PROGRAM TO IMPROVE AIR QUALITY IN TIJUANA-ROSARITO

CONTENTS

1. FOREWORD

More than five years after the signing of the North American Free Trade Agreement (NAFTA), the northern region of Mexico already shows some changes in its economic and social dynamics, particularly in the border cities facing environmental challenges due to their natural growth and other causes induced by NAFTA. The communities in the binational border region show a legitimate concern that has led them to analyze the benefits and repercussions that can be expected in the immediate future and in the long-term due to their development. This concern has been particularly reflected in the Tijuana-San Diego[1] region.

Spatially, conurbation appears as a current trend between Tijuana and Rosarito∗ and with the city of Tecate in a not so far future. The intense relations that exist between these two cities in the exchange of goods and services promote and allow us to foresee an integrated metropolitan zone, as has happened in other parts of the country. For this reason, it is necessary to institute a joint air quality management, in order to integrate development strategies that are compatible with the environment and diminish the harmful effects on air quality.

The *Program to Improve Air Quality in Tijuana-Rosarito 2000-2005* represents the joint effort between the public, the local economic sector, and the three levels of government, to design and implement a set of actions with the purpose of controlling the sources of pollutants that affect air quality in the region.

Tijuana-Rosarito plays an important role in the national and regional economy due to its urban, demographic, manufacturing and entrepreneurial dynamics, as well as its proximity to the United States. This makes Tijuana-Rosarito, along with Mexicali and Ciudad Juárez, one of the most important border cities. The region's growth brings along social and economic benefits, but also problems related to urban development and the provision of infrastructure and services, which generate environmental problems, in particular the degradation of air quality.

Although there have been isolated attempts in the region at solving this problem, these have not always been successful, nor have they come up as a result of

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[1] Sánchez R.A., Ganster P. (1999). El desarrollo sustentable en la región Tijuana-San Diego. Center for U.S.-Mexican Studies. University of California, San Diego.

∗ In general, this document makes reference of the urban areas in the cities of Tijuana and Rosarito; the official name of the municipality of Rosarito is Playas de Rosarito.

coordinated strategic planning by the three levels of government. This has caused resources and efforts to fade away, decreasing the effectiveness of these efforts.

Some of the most noticeable contrasts between the two sides of the border are seen in their vehicular fleets. San Diego County has a large number of newer model vehicles equipped with the latest emissions control technology. On the other hand, Tijuana-Rosarito has a large number of vehicles that are more than 15 years old and lack adequate emissions controls. Other examples of the differences between the two sides of the border are the road networks and the amount of paving. In Tijuana-Rosarito approximately 50% of the roads are unpaved[2].

Although in some cases the low level of technological development can be an important factor in the degradation of air quality, the use of large volumes of fuels is comparable in terms of atmospheric emissions contribution. The longer the distance traveled, the larger the amount of energy consumed, which in turn leads to larger amounts of pollutant emissions. This is true even for vehicles equipped with emissions control devices that are in good working condition.

On the other hand, the presence in the Tijuana-San Diego Region of Mexican and US authorities with different responsibilities and jurisdictional structures; the proliferation of a large number of industrial, commercial and service activities, require the need for integrated and complex approaches toward solving the air pollution problem. Community involvement on both sides of the border is another element that requires the appropriate coordination between officials from both countries, for the enforcement of the necessary measures. Community involvement becomes a means to ensure permanent compliance with the Program's actions and requirements, evaluating its efficiency and giving it direction. The active involvement of multi-sector groups, such as the Tijuana-Rosarito-San Diego Binational Air Quality Alliance, Grupo Proyecto Fronterizo de Educación Ambiental A.C., Grupo Ecologista Gaviotas de Rosarito, just to mention a few, are examples of the level of participation and involvement of the community in this region.

The Program to Improve Air Quality in Tijuana-Rosarito 2000-2005 proposes 25 concrete measures that will allow, in the medium term, the gradual reduction of air pollution in the city, until air quality standards are eventually complied with and maintained. The development of these measures was a joint effort between municipal, state and federal environmental authorities, members of the academic community, and non-governmental organizations. The program seeks to propose a set of guidelines, primarily of preventive nature, to be followed and

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[2] Sánchez R.A., Ganster P. (1999). El desarrollo sustentable en la región Tijuana-San Diego. Center for U.S.-Mexican Studies. University of California, San Diego.

whose impact will not only benefit Tijuana and Rosarito, but the entire binational airshed.

This document consists of two separate parts; the first includes chapters two to four and presents a general overview and a diagnosis of the current air quality situation, as well as a review of the major efforts undertaken to this date to control air pollution. The second part includes a preliminary emissions inventory the to be completed, in its first draft, on the second half of 2000. This detailed inventory is being developed with the financial and technical support from the Western Governors' Association (WGA), California Air Resources Board (CARB), and the US Environmental Protection Agency (EPA). Likewise, the second part presents a description of the Program's objectives, goals, and proposed actions. The contents of each chapter are briefly described in the following paragraphs.

Chapter 2 establishes a general frame of reference about the reasons for developing the Program, including a brief account of the historical evolution of the region, and a description of the air quality management mechanisms in the Tijuana-Rosarito-San Diego binational airshed.

Chapter 3 addresses the general characteristics of Tijuana-Rosarito, including its socioeconomic, urban and transit characteristics. Also, it includes a brief description of recent air quality research studies and the main conclusions that have been drawn regarding the understanding of emissions sources and the behavior of pollutants in the region.

Chapter 4 presents a discussion of Mexico's current air quality standards and a general review of the health effects from pollutants, as well as statistics and trends for the different pollutants measured by the monitoring network. It also contains a description of the main meteorological variables that affect the spatial and temporal distribution of pollutants.

Chapter 5 presents the energy balance and the quality of the different types of fuel consumed in Tijuana-Rosarito, and the preliminary emissions inventory identifying desegregated pollution sources for the following sectors: industrial, commercial, services, transportation, and, soils and vegetation.

Chapter 6 explains the objectives and goals of the Program; it also describes specific control measures for each sector, naming the parties responsible for implementing these measures, as well as the management mechanisms that are expected to be followed.

Finally, the document has a bibliographic section and a series of technical annexes to support each chapter.

The *Program to Improve Air Quality in Tijuana-Rosarito 2000-2005* is available on the web page of Instituto Nacional de Ecología at: http://*www.ine.gob.mx*. The document can be consulted or downloaded from this site. Additional copies can be requested through the State Government and the City Governments of Tijuana and Playas de Rosarito.

2. INTRODUCTION

The cities of Tijuana and Rosarito, Baja California, are located in a strategic place of the US-Mexico border. They emerged as a consequence of a series of economic and social movements that arose because of their proximity to the United States. Historically, with the US-Mexico War of 1848 and the signing of the Guadalupe Hidalgo Treaties, the border towns of Tijuana, Tecate and Mexicali were founded. Tijuana has been a privileged place for handling important migrant flow since the 1940s.

Since that time there have been special economic characteristics which have had a strong influence on the region, making it a spatial regulator of the workforce that moves across the border. This comes as a result of their geographic proximity to the US and the relative economic integration of Tijuana-Rosarito with that of Southern California, the most dynamic economy in the US. These differences are also evident in the level and quality of life and, sometimes, in the environmental conditions on both sides of the border.

2.1. Historical background

The region that includes San Diego and Tijuana was inhabited by the Kumiai Indians, who along with the Pai-pai, Cahuilla, Akaula, Cocapah and Kiliwa, make-up the Yuman family of languages. This is one of the oldest ethnic groups in North America. Their semi-nomadic nature did not allow them to reach an advanced cultural development and thus they did not leave any archeological traces such as those left by the Mid-American groups. However, it is known that these people lived in huts, and that they were gatherers, fishermen and hunters.

The city of Tijuana is located in the valley of Tijuana. It has a surface area of 1,727 km^2 and it is shaped like a rectangle. Tijuana neighbors to the north with San Diego County, California, to the south with the municipalities of Playas de Rosarito and Ensenada, to the east with the municipality of Tecate, and to the west with the Pacific Ocean.

Tijuana has two mountain ranges in the shape of hills or cliffs, running from Sierra de Juárez all the way to the Pacific Ocean. The Tijuana River originates in this mountain range from a series of tributaries, at an elevation of 1,860 meters. These tributaries have a length of 40 kilometers and empty their waters into Rodriguez Dam. From this point on it is known as the Tijuana River. It flows across the valley, crosses the US-Mexico border, and empties its waters into the Pacific Ocean.

The first boat expedition in that zone was led by Juan Rodríguez Cabrillo in 1542. In 1602 Sebastián Vizcaíno led an expedition in which he traveled along the coastline between the cities of Rosarito and San Diego, and he made the first map of the California coastline. In 1769 a description of this area was published in the diaries of Friar Juan Crespí and Friar Junípero Serra.

Like in most of the Mexican territory, missionary congregations were in charge of providing spiritual advice to the people that lived in the lands that they were exploring. The border between Higher (Alta) and Lower (Baja) California was delineated by the area of influence of the Franciscan and Dominican orders. In 1769, Friar Junípero Serra founded the mission of San Diego, which incorporated the Indians of what is known today as Tijuana and Rosarito. In 1787, this Dominican friar founded the mission of San Miguel Arcángel, and established the limits between both Californias along El Rosario wash. This dividing line between missions turned into a political division when viceroy José de Iturrigaray declared Alta and Baja California independent provinces. Thus the valley of Tijuana became part of the mission that was founded in San Diego.

