Baseline studies

3.1 Available data

Data on meteorology and air quality have been collected from several sources. This information has been important to classify the present situation at the airport as well as providing valuable input to estimating future impact.

3.1.1 Meteorological data

Meteorological data are being collected on an hourly basis by the EIMP/EEAA programme at Abbaseya, only about 6 km southwest of the airport area. These data have been statistically treated and will be further evaluated and prepared for application in the modelling activity for the airport assessment.

Local meteorological data was also supposed to be collected at the terminal area during one month of air quality measurements performed in July-August 2003. These data would give information about the representativity of the Abbaseya data.

The air quality station at Abbaseya includes the following meteorological data, which are being measured continuously and transferred to a database as hourly average data:

- The wind speed
- Wind direction
- Temperature
- Humidity
- Net Radiation

Climatological data from the Egyptian Meteorological Authority (EMA) has been requested for this purpose. We have received a short summary of climatological data from the Cairo Airport Authority (Appendix B, Meteorology). Thirty-year statistics have been presented as wind roses for the airport. Any information on mixing heights and vertical temperature statistics based on radiosonde data in the lower atmospheric boundary layer has not been available, and these data have been estimated based on a meteorological pre-processor model (Bøhler, 1996). Atmospheric stability conditions as input to models were also be estimated using the NILU meteorological pre-processor.

3.1.2 Air quality data from permanent networks

General information about background air quality in the Greater Cairo area has been based on data collected from the EEAA air quality networks. EIMP (Environmental Information Monitoring Program) has been operating air quality measurements since 1998. The measurements are operated by EEAA in co-operation with Cairo University (CEHM) as a sub-contractor. (Abdelhady et al. 1999, 2000). The other network is mainly based on measurements of suspended particulate matter (PM_{10} and $PM_{2.5}$). This CAIP (Cairo Air Improvement Project) network is also operated under the supervision of EEAA.

Five years of data have given EEAA a comprehensive database to evaluate typical levels of SO_2, NO_2, PM_{10}, ozone, CO, black smoke (soot) and suspended particles in the air. Information is also available on some selected VOC, and on lead (Pb).

The EIMP program is operating 14 stations in the greater Cairo area. The data collected from one of these stations at Abbaseya, about 6 km south-west of the airport, will be considered representative for this study. The station is installed at the top of the Meteorological Authority Building in Abbaseya square. It is equipped with continuous monitors to measure the following parameters since the beginning of 2000 till now:

- Particulate Matter (PM_{10})
- Sulphur dioxide (SO_2)
- Ozone (O_3)

The station also includes a complete Automatic Weather station (see above).

The other source of information for air quality is the data collected at two sites in the CAIP air quality network, Heliopolis and Koby ElKoba stations. The CAIP monitoring network is measuring PM_{10} and $PM_{2.5}$ as daily average concentrations once every 6 day. The filters collected are being analysed for lead. This network started in September 1998 and is still running.

3.1.3 Background measurements at the airport area, 2003

Within the short deadline of the project it has been very limited possibilities to collect background information at the airport and in areas of the new terminal. However, we have included some measurements performed from a mobile station and from passive sampling.

The mobile laboratory has been located at 4 different locations in the airport area to measure in a continuous basis the concentrations of:

- Nitrogen oxide (NO_2, NO_x) (1 hour resolution)
- Sulphur dioxide (SO_2) (1 hour resolution)
- Carbon monoxide (CO) (1 hour resolution)
- Ozone (O_3) (1 hour resolution)
- Hydrocarbon (NMHC) (1 hour resolution)
- Particles < 10 um (PM_{10}) (24 hour average)

The locations of the mobile lab are as follows:

- Site (1) in front of the loading/unloading area of TB2 to monitor the effects of the cars and traffic and the movement of passengers in this area.
- Site (2) at the parking lot of TB2 (the proposed site of TB3): to monitor the existing concentrations at the proposed site of TB3.
- Site (3) inside the existing Runway: to monitor the air quality near the landing and take off areas.
- Site (4) inside the existing Runway to monitor the air quality near the existing utilities (power stations, fuelling tanks).

The positions are indicated in Figure 2.

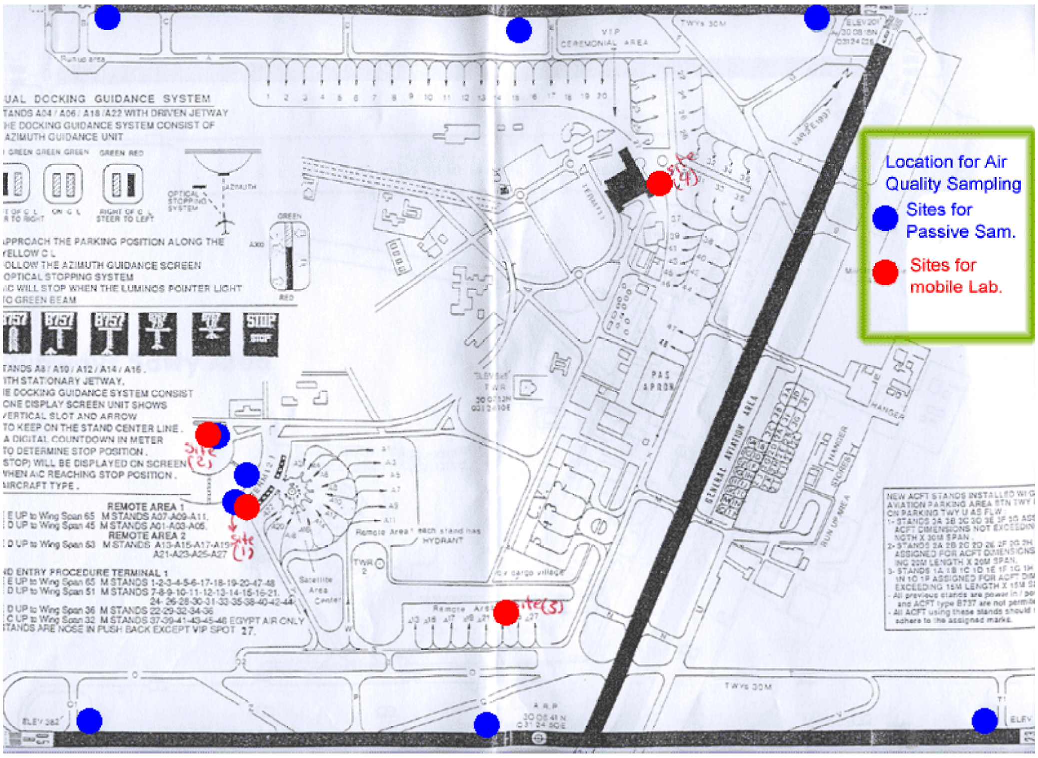

Figure 2: Location of the mobile laboratory for air quality monitoring at the airport, July-August 2003.

There will be also samples of NO_2, SO_2, and VOCs collected with passive samplers and steel canisters at the same locations and at additional locations as indicated in Figure 2. Concentrations will be determined by chemical analyses in the laboratory and he data will be available after a few days.

3.2 Air quality in the surrounding area of the Cairo airport

3.2.1 Suspended particles (PM_{10})

Particles can be suspended in the air for long periods of time. Some particles are large or dark enough to be seen as soot or black smoke. Others are so small that individually they can only be detected with an electron microscope. Some particles are directly emitted into the air. They come from a variety of sources such as cars, trucks, buses, factories, construction sites, unpaved roads, stone crushing, and burning of waste and wood.

Thoracic particles that may be transported to the lung after breathing is from a health point of view the most interesting indicator for ambient dust. These particles are less than 10 micrometer in diameter and are called PM_{10}. A part of the PM_{10} is black smoke or soot most often originating from combustion.

The average PM_{10} concentrations at Abbaseya ranged typically between 100 and 300 $\mu g/m^3$ as seen in Figure 3. PM_{10} concentrations measured with different type of instruments; in different measurement programmes at a variety of sites and at different seasons have been studied as part of the EIMP programme (Sivertsen, 2003). The results of these studies indicate that the typical average background concentration of PM_{10} seems to be around 70 to 80 µg/m^3. A level of 70 µg/m^3 is equivalent to the Air Quality Limit value for 24-hour average PM_{10} concentrations as given by the Law no. 4 of Egypt.

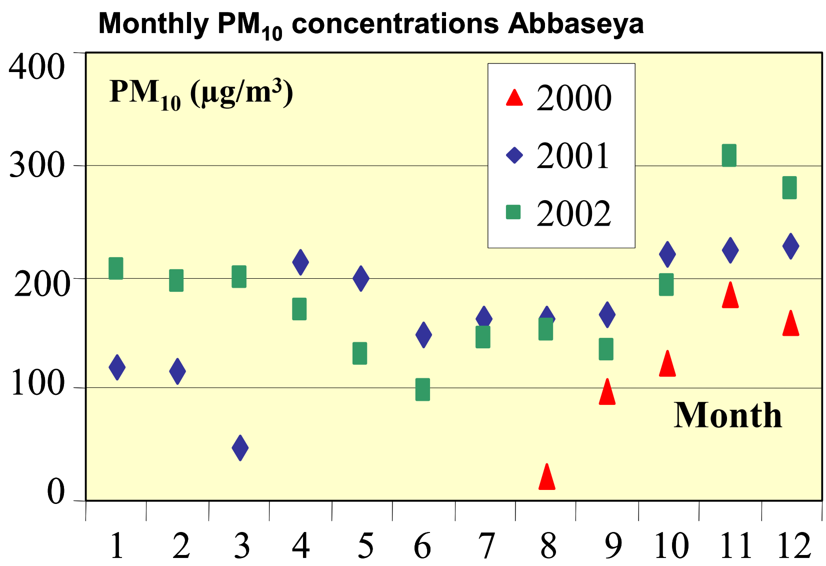

Figure 3: Monthly average concentrations of PM_{10} at Abbaseya measured during the years 2000, 2001 and 2002.

These levels can be found also in areas where local anthropogenic sources do not impact the measurements. The "natural background" levels are thus assumed to be originating from wind generated dusts in the desert areas surrounding the large urban areas such as Cairo.

Concentrations of suspended dust measured as PM_{10} are exceeding national and international air quality limit values almost in all sites measured in greater Cairo area.

3.2.2 Sulphur dioxide (SO_2)

Sulphur is prevalent in all raw materials, including crude oil, coal, and ore that contains common metals like aluminium, copper, zinc, lead, and iron. SO_2 is formed when fuel-containing sulphur, such as coal and oil, is burned, and when gasoline is extracted from oil, or metals is extracted from ore. SO_2 dissolves in water vapour to form acid, and interacts with other gases and particles in the air to form sulphates and other products that can be harmful to people and their environment.

The SO_2 concentrations measured at both sites (Abbaseya & Nasr City) rarely exceed the AQL values as given by Law no. 4. During three years of measurements (from 2000 to 2002) the daily average-air quality limit value has been exceeded only one time at Abbaseya station while at Nasr City there were no exceedances at all.

Typical monthly average concentrations of SO_2 as measured at Abbaseya are presented in Figure 4. The SO_2 concentration normally ranges between 20 and 60 µg/m^3. The highest concentrations occurred during the winter season, when the winds are most often blowing from the city centre of Cairo to the measurement site.

