Air Quality Management and Estimated Health Impact of Pollutants in Urban and Industrial Areas
Chekka and Koura Region

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Disclaimer

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Executive Summary

Criteria air pollutants (PM_{10}, CO, SO_2 and NO_2) as well as general meteorological conditions were monitored at five locations in and around the cement industry zone in Chekka and the surrounding Koura villages of Kefraya, Kfar Hazeer, Fih, and Enfeh.

Two Environmental Monitoring Stations were deployed continuously to survey these locations for periods of two weeks each over a period extending from December 2002 to January 2004. Data collected showed that:

1. EPA standard levels of NO_2, SO_2, and PM_{10} are exceeded in more than one location and for long periods of time, probably during the whole dry season.

2. Levels and locations of measured pollutants are in agreement with the dominant wind directions, and the observed meteorological conditions.

The latest EPA recommended software CALPUFF was used to develop a diffusion and dispersion model over the Koura region. Extensive modeling has allowed the development of a large data base of scenarios for smoke stack emissions. Results have confirmed that the industrial plants smoke stack do not account for more than a fraction (10 to 20%) of the pollution observed. The rest is produced by the secondary sources (mills, quarries) and the private power plants operating in each industrial compound.

The levels of pollutants measured can be associated with a wide range of health and environmental impacts. The immediately exposed population exceeds 35,000 people. Health impact estimates predict higher mortality risks for cardio-pulmonary deaths and lung cancer. This is corroborated by anecdotal evidence, and partial statistics collected by the local municipalities.

Stakeholders consisting of the local citizenry, local municipalities, industry representatives, and the ministry of environment where brought together around the results of this project. Multiple meetings resulted in the creation of a first of a kind tri-partite environmental partnership between the Municipalities of Koura and Chekka, the Association of Lebanese Industrialists, and the Ministry of the Environment, facilitated by LAU. This environmental partnership laid the cornerstone for an environmental management action plan.

Chapter 1 Introduction

"The World Health Organization (WHO) estimates that every year 800,000 people die prematurely from lung cancer, cardiovascular and respiratory diseases caused by outdoor air pollution worldwide. Other adverse health effects include increased incidence of chronic bronchitis and acute respiratory illness, exacerbation of asthma and coronary disease, and impairment of lung function." (World Bank, 2003). Whereas the industrialized world in North America and Europe has fully realized the importance of airborne pollution and its effects on public health and the environment, countries in transition such as Lebanon have not yet developed the necessary awareness nor the administrative and legislative mechanisms by which air pollution can be controlled and reduced in a cost-effective way.

The U.S. Environmental Protection Agency (EPA) identifies the principal primary air pollutants (criteria pollutants, see Appendix A) as being: sulfur dioxide, particulate matter, nitrogen dioxide, carbon monoxide, ozone, lead, and air toxics (chlorine, dioxins, furans, etc…). Recent results of a large epidemiological study on the impact of air quality, particularly long term exposure to particulate matter, from the American Cancer Society study by Pope et al. (1995), are now available and can be used for an estimate of health impacts of air pollution. Levy et al. (1999 and 2000) from the Harvard School of Public Health have used these results to develop a methodology and a damage function model for deriving morbidity outcomes, and have applied it to calculate premature deaths and other health impacts in New England due to two power plants emissions. Other studies have linked spikes in deaths from pulmonary related complications directly to spikes in air pollution. These studies were carried out in widely divergent major cities such as Athens, Sao Paolo, Beijing, and Philadelphia (Health Effects Institute, 1995). The World Health Organization (WHO, 1996) and the American Lung Association (ALA Press Release, 2002) have singled out particulate matter as probably the pollutant most responsible for the life-shortening effect of air pollution. With no threshold as to levels of exposure, it was found that mortality can increase by up to 4% from long term exposure to a 10 $\mu g/m^3$ increase in the annual average of particulate matter (PM_{10}). Particulate matter levels are usually below 50 $\mu g/m^3$ in American and Western European cities but can reach more than twice that level in some other parts of the World (WHO, 1994).

In Lebanon, the different environmental stake holders have recently started to realize the seriousness of air pollution problems mainly in urban areas and around some industrial zones. To date of this report very limited data on air quality was available from field measurements carried out by the American University of Beirut (AUB), LAU and other agencies.

Academic research work on air pollution in Lebanon started in 1995 (Chaaban, 1996), followed by multiple contributions by M. El-Fadel (2000, 2001 and 2002) through the Urban Air Quality Assessment for the city of Beirut conducted within the study of the BUTP (Beirut Urban Transportation Program) funded by the World Bank, and other USAID and AUB funded projects. Karam (1999 and 2002) at LAU has also carried out multiple air quality sampling campaigns in Beirut, Byblos, Laqlouq, Zouq, Chekka, Batroun, and other locations from 1998 to 2002 (Karam, unpublished database available at LAU Civil Engineering Laboratories). All the data collected so far spans short periods of time, and is at best indicative. Proper analysis requires long periods of air quality measurements correlated with general atmospheric conditions, and surrounding economic activity. The Ministry of the Environment (MOE) has adopted or recommended many legislative texts based on international standards and practices, and black box type analyses at the Ministry. No field surveys or air quality assessment was carried by the MOE.