The first governor of Alta California was Luis Argüello, whose term began in 1823. The Argüello family received the lands that comprised the *Tía Juana Ranch Complex*, which belonged to the Indians of that region. The Argüello family controlled this zone for many years.

In 1833 the missions were secularized, giving more power to the civilians and leaving out the missionaries who were substituted by priests who reported to a bishop. This was a period of political instability, which was occurring all over the country. The governors, who had civilian as well as military power, replaced each other in rapid succession. There were even some attempts to annex on the part of some pro Americans, who wanted to be part of the already powerful United States.

As a result of the War of 1848, the signing of the treaty of Guadalupe Hidalgo the border communities of Tijuana, Tecate and Mexicali in Baja California were established. The first Customs station in Tijuana was established in 1874, close to the dividing line between the United States and Mexico. The purpose of this station was to regulate commerce and to keep a record of the goods that were being transported from south to north and vice versa.

Tijuana was established on July 11, 1899, even though the community had acquired the political designation of municipality in 1888. It is worth noting that until recently, it included the municipality of Playas de Rosarito.

In 1900 it became the first subprefecture of the municipality of the Distrito Norte de la Baja California. Its location on the border allowed for the beginning of the development of tourist activities. In 1908, by presidential decree, gambling was allowed in the territory of Baja California. The greyhound track, the horse race track, casinos and nightclubs were built as a result of this decree.

The enforcement of the Volstead Act (dry act) passed by the United States Congress in 1920, which prohibited the production, sale and consumption of alcohol, led to the proliferation of cantinas and nightclubs, and significantly increased the flow of tourism into Tijuana.

The Foreign Club and the Agua Caliente Jockey Club were established in this decade. Due to this influx of tourism, curio shops, hotels and restaurants were established. The income from the taxes allowed for the development of important public works, the most distinguished among them being the Rodríguez Dam completed in 1937.

The repeal of the Dry Act had a negative impact on the service sector and as a result many of the businesses had to close. In 1935, President Lázaro Cárdenas ordered that all of the gaming establishments in the nation be closed. This caused much discontent in a good part of the Tijuana community, which benefited both directly and indirectly from the work of the casinos.

The repatriation of Mexicans who had settled in the United States, provoked by the crisis of 1929, had an effect upon the population development of the City of Tijuana. Adding to this the entry of the United States into the Second World War created the need to contract Mexican workers for the centers of production which were left empty as a result of U.S. citizens fighting for the allied cause.

Thus an important migratory stream was developed during this period. Thousands of workers hoped to be contracted under the Bracero program. The families of these workers founded and chose to live in the developments (colonias), that now surround the central part of the city.

The considerable increase in population and growth of the city during the subsequent decades favored the border industrialization program, which facilitated the creation of maquiladora industries. These industries employed thousands of workers and are one of the strongest foundations of the regional economy, along with the tertiary sector of services and commerce. The agricultural sector consists primarily of, and was basically developed for the exportation of cotton and vegetables.

Tijuana has existed as a municipality for 110 years, is now one of the ten most important cities in the country with a population of approximately 1.3 million people. It is an example of a dynamic city that offers opportunities for development and progress, since its strategic location creates many economic and cultural exchanges, establishing itself on an international scale as an important trade center.

2.2. Economic development of the region and air Quality

The promotion of the development of the northern border in order to link it to the rest of the country began with the Border Program. The purpose of the program was to use domestic merchandise to supply the region and to establish industry that was geared toward local consumers. In the 1980s the Program to develop the Northern Border was initiated, as a strategy on the part of the federal and state governments to convert this region into a source of foreign currency and employment.

The location of the Tijuana-Rosarito-San Diego region within the same atmospheric airshed has generated binational implications as a result of a history of economic and social interdependence. In this sense, the peculiar nature of the region determines that, even though the amount and type of emissions and pollutants may be different on both sides of the border, the effects are felt on both sides. The need to explain and understand the environmental conditions from an integrated binational perspective comes from this fact.

Air quality deterioration in the region has been the result of the lack of planning in the development and evolution of the region. San Diego County is currently in non-attainment with the standards for ozone and particulate matter (PM10.) On the other hand, Tijuana-Rosarito is in non-attainment with the National Mexican Standards for PM10 and ozone, and occasionally for nitrogen dioxide. One aspect in particular that contributes to the levels of contamination in this area is the transport of ozone from Los Angeles. For example, it has been estimated that ozone transport from Los Angeles contributes more than half of the daily exceedances of the air quality standards in San Diego[3].

As a consequence of the 1990 amendments to the Clean Air Act in the United States, the EPA designated San Diego County as a “serious non-attainment area” for ozone. As a result, the County had to develop and enforce a State Implementation Plan, which created a series of emissions control measures to allow San Diego County to get back in compliance by 1999. Likewise, San Diego is in non-attainment with the state ozone and PM10 standards, which are tougher than the federal standards. As a result, the Regional Air Quality Strategy (RAQS) for the San Diego Air Basin, which is permanently evaluated and supervised by CARB, was implemented in 1992.

On the other hand, efforts to abate pollution in Tijuana-Rosarito have been sporadic and have not been part of a strategic plan. The main actions undertaken

[3] www.sdapcd.co.san-diego.ca.us/news/FAQS.htm.

up to this point are the result of efforts led by local and federal authorities, or derived from technical cooperation, through the Border XXI Program's Air Quality Binational Workgroup, which currently focuses its efforts on guiding and improving the scientific and technical knowledge of the problem. Some of the activities that this workgroup intends to undertake include the identification of pertinent measures to reduce emissions and bring the Tijuana-Rosarito-San Diego airshed into compliance with air quality standards within the next few years.

2.3. Air quality management in the Tijuana-San Diego international airshed

The different agencies from the three levels of government are working jointly in the management of air quality in the Tijuana-Rosarito-San Diego binational airshed, in order to accomplish the goals set for the different projects. SEMARNAPs Federal Delegation in Baja California, the agency in charge of organizing air quality meetings, is coordinating these actions. In order to accomplish its mandated tasks, SEMARNAP seeks the support from the National Institute of Ecology (INE) and the Attorney General on Protection of the Environment (PROFEPA). INE fulfills its policy functions through the Subdelegation on the Environment. This subdelegation issues the Annual Operating Licenses that are used to integrate the emissions inventory for the industrial sector and the air quality monitoring data. PROFEPA is in charge of verifying policy in the industrial sector that falls under federal jurisdiction, in order to make sure that industrial emissions are within the standard.

The State Government, through the Department of Ecology, regulates the emissions sources that fall under State jurisdiction. In order to fulfill its mandate, it delegates responsibilities to the Ecology Departments of the Municipalities of Tijuana and Rosarito. These three agencies are involved, along with SEMARNAPs Delegation, in the integration of a regional air emissions inventory.

In reference to the Border XXI Program, the US EPA Region IX (which includes the states of California, Arizona, Nevada, Hawaii and the Pacific Islands, with headquarters in the city of San Francisco), is involved in the air quality work that is currently taking place in this region. Region IX has actively supported the installation and operation of the Air Quality Monitoring Network and has granted resources to the Western Governors' Association (WGA) to develop an emissions inventory, and to other organizations, such as the Center for Information on Air Quality (CICA), to carry out other studies. The California Air Resources Board (CARB) has supervised the operation of the monitoring network in San Diego and is involved in air quality projects of the binational airshed, in coordination with San Diego Air Pollution Control District, the local agency in charge of air quality management in San Diego County.

The following is a description of the 1983 La Paz Agreement, its programs within the framework of the 1992-94 Border Integrated Environmental Program (BIEP) and the 1996 Border XXI Program, as well as the activities of the Border XXI Air Workgroup in the Tijuana-Rosarito region.

1983 La Paz Agreement

The formal joint effort on the part of the United States and Mexico to protect and improve the environment in the border region began in 1983. The signing of the 1983 *Agreement between the United States of America and the United Mexican States on Cooperation Regarding the Protection and Improvement of the Environment in the Border Area* is also known as the “La Paz Agreement”.

This agreement establishes a series of objectives related to border environmental cooperation, a mechanism for additional agreements, annexes and technical actions, as well as high level meetings and special techniques for promoting and fostering the cooperation between these two countries. This agreement also establishes formal communication procedures between the two countries and calls for the appointment of National Coordinators to direct and supervise the implementation.

The La Paz Agreement regulates a framework of cooperation between US and Mexican authorities to prevent, reduce and eliminate air, water and soil pollution sources along a 100-kilometer wide border zone on either side of the international border. This Agreement sets the general guidelines that must be applied in the specific projects mentioned in its five technical annexes. Some air quality issues are addressed in Annex IV, which is known as the *"Agreement between the United States of America and the United Mexican States on Cooperation Regarding Transboundary Air Pollution caused by Copper Smelters Along their Common Border";* and Annex V, known as the *"Agreement between the United States of America and the United Mexican States on Cooperation Regarding International Transport of Urban Air Pollution".* BIEP and the Border XXI Program were developed under the auspices of this Agreement, and are described in the following pages. It is important to mention that all air quality related binational activities are currently being carried out through the Air Quality Workgroup and are covered by Annexes IV and V. Annex G of this document includes the La Paz Agreement and those two annexes.