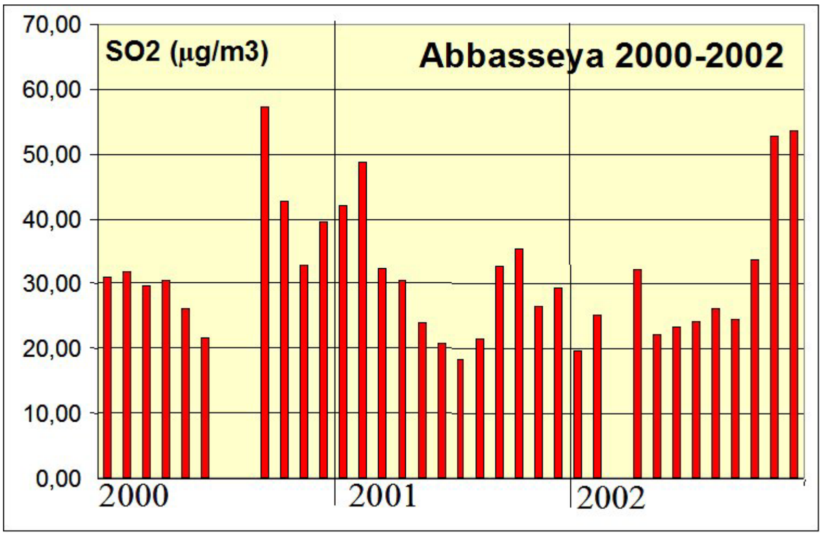

Figure 4: Monthly mean SO2 concentrations at Abbaseya from 2000 to 2002.

SO_2 concentration distributions have also been studied in the Cairo area using inexpensive passive samplers (Sivertsen, 2001 b). These measurements have been compared to data from the monitoring sites. The SO_2 concentrations measured in Cairo were averaged over a period of two weeks. To discuss the possibility for the air pollution concentrations to exceed a given air quality limit values, the measured levels should be compared to concentrations of SO_2 of about 100 µg/m^3.

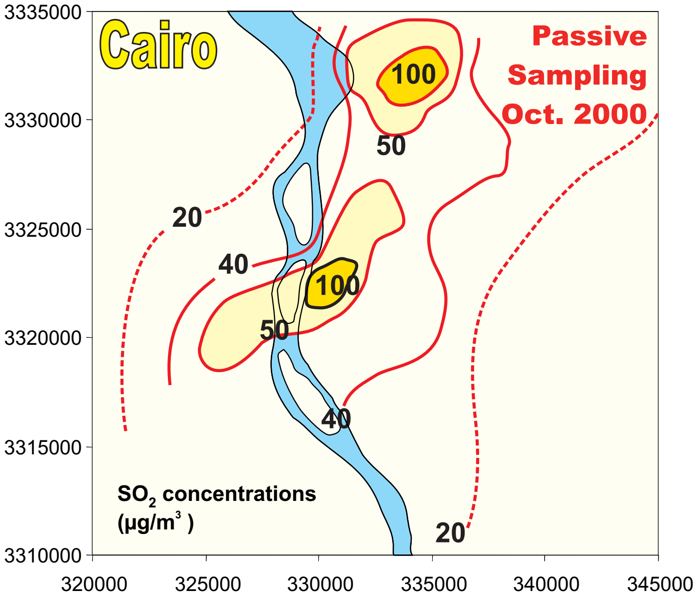

Figure 5: SO_2 concentrations measured by passive samplers in Cairo, 14-28 October 2000

Two areas were identified during this measurement period to have a potential for exceeding the air quality limit values given by Egyptian air quality law. These areas were found around the industrial area Shoubra EL Kheima north of the city and in the city centre itself.

Most of the city centre areas of Cairo had concentrations exceeding 50 µg/m^3, which is the annual average concentration limit given by World Health Organisation. The results from the passive sampling programme compared reasonable well with measurements performed by the permanent network of monitors and sequential samplers operated by the EIMP/EEAA programme. It could be concluded that the expected annual average concentration level around the Cairo airport area could be slightly less than 50 µg/m^3.

3.2.3 Frequency distributions of PM_{10} and SO_2

The frequencies of one-hour average concentrations of SO_2 and PM_{10} as measured at Abbaseya is presented in Figure 6. Again we can see that for some months (July and November 2002) the one-hour average PM_{10} concentrations exceeded 1000 µg/m^3 during more than 1% of the time. PM_{10} is a major air pollution problem in the greater Cairo area.

SO_2 concentrations exceeded 170 µg/m^3 during more than one percent of the time in November 2002. The air quality limit value (1-h average) for Egypt is 350 µg/m^3. During one air pollution episode in April 2003 SO_2 concentrations were recorded at 400 µg/m^3 during one hour at Abbaseya. This was again one of the very specific air pollution episodes over Cairo described in several reports. (Sivertsen et al., 2001) (Sivertsen and Dreiem, 2000 Appendix I).

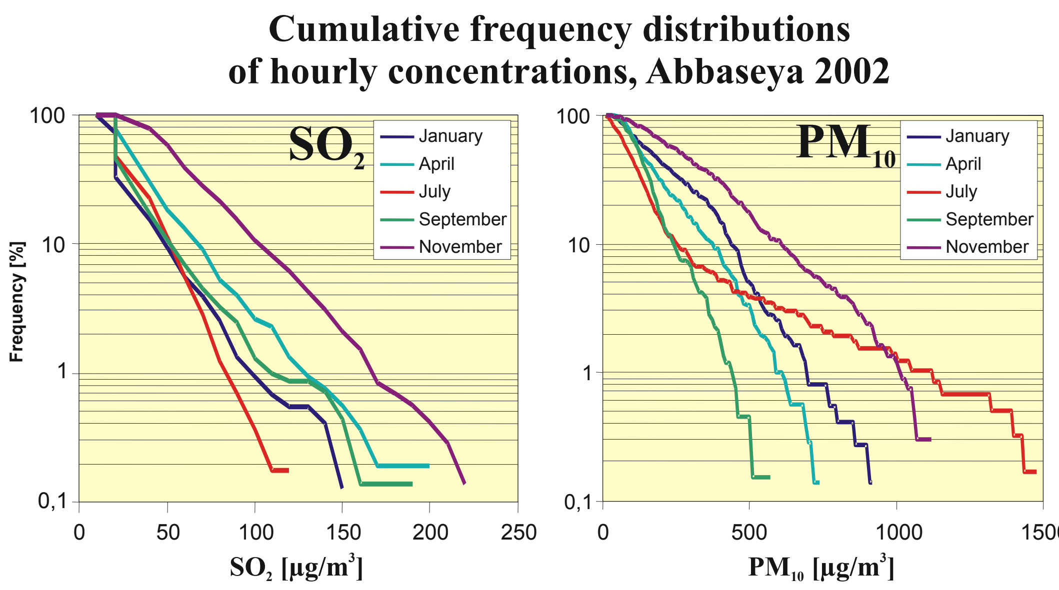

Figure 6: Cumulative frequency distributions of hourly concentrations of SO_2 and PM_{10} measured at Abbaseya 2002.

3.2.4 Nitrogen oxides and NO_2

There are no NO_2 concentration measurements available at Abbaseya. However, NO_2 is being measured at many other sites. One typical example of measurement data collected at FumAl Khalig Square in Cairo is presented in Figure 7.

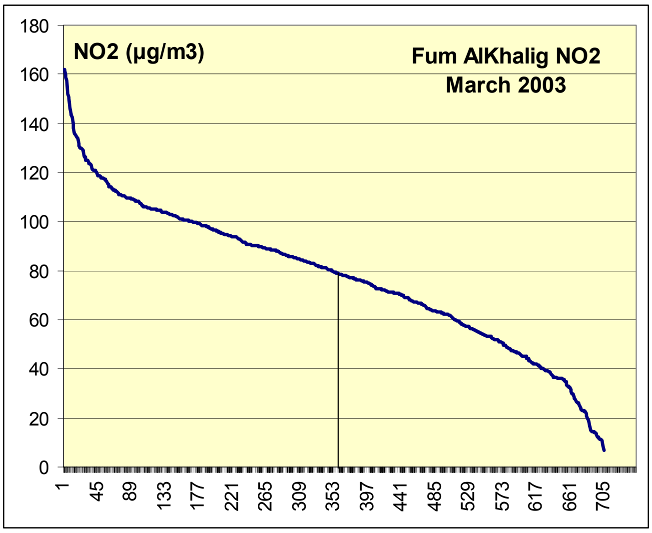

Figure 7: A typical distribution of NO_2 concentrations measured at FumAl Khalig Square in Cairo, March 2003.

The median concentration of NO_2 was 80 µg/m^3 while the hourly maximum concentration was measured at 162 µg/m^3. From the field study using passive samplers (Sivertsen, 2001 b) it was shown that typical NO_2 concentrations in the greater Cairo area ranged between 40 and 90 µg/m^3 as weekly average concentrations. The one-hour average limit value of 400 µg/m^3 was not exceeded in 2002. However, the 24-hour average limit value of 150 µg/m^3 was exceeded during one to five days in the streets of Cairo.

3.2.5 Carbon monoxide (CO)

In the streets of Cairo it seems evident that the 8-h average Air Quality Limit value is more often exceeded than the 1-h average values. Traffic jam and traffic congestion in the busiest streets is probably the main reasons for these relatively high CO concentrations. The Air Quality Limits in Law no. 4 for CO also include an 8-hour average value of 10 mg/m^3.

The main reasons for exceeding the CO limit values are petrol cars idling in congested streets. Idling at the unloading/loading area of the airport may very well be a reason for high CO concentrations in the future.

3.2.6 Ozone

High concentrations of surface ozone have been observed as a result of regionally produced secondary pollutants in the Cairo region. Also the background measurements of tropospheric ozone at Ras Mohamed, at the southern tip of Sinai, show high concentrations of ozone, especially in the summer season.

The urban area of Cairo experiences occasionally very high air pollution levels due to emissions at ground level of pre-cursors such as NO_x and HC and limited dispersion conditions during adverse meteorological situations (low wind inversion conditions).

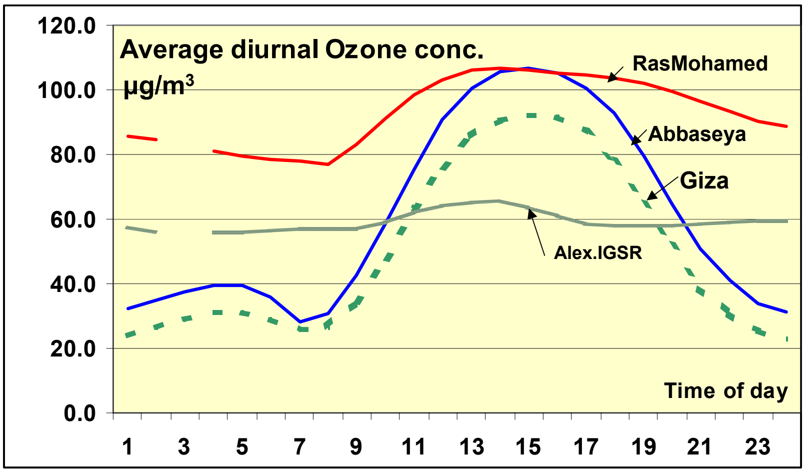

Figure 8: Annual average diurnal variation of ozone measured at 4 sites in Egypt 2000-2002

In the greater Cairo area the transport time during hot summer days is long enough so that large amounts of harmful ozone is being created in the area. Afternoon maximum concentrations as recorded at a roof station at Abbaseya are typical examples of this kind of regional formation of ozone. The site of Abbaseya represents the kilometre scale urban areas away from local sources.

Afternoon average concentrations at Abbaseya were 100 µg/m^3 as seen in Figure 8.

3.2.7 Background measurements at the airport area, 2003

As Part of this Environmental Impact Assessment study at the new airport terminal, air pollution measurements is being undertaken around the new terminal using an air pollution mobile laboratory, passive sampling and VOC canisters.

The first results based on measurements undertaken from 1 to 18 July 2003 are presented below.