Decision makers have little to go on in terms of actual pollutant concentration levels and their health impact on the public. In the absence of air pollutants emission modeling tools correlated to reliable field data, and proper epidemiological modeling of health impacts, these decision makers are incapable of developing and implementing an effective air quality management plan, even less establish proper air pollutants target reduction levels.

Negative health impacts with the tremendous associated economic cost, especially at the level of respiratory problems, asthma, lung cancer, and ultimately premature deaths have so far gone unchecked.

The continuous deterioration of air quality in urban areas due to transportation vehicles emissions as well as a host of diffuse sources, and the lack of emissions control in industrial zones have resulted in unresolved conflict situations between grass roots organizations, municipalities, and environmentalists pitted against governmental agencies, power plants, and large industrial facilities (e.g. Zouq inhabitants versus Zouq power plant and industry, and Koura Municipalities versus Chekka cement factories).

In the following we present the results of a project carried out by LAU and funded by USAID from September 2002 to February 2004, to monitor the quality of the air in a major urban/industrial region: Chekka and Koura, to develop medium and large scale computer modeling tools to study the diffusion and dispersion of pollutants, to assess the actual and potential health hazards to which the local population is exposed to, and to develop the mechanism for all stakeholders to join efforts and agree on an action plan to improve environmental conditions in the region.

Chapter 2 Scope of Work

This report is one the deliverables of the project funded by USAID at LAU. The scope of the work presented in this report can be summarized as follows:

Measurement Campaign

Carry out an air quality measurement campaign centered around the Chekka cement industrial area, with reference measurements in select urban locations, and rural areas:

Long term field measurements of criteria pollutants (particulate matter, sulfur dioxide, nitrogen oxides, carbon monoxide) as well as local atmospheric conditions (wind speed, wind direction, temperature, and relative humidity) would be carried out over a period of one year to establish a reference baseline and to provide data that can be used in the computer modeling.

Computer Model

Develop a computer based model that can be used to simulate and predict the diffusion and dispersion of pollutants emitted from point sources (smoke stacks) and area sources (quarries) in the Chekka zone:

Using state of the art air quality modeling software tools endorsed by the EPA, and other agencies in the US, a computer model would be developed for the region. Pollutant emissions (particulate matter and sulfur dioxide) would be modeled based on available data. Dispersion and diffusion over the areas would be carried out to the precision limits allowed by the quality of the atmospheric data gathered.

Model Validation

Validate the computer model predictions against field measurements:

Estimated and/or documented emissions from select sources would be used to model the dispersion of some criteria pollutants over the concerned area. Results would be interpreted and compared to field data measurements and an analysis of the impact of particular source emissions would be presented.

Health Impact

Establish the size of the exposed population, the levels of exposure, and calculate the health impact at measured and predicted levels of pollutants:

The villages in the vicinity of the industrial zone in Chekka would be surveyed. The size of the exposed population estimated and field data collected as to the general health conditions relating to air pollution. Levels and type of exposure would be identified for a first estimate of the actual and potential health impacts of airborne pollution.

Action Plan

Develop an action plan in consultation with the key stakeholders in the region (Koura and Chekka municipalities, cement industries and NGO's):

Contacts would be established with all stakeholders, and a positive atmosphere for constructive action would be established in order to bring all concerned parties together to set up objectives and develop an environmental management action plan. A draft action plan would be proposed for discussion.

Chapter 3 Field Work

Description of the data collection program

A first field data collection campaign has been launched in November, 2002, and was concluded in March, 2003 to establish base line parameters in those regions with the reportedly highest level of pollution. Locations in Fih, Enfe, Chekka, Kfar Hazeer, and Kefraya have been monitored, for periods of time of the order of a week or two in order to confirm baseline measurements, and benefit from the rainy weather to establish absolute lows. Additional equipment for particulate monitoring has been acquired by the Civil Engineering Laboratories, and has been used in the summer for the second phase data collection campaign from April 2003 to the end of September 2003. Up to two air quality monitoring stations and two dust monitors have been used to cover the areas in question. Short measurement trips have been organized to Beirut, Bcharri (upper mountains) and other areas for reference and comparative data.

A third and last data collection campaign from October 2003 to the end of December 2003 has been carried out to complete a full one year cycle of data collection and measurements in the region. The air quality data as well as the meteorological data has been recorded, and processed in an extensive database for use by this project and others.

The full database is available at LAU and the summaries of results have been included in this report (Appendix B).

The equipment used included two mobile environmental monitoring stations (EMS) capable of logging air quality measurements (CO, NO_2, and SO_2) and meteorological data in a continuous fashion over long periods of the order of a few weeks. Particulate matter was measured with hand held monitors with one day autonomy.