1992-94 Border Integrated Environmental Program

After the signing of the La Paz Agreement, a series of technical activities were initiated that were channeled through and incorporated into the BIEP, which was unveiled in 1992. In this stage of cooperation the BIEP proposed to deal with the most serious and prevalent environmental problems that existed in the border region, and it was acknowledged that there was incomplete knowledge on the environmental conditions along the border. For this reason, the BIEP was considered a plan that would evolve as new knowledge emerged.

BIEP also recognized that its success depended upon a collective effort. The participation of state and municipal governments, industry, commercial associations, NGOs, educational institutions and the general population was vital to the accomplishment of the set goals.

The objectives planned by BIEP were: i) to strengthen the accomplishments of the existing legislation ii.) Reduce pollution through new initiatives iii) increase the level of cooperation in planning, training and education, and iv) improve knowledge about the environmental problems along the border.

Some of the relevant actions concerning air quality included the creation of work groups to deal with compliance with environmental regulations, pollution prevention, and, in particular, directives to reduce pollution through new initiatives to control industrial sources. In addition, they established street paving programs as a means of reducing particulate emissions and to improve roads, bridges and traffic flow, mainly in highly congested urban areas.

Specifically, BIEP allowed for the beginning of a series of joint activities in the Tijuana-Rosarito-San Diego area, such as the first air quality studies.

Border XXI Program

As mentioned earlier, Annex V of the La Paz Agreement allows both Mexico and the United States to evaluate the causes and formulate solutions to the air quality problems in border sister cities.

The Border XXI Program (unveiled in December 1996) represents an innovative binational effort that brings together the diverse US and Mexican federal entities responsible for the shared border environment, to work cooperatively toward sustainable development, through the protection of human health and the environment, as well as the proper management of natural resources in both countries.[4]

The Border XXI Program lists long and short-term environmental objectives as part of its mechanism for implementation within the border region. This plan is the result of a great amount of input from the community, including the general public, state, local and federal governments, non-governmental organizations,

[4] El texto completo del Programa Frontera XXI puede ser consultado en: http://www.semarnap.gob.mx/ucai/FronteraXXI/fron21.htm.

and consultants. During the development of the program a strong effort was made to include public input.

The program also reflects a new institutional arrangement created by the signing of the North American Free Trade Agreement (NAFTA) in 1993, and assumes close coordination with the Border Environmental Cooperation Commission (BECC) and the North American Development Bank (NADB), which seek to support the development of environmental infrastructure along the border. Likewise, Border XXI coordinates its efforts with the Environmental Cooperation Commission, which was also formed within NAFTAs framework to promote environmental cooperation in the region.

The central strategy of the Program includes three points, which are instrumental to the accomplishment of its objectives:

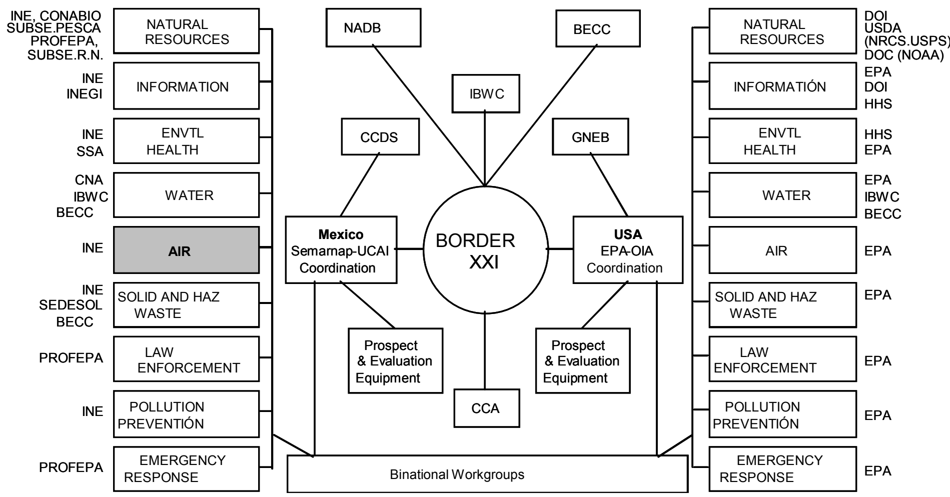
- Ensure public involvement in the development and implementation of the Border XXI Program.
- Strengthen the capacity of local and state institutions, as well as decentralize environmental management to ensure the participation of these institutions in the implementation of the Program.
- Guarantee interinstitutional cooperation to take full advantage of available resources and to avoid duplication of efforts between the government and other organizations, and to reduce the burden placed upon the border communities by the coordination of multiple entities.

Figure 2.1 shows the way in which the Program operates. Leadership of the Program is entrusted to the National Coordinators. Currently, there are nine work groups; six are coordinated by INE, as shown in Figure 2.1. The co-chairs of the Binational Workgroups are responsible for coordinating the implementation of activities of the different technical groups. Particularly, the Air Quality Workgroup is co-chaired by one representative from EPA and INE.

The EPA and INE have developed their respective national strategies to improve air quality. Those strategies are based on the basic air quality standards for each country. Both have established similar air quality standards for carbon monoxide, sulfur dioxide, nitrogen dioxide, ozone, and PM10, although EPA recently reviewed and updated the standards for ozone and particulate matter.

The parties involved in the Border XXI Air Quality Workgroup seek to improve the collaboration between border environmental entities at the various levels of government, with the objective of improving air quality in the border region between Mexico and the United States. With this objective in mind the Workgroup continues its efforts through sub-workgroups, one of them being Tijuana-Rosarito-San Diego.

Figure 2.1. Border XXI Program Organizational Chart



Due to the nature of the air quality problem, there is a strong link between the air quality workgroup and the pollution prevention, environmental information and environmental health workgroups, since they all deal with multi-media topics that require joint analysis and intervention.

A central aspect of Border XXI is the development of environmental goals and indicators, or success measures to monitor the progress in meeting the long-term objectives within the program, as well as the agreements to undertake decentralization actions in the northern border region.

The objectives outlined in the Program regarding air quality for the next five years, from its inception, included:

- Develop programs to study and improve air quality(monitoring, emissions inventories and modeling, among others)
- Continue strengthening institutional expertise and training in the border area. Stimulate community involvement.
- Review and recommend strategies for air pollution abatement directed toward vehicular, industrial and natural sources.
- Study the potential of economic incentive programs to reduce air pollution.

As previously stated, the air quality workgroup conducts its activities through the sub workgroups, which consist of sister city pairs and whose project objectives extend through the length of the border. These objectives are listed in Table2.1.

Table 2.1. Sub Workgroups and Projects within the Border XXI Air Quality Workgroup

Sub workgroups
• Tijuana-Rosarito-San Diego air quality programs • Mexicali-Imperial Valley air quality programs • Ambos Nogales air quality programs • Douglas-Agua Prieta air quality programs • Cd. Juárez-El Paso-Sunland Park air quality programs • Brownsville-Laredo air quality programs • Air quality and energy • Border vehicular congestion • Air quality in Big Bend
Projects
• Air Quality Monitoring in Mexicali • Air quality monitoring in Tijuana-Rosarito-Tecate • Intensive Air quality monitoring Study in California-Baja California • Emissions Inventory Development Program for Mexico • Development of the Emissions Inventory for Mexicali • Validation of the Emissions Inventory for Mexicali • Development of the Emissions Inventory for Tijuana-Rosarito-Tecate • Center for Information on Air Pollution (CICA) • Air Pollution Training Program for Mexico • Methods to calculate unique source category emissions in Mexicali • Joint Advisory Committee for the Improvement of Air Quality in Ciudad Juárez-El Paso-Doña Ana County

The Work Group continues with its regional efforts to promote and reinforce the air quality monitoring networks, develop emissions inventories and model air quality, with the purpose of analyzing the formation and dispersion of pollutants. The group also promotes the creation of programs and strategies to improve air quality that serve as tools for local environmental managers to characterize the interrelationships between air quality, soil use, transportation planning and economic development. Some of the studies conducted under the coordination of this group are described in chapter 3.

Some of the most relevant projects include the creation of the Center for Information on Air Pollution (CICA), which operates under the auspices of the EPA. CICA provides free information and advice on subjects related to air pollution and sponsors the development of technical studies on border-specific topics. Another project is the development of the Emissions Inventory Methodology for Mexico. This project is being supported by WGA and has allowed, for the first time in Mexico, to develop a series of manuals, a course which has been conducted successfully in various of cities in the country, and the integration of the inventories for the cities of Mexicali and Tijuana-Rosarito-Tecate. These activities are described in depth on INEs web page at (http://www.ine.gob.mx), which also provides the necessary links to access CICAs and the WGAs web pages.

As a result of the comments received on the Border XXI Program, the Air Quality Workgroup designated resources for the creation of two new sub workgroups, including the borderwide energy sub workgroup and the vehicular congestion sub workgroup. The former has the objective of promoting energy efficiency, thus reducing air pollution. The latter will provide possible mechanisms for reducing air pollution due to vehicular traffic congestion at the ports of entry.

2.4. Co-responsibility in air quality management

On the Mexican side, the government institutions that are responsible for air quality management are: SEMARNAP at the federal level, the State of Baja California at the state level, and the governments of the municipalities of Tijuana and Rosarito at the local level. On the United States side: the US Environmental Protection Agency (EPA) is responsible at the federal level; California Air Resources Board (CARB) at the state level; and, San Diego County Air Pollution Control District (SDAPCD) at the local level.