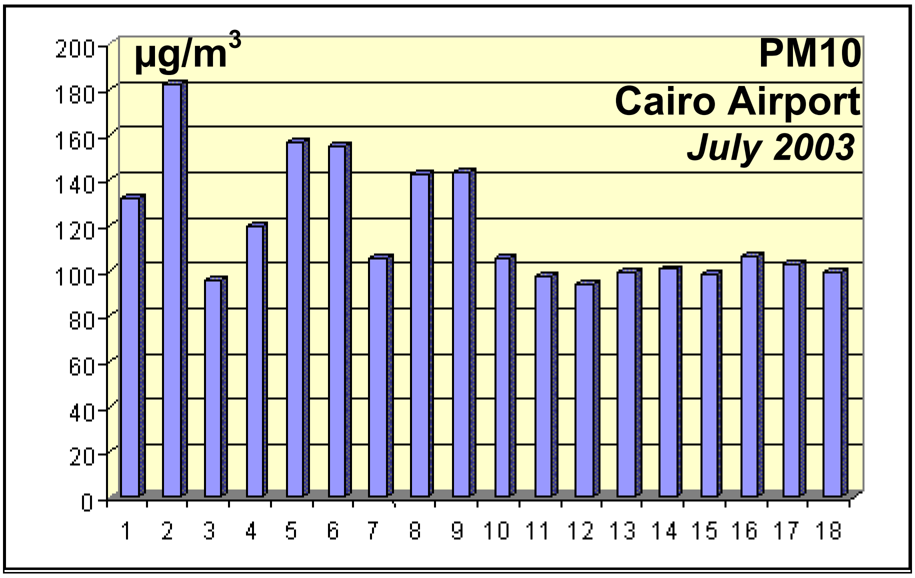

Figure 9: Daily average concentrations of PM_{10} measured at the Airport Terminal 2 (location 1 and 2) from 1 to 18 July 2003.

As can be seen from Figure 9 the daily average PM_{10} concentrations ranged between 100 and 180 µg/m^3. The limit value given in Law no.4 of Egypt is 70 µg/m^3 for this averaging time. As mentioned before we have seen that studies undertaken as part of the EIMP programme have indicated that the typical average background concentration of PM_{10} seems to be around 70 to 80 µg/m^3. The concentrations measured in the airport area were more than twice that level. This indicates that there are local sources for suspended particulate matter in the area generated by traffic, local burning and other sources in the greater Cairo area.

The highest one-hour average concentration of PM_{10} was recorded in the evening of 5 July at 22.00 hrs. The level was at this hour 357 µg/m^3.

Hourly concentrations of NO_2 and ozone are presented in Figure 10. During the first week of measurements for NO_2 concentrations the maximum recorded *l*concentration as one-hour average was around 50 µg/m^3. The main local source for these concentrations was probably vehicle emissions. Some emission may also have been generated from aircraft movements. The permissible air quality limit value as given in Law no.4 is 400 µg/m^3.

Hourly ozone concentrations ranged from 5 to 84 µg/m^3. A very clear diurnal pattern can be seen in the data, with a maximum from midday till late afternoon. This was the same case for the NO_2 concentrations, but less pronounced than for ozone.

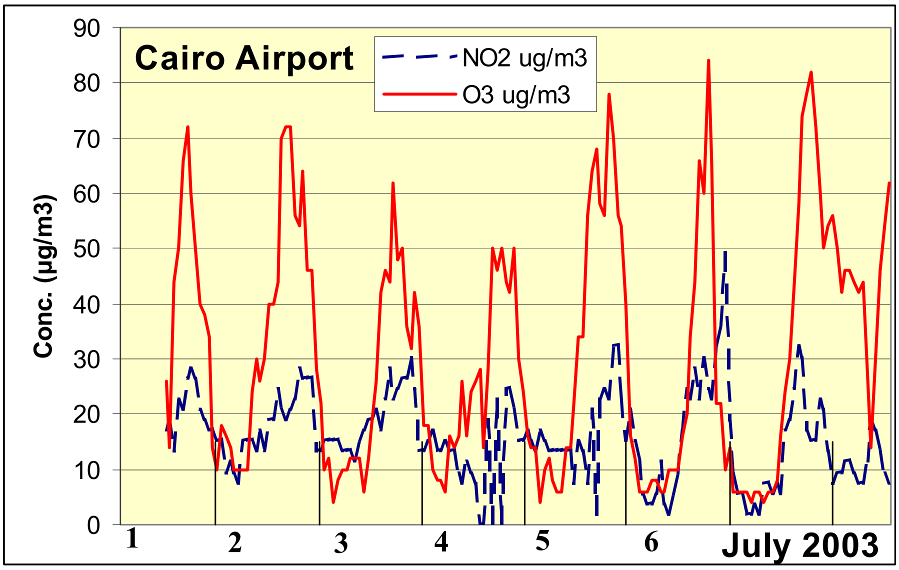

Figure 10: Hourly concentrations of NO_2 and ozone measured at the airport terminal 2 (N 30º 06' 37.1", E 031º 23' 58") from 1 to 8 July 2003.

This pattern indicates that ozone is formed regionally in the greater Cairo air basin. Afternoon concentrations of 80-90 $\mu g/m^3$ are quite normal for residential areas in the outskirts of the big city. We should be aware of the fact that the winds were probably from northerly directions so it is not the result of emissions of precursors in the Cairo city area we see. In these cases the ozone concentrations could easily be twice as high.

Figure 11 shows that the CO concentrations measured at the terminal during the first week of July 2003 most often was 1 and 2 mg/m^3. Only two hours were observed higher than 5 mg/m^3.

Passive sampling study is being done parallel with the continuous measurements around the terminal area. Three samples have been taken around the new terminal area showing that SO_2 concentrations are fairly low in the area: The highest concentration recorded was 69.4 $\mu g/m^3$.

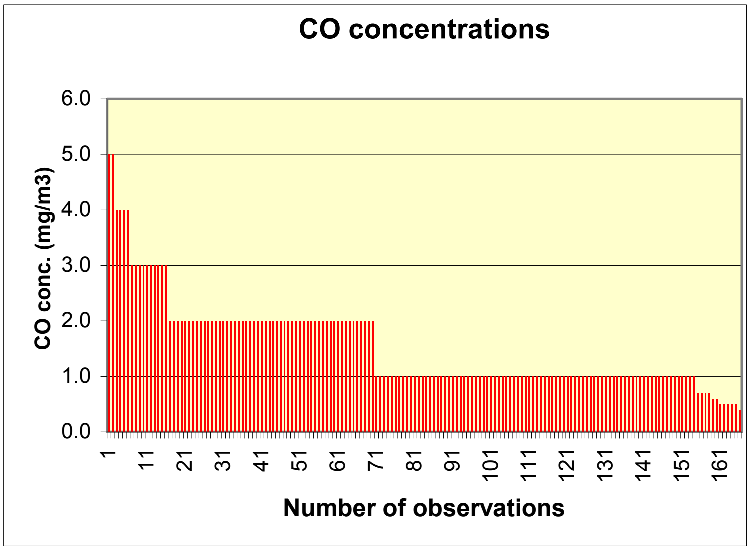

Figure 11: CO concentrations (hourly average) measured from 1 July to 8 July 2003.

VOC measurements around the new terminal during the first week shows that there is high concentrations of carbon emissions in the area since the concentrations of C1-C4 was 316.2 µg/m^3 while the concentrations of the other volatile compounds were at the normal level since the concentrations of n-Butane, Iso-Butane and n-Pentane were 2.2, 6.2 and 16.4 µg/m^3 respectively

3.3 "Background" air quality at the airport, a summary

Background concentrations have been evaluated based on measurements performed by the EIMP/EEAA programme as well as from the short-term measurements performed at the airport during July 2003. (Ahmed, 2003), (Sivertsen et al., 2001).

The data have been presented above and a summary of average background concentrations is given in the following table.

Table 1: Average background concentrations of some air pollutants in the Cairo Airport area.

Compound	Annual average ($\mu g/m^3$)	Max. daily ($\mu g/m^3$)	Max. hourly ($\mu g/m^3$)
NO_2	40 - 60	100	240
SO_2	45	130	250 (400*)
PM_{10}	170	700	2000
CO	-	5	30
Ozone	60	130	150

*) Maximum concentration during an air pollution episode

Suspended dust (measured as PM_{10} and TSP) is the major air pollution problem in Egypt. Annual average concentrations of PM_{10} range between 100 and 200 $\mu g/m^3$ in urban and residential areas and between 200 and 500 $\mu g/m^3$ near industrial areas. Daily average concentrations of more than 6 times the Air Quality Limit value for Egypt are being recorded occasionally in the urban areas of Cairo. The natural background concentration of PM_{10} in Egypt has been evaluated to represent levels close to or around the Air Quality Limit value of 70 $\mu g/m^3$ as a daily average. (Sivertsen and Dreiem, 2003)

High concentrations of NO_2 are most often observed in the most busy streets of Cairo and near major roads. Average concentrations of NO_2 measured at the airport in July 2003 were about 30 $\mu g/m^3$, while hourly maximum concentrations are expected to reach more than 200 $\mu g/m^3$ at the most busy hour of the year. Based on NO_2 measurements undertaken in Cairo city there are reasons to believe that the annual average NO_2 concentrations may be 40 to 60 $\mu g/m^3$ in the airport area.

The concentration of SO2 is normally expected to be much lower than the limit values. However, during air pollution episodes over Cairo relatively high hourly concentration of more than 400 $\mu g/m^3$ has been observed. This was the case during an episode on 24 April 2003 (Sivertsen and Dreiem, 2003).

Background ozone concentrations are important for the formation of secondary pollutants such as NO_2. Typical daily average concentrations in the greater Cairo area ranges between 110 and 130 $\mu g/m^3$.

CO concentrations are probably most interesting in the near Terminal area where cars are idling (load/unload zone). The highest hourly average CO concentration measured in July 2003 was 5.6 mg/m^3. Close to the unloading zone it is expected that the concentrations during rush hours may reach up to 30 mg/m^3.

4 Modelling, methods and modelling area

4.1 Dispersion models

NILU developed source oriented numerical dispersion model EPISODE calculates spatially distributed hourly concentrations from point, line and area sources. The NILU models ROADAIR and CONTILENK are used to estimate sub grid concentrations close to roads within the square grid. A puff-trajectory model, INPUF, is used to calculate the influence of point sources.

Similar estimates as the ones prepared for the Cairo International Airport have been performed for the Oslo Main Airport Gardermoen in Norway, and presented in several reports (Slørdal et al., 1999, Gram and Walker, 2002).

The concentrations may be given as grid distributed concentrations (field data set), concentrations along roads (line data set), and as concentrations in points (receptor point or building point data set).

The USEPA AERMOD model is also available in the NILU model library, and has been tested together with the NILU models. The NILU EPISODE model system is, however, a more flexible dispersion model, which has been proven excellent in international model comparison studies (see: www.nilu.no/aqm/models).

Another dynamic model, which is being used by NILU, is the TAPM model. This is a PC-based 3-D prognostic model for air pollution studies. This model predicts all meteorological parameters, which imply that no local data are needed. It also predicts pollution parameters directly (including photochemistry) on local, city or inter-regional scales (Physick et al., 2002)

The EPISODE model, which represents the core of NILU models, is described on the web as part of models database within the European Topic Centre on Air Quality (ETC-AQ) (www.etcaq.rivm). The Model Documentation System has been developed by the European Topic Centre on Air Quality (ETC-AQ) with the aim to provide guidance to model users in the selection of the most appropriate model for a specified application.

Spatial concentration distributions have been estimated for nitrogen oxides (NO_x), carbon monoxide (CO) and hydrocarbons (HC). Emission sources such as airplanes, road traffic and point sources were included in the estimates.

Most of the sources were treated as line sources, but also methods estimating the sources as a line of point sources has been tested and evaluated. Emission from single sources is treated in the models as point sources. A detailed description of the EPISODE model may be found in several NILU reports (Slørdal et al., 2003).

A number of concentration fields have been estimated for a variety of options and test cases. It will thus be impossible to present all of these in this report. The presentations presented are thus extracts of the results.

The principle of the model, which enables the results to be treated individually, in order to evaluate the importance of emissions from the airplanes relative to cars and other sources, is presented in Figure 12.