The geographic region is shown on the attached maps (Appendix D). Five measurement stations were located in and around the Chekka industrial zone and monitored on a rotating schedule.

They are: Chekka, Kefraya, Kfar Hazir, Fih, and Enfeh. They form half a circle around the sources of pollutants.

The period covered by the measurements spans over ten months and covers the two dominant meteorological regimes of Lebanon, the wet and rainy season which usually spans from May to October, and the wet season which spans from November to April. During the wet season frequent rainfall and atmospheric humidity act as natural filters that clean the air from pollutants. During the dry season pollutants can build up to high levels in the air given the absence of rain, and the high frequency of atmospheric inversions. These inversions reduce the natural ability of the air layers to mix thus reducing the diffusion and dissipation of air borne pollution across large masses of air.

The sources of possible pollution were identified as follows: the kiln smoke stacks of the two operating cement factories, the power plants of the two main factories with combined power in excess of 100 MW, the clinker mills inside the same factories, two limestone quarries (one for each factory), and the transport routes (conveyor belts and trucks).

The data collected is summarized (Appendix B) for the purpose of presentation in this report in the form of time lines showing the location, date, and value of measurements as compared to the EPA air quality red line levels.

Discussion of measurements

In the following we discuss the results of the field data collection to date, by type of pollutant.

Carbon Monoxide

Carbon Monoxide, CO, is a pollutant that characterizes incomplete combustion of hydrocarbons and inorganic materials. It is a highly toxic gas, and exposure to high levels of CO can cause death by asphyxia within few hours.

With reference to the attached charts (Appendix C), we can see that the data collected shows consistently very low levels of CO in the air which is an indication of the absence of inefficient combustion processes. All measured levels are way below the EPA 1-hour and 8-hour exposure standards, albeit dry season levels are slightly higher than wet season levels as expected.

Nitrous Dioxide

Nitrous dioxide, NO_2, and in general all nitrous oxides NO_X, are mainly caused by the high combustion temperature in engines, ovens, and high temperature processes. They result from the oxidation of nitrogen contained in the air when exposed to very high temperatures such as in internal combustion engines (in cars, trucks or buses), fuel or diesel power plants, and cement kilns. Nitrous oxides cause acid rain, acidification of the soil, photo-chemical smog, and may result in breathing and pulmonary health effects when inhaled in large concentrations. Given that exposure levels are not well defined, the EPA has set an annual exposure standard. This level is however very low.

The measurements in the Chekka and Koura region have showed a very interesting phenomenon. While most of the time relatively low measurements are noted, which probably correspond to normal transportation and industrial activities, we have monitored periods where measurements have jumped to very high levels that are orders of magnitude more than the annual average. These singular events, which extend from a few hours to a few days, seem to correspond to irregular industrial activity. On at least one occasion, these measurements were correlated with a cloud of industrial emissions enveloping a Chekka neighborhood, waking up the sleeping residents and causing everybody breathing problems due to excess NO_X inhalation. These high levels of nitrous oxide have not been correlated with other emissions. Oven temperature problems, or shut down problems in one of the factories are thought to be the obvious source.

Sulfur Dioxide

Sulfur dioxide, SO_2, and in general all sulfur oxides are the result of the combustion of sulfur present at different concentrations in fuels and other raw materials used in industry. Sulfur is sometimes present at high concentrations in the coke and petroleum coke used as fuel in cement kilns, as well as in lower concentrations in the fuels used for power plants and large machinery. Sulfur oxides are the major cause of acid rain, and can cause irreversible damage to ecosystems and property. Exposure to sulfur oxides over a few

hours, even at low concentrations can result in respiratory tissue burns and serious pulmonary problems. The EPA has set 3-hour and 24-hour exposure standards.

With reference to the attached charts (Appendix C), the measurements in the Chekka and Koura region have showed a significantly high level of sulfur oxides during the dry season in the three regions under the wind from the factory smoke stacks: Chekka, Enfeh, and Fih. It is interesting to note that levels in Chekka while still unsafe are slightly lower than those of Fih and Enfeh, where the dominant winds seem to be driving most of the gaseous emissions. The observed levels in Enfeh and Fih are four to ten times the EPA limits, thus pointing to a serious health exposure problem.

Particulate Matter

Particulate matter, PM_{10}, is defined as air borne particles whose diameters are 10 microns or less. Until recently, the impact of inert air borne dust particles was down played. Results from cohort studies over close to twenty years have however shown the cumulative damage of inhaling small particles on the pulmonary and cardio-vascular systems. In spite of the fact that no minimal safe exposure level can be defined, the EPA has set a standard exposure levels (24-hour and annual) which it continuously revises as new information becomes available. Revisions have so far been to lower recommended safe levels as all available information seems to indicate long term irreversible negative health effects.