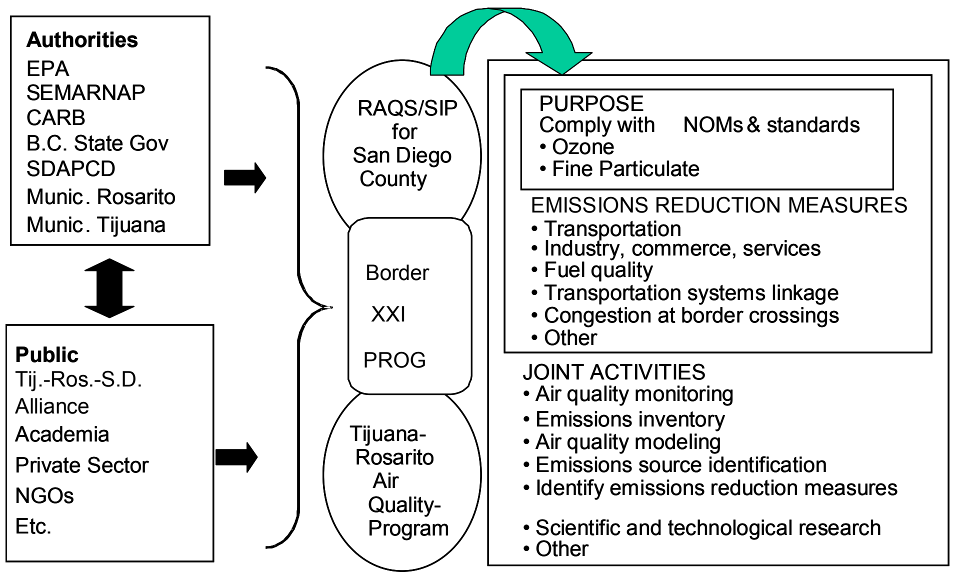
This institutional arrangement complicates the implementation of solutions for the environmental problem, due to the existence of different legal frameworks on each side of the border. The operation of pollution sources must abide by a specific set of regulations, at the municipal, state or federal level. Harmonization of legal and policy frameworks is not very feasible in the short-term. Therefore, it is more realistic to assume that binational work will take place under different frameworks during the next few years, as far as administrative and compliance requirements, as well as pollution emissions limits. However, this is not an obstacle toward taking action. On the contrary, it represents an opportunity for all the parties involved to seek novel solutions to the problem.

These different action frameworks make-up one of the aspects that make it difficult to coordinate and implement actions. In this sense, the role of the municipalities in the subject of air pollution abatement deals with the prevention and control of emissions generated by mobile and stationary sources operating as commercial or service establishments. Likewise, the State Government and SEMARNAP have jurisdiction over industrial sources of diverse nature.

On the other hand, in the United States, major sources can be subject to the compliance of numerous regulations and programs related to air emissions, in addition to particular limits that are set for different pollutants. One of these regulations deals with attainment and maintenance of air quality standards, the regulation of toxic substances, the acid rain program, and the program to reduce the emission of substances that destroy the stratospheric ozone layer, which will necessarily require a full level of participation.

Based on this environmental action framework, the objective of any activity that is undertaken in the binational airshed should be to reduce emissions, or at least avoid increasing them. All of this must be done under a concurrence scheme, with the ultimate objective of diminishing the levels of fine particulate and ozone that are present in the airshed. This concept is illustrated in Figure 2.2, where the Air Quality Workgroup appears as the point of convergence for all specific and joint activities that are taking place in Tijuana-Rosarito-San Diego.

Figure 2.2. Interrelation and objectives of the programs and activities to improve air quality in the Tijuana-Rosarito-San Diego region



Here we can observe the role that the public will play as an entity that provides advice and issues recommendations to federal and local authorities, for the improvement of air quality in the region.

The air pollution elements that are present in this binational airshed, as well as the opportunities that exist for the joint development and application of control measures, can be analyzed following the traditional air quality management approach. Under this approach, the physical, chemical and climatological aspects of air pollution must be characterized, in order to understand its time-space behavior. Afterwards, it is necessary to understand its behavior in terms of air pollution sources, in order to be able to identify them, quantify their contribution to the problem, and design opportunities to reduce them in an efficient manner with the lowest economic, social, and political cost. Progress in the following areas is very important to accomplish this objective:

- the conjunction and development of a complete emissions inventory, which is temporally and spatially desegregated, for the entire airshed,
- have in place a regional air quality monitoring network that allows an integrated view of air quality, and
- measure and evaluate the benefits that are achieved through emissions reduction, using air quality simulation models.

It is also relevant to improve volume estimates for major source emissions, particularly those related to transportation. During this process it is of utmost importance to use standardized techniques and methods in the development of emissions inventories for the airshed as a whole.

Within this framework, the *Program to Improve Air Quality in Tijuana-Rosarito 2000-2005* proposes an agenda that includes concrete measures assigned to the different levels of government, that allow, within a reasonable period of time, compliance with air quality standards to protect the health of the general population. Government authorities, as well as the public, were involved in the development of these measures. This Program should be considered as a dynamic instrument that must be permanently updated and adapted.

3. GENERAL CHARACTERISTICS

3.1. Socioeconomic characteristics

The main objective of this section is to provide information about the relevant social, demographic, and economic characteristics of the Tijuana-Rosarito region. This has the purpose of describing population dynamics and their relation to the local economy, as well as to have the ability to set a forecast in terms of its implications on the program. Those variables are not bound to any standards and cannot be seen in an isolated manner, since they both produce reciprocal conditions that are generated by their own nature.

Demographic characteristics

The population of the State of Baja California in the year 2000 was estimated at almost 2.5 million people, of which approximately 50% are concentrated in the city of Tijuana and almost 3% in Rosarito[5]. The region has a vehicular fleet of approximately 360 thousand units in Tijuana and 11 thousand in Rosarito. The surface are of these municipalities is 1,727 km^2 for Tijuana and 41 km^2 for Rosarito.

The demographic aspect sets Tijuana apart from the other municipalities in Baja California. Its demographic growth was almost explosive during the 1970-1990 period, with a 3.8% annual growth, which doubled its population.

Table 3.1 shows a comparison of the demographic data for Tijuana-Rosarito with that for San Diego, California.

Table 3.1. Comparison of some urban and demographic aspects of Tijuana-Rosarito and San Diego

	Unit	Tijuana-Rosarito	San Diego
Surface area	km^2	1,768	11,029
Population	Persons	1,275,781	2,600,255
Population density	Persons/km^2	721	236
Vehicular fleet	Number of vehicles	371,032	1,603,000
Persons per vehicle	Persons/vehicle	3	2

[5] INEGI (2000). Resultados Preliminares del XII Censo de Población y Vivienda 2000.

Immigration

As a transborder process, immigration refers to the circular movement of Mexican workers, whose starting and ending point are in the Mexican border region. It is difficult to precisely estimate their time of stay in the United States, as well as the frequency of their migratory movements. This scheduled immigration process makes itself evident in urban development mainly in three ways:

- The entrance of non-locally produced money, which has a consequence on the increase in the level of quality of life, urban demands and economic structure.
- Reduction in local labor market pressure.
- The formation of interurban and interregional networks that contribute to the integration of the city of Tijuana in the urban system of the southwestern United States.

This migratory phenomenon explains to a small extent the accelerated demographic growth that the cities of Tijuana and Rosarito have experienced in the last several years. It is important to mention that this migratory behavior has great influence on the urban growth of the region, since a large number of people who to Tijuana with the intention of crossing into the United States do not accomplish their goal and decide to stay in Tijuana.

Economic characteristics

Economic importance of Tijuana

The recent evolution of Tijuana reflects an important change in its economic base, mainly characterized by a lesser involvement in the production of traditional activities and fast industrial growth. Although this is part of a widespread transformation and expansion process of the international industry located at the border, the transition from a duty-free zone scheme to that of the rest of the country, as well as the slow economic growth in California, have accentuated this structural growth.

For many years it was talked about the tertiary economy of Tijuana, where the commerce and service branches generated most of the aggregated value for the economy and also the largest number of jobs. During the 1950s, in the middle of the economic expansion of the United States, the tertiary sector accounted for three-quarters of the regional product. However, as the secondary sector grew during the 1960s and 70s, its contribution decreased. The secondary sector was mainly noticeable with the presence of the maquiladora industry, which currently represents almost 80% of the private investment in Tijuana (Table 3.2).

Table 3.2. Private Investments in Tijuana, 1997 (Millions of dollars)

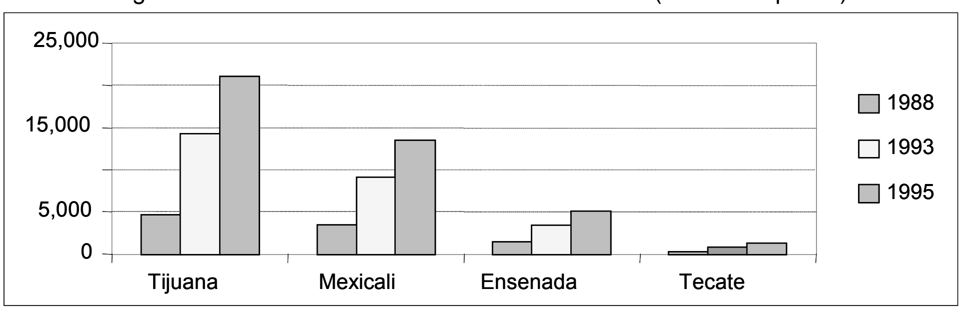
Sector	Investment	Percentage
Maquiladoras	480	77.3
Commercial and service infrastructure	51	8.2
Industry	34	5.5
Housing	30	4.8
Industrial infrastructure	26	4.2
Total	621	100

Source: Revista Análisis de las Estadísticas Básicas de Baja California, IV Trimestre 1997, Secretaría de Desarrollo Económico.