For each hour the hourly concentrations are estimated in a 250x250m grid or in a resolution given by the emission data.

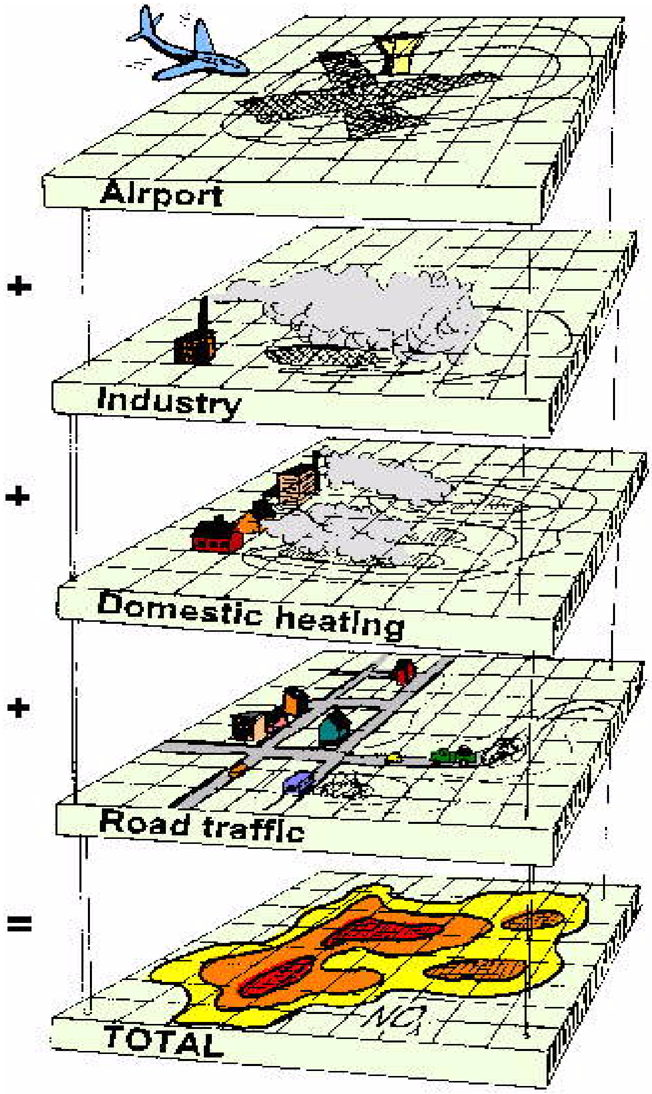

Figure 12: Dispersion models can be used to evaluate the relative importance of different sources.

4.2 Modelling area

Before starting the modelling process and the collection of emission data we have defined the modelling area. For this preliminary environmental impact assessment study we have selected a grid of 13 km x 13 km. The grid is presented with 500 m resolution in Figure 13.

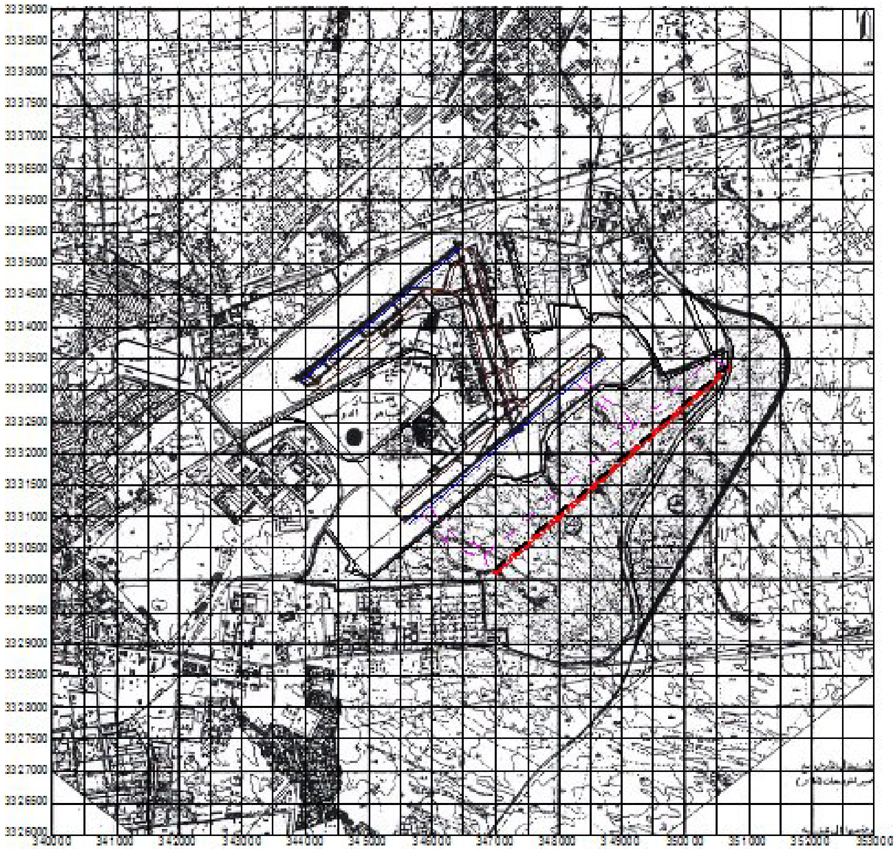

Figure 13: The modelling area and grids (500 m x 500 m) selected for the modelling of air pollution concentrations as a result of the airport activities.

5 Input data for modelling

The following input data have been prepared for the modelling of air pollution impacts:

- Meteorological data; wind direction, wind speed, stability and turbulence,
- Background concentrations (observed air quality in the area)
- Emission data; air traffic, road traffic point sources.

5.1 Meteorological data

Meteorological data have been based on measurements of winds performed by the EIMP/EEAA programme at Abbaseya. Stability and turbulence has been estimated using the NILU meteorological pre-processor (Bøhler, 1996).

Meteorological statistics has been presented in Appendix B. For modelling purposes hourly data for one winter month and one summer month has been prepared including all the necessary parameters. The input data have been verified to be representative for the typical winter and summer conditions at the airport area.

Meteorological data have also been produced by the dynamical meteorological forecast model which is part of the TAPM model. These data are used directly as input to the model estimates performed with the TAPM model.

5.2 Background concentrations

Background concentrations have been presented in Chapter 3.3 and the concentrations presented in Table 1 has been used as input to the model results whenever necessary.

5.3 Emission data

For estimating the emissions of air pollutants we have used methods and approaches used in earlier impact assessment studies used at Oslo Airport Gardermoen, in 1992 (Grønskei et al., 1992), in 1995 (Knudsen et al., 1995) and in 1998/9 (Gram and Walker 2002).

Based on emission input data as developed in the following chapters emission models have been applied to develop an emission inventory for the airport area. This inventory is used as part of the input data to the dispersion models and has been divided into:

- Point sources (stacks and combustion sources)
- Line sources (road traffic and plane movement on apron, taxing lanes and landing – take-off)
- Area sources (diffusive emissions, storage areas etc.)

The estimates have included nitrogen oxides (NO_x, estimated as NO_2), carbon monoxide (CO), hydrocarbons (HC, or VOC, volatile organic compounds) and exhaust particles.

The TOR specified that the “required emission inventory for the airport site will be undertaken as a desk top assessment”. Data prepared by other institutions should have been used in preparing this inventory database. However, only limited amount of information has been available in the study so far. Information about emissions from surface traffic, air traffic, buildings and fuel storage areas have been estimated based on whatever information could be collected during the short period of this project.

Road traffic
If road traffic emission data have already been compiled and estimated, these data would be most helpful. However, we did not receive this information. We therefore tried to estimate the emission based on the following data:

- Traffic density numbers (to and from the terminal building)
- Composition of cars (taxi, private, trucks, buses)
- Idling time at terminal
- Emission factors for car fleet in Cairo (if available).

Air Traffic
For the air traffic activity we need

- Number of flights per day (average and maximum)
- Weekly distribution and number of flights per hour if available
- Composition of the fleet
- Time consumption and location of idling, taxing and take off activities
- Emission factors (if available, otherwise collect from ICAO databank)

We have for these calculations received time schedules for regular flights during one winter week and one summer week. We had no information about aircraft types. This has been estimated from prognostic reports.

Buildings and ground activities
Activities at ground level, which may produce air pollutants, have to be identified. Location of buildings and possible stacks, included stack heights for air pollution emissions must be specified.

The location of possible power plant or other boilers using fossil fuels have to be specified. Consumption (annual or monthly) of fossil fuels is needed. Other activities such as waste burning must be indicated.

Fuel storage areas
Fuel storage area location and storage methods should be provided. If emission estimates have already been undertaken, these data will be valuable to the total assessment. Some VOC and HC measurements will be undertaken on the existing terminal area, but we don't believe that these data will provide adequate information concerning possible emissions from existing and future storage areas. For this purpose more detailed field investigations using tracer techniques will have to be undertaken in the future.

The diffuse emissions of jet fuel and un-burnt hydrocarbons from the aeroplanes is mainly an odour problem, and ventilation intakes for the terminal building should be located in such a way that smell in the terminal building is being avoided.

Other activities linked to fuels storage, filling, leakages, waste and transport may also represent valuable input.

5.3.1 Air traffic emissions

The emission from aircrafts has been estimated based on the data and procedures presented below.

The emissions from an aircraft can be divided into several steps:

- Approach, normally outside the modelling grid
- Landing, breaking of the aircraft
- Taxing to the terminal gate
- Taxing to the runway
- Take-off, on the runway and up to 100 m
- Climbing, normally outside the modelling grid

Together, these steps make a LTO-cycle (landing and take-off cycle).

An aircraft engine is constructed to give as much power as possible from the fuel when the aircraft is in the air. In addition noise regulations applies at modern engines. At the ground, the engine is used to move the aircraft around slowly, the combustion is bad and the emissions are high. About 98% of the CO-and HC-emissions and about 75% of the NO_x emissions normally comes from the taxing. It is thus important to get good quality data for the taxing at the airport.

The different types of aircrafts are equipped with different engine types. From this the emission factors for the specific aircrafts have been developed to be used in the modelling. The emission factors for different engines and aircrafts have been grouped in several classes according to the engine type power etc. (Tail number and call sign are additional information for the quality assurance of the input data.)

From Runway, Terminal gate and Destination the route of each aircraft is determined. The number of seconds an aircraft is spending at each location in the modelling grid (within a 100x100 m) has been estimated from the aircraft operations at the airport, based on detailed studies of the aircraft traffic at Oslo Airport Gardermoen (Gram and Walker, 2002) It is assumed that the aircrafts are taxing with a speed of 30 km/h.

5.3.1.1 Air traffic data

The total number of flights at Terminal 1 at Cairo Airport (in 2002) was 28,104. From Terminal 2 the total number of flights was 20,397. The total number of flights from the Cairo airport in 2002 was 81340 bringing 8.4 million passengers. The daily traffic at Cairo airport is presently about 150 movements. The peak hour reaches 20 movements, with a different distribution according to the time of the day:

- About 15 departures by hour in the early morning
- About 15 arrivals by midday and at the end of the afternoon

These numbers represent about half of the traffic density at Oslo International airport Gardermoen. The number of passengers travelling from Oslo Airport was in June 2003 1.3 million. On an annual basis the number in Oslo are about 13 million passengers.

From a purely geographical point of view the main flows come from or go to:

- North/West: International flights to/from Europe, domestic flight to north Egypt
- South/East: International flights Amman, Jeddah, FIR + domestic flights from south Egypt

The projected air traffic has been presented by the Cairo Airport Master plan based on forecasts from 1994 by NACO. The year 2020 figures were based on a total of 12 million flights in 2000, which indicates that the estimate may be an overestimate of the situation in the future. The following table shows the results of these estimates (year 2020).