With reference to the attached charts (Appendix C), the measurements in the Chekka and Koura region have showed a significantly high level of PM_{10} in the air with almost all locations exceeding safe limits at some point in time. It is however noted that Kfar Hazeer which showed no gaseous pollutants in its air being shielded by the dominant wind with respect to the smoke stacks, has high levels of PM_{10} due to the proximity of quarries to its perimeter.

Chekka shows consistently the highest PM_{10} values, being the closest to all sources, and because particulate matter does not get transported by the wind as far as gaseous emissions.

In conclusion, we note the following:

1. EPA standard levels of NO_2, SO_x and PM_{10} are exceeded in more than one location and for long periods of time, probably during the whole dry season.
2. Levels and locations of measured pollutants are in agreement with the dominant wind directions, and the observed meteorological conditions.
3. The levels of pollutants measured can be associated with a wide range of health and environmental impacts. This corroborates anecdotal evidence, and partial statistics collected by the local municipalities.

Chapter 4 Computer Modeling

The EPA recommended software CALPUFF (Scire, J. et al.) was selected to develop a computer model for dispersion and diffusion of pollutants from different types of emission sources. A brief description of the capabilities of the software is given in Appendix A. In conjunction with CALPUFF, the commercially available software CALPUFF View (Thé, J. et al.) was used. It served as a graphical users interface that facilitated and organized input to and output from CALPUFF.

Extensive air pollution dispersion and diffusion modeling was carried out resulting in a large data base of scenarios for smoke stack emissions that can be compared with the field data gathered until December 2003. Results have confirmed that the industrial plants smoke stack do not account for more than a fraction (10 to 20%) of the pollution observed. The rest is produced by the secondary sources (mills, quarries) and the private power plants operating in each industrial compound. Simulations for PM_{10} dispersion from the quarries treated as area sources has provided ample support to field measured data.

The computer model was used to answer simple as well as complex questions about the possible origin and fate of air pollutants in the region. Hypothetical scenarios have been established and compared to ground level actual measurements in order to assign critical responsibilities. Sample results of the model simulations using actual meteorological data are detailed in Appendix D. The color plots for SO_2 concentrations are not included in the appendix; however, the color distribution is close to the PM_{10} concentrations which are included.

The pollution sources considered in the simulation consisted either of four point sources or two area sources each simulated separately. The point sources accounted for the two cement factories with two smoke stacks each and the area sources accounted for a single quarry for each factory. The emission rates for the point sources were set according to the stack characteristics (exit velocity and stack diameter) shown in the table (at the end of this chapter) using limit gas concentrations set by the "Updated Lebanese Standards for the Portland Cement Industry": 800 mg/m^3 for SO_2 and 200 mg/m^3 for PM_{10}.

Ground concentrations for SO_2 and PM_{10} were evaluated at discrete sampling points. Various arrangements of sampling points were considered: (1) distributed uniformly over a rectangular grid, (2) distributed uniformly over a circular grid centered at the point sources and (3) placed at each of the five locations of the Environmental Monitoring Station.

Details of the computer model and all the simulation results are available upon request from the civil engineering department, LAU.

Stack Characteristics					Emissions	
Source Label	Stack Height	Stack Diameter	Exit Velocity	Exit Temperature	PM_{10}	SO_2
	(m)	(m)	(m/s)	(^oK)	(g/s)	(g/s)
Cement Factory #1						
SNC-1	87	2.8	7.5	400	9	36
SNC-2	64	2.8	7.5	400	9	36
Cement Factory #2						
HC-1	108.5	5.7	7.5	400	38	152
HC-2	36	3.7	7.5	400	16	64

Chapter 5 Health Impact

Background on Air Pollution Health Impact

In a 16-year study published in March 2002 in the Journal of the American Medical Association, Pope et al. (2002) provided the strongest evidence to date that long-term exposure to fine particulate air pollution common to many urban and industrial areas significantly increases residents' risk of dying from lung cancer and heart disease. The level of lung cancer risk associated with exposure to fine particles emitted by coal-fired power plants, factories and diesel trucks is comparable to the risk posed by long-term exposure to second-hand smoke from cigarettes.

To assess the relationship between long-term exposure to fine particulate air pollution and all-cause, lung cancer, and cardiopulmonary mortality, vital status and cause of death data were collected by the American Cancer Society as part of the Cancer Prevention II study, an ongoing prospective mortality study, which enrolled approximately 1.2 million adults in 1982. Participants completed a questionnaire detailing individual risk factor data (age, sex, race, weight, height, smoking history, education, marital status, diet, alcohol consumption, and occupational exposures). The risk factor data for approximately 500 000 adults were linked with air pollution data for metropolitan areas throughout the U.S. and combined with vital status and cause of death data through December 31, 1998. Fine particulate and sulfur oxide–related pollution were associated with all-cause, lung cancer, and cardiopulmonary mortality. Each 10 μg/m^3 elevation in fine particulate air pollution was associated with approximately a 4%, 6%, and 8% increased risk of all-cause, cardiopulmonary, and lung cancer mortality, respectively. Measures of coarse particle fraction and total suspended particles were not consistently associated with mortality. The authors concluded that long-term exposure to combustion-related fine particulate air pollution is an important environmental risk factor for cardiopulmonary and lung cancer mortality.