Macroeconomic Indicators

The gross domestic product for the State of Baja California has been increasing, going from almost 10 thousand million pesos in 1988, to almost 41 thousand million in 1995. Tijuana's economy has contributed to almost 50% of the State's GDP, as can be seen in Figure 3.1.

Figure 3.1. Distribution of Gross Domestic Product (Millions of pesos)



Source. Developed by the Secretariat of Economic Development of the State of Baja California, based on data from INEGI, 1988-1993, and CEDECO, 1995.

Due to its international character, Tijuana's economy will continue depending on external factors related to the international trade of industrial products, the economic cycles of the United States, and the behavior of the macroeconomic variables in Mexico. Each of these can individually impact, in a positive or negative way, the productive activities of this border region.[6]

Economic development of Tijuana and Rosarito

The maquiladora industry has played an important role in the economic growth of the city. During the 1950s and 1960s the tertiary nature of Tijuana's economy was accentuated. In 1950, 54% of the economically active population was dedicated to tertiary activities and by 1960 this percentage increased to 55%. Occu-

6 XV Ayuntamiento de Tijuana, Plan Municipal de Desarrollo 1996-1998, Tijuana, Baja California.

pation in the industrial sector increased in relative terms, whereas the primary sector lost importance in absolute and relative terms.

The industrialization process started with the Border Industrialization Program in 1966, which had the objective of abating unemployment in the northern border region and stimulate its industrial development and regional integration to the country. Currently, the manufacturing activity covers several categories, providing dynamics to this productive sector.

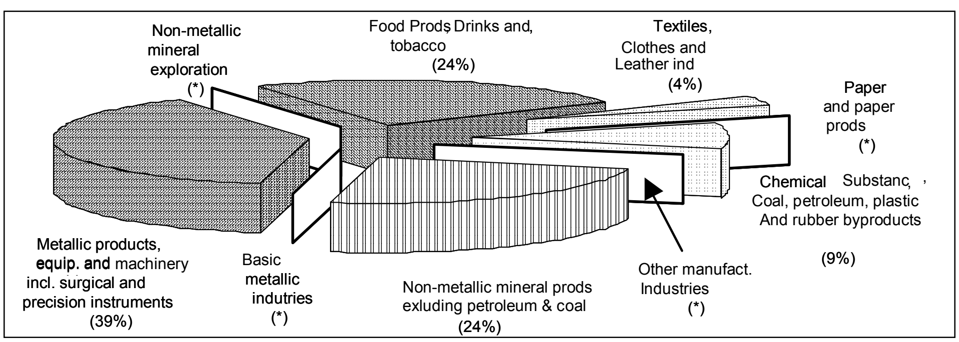
The most important categories, in terms of the number of establishments, are: metallic products, equipment and machinery; food, drink and tobacco products; and, non-metallic mineral products (Table 3.3 and Figure 3.2). These subsectors contribute significantly in providing formal jobs.

Table 3.3. Manufacturing establishments by sub-sector in Tijuana and Rosarito

	Economic units	***Staff employed***
Non-metallic mineral exploitation	*	94
Food, drink, and tobacco products	230	2,820
Textiles, garments and leather industry	34	1,129
Paper and paper products	*	1,063
Chemical substances, petroleum, coal, rubber and plastic byproducts	86	97,064
Non-metallic mineral products, excluding petroleum and coal byproducts	230	2,868
Basic metallic industries	*	12
Metallic products, equipment and machinery. Includes surgical and precision instruments	363	16,876
Other manufacturing industries	*	3,447

Source: XIV Censo Industrial, Censos Económicos 1994. Baja California.
MNP- Thousands of New Pesos * Data was omitted to maintain confidentiality, INEGI

Figure 3.2. Economic units by subsector in Tijuana and Rosarito



Source: XIV Censo Industrial, Censos Económicos 1994. Baja California.
MNP- Thousands of New Pesos * Data was omitted to maintain confidentiality, INEGI

With respect to the services sector, automobile repair and maintenance contribute the largest number of jobs (Table 3.4).

Table 3.4. Service establishments for some activity branches in Tijuana and Rosarito*

	Establish-ment	**Personnel used**
Dry cleaning and laundering services	179	608
Equipment and machinery repair and maintenance. Includes transportation equipment	95	335
Automobile repair and maintenance service	1,612	4,259
Services related to ground transportation	102	522
Services related to air transportation	**	346

Source: INEGI, 1994 XI Censos económicos 1994, Censo de servicios de Baja California.
* 1993 numbers. ** Data omitted to maintain confidentiality, INEGI.

Economically active population and employment levels by activity sector

The economic development in Tijuana and Rosarito can be compared to that of other border cities around the country, since it has become a job-generating zone in response to the increasing job demand of the maquiladora industry.

With respect to the economically active population by activity sector in Tijuana, the largest percentage comes from the tertiary sector (commerce and services), accounting for 52% of the total active population. Although the tertiary sector continues having a determining impact on the local economy, its loss of predominance contrasts the accelerated growth of the secondary sector (31%), with strong contribution from the maquiladora industry and lesser contribution from the construction industry.

With respect to the primary sector, this sector showed decreasing trends since the 1940s and, starting in the 1980s it has maintained a constant growth, although it still has a minimum percentage of contribution, which is not very representative of the city's local economy.

Employment levels

Due to the diversification of the economic base, diversification of jobs by sector is mainly linked to growth in the industrial sector, which practically doubled in less than ten years. Due to its quick expansion, salaries and types of jobs offered, the industrial sector is the one that shows the highest rate of staff rotation. This is made easier by a shortage of a highly specialized labor force, which is due to the nature of the jobs that characterize the economy of the city.

It is important to mention that Tijuana has the lowest rate of unemployment in Mexico with 1.2%, as opposed to the national average of 4.2%. At a regional level, in comparison with San Diego, Tijuana shows a tendency for reducing its unemployment rate, whereas San Diego remains constant at 4.3%[7].

3.2. Urban and road service characteristics

Road services

Currently, the city of Tijuana has 13 million square meters of paved roads, representing 60% of the urban limits, which indicates that 40% of the streets are unpaved. It can be mentioned that the roadway structure of this city is radial, with 57 road nodes, and the average travel velocity in the city is between 40 and 60 km per hour. Table 3.5 lists the main roads in Tijuana.

Table 3.5. Road system in Tijuana

Road system	Location
Toll Federal roads	• Tijuana-Ensenada scenic road where tourist vehicle prevail with 82%, 1% buses and 17% freight trucks. • Tijuana–Tecate highway, with annual average of 81% tourist vehicles. • Transpeninsular highway that runs through the length of the B.C. peninsula and starts in Tijuana. • Federal highway No. 2 communicates Baja California with the rest of the country.
Toll-free federal roads	• Tijuana to Rosarito–Ensenada highway. • Tijuana–Tecate highway, from the intersection of the Federal highway with Blvd. Insurgentes to the intersection with Blvd. Díaz Ordaz, in the La Presa delegation. • Tijuana–Mexicali highway, including the exit stretch from Km. O to Km. 1 of the Federal Highway, and the highway stretch on Blvd. Mesa de Otay of the Mexicali–Tijuana highway. • The 2-km stretch from Calle 16 to Colonia Libertad leading to the airport. • The 5.3 km stretch of road through the Tijuana airport. • The stretch of the boulevard that leads to the international port of entry by the commercial access in La Mesa de Otay. • The stretch of Tercera Oeste Boulevard that leads to the Otay port of entry. • The 4.2 Km stretch of the toll-free road to Ensenada (all the way to the traffic light at the entrance to San Antonio de los Buenos). • The road stretch in San Antonio de los Buenos on the Tijuana–Ensenada road. • All the stretches of the Tijuana–Ensenada highway, leading to Playas de Tijuana.

[7] Information collected from *"The San Diego/Tijuana Economic Review",* 1997.