Aircrafts in 2020	Total aircraft movements	Total passengers
International flights	113 700	21 011 000
Domestic flights	66 700	9 830 000
Non passenger aircrafts	12 600	
Total	193 000	30 841 000

In the air operation description it is specified that with the mix traffic defined with 65% of medium jets and 35% of heavy jets, the potential runway system capacity should be 70 to 80 movements (ARR and DEP) per hour. Assuming an initial total traffic at Cairo Airport of 100 000 movements, and that 50% of the traffic will use the new runway, with another 50% for take off, a figure of 25,000 departures can be taken as a basic design. The expected final traffic for 2020 is 200,000 movements for the airport, which corresponds to 50 000 departures. The average number of departures per year from 2004 till 2020 will be about 35,500.

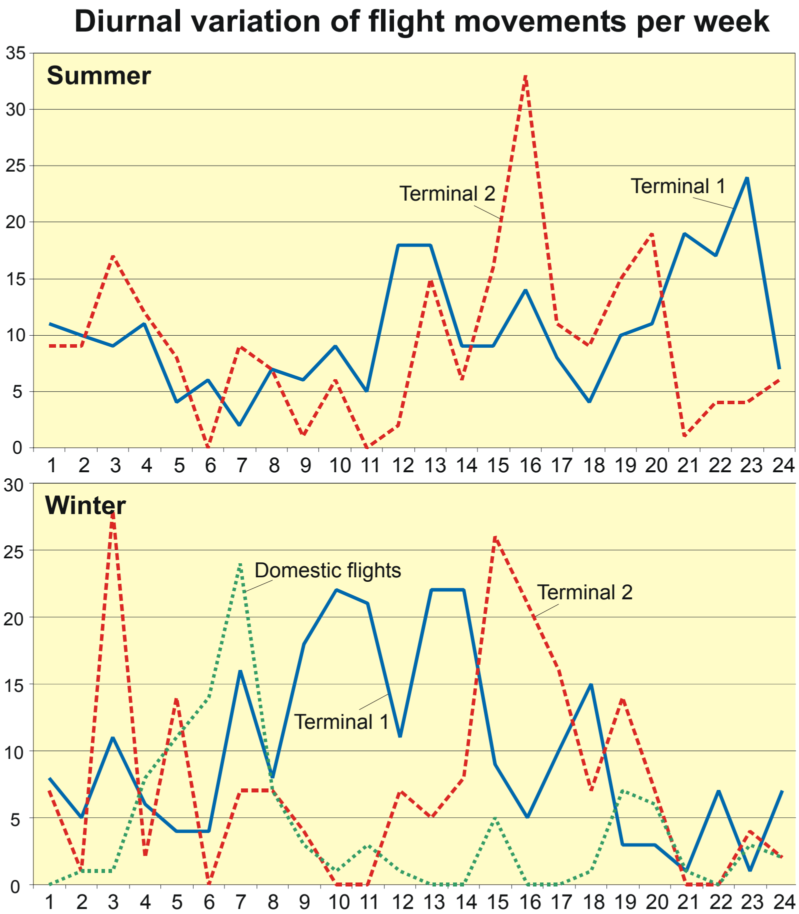

Figure 14: The diurnal variation of flight movements at Cairo Airport per week for a typical Summer and Winter season (2002).

The diurnal variation of traffic density is presented as weekly averages for the summer and winter season for Terminal 1 and Terminal 2 in Figure 14 based on actual data collected for the traffic in 2002.

At Terminal 2 in the winter season there is a clear peak in traffic at night and in the afternoon, while in the summer season there is only this peak in the afternoon. At Terminal 1 there is a more evenly distributed traffic over the whole day. In winter, however, most of the traffic is at daytime between early morning and late afternoon.

Information concerning the type of aircrafts operating at Cairo Airport has been limited. Estimates have been based on the Consultancy Services Contract report for Terminal area no. 3 (NACO –ECG 1994) as well as from Task 1.3 Study and Recommendations (Arab Consulting Engineers, 2002). The traffic distribution considering typical aircrafts operating on the Cairo Airport runway has been estimated and presented in Table 2.

Table 2: Estimated distribution of aircraft types at Cairo Airport 2000 and 2020.

Aircraft		**Traffic (departures) on new runway**		
Class	**Reference aircraft**	**Percentage**	**2000**	**2020**
E or F	B 747-400	20	5000	10 000
D	B 767-300	15	3 750	7 500
C	A 320-200	50	12 500	25 000
Others	Fokker 100	15	3 750	7 500
		Total	**25 000**	**50 000**

In the dispersion estimates it will be assumed that runway O5L/23L will be used with restrictions because of environmental constraints.

From all the different observed movements we have performed the present day situation based on the following actual flight information:

Number of total movements: Winter season = 1047 movements per week
Summer season = 946 movements per week.

The total annual number of movements is thus about 52 000. This is in accordance to the estimated distribution of aircrafts in Table 2.

This number is on the other hand only about half of the prognoses presented by NACO and ECG (NACO 1994). The annual grand total aircraft movements was at that time estimated to be 108 000 in 2005 (see Appendix C).

5.3.1.2 Emission estimates

For each of the aircraft type the emissions can be estimated from the amount of fuel consumed in each of the movement mode. The emission may be estimated in kg/s for HC, CO and NO_X based on the factor given as g/kg of consumed fuel.

Typical emission factors are presented in Appendix D. The estimates apply for taxing, departure and landing. For the more recent aeroplanes the data are taken from "Jane's all the world's aircrafts" (Jane, 1996) and emission factors have been also estimated from ICAO (ICAO Engine Exhaust Emissions Data Bank, 1995 and ICAOs Internet pages). New data are available for B737-600/700/800 and Airbus 321-B 757.

The emission of compound K from one aircraft of class L in grid point (I,J) can be estimated from:

Emission(I, J, K) =
N(number of engines) * [Time (I, J) * Consumption(L) * emission factor(K,L)]

In our estimates of the situation 2003, we have weighted the emissions from the different types of aircrafts by the distribution given in Table 2. As we do not know exactly what type of aircraft is moving when, we have used the air traffic information received for 2002 and estimated a total emission in the different modes hour by hour throughout one summer week and one typical winter week. The result has then be fed into the dispersion models.

A summary of input information given for emission estimates is presented in Appendix E. The total estimated emissions representative for the present traffic flow is presented in Table 3.

Table 3: The total emissions of HC, CO and NO_x at Cairo Airport estimated based on the traffic reported in 2002.

	Total emissions 2002/2003, (kg/half year)			
	winter			
	fuel	HC	CO	NOx
Arrival	512	841	4942	5256
Taxe	521	7360	18828	1756
Taxe	686	9689	24785	2311
T-O	920	1007	1682	21350
	summer			
	fuel	HC	CO	NOx
Arrival	463	760	4465	4749
Taxe	468	6609	16905	1577
Taxe	635	8976	22961	2141
T-O	831	910	1520	19288

As can be seen most of the NO_x is produced during take-off, while CO emissions are most significant during taxing.

5.3.2 Road traffic emission, present situation

For the car traffic we have requested data for the main roads (roads with an annual daily traffic ADT > 10000 within about 10 km from the airport), traffic volume ADT, speed and typical traffic composition (private cars, taxies, buses, lorries and motorcycles). To make a complete assessment for different time periods, data for the time variation of traffic density and traffic composition is needed (for each hour over the week and for as many roads as possible).

The main roads surrounding the Cairo Airport are presented in Figure 15.

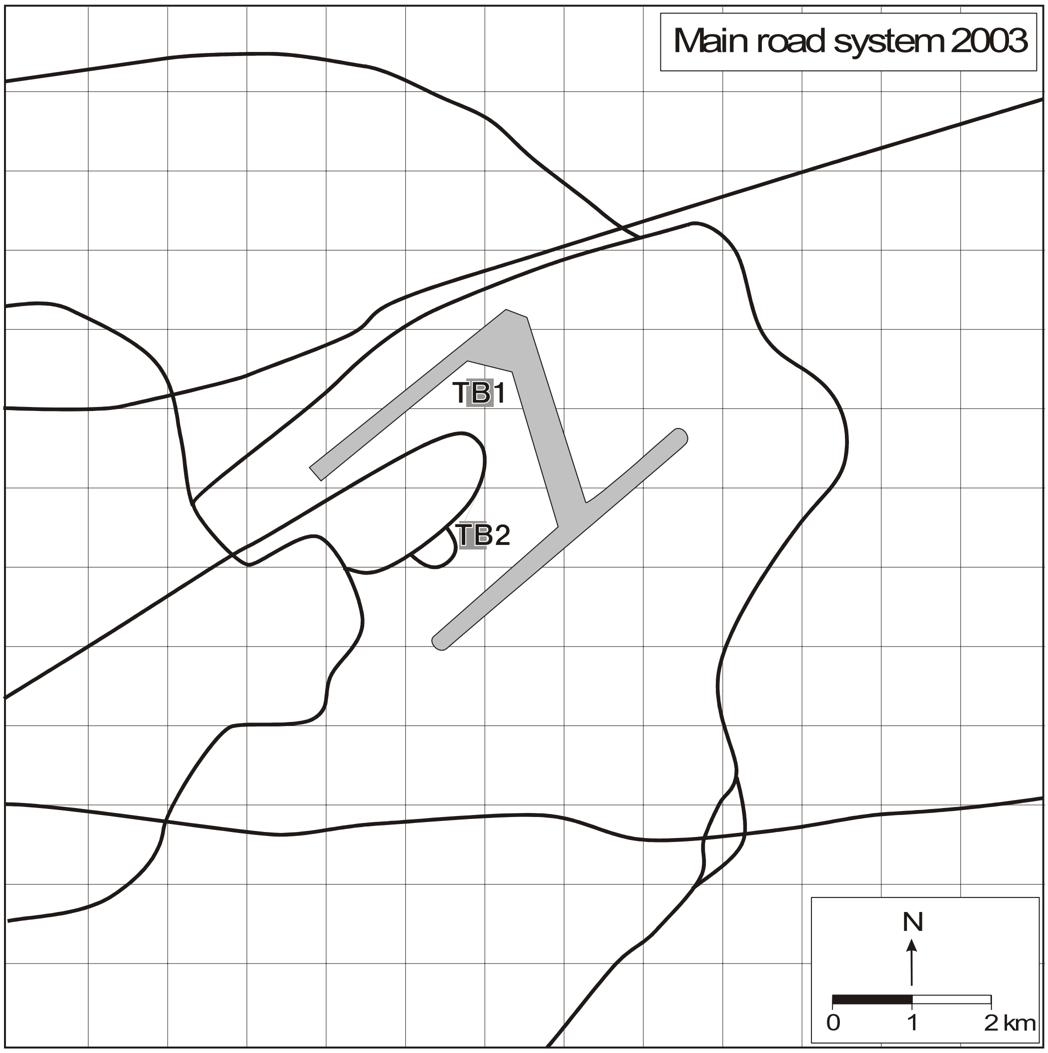

Figure 15: The main road system in the surroundings of the Cairo Airport.

Traffic flows and traffic densities on the roads other than the traffic to the airport has not been possible to obtain. Model estimated emissions from traffic has presently only been related to the transport of passengers and goods to and from the airport. The concentrations estimated will thus be related to the impacts from the airport activities only.

The Cairo International Master plan report “Annex B, Landside traffic” presents data on the projection of road traffic to and from the airport in the future. On the basis of design traffic flow, typical requirements for the landside traffic related facilities have been designed.

It is assumed that terminal 2/3 will handle 14 million passengers at a time when the total airport will handle 20.7 million passengers. In the Master plan report the estimated capacity will reach 30 million in year 2010. Our estimates for the impact of emissions from the roads have been based on an estimated peak hour traffic including passengers, meters and greeters at the ultimate development of the airport. As presented in Appendix C1 the total annual passengers in Terminal 1 and Terminal 2/3 is estimated at 70 million.

For the emission estimates used as a basis for the impact assessment we have thus used the numbers of passengers and cars presented in Table 4.