Estimated Direct Health Impact

The lack of detailed medical records, and properly documented epidemiological studies, as well as the limited amount of air pollution measurements renders any attempt at a detailed estimation of health impacts rather academic.

However, without delving too deep into the topic, it is easy to use the recent statistical data provided by Pope et al. (2002) to perform some very simple calculations.

Reference measurements in urban areas such as Beirut and Byblos have shown that levels of PM_{10} are on average at least 50 g/m^3 less than in Chekka. Rural coastal and upper mountain areas may show average levels lower by as much as 100 g/m^3 (unpublished database at LAU).

An estimated total of 35,000 people live permanently in the immediate vicinity of the main cement factories in the Chekka region, i.e. within a 5 km radius as shown in the table (at the end of this chapter). This population may swell to well over 50,000 in summer time. More than 150,000 would fall within the 10 to 15 km radius at which serious levels of exposure can still be expected depending on weather conditions.

Noting that every 10 g/m^3 cause a 4%, 6%, and 8% increase in mortality risks for all-cause, cardiopulmonary disease, and lung cancer respectively it can be conservatively posited that the population in the immediate vicinity of the Chekka industrial zone has 20%, 30%, and 40% at least increased risks of mortality due to all-cause, cardiopulmonary disease, and lung cancer when compared to the urban population of Lebanon, and about twice that much when compared to the rural population of Lebanon. The Environmental Committee of the Municipalities of Koura has provided some patchy data on the survey of recent mortality and morbidity they carried out in order to identify local distortions that may be assignable to extended exposure to air pollution. It is evidenced beyond the shadow of a doubt that lung cancer mortality risks are higher in Fih, Chekka, and a few other villages than the regional or national average.

For every single death per year due to air pollution, health scientists have estimated that there are 3.5 hospital admissions for asthma and 3 non-asthma respiratory admissions, 47 respiratory emergency doctor visits, 2,400 asthma attacks, 12,400 restricted activity days, and 26,600 acute respiratory symptom days. Local doctors in Chekka and Koura have consistently reported higher asthma cases and respiratory related diseases especially among the vulnerable population of the young and old. Some environmental NGO's , working in the region have volunteered the estimate of ten deaths per year related to air pollution in the region. In the absence of official life and injury evaluation procedures, it is proposed to use the costs developed for traffic accidents. These costs are estimated at 50,000 to 200,000 USD for a lost life, and at close to 500,000 USD for permanent disability.

Using a similar scale, the direct economic cost associated with ten deaths/year and the sum of all other air pollution related hospitalizations and medical costs can be estimated conservatively to be on the order of 5 million USD per year. The actual economic cost may be much larger than this estimate when the whole area population is included as well as long term cumulative exposure effects are factored in.

Finally, it is important to note that air pollution health impacts are cumulative, and the current health status among the resident population is the result of long years of unchecked pollution and unknown environmental conditions.

Name of Locality	Estimated Population	Distance from Factory 1 (m)	Distance from Factory 2 (m)	Distance from Quarry 1 (m)	Distance from Quarry 2 (m)
Chekka	14839	720	2335	3085	2629
Kefraya	1610	3148	681	3935	859
Enfeh	9704	2155	4939	2960	4782
Kfar hazeer	4066	4429	4925	2177	3711
Fih	3244	5346	7554	3608	6736

Chapter 6 Action Plan Consultations

Historical Overview

The cement industry has been established in the Chekka region since 1932. The industrial region reached its full size in the mid sixties to early seventies with about five different factories. The factories were not damaged during the civil war years and productions continued during that time save for few periods of interruption. It would be safe to say that the activities of the industry have gone practically unregulated until 1997, with all what that entailed in terms of environmental damage that the region has sustained to its soil, water, ecosystems, and population. The assessment of the historical environmental impact of the industrial activities on Chekka and the Koura villages was beyond the scope of this report.

At the end of the civil war in 1990, the country engaged in a major reconstruction effort and the cement industry went through a restructuring and retooling phase with new production lines being built and older ones retired. The Lebanese cement industry today is technologically globally competitive, but it still operates in a dated legislative, regulatory, and administrative framework. In 1997, the newly formed ministry of environment addressed the environmental impact of the cement industries through an indicative memorandum, under pressure from environmental groups and local municipalities. The memorandum was supported at the time by all stakeholders, and constituted at the time an excellent first step towards a comprehensive environmental management plan for the region.

Unfortunately, it remained a first step, and the Ministry of Environment has only been able to apply emission controls over the main smoke stacks since that time.

The heated debates, conflictual situations and lack of solid data have since prevented the stakeholders from moving forward towards the stated goals in the memorandum of 1997.

One of the main objective of this work, was to restart the process of environmental debate by setting it on the proper scientific fact based footing, and engaging all stakeholders in a fruitful and goal oriented cooperation.