Road system	Location
Primary road system	• Playas sector, Paseo Playas de Tijuana stretch. • Cañones sector, continuation of Calle Segunda by Génova and Allende, Ave. Internacional, South Freeway, Blvd. Fundadores. • Aguaje de la Tuna sector, toll-free federal road to Ensenada. • Central sector, Calle Segunda and Tercera, Ave. Revolución, Ave. Paseo de los Héroes, Ave. Paseo Tijuana, Ave. Padre Kino. • Hipódromo sector, Blvd. Agua Caliente, Blvd. Salinas, North freeway, Calz. Lázaro Cárdenas. • La Gloria sector. • Otay sector, Calle 16, Ave. Aviación, Road to the Airport, Calz. Tecnológico Rampa Buena Vista, return road from the airport, Ave. J. Rendón Ibarra, second axis East-West. • La Mesa sector, Blvd. Gustavo Díaz Ordaz, Ave. Sánchez Taboada, Paseo Reforma. • Río Tercera Etapa Sector, continuation Calz. Lázaro Cárdenas, Calle Benton, Blvd. San Martín, Blvd. Insurgentes, Blvd. Simón Bolívar. • Cerro Colorado sector, CETYS ramp, Paseo de Cucapá. • La Presa sector, continuation Blvd. Insurgentes. • La Presa Este sector, limit of Calle Sauce and limit with Tijuana–Tecate–Mexicali Hwy. • Florido sector, Calle Sauce, Ave. Guadalupe. Victoria, Ruta Independencia, Ave. Javier Mina.
Secondary road system	• Playas sector, Ave. Paseo Playas de Tijuana, Paseo Ensenada, Paseo del Pedregal. • Cañones sector, Ave. Sánchez Taboada, Paseo Montaña, Cañón de los Rosales. • Obrera sector, Ave. de las Palmeras, Ave. Braulio Maldonado, cañón K, calle Chopo Ortega, cont. calle Nueve, Cañón Johnson, Ave. Artículo 123, Cañón Jalisco, Ave. Centenario, Calle Cerro de la Silla, Prol. Gral. Ferreira. • Aguaje de la Tuna sector, calle Plutón. • Central sector, Ave. Constitución, Ave. Fco. I. Madero, Ave. Negrete, calle Nueve, calle Diez, Blvd. Sánchez Taboada. • Hipódromo sector, Ave. de los Olivos, Ave. Mocorito, Ave. Hipódromo, Blvd. Lomas, Blvd. Las Américas, Blvd. Las Palmas, Ave. de las Ferias, Ave. López Lucio, Ave. Ermita, calle de Los Pollos, calle Papagayo. • La Gloria sector. • Otay sector, Ave. Pino Suárez, Ave. Félix Parra, Ave. Contreras, Ave. Universidad, Ave. Ingenieros, Ave. Humboldt, Ave. Josefa Rendón Ibarra, Blvd. Bellas Artes, Ave. López Portillo Ote–Pte, Ave. Alfonso Vidal y Planes, Ave. Sor Juana Inés de la Cruz, eje uno Ote–Pte, Ave. Los Mochis, Ave. Industrial, calle Maquiladoras. • La Mesa sector, calle Lomas Hipódromo, Blvd. Pacífico, Blvd. Las Huertas, Ave. Paseo de las Lomas. • Río Tercera Etapa sector, Ave. 20 de Nov., Blvd. Ferrocarriles, Ave. de los Árboles. • Alamar sector, Ave. de los Grandes Lagos, Ave. del Fuerte. • Cerro Colorado sector, Ave. San Pedro Mártir, Ave. paseo Guaycura, Ave. Cochimie, Ave. Miguel Alemán, Ave. Las Hojas, Ave. Cachimín. • La Presa sector, Blvd. Las Fuentes, Ave. Los Pinos, Ave. México lindo, calle General Contreras, Ave. Margaritas, Ave. Los Reyes, Ave. de las Presas. • La Presa Este sector. • Florido sector, Ave. María Herrera, ruta Hidalgo, road H. Galeana. • Matamoros sector, Calz. Lázaro Cárdenas, road to Ejido Matamoros.

Source: Programa de Desarrollo Urbano del Centro Población Tijuana, 1998.

With respect to the municipality of Rosarito, 95% of the streets are unpaved and the average travel velocity is about 30 km per hour. Table 3.6 lists the main roads of his municipality.

TABLE 3.6. Road system of the municipality of Rosarito

Road system	**Location**
Regional high-way	• Tijuana–Ensenada scenic highway. • Tijuana–Ensenada toll-free highway.
Primary road system	• Benito Juárez Norte and Centro Boulevard. • Vicente Guerrero Boulevard. • Convergence with regional roads.
Secondary road system (paved)	• Ave. López Mateos, Ave. Quetzalcóatl, Ave. Fundadores de B. C. • Blvd. Los Cuñados. • Ave. Paseo de las Lomas. • Blvd. SHARP. • Road to PEMEX. • Access to CFE. • Calle Lázaro Cárdenas, Calle Dátil, Calle Art. 27, Calle Tijuana, Calle Villa del Mar. • Calle la Fuente, Calle Corvera Kiriakides, Calle Mexicali, Calle Ensenada, Calle Fco. Villa, Calle Lázaro Cárdenas, Calle 5 de Mayo, Calle del Ángel. • Calle la Casa de la Langosta. • Calle del Sauz, Calle Abeto. • Calle Parque Abelardo L. Rodríguez. • Calle del Nogal, Calle Eucalipto, Calle La Palma. • Calle Morelos. • Calle La Barca.
Secondary road system (unpaved)	• Calle Art. 27, Calle Morelos, Calle Emiliano Zapata. • Access street to Colonia adjoining Terrazas del Pacífico. • Access streets to Cañón Rosarito, Colonia Morelos, to Lomas Altas I and II, and to Playas de Santander. • Access street to Colonia Nuevo Rosarito. • Calle 5 de mayo, Calle Faustino Alvarado, Calle Diego Esquivel. • Blvd. Los Cuñados, Blvd. Fundadores de Baja California. • Ave. General Juan Vicario.

Source: Dirección de Obras Públicas y Desarrollo Urbano Municipal, Rosarito, 1999.

Vehicular Fleet

A large part of the air pollution in the area is generated by urban, road and transportation sources. The first category includes aspects that impact both sides of the border, as well as the number of booths where a large part of the tourist and commercial exchange take place. Some aspects such as the type and quality of public transportation, roads and maintenance have implications that have yet to be evaluated in a precise manner to generate indicators that lead to actions and priorities for the competent authorities. Table 3.7 shows the vehicular fleet broken into vehicle type for each municipality in the study area.

Table 3.7. Vehicular fleet of Tijuana-Rosarito

Type	# of vehicles in Tijuana	# of vehicles in Rosarito
Private cars	260,996	7,901
Taxi cabs	7,125	460
Pick-up trucks	79,533	613
Gasoline-fueled passenger trucks	1,380	12
Diesel-fueled passenger trucks	2,219	20
Gasoline fueled freight trucks	1,258	227
Diesel-fueled freight trucks	8,490	1,204
Motorcycles	2,187	330
Total	363,188	10,767

Source: Secretaría de Planeación y Finanzas del Gob. del Edo., 1998.

International Border Crossings

In 1997, approximately 53 million vehicles crossed the border at the two international ports of entry (Table 3.8), an increase of 4% with respect to1995. During the same year 7 million vehicles crossed the border at Mexicali and a little more than 1 million at Tecate. Assuming a conservative 8-minute average queue time per vehicle, the border crossing area in Tijuana is being impacted by approximately 18 thousand tons/year of vehicular emissions. Table 3.9 indicates the number of vehicles that crossed the Tijuana border monthly in 1997. As can be observed, the magnitude of the crossings seems to increase during the summer vacation period and they occur mainly at the city port.

Table 3.8. Number of vehicles that entered through Tijuana

Port of Entry	Year	Total
San Ysidro and Otay	1995	50,995,661
San Ysidro and Otay	1996	52,415,600
San Ysidro and Otay	1997	53,046,949

Source: Revista Tijuana Hoy, No.4 (Migración), XV Ayuntamiento de Tijuana.
The San Diego Tijuana Economic Review, Volume 3, Number 1, April 1997.

Table 3.9. Vehicle crossings in the international border of Tijuana, 1997

	Number of vehicles		
Month	**Tijuana POE**	**Otay POE**	**Monthly Total**
January	3,459,718	826,760	4,286,478
February	2,905,400	750,700	3,656,100
March	3,360,631	887,686	4,248,317
April	3,284124	866,874	4,150,998
May	3,252,468	833,005	4,085,473
June	3,258,688	912,980	4,171,668
July	3,990,940	834,886	4,825,826
August	4,112,921	850,166	4,963,087
September	3,954,009	832,162	4,786,171
October	3,902,778	881,597	4,784,375
November	3,724,035	797,458	4,521,493
December	3,792,265	774,698	4,566,963
Annual Total	42,997,977	10,048,972	53,046,949

Source: US Immigration and Naturalization Service, 1997.

Soil uses

The city of Tijuana has an urban zone surface area of 298.6 km^2, of which 66% is residential, 9% for industrial use, 7% for commercial use and 18% for other uses.

Table 3.10. Soil uses in Tijuana

	Surface area (hectares)				
Soil use	**1995**	**1996**	**1997**	**1998**	**2000**
Agriculture	141.66	141.66	141.66	141.66	141.66
Agroindustry	863.82	863.88	863.94	864.00	864.12
Green areas	184.99	186.67	188.35	190.03	193.39
Commercial	1,821.17	1,877.91	1,934.65	1,991.39	2,104.87
Controlled-transition	1,644.55	1,644.70	1,644.85	1,645.00	1,645.30
Equipment	1,107.79	1,201.94	1,296.08	1,390.23	1,578.52
Housing	15,563.40	16,403.00	17,242.59	18,082.19	19,761.38
Industry	1,522.16	1,739.89	1,957.63	2,175.36	2,610.83
Water mass	812.02	812.35	812.67	813.00	813.65
Metropolitan park	75.91	76.54	77.17	77.80	79.06
Special use	46.13	50.20	54.28	58.35	66.50
Total	23,783.60	24,998.74	26,213.87	27,429.01	29,859.28

Source: IMPlan: Proyección lineal con base en la carta urbana 1995, y actualización de los usos de suelo, 1998.

With respect to soil use in Rosarito, 57% of the surface corresponds to the urban zone, 20% are rural lands and barren lots, 10% is for residential use and 13% for other uses (Table 3.11).