Table 4: Number of peak hour passengers at ultimate development stage for two separate terminals and for one terminal, traffic including passengers, meters and greeters.

	Two terminals		One terminal
	TB 2/3	TB4	TB all
International	8250	5100	13000
Domestic	4350	800	4300
Total	12600	5900	17300

The total number of passengers moved at the airport in 2002 was about 10 million. For estimates of the relative impact of road traffic we have assumed a slightly overestimate of the total peak hour traffic today of 6000 passengers, which corresponds to the prognoses for an annual traffic capacity of 20 million passengers. We have further assumed that all traffic is passing Terminal 2.

To enable estimates of emissions using international emission factors, we have divided the traffic into vehicle types. Transportation modes have been taken from the Master Plan Annex B report. The traffic composition is given by:

From Master plan	Emission classes
Private cars	Light gasoline vehicles
Taxis	Light gasoline vehicles
Mini buses	Light-heavy vehicles (diesel)
Large buses	Buses (diesel)
Lorries	Heavy-heavy vehicles (diesel)

Based on the Master plan we have evaluated the relative composition of cars to arrive at the airport road during peak hour. This is the hour when the combination of passengers, employees and others are at maximum. The input data for modelling emissions is presented in Table 5.

Table 5: Distribution of cars on the airport road during peak hour (based on data for Development stage 1) and emission factors used.

Type of car	**Fraction of type**	**Number passengers**	**Number of cars**	**Emission factors (g/km)**			
	%		N/h	NO_x	**PM**	**HC**	**CO**
Private cars	24	1440	700	1.93	0.035		10.4
Taxis	40	2400	1000	1.93	0.035		10.4
Mini buses	15	900	140	6.45	0.45		5.4
Large buses	20	1200	60	13.5	0.9		4.2
Lorries	1		2	15.25	1.6		7.3
Total	**100**	**6000**	**1902**				

To estimate the emissions of air pollutants on the roads leading to and from the airport we have used the following simple formula.

$$Q(tot) = \Sigma \{N(i) \times f(i) \times vel(i)\}$$

Where:
- Q(tot) = total emission rate on the road (g/h)
- i=type of vehicle
- N(i) = number of vehicles per hour
- Vel (i) = average car speed on the road (km/h)
- f(i) = emission factor for vehicle type i (g/km)

For estimates of emissions of pollutants in the unloading/loading area at the Terminal we have used the following formula:

$$Q(A) = \Sigma \{ N(i) \times f(i) \times t \}$$

Where:
- Q(A) = emission rates per hour in the unloading/loading area A at the terminal
- i = vehicle type
- N(i) = number of vehicles of category i
- f(i) = emission factor for idling for vehicle type i (g/s)
- t = idling time during loading/unloading.

The data used for the estimates of emissions in the loading zone, when cars are idling, are given in Table 6.

Table 6: Emission factor for different type of vehicles at idling, "Summer conditions" (US-EPA, 1998).

Type of car	Number of cars	Idling time	Emission factor (g/h)			
	N/h	sec	NO_x	HC	CO	Exh.particle
Private cars	700	5	4.72	16.1	229	2.62
Taxis	1000	10	4.72	16.1	229	2.62
Mini buses	140	15	5.71	24.1	339	2.57
Large buses	60	20	55.0	12.5	94	2.52
Lorries			25.0	8.0	50	2.59

The total emissions estimated from the traffic on the roads leading to and from the airport as well as the emissions generated while cars are idling in the loading and unloading zone at the Terminal are presented in Appendix F3. The estimated emissions are summarized in Table 1.

Table 7: Estimated emissions for the peak hour traffic leading to and from the Airport, as well as emissions from idling in the loading area at the Terminal building.

	Emission (g/h)			
	NO x	**PM10**	**HC**	**CO**
Road traffic	72193	2582	71385	268724
Load/unload idling	197	61	393	5439
Total	**72390**	**2643**	**71778**	**274163**

6 Model results

The results from air pollution modelling of the present air quality at the airport are presented as spatial concentration distributions in the following chapters.

6.1 Nitrogen oxide concentrations

Preliminary estimates of NO_2 concentrations have shown that the highest concentrations close the runways may exceed the present NOx concentrations measured at the Terminal 2 building.

6.2 Carbon monoxide (CO) concentrations

The highest CO concentrations seem to occur in the loading/unloading zone at Terminal 3. At peak hour, based at the time when the international flight activity is at its highest, the CO concentrations inside the loading zone could reach 30 mg/m3 as an hourly average and more than 10 $\mu g/m^3$ as an 8-hr average.

6.3 Concentrations of hydrocarbons

The estimated concentrations of hydrocarbons are small compared to measurements that have been performed in the streets of an urban area. Further details will be presented when the final results of modelling will be available.

7 Air Quality assessment

The air quality in the airport area of Cairo is dominated by sources other that linked to the airport activities. The main air pollution problem in the area is the high concentrations of suspended dust in the air. The sources for this dust is natural windblown dust combined with emissions from traffic, open air waste burning and other sources. The airport activities only contribute with less than 10% of the total dust burden.

Nitrogen oxide concentrations may reach relatively high levels close to the road systems and under the take-off flight pattern at the runways. Even when added to the regional impact from all other sources in the greater Cairo area we do not believe that the limit values specified by the Law no. 4 of Egypt will be violated.

High CO concentrations may occur close to the Terminal building due to idling of a number of vehicles. In the maximum hour scenario the ground level concentrations in the unloading/loading zone could reach about 6 mg/m3 depending on the air exchange rate; wind speed and atmospheric stability. Limit values given in the Egyptian Law no.4 will not be exceeded under normal conditions under normal conditions

Potential effects of pollutants have been compared to World Health Organisation guideline values. There are no reasons to believe airport activity emissions will cause any adverse health impact. Compared to the impact in the city centre of Cairo the concentration levels at the airport will be moderate. There are, however, reasons to follow the PM_{10} concentration in synergy with ozone concentrations during some specific meteorological conditions. This will be discussed further in later reports

8 Summary and conclusions

The present air quality situation at the Cairo International Airport has been evaluated based on measurements administrated and collected by the Egypt Environmental Affairs Agency (EEAA).

The main air pollution problem is suspended particulate matter originating from traffic, open air burning and natural wind blown dust. Ozone concentrations may also during specific periods in the summer season exceed the limit values given in Law no. 4 of Egypt. The combination of these pollutants may in some specific meteorological situations cause some adverse effects to people’s health. This will, however, have to be investigated more closely.

Calculations of emissions and concentrations of NO_X, CO, PM_{10} and HC (VOC) around the airport have been performed for 2002/03 and for future developments. The results indicated that the contribution from the airport on a local and regional scale is small. Close to the roads and in the maximum impact areas of the emissions from airport activities the additional contribution could reach up to 25 % of the existing concentration levels.

The NO_2 (NO_X) concentrations were closest to the air quality guidelines, while CO concentrations in some cases near the terminal building could reach levels

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Appendix A

Air Quality Limit Values

Air Quality Limit values for Egypt

Air Quality Limit values are given in the Executive Regulations of the Environmental Law no. 4 of Egypt (Egypt 1994). These Air Quality Limit values are presented in

Ambient Air Quality Limit values as given by Law no.4 for Egypt (1994) compared to the World Health Organisation (WHO) air quality guideline values.

Pollutant	Averaging time	Maximum Limit Value	
		WHO	Egypt
Sulphur dioxide (SO_2)	1 hour	500 (10 min)	350
	24 hours	125	150
	Year	50	60
Nitrogen dioxide (NO_2)	1 hour	200	400
	24 hours	-	150
	Year	40-50	
Ozone (O_3)	1 hour	150-200	200
	8 hours	120	120
Carbon monoxide (CO)	1 hour	30 000	30 000
	8 hours	10 000	10 000
Black Smoke (BS)	24 hours	50 *	150
	Year	-	60
Total Suspended Particles (TSP)	24 hours	-	230
	Year	-	90
Particles <10 µm (PM_{10})	24 hours	70 **	70
Lead (Pb)	Year	0.5-1,0	1

* Together with SO_2 ** Norwegian Air Quality Limit value

Dust fall (DF), which are measured as part of the programme, have no Air Quality Limit value. However, some countries normally state that when dust fall values exceed 10 g/m^2 per 30 days, the area may be considered unclean (polluted).

Appendix B

Meteorological data

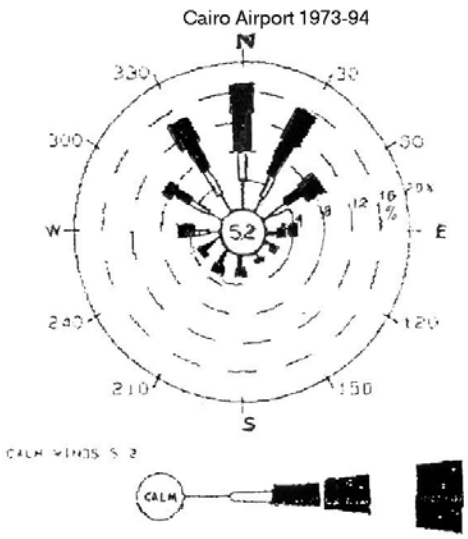
A summary of meteorological condition at the airport area has been based on data collected at the airport and data from the EIMP/EEAA measurement station at Abbaseya.

Climatological data Airport

Air temperature
Temperature data have been collected at the airport during the period 1961-1990. Cairo Airport reference temperature is 35°C.

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
18.8	20.6	23.7	28.5	32.1	34.7	34.4	34.0	32.7	29.7	24.7	20.3	**27.9**

Wind
The following wind frequency distribution (wind rose) has been based on measurements between 1973 and 1994.



A first analyses of the wind data from the airport indicates that:

- The predominant wind directions on an annual basis are from around North ± 45 degrees.
- Most wind speeds are ranging between 7 and 10 m/s. For flight conditions that correspond for code number 2 to a usability factor of 91% (which respects the minimum global usability factor of 80%) and for code numbers 3 and 4 to a usability factor of 100% (which respects the minimum global usability factor of 95%).

Sand storm and dust
Sand storm and dust corresponds to a yearly mean of 5.6 days per month. This lower visibility may lead to use the runway with precision approach conditions.

The monthly and annual mean number of days of occurrence of sand storm is presented in the following table:

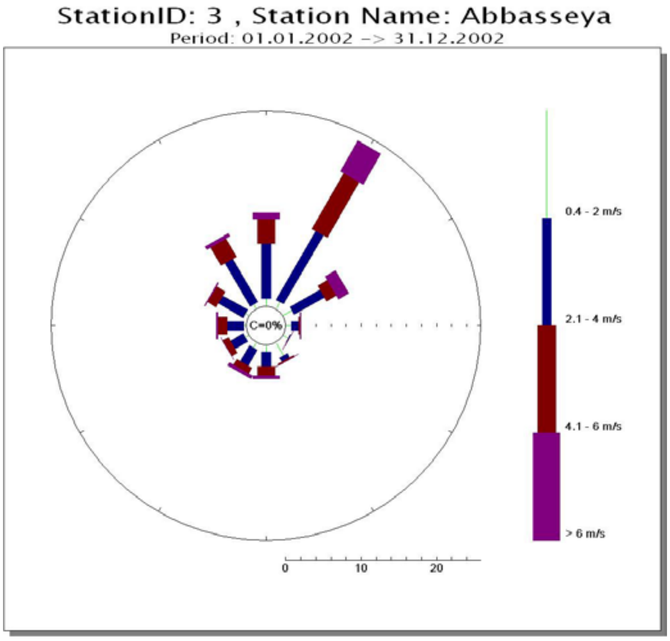
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
0.4	0.8	1.0	1.0	0.4	0.1	0.0	0.1	0.1	0.1	0.2	0.4	**0.4**

The monthly and annual mean number of days of occurrence of dust is presented in the following:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
8.1	8.9	8.4	8.3	5.2	2.4	2.3	1.3	1.2	3.2	4.4	7.7	**5.2**

Wind at Abbaseya

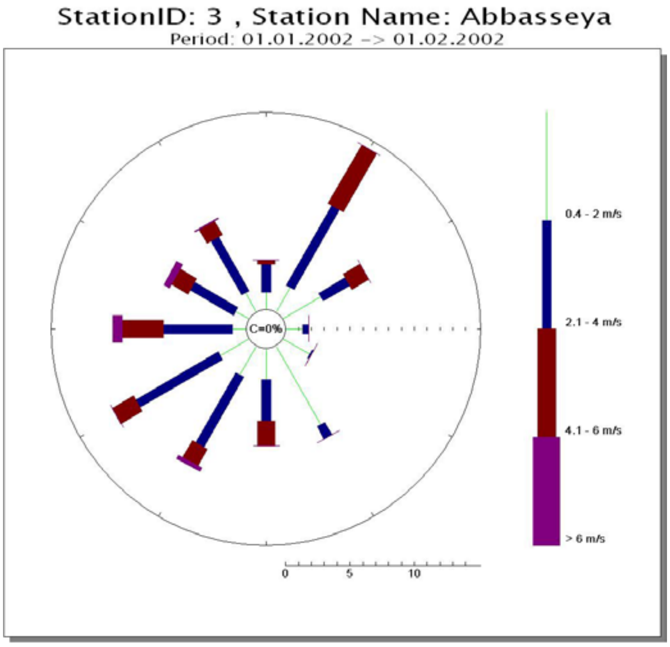
The wind frequency distribution for Abbaseya for 2002 is presented in the following Figure.