Consultation Process and Action Plan Development

The representatives of the Koura municipalities were informed early on of the USAID funded project for coordination and stakeholder participation. Municipality presidents as well as private citizens assisted extensively in the location and maintenance of the data collection stations.

A first stake holder meeting/workshop was held at LAU on October 27th, 2003, between the environmental committee of the municipalities of Koura, the municipality of Chekka, active citizens, and representatives of the medical profession in the region. The preliminary findings from the measurement campaign were presented by Dr. Karam and different action plan options were discussed.

Informal contacts were also established with the cement factories in Lebanon, including Sibline which is located in the south of Lebanon outside the Chekka industrial zone.

Based on these contacts, and the first stakeholders meeting a second stakeholders meeting was carried out with the Cement industries representatives and the Association of Lebanese Industries (ALI) on the 15th of January, 2004.

Partially as a result of the work done by this project, and different international trade requirements, the ALI decided to activate its environmental committee and empower it to represent all industries, including the Cement industry in Chekka.

Following heated debates and multiple discussions and side meetings, a third and a fourth closed door joint stakeholders meeting took place at LAU, attended by the municipalities and the industrialists, and facilitated by Dr. Karam on January 21st, and 28th, 2004. The result was the creation of tri-partite environmental partnership between the Municipalities of Koura and Chekka, the ALI, and the Ministry of the Environment, facilitated by LAU.

A conference was organized on the 29th of January, presenting the results of the study, and a review on air pollution policies by an invited international expert, Mr. Peter Rombout of the National Institute for Public Health and the Environment in the Netherlands. The conference culminated with the announcement of the environmental partnership and the draft action plan. This partnership, a first of its kind in Lebanon, was well advertised in the local news, and all stakeholders have committed in good will to its success.

LAU is maintaining contact with all stakeholders, awaiting the reorganization following the municipal elections of spring 2004 before re-activating the partnership and the discussions of the action plan.

The original draft proposal for the partnership is presented in Appendix E, noting that all procedural and administrative items are still under discussion between the different stakeholders.

Chapter 7 Conclusions

1. The current levels of air pollution in Chekka and the Koura region are above safety levels as defined by the EPA, for at least two months per year.
2. Activities related to the cement industry are the main source for these pollutants.
3. The local population is subject to higher risks of mortality by cardio-pulmonary diseases and lung cancer due to air pollution exposure than the average Lebanese population.
4. All stakeholders realize the need for action, and an environmental partnership between the local municipalities, the industry, and the ministry of environment was launched to adopt and execute an environmental management action plan for the region.

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Appendix A Excerpts from the EPA webpage

1. National Ambient Air Quality Standards.

2. Recommended Dispersion Models.

Excerpts from the U.S. EPA webpage www.epa.gov

U.S. Environmental Protection Agency

The EPA Office of Air Quality Planning and Standards (OAQPS) has set National Ambient Air Quality Standards for six principal pollutants, which are called "criteria" pollutants. They are listed below. Units of measure for the standards are parts per million (ppm) by volume, milligrams per cubic meter of air (mg/m^3), and micrograms per cubic meter of air ($\mu g/m^3$).

National Ambient Air Quality Standards

Pollutant	Primary Stds.	Averaging Times	Secondary Stds.
Carbon Monoxide	9 ppm (10 mg/m^3)	8-hour[1]	None
	35 ppm (40 mg/m^3)	1-hour[1]	None
Lead	1.5 $\mu g/m^3$	Quarterly Average	Same as Primary
Nitrogen Dioxide	0.053 ppm (100 $\mu g/m^3$)	Annual (Arithmetic Mean)	Same as Primary
Particulate Matter (PM_{10})	50 $\mu g/m^3$	Annual[2] (Arith. Mean)	Same as Primary
	150 ug/m^3	24-hour[1]	
Particulate Matter ($PM_{2.5}$)	15 $\mu g/m^3$	Annual[3] (Arith. Mean)	Same as Primary
	65 ug/m^3	24-hour[4]	
Ozone	0.08 ppm	8-hour[5]	Same as Primary
	0.12 ppm	1-hour[6]	Same as Primary
Sulfur Oxides	0.03 ppm	Annual (Arith. Mean)	-------
	0.14 ppm	24-hour[1]	-------
	-------	3-hour[1]	0.5 ppm (1300 ug/m^3)

[1] Not to be exceeded more than once per year.

[2] To attain this standard, the expected annual arithmetic mean PM10 concentration at each monitor within an area must not exceed 50 ug/m^3.

[3] To attain this standard, the 3-year average of the annual arithmetic mean $PM_{2.5}$ concentrations from single or multiple community-oriented monitors must not exceed 15 ug/m^3.

[4] To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must

U.S. Environmental Protection Agency

not exceed 65 ug/m^3.