Table 3.11. Soil uses in Rosarito

Soil uses	Surface area (hectares)
Urban area	2,335.90
Housing	408.13
Commercial	108.36
Industrial	21.49
Equipment	34.43
Rural and vacant lots	824.02
Road infrastructure	397.79
Total	4,130.12

Source: Plan Municipal de Desarrollo de Rosarito 1998-2001.

3.3. Previous air quality studies and programs

The following is a summary of results obtained through some research and studies conducted in recent years to characterize the air quality situation and control air pollution sources in the Tijuana-Rosarito-San Diego region. Special attention is given to those studies that tend to provide a better understanding of the processes that lead to high concentrations of fine particulate and ozone. Also, a brief description of those studies that are currently underway or about to get underway is provided.

Climatology of Diffusion for the City of Tijuana, B.C. (Jáuregui, 1981)[8]

The objective of this study was to describe the synoptic systems that define the weather in the Tijuana area, as well as to examine the meteorological factors that have the greatest influence on the dispersion and transport of pollutants that are emitted into the urban atmosphere of this zone.

According to an analysis of the superficial air flow lines, the author draws some conclusions as far as atmospheric pollutant transport and points out that during the night and the early morning hours, pollutants that are emitted into the atmosphere in Tijuana tend to be transported to the northwest side of the city, in the direction of San Isidro, California. At noontime, when the western breeze mechanism kicks in, pollutants that traveled to the northwest earlier in the day, converge at the southern edge of the urban area of San Diego and later on are transported in the direction of Tijuana by reverse flow. According to the author, due to the fact that westerly and westerly-northwesterly winds are more intense than those coming from the southeast, pollutant transport is faster upwind in the airshed, all the way to Rodríguez dam. In the afternoon, pollutants are confined in this way to mountain slopes, in the surroundings of the dam.

According to the author, pollutants can follow an alternate route, along the course of Alamar wash, with an almost east-west direction. According to this route, the cloud of pollutants that comes from the southern end of San Diego, goes over the course of the river (in central Tijuana, where there is channeling), where it receives the contribution from emissions sources in Tijuana. At that point, it splits into two separate flows, one in the direction of the dam and the other along the Alamar wash riverbed to the east. It goes around Colorado hill to the east, until it reaches the area around Rodríguez dam. At nighttime the breeze-wind of the valley weakens until midnight, when the flow is reversed and pollutants are slowly transported back to central Tijuana and over the border.

Second Triennial Review of the Impact of Pollutant Transport on Ozone Concentration in California. (Nov. 1996)[9]

The amendment to the California Clean Air Act of 1992, recognizes that ozone and its precursors can be transported by the wind for long distances and cause

8 Jáuregui, O.E. (1981). Climatología de Difusión de la Ciudad de Tijuana, B.C. Boletín del Instituto de Geografía. Número 11. Universidad Nacional Autónoma de México. México.

9 Air Resources Board (1996). Second Triennial Review of the Assessment of the Impacts of Transported Pollutants on Ozone Concentration in California. State of California. California Environmental Protection Agency.

air quality problems in areas outside of the Districts and airsheds where they originate.

The purpose of this report was to follow-up on:

- The identification of the areas affected by pollutants that are transported from one airshed or region to another, and which are their sources.
- The determination of the relative contribution of the concentrations of ozone and its precursors from one area to another as far as origin, classifying an area as “Responsible, Significant, or Insignificant” and their combination according to the standard.

This report corresponds to the second triennial update, in which 26 pairs of pollutant transport types were analyzed for the first time. The original version was done in 1990, taking into account only 14 different pairs of combinations of pollutant transport.

The conclusions from this second revision are shown in Table 3.12, which categorizes ozone precursor zones based on their contribution to the transport of pollutants to a different airshed.

Responsible area: This is the classification given to zones where transport of ozone and its precursors originates, affecting a different area and causing a violation of the State air quality standards.

Significant: This is the classification given to zones where transport of ozone and its precursors originates in conjunction with the own contributions of the affected area, contributing to violations of the State air quality standards.

Insignificant: This is the classification given to zones where there is no transport of ozone and its precursors or which do not contribute significantly to a violation of the existing standards.

Table 3.12. Characterization of the type of ozone transport in the State of California

Pairs of pollutant transport types	**Classification**	
	previous	**Proposed**
1. Broader Sacramento Area – Mountain Counties	O	O
2. San Joaquín Valley – Mountain Counties	O	O
3. San Francisco Bay – Mountain Counties	S	S
4. Mexico – Southwest Desert	O, S	-
4b. Mexico - Salton Sea	*O, S*	**-**
5. Mexico – San Diego	O, S, I	O, S, I
6. San Joaquín Valley – South Central Coast	S, I	S, I
7. San Francisco Bay Area – Broader Sacramento Area	O, S, I	O, S, I
8. San Francisco Bay – San Joaquín Valley	O, S, I	O, S, I

Pairs of pollutant transport types	Classification	
	previous	Proposed
9a. South Coast – Southeast Desert	O, S, I	-
9b. South Coast – Mojave Desert	-	O, S
10. Broader Sacramento Area – Upper Sacramento Valley	O, S, I	O, S
11.a San Joaquín Valley – Southeast Desert	O, I	-
11.b San Joaquín Valley - Mojave Desert	-	*O*
12. South Coast - San Diego	O, S, I	O, S, I
13. South Coast - South Central Coast	S, I	S, I
14. South Central Coast - South Coast	S, I	S, I
15. San Joaquín Valley - Broader Sacramento Area	S. I	S, I
16. San Joaquín Valley - Great Basin Valleys	O	O
17. Broader Sacramento Area – San Joaquín Valley	S, I	S, I
18. Broader Sacramento Area – San Francisco Bay Area	S, I	S, I
19. California Coastal Waters – South Central Coast	S	S
20. Bay Area - North Central Coast	O, S	O, S
21. San Joaquín Valley - North Central Coast	-	*S*
22a. Southern Coast – Southeast desert	O, S, I	-
22b. Southern Coast – Salton Sea	-	*O, S*

* Changes proposed by the staff are presented in *italic* letters
O = Origin; S = Significant, I = Insignificant.

Bold letters indicate transport from Mexico to areas in California, and from the southern coast to San Diego, without indicating ozone transport to Tijuana. The report does not mention if there are other types of ozone transport from areas in California to Mexico and it does not provide any details about the way in which the amount of pollutant transport is estimated.

1997 Southern California Ozone Study (SCOS97). Operational Plan for the Program (Fujita et al, 1996)[10]

The State of California developed the Operational Plan for the Southern California Ozone Study, as a response to the Clean Air Act amendments of the 1990s, which were geared toward intensifying the efforts to control air pollution in the United States. This effort was led by CARB to deal with the existing ozone problem in that region.

The Plan describes the activities that must take place to get a better knowledge of the behavior of ozone in southern part of the State, and provides the modeling tools for emissions control. It also contemplates updating the emissions inventory, inten-

[10] Fujita M. E., Green M.C. Keislar E. R, Koracin R.D., Moosmuller H. and Watson G.J. (1996). 1997 Southern California Ozone Study (SCOS97). Field Study Plan. Draft prepared for the State of California. Air Resources Board. Reseach Division. P.O. Box 2815, Sacramento, CA 95812. Under contract No. 93-326.

sifying monitoring efforts for ozone and its precursors, and estimating future concentrations of ozone based on photochemical modeling.

The sections included in this plan are: background on the objective of the study; conceptual model of ozone episodes and transport scenarios that serve as the basis for the development of the empirical design (SCOP 97); meteorological and air quality measurements; options for the necessary complementary measurements in the field study; planning process and preliminary activities, and necessary support for the field study; quality assurance of the data and data handling within the study; data analysis and modeling activities associated with the study; program management; and, cost estimates for SCOP 97 Program concepts.

Spatial Modeling of Air Pollution from Industries and its Relation to the Residential Areas in Tijuana, Mexico. (Obee, 1997)[11]

The study in question was developed in 1997, given the existing air quality problem in the border zone of Tijuana and the interest for learning future projections. The study focuses on finding out the spatial relation of air pollutant emissions with the location of industrial and residential areas, and some socioeconomic characteristics of Tijuana. Some projections are made for the year 2020.

The objectives of this project were:

- To provide a preliminary exploration of the distribution of air pollutants and examine the relation between the urban structure and the different types of residential areas located in the proximity of the industrial area, and its effects.
- To use the model known as “Industrial Pollution Projection System (IPPS)”, with the purpose of evaluating the risks of the future emission of industrial pollutants into the atmosphere and population growth, through population density projections and industrial activity, within the urban structure.

Although there were certain restrictions to carry out the study, in terms of data availability for the model, some of the more outstanding results include:

- Emissions estimation for SO_2, NO_2, CO_2, COV, and PM10 based on a total of approximately 70 thousand employees representing each and every one of the industries that are present in the area, from 1993 to 2020.
- Residential areas that are located a short distance from industries were identified. These were classified as higher, middle, and lower class residential zones. The

[11] Obee J.A. (1997). Spatial Modeling of Industrial Air Pollution and its Relationship to Residential Areas in Tijuana, México. A thesis presented to the Faculty of San Diego State University. For the degree Master of Arts in Geography.

population affected was approximately 15,271 people, in an area of 2,442 km^2. These residential zones were locate between 500 and 1,960 meters from the industrial sources.

- The future urban structure was analyzed in relation to the number of people, and a population increase from 743,000 people in 1990, to a 1,789,000 for the year 2020, was considered.