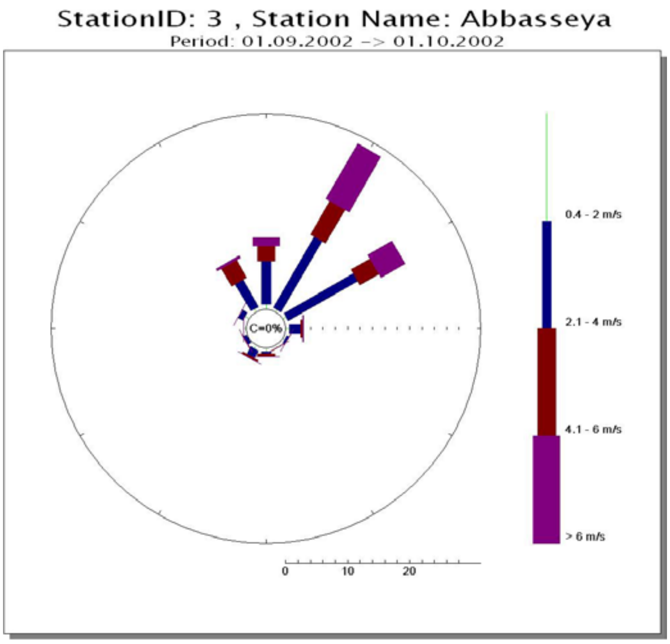


Compared to the 30 year average wind rose based on data fro the Airport there is a slight shift in wind directions at Abbaseya indicating that the wind is more canalised down the valley from around North-north-east.

This may be a realistic feature that indicates that emission released at the surface will be transported more along the valley than indicated by the measurements at the airport. We thus assume that the wind frequencies reported by the Abbaseya measurements will be representative for the low level emissions of air pollutants at the airport area.

The wind frequency distributions used in the model estimates have been selected for one winter month (January 2002) and one summer month (September 2002) as presented in the following Figures.





In the summer season the winds are almost always from northerly directions blowing air pollutants into the Cairo city centre, while during the winter months it is much more frequently blowing from around south and west blowing air pollutants emitted at the airport area away from Cairo city centre.

Appendix C

Number of passengers and aircraft movements

Appendix C1: Estimated number of passengers at peak hour traffic.

DISTRIBUTION OF PEAK HOUR PASSENGERS/
MEETERS/GREETERS AT ULTIMATE DEVELOPMENT STAGE –
70 MILLION PAX IN TB1 AND TB2/3
(International Arrivals Peak)

	TB1 AND TB2/3		TB 2/3		TB 4	
Annual Pax (Airside)	70 000 000		50 000 000		20 000 000	
Peak Hour						
Total Pax - Airside	18 200		13 250		6 200	
Total Pax – Landside (95%) 5 % transit?	17 300		12 600		5 900	
Total Arrivals	10 400		7 550		3 550	
Total Departures	6 900		5 050		2 350	
International Total	13 000		8 250		5 100	
International Arrivals						
. Egyptians (40%)		3 100		1 980		1 220
. Foreign Tourists (30%)		2 350		1 485		915
. Business and Other Foreigners (30 %)		2 350		1 485		915
Total International Arrivals	7 800		4 950		3 050	
Meeters		9 725		6 188		3 813
International Departures						
. Egyptians (40%)		2 100		1 320		820
. Foreign Tourists (30%)		1 550		990		615
. Business and Other Foreigners (30 %)		1 550		990		615
Total International Departures	5 200		3 300		2 050	
Greeters		5 750		3 630		2 255
Domestic Total	4 300		4 350		800	
Domestic Arrivals						
. Egyptians (20%)		500		520		100
. Foreign Tourists (50%)		1 300		1 300		250
. Business and Other Foreigners (30 %)		800		780		150
Total Domestic Arrivals (60%)	2 600		2 600		500	
Meeters		2 450		2 470		475
Domestic Departures						
. Egyptians (20%)		350		350		60
. Foreign Tourists (50%)		850		875		150
. Business and Other Foreigners (30 %)		500		525		90
Total Domestic Departures	1 700		1 750		300	
Greeters		1 200		1 225		210

Appendix C2: Prognoses for Total Aircraft movements and annual passenger movements at Cairo Airport.

Cairo International Airport Traffic Forecast 1993-2020

Annual Total Aircraft Movements

	High scenario, Table 4.5					Low scenario, Table 4.12				
	Pax			Non-pax	Total Aircraf	Pax			Non-pax	Total Aircraft
	Int'l	Domestic	Total		Movements	Int'l	Domestic	Total		Movements
1983	53 896	14 002	67 898	0	67 898	53 896	14 002	67 898	0	67 898
1992	48 689	19 896	68 585	2 195	70 780	48 689	19 896	68 585	2 195	70 780
1995	51 600	26 100	77 700	5 400	83 100	50 700	24 400	75 100	5 300	80 400
2000	64 600	35 400	100 000	7 000	107 000	59 900	26 600	86 500	6 100	92 600
2005	81 500	46 200	127 700	8 900	136 600	70 000	31 700	101 700	7 100	108 800
2010	100 900	59 100	160 000	11 200	171 200	80 400	37 300	117 700	8 200	125 900
2015	121 400	73 500	194 900	13 600	208 500	90 200	42 000	132 200	9 300	141 500
2020	139 400	87 400	226 800	15 900	242 700	98 000	45 400	143 400	10 000	153 400

Annual Passenger Movements

	High scenario, Table 4.2 and 4.3					Low scenario, Table 4.9 and 4.10				
	Pax			Non-	Passenger	Pax			Non-	Passenger
	Int'l	Domestic	Total	scheduled	Movements	Int'l	Domestic	Total	scheduled	Movements
1983	5 397 997	1 068 543	6 466 540	620 954	7 087 494	5 397 997	1 068 543	6 466 540	620 954	7 087 494
1992	4 924 507	1 962 673	6 887 180	852 625	7 739 805	4 924 507	1 962 673	6 887 180	852 625	7 739 805
1995	5 626 000	2 472 000	8 098 000	993 000	9 091 000	5 466 000	2 338 000	7 804 000	964 000	8 768 000
2000	7 756 000	3 633 000	11 389 000	1 369 000	12 758 000	6 809 000	2 761 000	9 570 000	1 202 000	10 772 000
2005	10 634 000	5 264 000	15 898 000	1 877 000	17 775 000	8 499 000	3 574 000	12 073 000	1 500 000	13 573 000
2010	14 248 000	7 418 000	21 666 000	2 514 000	24 180 000	10 426 000	4 518 000	14 944 000	1 840 000	16 784 000
2015	18 415 000	10 068 000	28 483 000	3 250 000	31 733 000	12 467 000	5 497 000	17 964 000	2 200 000	20 164 000
2020	22 592 000	13 035 000	35 627 000	3 987 000	39 614 000	14 387 000	6 372 000	20 759 000	2 539 000	23 298 000

Appendix D

Emission factors for different types of aircrafts

Emission factors from aircrafts

It has been difficult to get an exact survey of the emissions from the different type of planes operating at Cairo Airport. Most of this study has therefore been bases upon the emission study of Oslo Airport Gardermoen.

All types of planes were allocated to one of the emission classes 1-7, based on engine size and type. In addition there was data for GA-traffic (General Aviation), together with 11 emission classes.

We have used data from the literature on similar type of planes, but different companies may use different engines and there have been recent changes due to the fact that many companies want to reduce the noise levels. In this study we have used data given by Jane (1996) as well as from the ICAO Engine Exhaust Emissions Data Bank (1995) and ICAOs Internet Aviation emission databank (2001).

For each of the emission class the consumption of fuel was given in g/s for departure, landing and taxing/idling. For Cairo Airport the emission data were distributed according to the aircraft types in Table 2 and a weighted set of emission factors. The following table presents the emission factors used in this study.

Table C.1: Fuel consumption and emission factors.

			Take-off				Approach				Idle			
Code	Aircraft type	% traffic	fuel kg/s	HC g/kg	CO g/kg	NOx g/kg	fuel kg/s	HC g/kg	CO g/kg	NOx g/kg	fuel kg/s	HC g/kg	CO g/kg	NOx g/kg
C	MD81-87,A320,o.l.	50	1,32	0,28	0,8	25,7	0,3833	1,6	4,17	9,1	0,1372	3,33	12,27	3,7
D	A330.B767.MD11.DC9	15	2,342	0,06	0,44	32,1	0,6584	0,13	2	11,6	0,208	9,92	41,86	3,98
E/F	B737-600/700/800	20	0,903	0,07	4,26	13,25	0,278	0,36	11,37	9,39	0,102	8,11	49,71	3,75
other	Turbo.DH8.EMB.F50	15	0,064	6,21	3,4	19,25	0,034	5	33,24	13,93	0,019	62,37	91,94	1,16
	Weighted factor	100	1,2015	1,0945	1,828	23,2025	0,35111	1,6415	9,645	10,2575	0,1231	14,131	36,147	3,371

Appendix E

Aircraft emission estimates

E1: Time consumed in each of the modes; idling, taxing, take off

E2: Input data for estimating total emissions from aircrafts at the Cairo Airport in 2002.