[5] To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

[6] (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is <= 1, as determined by appendix H. (b) The 1-hour standard is applicable to all areas notwithstanding the promulgation of 8-hour ozone standards under Sec. 50.10. On June 2, 2003, (68 FR 32802) EPA proposed several options for when the 1-hour standard would no longer apply to an area.

Dispersion Models

Preferred/Recommended Models

The models offered in this area are currently listed in Appendix A of the *Guideline on Air Quality Models* (published as Appendix W of 40 CFR Part 51). See Appendix A of the *Guideline,* posted on the Modeling Guidance page of this website for a summary description of these models: BLP, CALINE3, CALPUFF, CTDMPLUS, ISC3, and OCD.

CALPUFF **a multi-layer, multi-species non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation and removal. CALPUFF can be applied on scales of tens to hundreds of kilometers. It includes algorithms for subgrid scale effects (such as terrain impingement), as well as, longer range effects (such as pollutant removal due to wet scavanging and dry deposition, chemical transformation, and visibility effects of particulate matter concentrations).**

Appendix B Field Measurements

1. Environmental Monitoring Station Records.

2. Dust Monitor Records.

3. Summary Table of Air Pollution Measurement Results.

Appendix C Measured Data Reduction

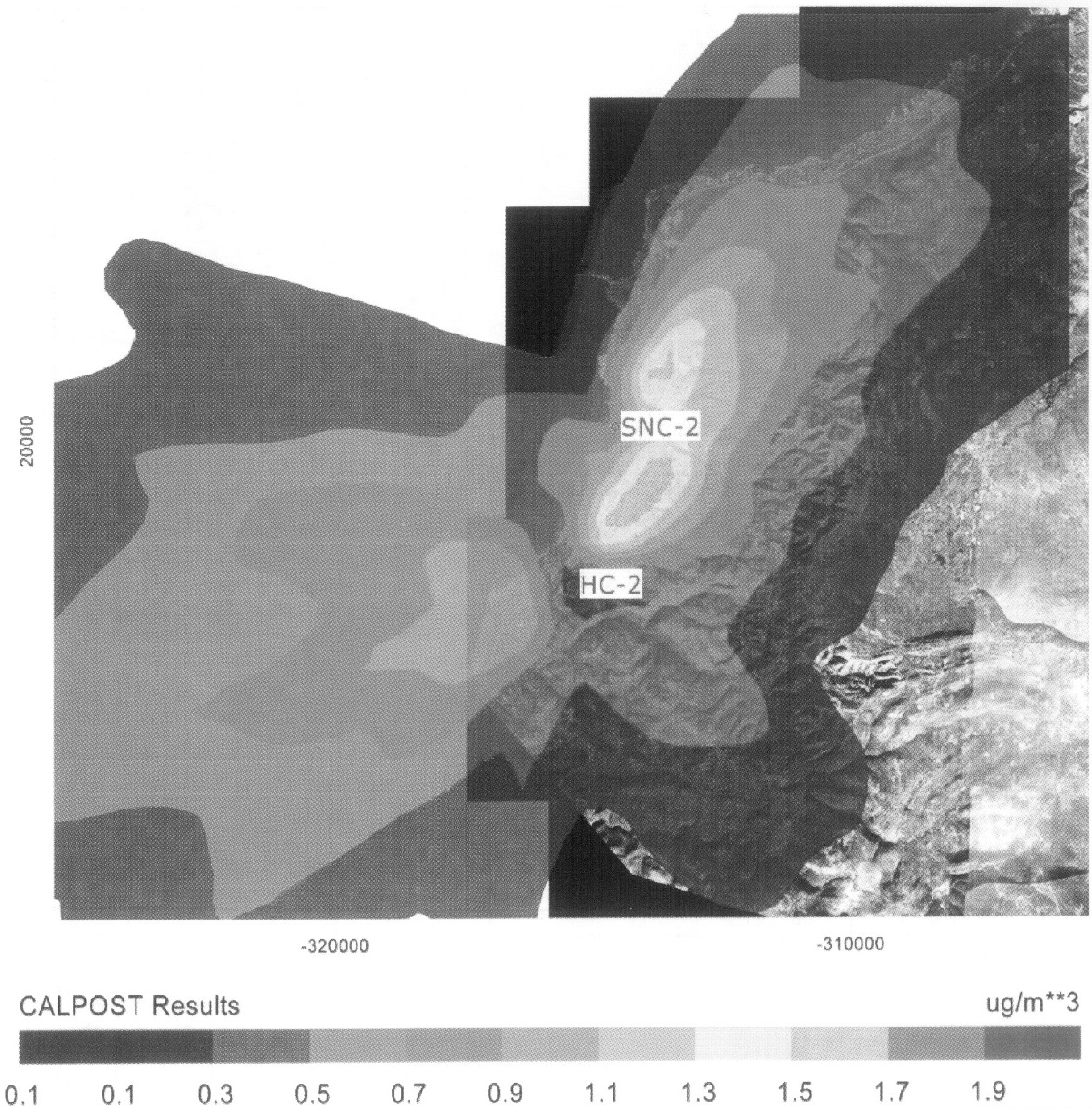
1. Chart for CO Concentration, 1-hour average.
2. Chart for CO Concentration, 8-hour average.
3. Chart for SO_2 Concentration, 3-hour average.
4. Chart for SO_2 Concentration, 24-hour average.
5. Chart for PM_{10} Concentration, 24-hour average.
6. Wind Rose for EMS record #1.
7. Wind Rose for EMS record #2.
8. Wind Rose for EMS record #3.
9. Wind Rose for EMS record #4.
10. Wind Rose for EMS record #5.
11. Wind Rose for EMS record #6.
12. Wind Rose for EMS record #7.
13. Wind Rose for EMS record #8.
14. Wind Rose for EMS record #9.
15. Wind Rose for EMS record #10.
16. Wind Rose for EMS record #11.
17. Wind Rose for EMS record #12.
18. Wind Rose for EMS record #13.
19. Wind Rose for EMS all records (#1 to #13).