	23L/2	23L/1	05R/2	05R/1	fuel	HC	CO	NOx
	seconds	seconds	seconds	seconds	kg/s	g/kg	g/kg	g/kg
Arrival	107,33	107,33	107,33	107,33	0,3511	1,6415	9,645	10,2575
Taxe	348	416	295	182	0,1231	14,131	36,147	3,371
Taxe	457	423	252	530	0,1231	14,131	36,147	3,371
T-O	56,32	56,32	56,32	56,32	1,2015	1,0945	1,828	23,2025

Emissions	23L/2				23L/1				05R/2				05R/1			
g/moveme	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx
Arrival	37,68	61,86	363,47	386,55	37,68	176,18	1035,20	1100,94	37,68	176,18	1035,20	1100,94	37,68	176,18	1035,20	1100,94
Taxe	42,82	605,09	1547,87	144,35	51,19	5878,29	15037,15	1402,34	36,30	4168,50	10663,37	994,45	22,40	2571,75	6578,75	613,52
Taxe	56,23	794,61	2032,68	189,56	52,05	5977,20	15290,18	1425,93	31,01	3560,89	9109,04	849,49	65,22	7489,17	19157,91	1786,63
T-O	67,67	74,06	123,70	1570,08	67,67	61,64	102,95	1306,76	67,67	61,64	102,95	1306,76	67,67	61,64	102,95	1306,76

Assumption: 50-50 05 and 23

									Sum emissions 2002/2003, unit: kg/half year							
Emissions	Terminal 2				Terminal 1				winter	14,872	12,324		summer	11,336	13,234	
g/moveme	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx	fuel	HC	CO	NOx
Arrival	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55	512	841	4942	5256	463	760	4465	4749
Taxe	39,56	559,01	1430,00	133,36	36,79	519,89	1329,92	124,03	521	7360	18828	1756	468	6609	16905	1577
Taxe	43,62	616,39	1576,78	147,05	58,63	828,52	2119,42	197,65	686	9689	24785	2311	635	8976	22961	2141
T-O	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08	920	1007	1682	21350	831	910	1520	19288

Arrival	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55	37,68	61,86	363,47	386,55
Taxe	42,82	605,09	1547,87	144,35	51,19	723,32	1850,32	172,56	36,30	512,93	1312,13	122,37	22,40	316,45	809,52	75,49
Taxe	56,23	794,61	2032,68	189,56	52,05	735,49	1881,46	175,46	31,01	438,17	1120,87	104,53	65,22	921,54	2357,38	219,84
T-O	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08	67,67	74,06	123,70	1570,08

	fuel	HC	CO	NOx	fuel	HC	CO	NOx
Arrival	975	1601	9408	10005	19	4	10	17
Taxe	989	13969	35734	3332	20	39	37	6
Taxe	1321	18665	47746	4453	26	52	50	8
T-O	1751	1917	3202	40638	35	5	3	70
sum,kg	5036	36152	96089	58429	100	100	100	100

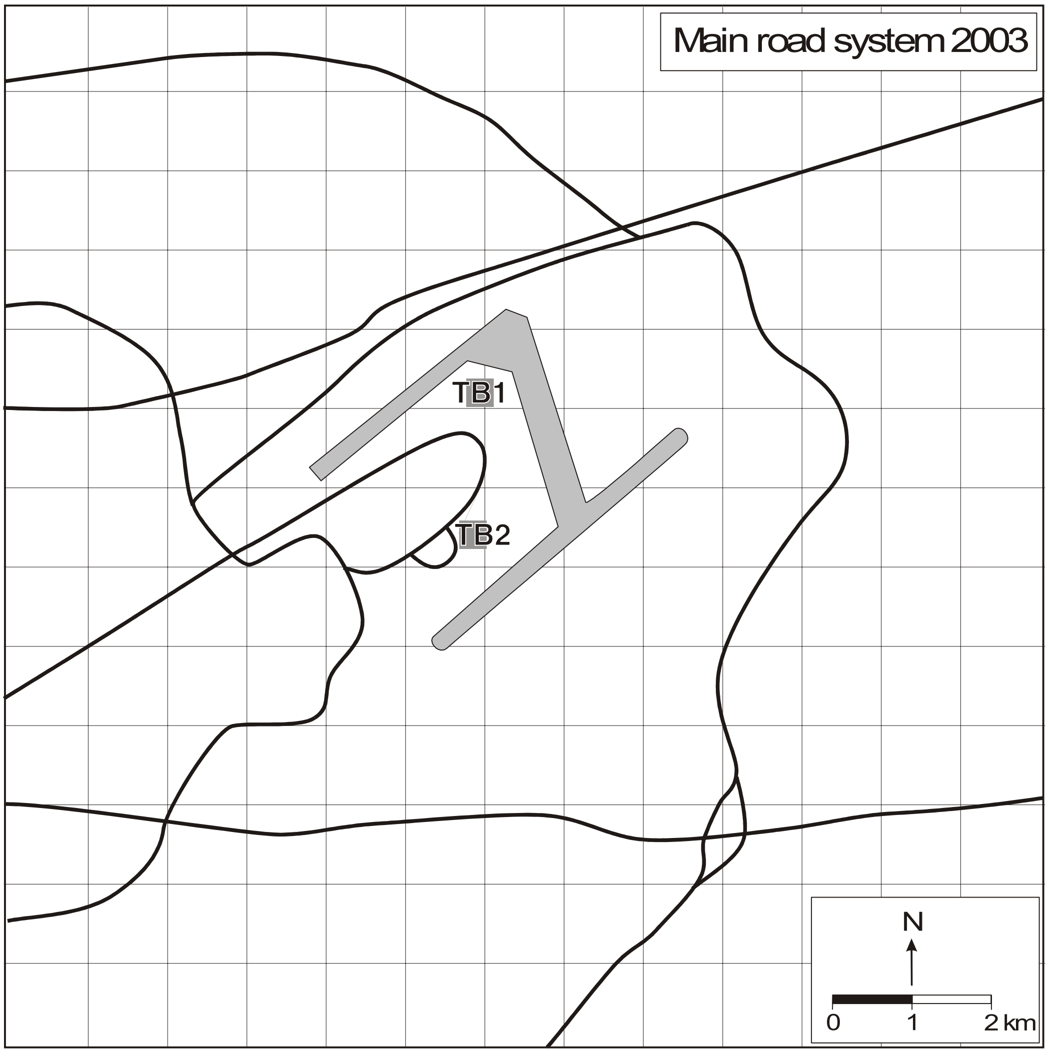
Appendix F

Road traffic

Car emission factors and emission estimates

Appendix F1 :

The road network in the surrounding areas of the airport as of 2003.



Appendix F2:

Idling Vehicle Emissions

Introduction

The following tables present idle emission factors, in grams per hour (g/hr) and grams per minute (g/min) of idle time, for volatile organic compounds (VOC), carbon monoxide (CO), and oxides of nitrogen (NO_x). Idle emissions of particulate matter (PM_{10}) are provided for heavy-duty diesel vehicles only; PM_{10} emissions from gasoline-fueled vehicles are negligible, especially when the elimination of lead in gasoline and reductions of sulphur content are accounted for. Emission factors are provided for both summer and winter conditions for VOC, CO, and NO_x. These idle emission factors are from the MOBILE5b highway vehicle emission factor model (VOC, CO, NO_x) and the PART5 model (PM_{10} for heavy-duty diesel vehicles only). These emission factors are national averages for all vehicles in the in-use fleet as of January 1, 1998 (winter) or July 1, 1998 (summer). PM_{10} idle emission factors for heavy-duty diesels are as of January 1, 1998 (US-EPA, 1998).

Winter Conditions (30°F, 13.0 psi RVP gasoline)

Pollutant	Units	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
VOC	g/hr	21.1	30.7	44.6	3.63	4.79	12.6	20.1
	g/min	0.352	0.512	0.734	0.061	0.080	0.211	0.335
CO	g/hr	371	487	682	10.1	11.5	94.6	388
	g/min	6.19	8.12	11.4	0.168	0.191	1.58	6.47
NOx	g/hr	6.16	7.47	11.8	6.66	6.89	56.7	2.51
	g/min	0.103	0.125	0.196	0.111	0.115	0.945	0.042

Summer Conditions (75°F, 9.0 psi RVP Gasoline)

Pollutant	Units	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
VOC	g/hr	16.1	24.1	35.8	3.53	4.63	12.5	19.4
	g/min	0.269	0.401	0.597	0.059	0.077	0.208	0.324
CO	g/hr	229	339	738	9.97	11.2	94.0	435
	g/min	3.82	5.65	12.3	0.166	0.187	1.57	7.26
NOx	g/hr	4.72	5.71	10.2	6.50	6.67	55.0	1.69
	g/min	0.079	0.095	0.170	0.108	0.111	0.917	0.028

Particulate Matter Emissions

The only vehicle category for which EPA has idle PM_{10} emission factors is heavy-duty diesels. Particulate emissions are also observed to be relatively insensitive to temperature, and so "winter" and "summer" emission factors for idle PM_{10} are the same.

Engine Size	Emissions
Light/Medium HDDVs (8501-33,000 lb GVW)	2.62 g/hr (0.044 g/min)
Heavy HDDVs (33,001+ lb GVW)	2.57 g/hr (0.043 g/min)
HDD buses (all buses, urban and inter-city travel)	2.52 g/hr (0.042 g/min)
Average of all heavy-duty diesel engines	2.59 g/hr (0.043 g/min)

Emission factors given for different vehicles moving at about 50 km/h

Basic Emission Factors

ECVC ID	Fuel ID	Component	Basic Factors	Basic Factor Unit
Light gasoline vehicles	8	CO	10,4	g/km
Light diesel vehicles	19		0,8	g/km
Light-heavy vehicles	19		5,4	g/km
Medium heavy vehicles	19		6	g/km
Heavy-heavy vegicles	19		7,3	g/km
Buses	19		4,2	g/km
Light gasoline vehicles	8	Nox	1,93	g/km
Light diesel vehicles	19		0,85	g/km
Light-heavy vehicles	19		6,45	g/km
Medium heavy vehicles	19		13,75	g/km
Heavy-heavy vegicles	19		15,25	g/km
Buses	19		13,5	g/km
Light gasoline vehicles	8	Exhaust particles	0,035	g/km
Light diesel vehicles	19		0,2	g/km
Light-heavy vehicles	19		0,45	g/km
Medium heavy vehicles	19		0,9	g/km
Heavy-heavy vegicles	19		1,6	g/km
Buses	19		0,9	g/km

Appendix F3:

Traffic emissions (g/s) from vehicles moving to and from the airport estimated for the peak hour traffic

Traffic on roads

x0	y0	x1	y1	Lenght(km	Nox(g/s)	PM10(g/s)	HC(g/s)	CO(g/s)
340004	3330423	342990	3332172	3459,9	9,7	0,35	9,55	35,95
342990	3332172	343715	3332534	810,6	1,1	0,04	1,12	4,21
343715	3332534	344099	3332364	420,1	0,6	0,02	0,58	2,18
344099	3332364	344738	3331873	806,1	1,1	0,04	1,11	4,19
344738	3331873	345207	3332087	515,3	0,7	0,03	0,71	2,68
345207	3332087	345527	3331916	362,5	0,5	0,02	0,50	1,88
345527	3331916	345783	3332193	377,3	0,5	0,02	0,52	1,96
345783	3332193	345591	3332492	354,9	0,5	0,02	0,49	1,84
345591	3332492	345996	3332876	558,1	0,8	0,03	0,77	2,90
345996	3332876	345975	3333558	682,7	1,0	0,03	0,94	3,55
345975	3333558	345570	3333622	410,2	0,6	0,02	0,57	2,13
345570	3333622	343715	3332534	2150,5	3,0	0,11	2,97	11,17
Total				14,4	72193	2582	71385	268724

The emissions above are presented for each road segment used in the model. The end points of each segment are given by UTM co-ordinates.

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STIKKORD Airport	Air Pollution	Impact assessment	

ABSTRACT

A preliminary air quality impact evaluation has been performed for the new Cairo International Airport. The investigations have been based on measurements of meteorology and air quality as well as modelling of emissions and air pollution concentrations.

Air quality data collected indicated that the air quality in the air port area is fair. The main problem is suspended particulate matter originating from traffic, open air burning and natural wind blown dust. Ozone concentrations may also during specific periods in the summer season exceed the limit values given in Law no. 4 of Egypt. Calculations of emissions and concentrations of NO_X, CO, PM_{10} and HC (VOC) around the airport have been performed for 2002/03 and for future developments. The results indicated that the contribution from the airport on a local and regional scale is small. Near to the roads and in the maximum impact areas of the emissions from airport activities the additional contribution could reach up to 25 % of the existing concentration levels.

The NO_2 (NO_X) concentrations were closest to the air quality guidelines, while CO concentrations in some cases near the terminal building could reach levels exceeding the limit values.

TITLE

Air Quality Impact Assessment, Cairo International Airport, Terminal 3 Baseline Studies

ABSTRACT

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