Appendix D Air Pollution Computer Modeling

1. Satellite photo for cement factories and quarries
2. Layout for point sources, area sources and receptors
3. PM_{10} concentration (24-hour average), sample run with uniform winds at 5 m/s blowing from the SW, simulation time is 2 weeks, and 4 point sources active.
4. PM_{10} concentration (24-hour average), sample run with uniform winds at 10 m/s blowing from the SW, simulation time is 2 weeks, and 4 point sources active.
5. PM_{10} concentration (1-hour average), sample run with uniform winds at 5 m/s blowing from the SW, simulation time is 2 weeks, and 2 area sources active.
6. PM_{10} concentration (24-hour average), sample run with uniform winds at 5 m/s blowing from the SW, simulation time is 2 weeks, and 2 area sources active.
7. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #1, and 4 point sources active.
8. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #2, and 4 point sources active.
9. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #3, and 4 point sources active.
10. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #4, and 4 point sources active.
11. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #5, and 4 point sources active.
12. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #6, and 4 point sources active.
13. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #7, and 4 point sources active.
14. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #8, and 4 point sources active.
15. PM_{10} concentration (length-of-run average), wind speed and direction according to EMS record #9, and 4 point sources active.

PROJECT TITLE:

Air Quality Management and Estimated Health Impact of Pollutants in Urban and Industrial Areas



COMMENTS:

PM10 concentration (length-of-run average). Wind speed and direction according to EMS record #6. Four point sources active.

LAU

Civil Engineering Department

MODELER:

G. Karam & M. Tabbara

0 3 km

DATE:

8/11/2004

PROJECT NO.:

268-G-00-02-00223-00

CALPUFF View - Lakes Environmental Software

Appendix E Draft Proposal for Partnership

Partnership for Environmental Quality

"...

Preamble

As a major contributor to the economy and prosperity of Chekka and the Koura region, the Cement industry recognizes its critical responsibility in maintaining the environmental quality of the area that has hosted it for the last seventy years or so.

Through the Association of Lebanese Industrialists (ALI), and in partnership with the local municipalities of the region, a long term action plan for the improvement and management of environmental air, water, and soil quality will be developed and implemented following sound scientific principles and with the assistance of the Lebanese American University and other academic institutions and NGO's. This pioneering activity is part of a new ***partnership for environmental quality*** *between local government, industry, and academic institutions that is meant to be emulated and reproduced across Lebanon at every industrial zone.*

All partners acknowledge the catalyst role that USAID has played in bringing about this new environmental quality management paradigm, through its support to the pilot study that LAU has conducted on the air quality in the region from 2002 till 2004. The continued support and funding of USAID, and other donor agencies such as the EU, will be critical for the successful implementation of this initiative during the first three years.

Steering Committee for the Partnership for Environmental Quality (PEQ) in Chekka

The stakeholders understand the critical need for quick and perseverant action in implementing, reviewing and reporting on the attached action plan. To that effect all parties agree to the formation for the PEQ in Chekka of a steering committee of six members, with a possibility of extending that number to eight, composed as follows:

-Three representatives of the Association for Lebanese Industrialists (ALI)

-Three representatives of the Chekka and Koura municipalities (Chekka + 2)

-Three representatives of the scientific advisory team (two from LAU + 1)

-One observer from the Ministry of Environment

The IPE committee shall convene automatically at least twice per month, and shall publish quarterly reports. The first committee shall establish internal operating rules. Chairmanship of the committee shall be by rotation every six months between the industry and municipality representatives, the secretariat shall be maintained by LAU.

Action Plan

Environmental quality management (air, soil, water) to maintain healthy and safe conditions at surrounding areas as per EPA and world standards.

Funding

Funding for the action plan is estimated at 150,000 to 200,000 USD per year for the first three years, including the cost of equipment. The starting funds would be contributed at 30% by the concerned industrial sector at ALI, while the remainder of the funds would be raised through donor agencies such as the EC, USAID, and the World Bank. ..."