- Generation of pollutants will increase between 275 and 600%, considering the number of employees in the industrial sector. Likewise, sulfur dioxide emissions will increase from 11,951 tons/year, estimated in 1993, to 75,465 for the year 2020, considering a maximum annual economic increase of 4%, under the highest scenario.

- The application of the IPPS model reflects a continuous industrial growth and an increase in air pollutant emissions. Therefore, air quality monitoring and policy in this zone must take into consideration the potential health risks and future air quality degradation in the airshed.

- Fertility, life expectancy, and particularly migration, could generate population growth in the city of Tijuana.

One of the general conclusions of this study is that, population growth, as well as an increase in air pollutant emissions, would press the urban infrastructure and environmental quality in the city of Tijuana, as well as the rest of the border region.

Air Quality Monitoring in Tecate (CICA Project CICA-97-05, in progress)[12]

The purpose of this project is to install and operate an air quality monitoring station in Calexico, California, and Tecate, Baja California. PM10, TSP, ozone and meteorological parameters (wind speed and direction, and temperature) will be monitored at this station.) Data collected must comply with CARBs strict parameters for quality assurance and quality control (QA/QC.) Data collected at this site will complement data collected through the monitoring networks of Tijuana and Mexicali. Data obtained in the three cities will be incorporated into a database, which will serve as the basis for the air quality management programs of the region. The following are the general objectives: (1) determine ambient air pollutant concentrations; (2) determine the amount of emissions originating from several source cate-

[12] Obee J.A. (1997). Spatial Modeling of Industrial Air Pollution and its Relationship to Residential Areas in Tijuana, México. A thesis presented to the Faculty of San Diego State University, for the Degree on Master of Arts in Geography.

gories and their relative impact; (3) recommend control strategies; and (4) measure progress and compliance with standards in the long-term.

Monitoring System for Afflictions that Indicate Health Harm due to Environmental Pollutants in the Northern Border (SSA, in progress)[13]

The concept of Afflictions that Indicate Health Harm or "Health Sentinel Event (ECS)" was first used as a method to determine the quality of medical care (illness or death) and applied in maternal mortality studies in the 1930s. Four decades later, the concept was modified to be applied in the area of occupational pathologies as an Occupational Health Sentinel Event [ECS(O)], which was defined as a "work related illness, handicap, or death" which depends on the presence of a specific event. ECS can be used to carry out epidemiological or industrial hygiene studies, as well as to define health protection or medical care programs. To date, the updated list includes 64 illnesses or conditions and is subject to periodic changes.

The "Monitoring System for Afflictions that Indicate Health Harm due to Environmental Pollutants in the Northern Border" project brings back the [ECS(O)] concept, and its relation to labor conditions, since it is expanded to general environmental pollution and its relation to morbidity conditions that cause death in the general population as well as workers.

This study is being conducted due to the accelerated industrialization process in the larger cities and the northern border region of the country. The study analyses mortality in the general population and tries to determine if there is a possible link to the different environmental contaminants that are generated locally in the states of Baja California, Coahuila, Chihuahua, Nuevo León, Sonora and Tamaulipas. As a result of this project, a "Monitoring System for Afflictions that Indicate Health Harm" that have a possible link to environmental pollutants (sentinel events) will be implemented in the Mexican Northern Border.

The general condition of the Mexican northern border states, as well as the branches and types of activities, agents, and pathologies, which were codified in accordance with the *General Classification of Diseases, Ninth Edition*. The industrial branches of greatest economic impact in their different processes are the following: mining, cement, salt extraction and processing, crude oil and natural gas extraction, glass industry, maquiladoras, among others.

The pathologies that caused general mortality in recent years in the Mexican northern border states, and which have a potential relation with environmental

[13] Secretaría de Salud (1999). Subsecretaría de regulación y Fomento Sanitario. Dirección General de Salud Ambiental. Sistema de Vigilancia de padecimientos marcadores de daño a la salud por contaminantes ambientales en la frontera norte. México, D.F.

pollutants, are mainly chronic-degenerative diseases. These diseases must be included as sentinel events.

The Health ministry, through its Environmental Health General Division, is conducting a pilot project to detect the possible health effects on the population as a result of air pollution.

This study is in its initial phase and has two elements. The first is air quality monitoring in some border cities (Ensenada, Tijuana, Mexicali, Cd. Acuña, Piedras Negras, Ojinaga, Sabinas, Cananea, among others); and the second element consists of an analysis of the correlation between the number of hospital admissions and respiratory health effects.

Report on the Status of the Environment and Natural Resources of the Mexican Northern Border (Health Chapter, 1998)[14]

The *Report on the Status of the Environment and Natural Resources of the Mexican Northern Border* presents a general picture of the health conditions that are encountered in the Mexican northern border region.

This report establishes that there are three large sets of conditions that affect the health of the population. The first set includes those that are associated to the capacity to ensure access to health care, education, housing, employment and public services. The second set includes those conditions that are related to the infrastructure of health services and to the ability if this infrastructure to promote and maintain health. The third set of conditions includes those that are linked to the condition of the environment resulting from human activities which, as a whole, have the ability to limit, obstruct, or impede the existence and the development of human beings and other living organisms that interact in a specific time and space.

SSA has developed a classification for the different municipalities in the northern border area, directly correlating the magnitude of the total population in the border region with the type and number of hospitals, as well as the quality of health care in that area.

According to this classification, there are municipalities that are rates as “One”, which are referred to as “Priority One”. These have 45% of the units of First Level of health care, 77% of the Second Level units, an 100% of the Third Level units. The municipality of Tijuana is classified as Priority One, with second level health care units.

[14] Instituto Nacional de Ecología, 1998. Available at *www.ine.gob.mx.*

Different from the rest of the country, mortality from chronic degenerative diseases (heart disease, diabetes mellitus and cerebrovascular diseases), in the border states exceed the national average.

It is important to highlight that the environmental health field is currently in its early stages, thus making epidemiological information very limited for different reasons. The area of concern my not be well known, there may not be a well established cause-effect, or there may not be a good record of events resulting from environmental contingencies that are harmful to human health. Furthermore, many of the effects of air pollution, on health and the environment, appear in the medium and long-term. Therefore, adverse health effects from air pollution remain intangible for a prolonged period of time, hindering its perception, timely detection, and true dimension. Under those circumstances, especially the lack of information, it has been difficult to conduct a detailed analysis of the direct impact of environmental deterioration on public health along the US-Mexico border. However, evidence supports the fact that environmental deterioration affects human health and that, at an extreme level, it can cause death.

1991 Triennial Update of the Regional Air Quality Strategy (RAQS) for the San Diego Airshed

The California State Act requires Districts in air quality non-attainment areas to prepare a strategy that identifies feasible control measures to come in compliance in the shortest time possible, and to provide an annual and a triennial report on the progress of those strategies. The Regional Air Quality Strategy (RAQS) was adopted on June 30, 1992 and amended on March 2, 1993. The first triennial review of the RAQS was performed on December 12, 1995 and the second one, on June 17, 1998. The latter analyzes the status of the RAQS between 1995 and 1997.

Of the 24 control measures that were scheduled to be implemented during the 1995-97 period, 6 (25%) were implemented, 6 (25%) were re-scheduled to be implemented between 1998 and 2000 (4 in 1998, 1 in 1999 and 1 in 2000), 9 (37%) were eliminated from the program, 2 (8.3%) were left pending, and 1 (4.2%) is being studied for possible implementation, using the existing regulations of he District. The delay in the adoption of certain control measures is attributed to limitations in control technologies. The control measures that were suppressed were determined not to be feasible, based on a cost-effectiveness emissions control update and recent amendments to California State Law.

In reference to compliance with air quality standards, San Diego is designated as a non-attainment area for the State standard of NO_2, SO_2 and CO. However, the 1991 RAQS triennial update is only geared toward complying with the requirements for ozone. In addition to complying with the State Act, San Diego must also comply with the requirements of the Federal Act, even though some of those are already covered by compliance with the State Act.

One of the main requirements of the RAQS was to submit an Implementation Plan, to be reviewed in 1994, demonstrating compliance with the air quality standard for ozone by 1999. Also, a review of the 1994 State Implementation Plan (SIP), was also required, including a review and update of the 1990 emissions inventory, a projection of future emissions, and emissions reduction measures for 1996 and 1999. Another requirement of the RAQS triennial update is to show progress on air quality as far as peak concentrations, population exposure to criteria pollutants.

CARBs guide establishes the inclusion of “air quality indicators”. Therefore, a report is presented to satisfy this requirement. The document shows the air quality control measures that were implemented in San Diego since 1981.

Status of control measures

The control measures may propose the adoption of new rules for currently uncontrolled emissions sources. The purpose of these amendments is to increase the strict control of regulated categories. However, in some cases, this control could be implemented by adopting the rule.

Table 3.13 synthesizes the status of the efforts that are being conducted by the District of San Diego and the amendments to the rules to implement the control measures adopted by the RAQS in 1991.

Table 3.13. Adoption of reviewed control measures included in RAQS/ Amended Programs

Rule #	Control measure	Pollutant	RAQS Program Adoption/Year of Amendment	Current adoption/Date of amendment	Adoption of reviewed program/Date of amendment
20.1-20.4,60	New revised sources	All	1992	Amended on 5/17/94	
67.4	Future control of can tops	ROG	1994	Amended on 7/25/95	
67.4	Future control of coil covers	ROG	1994		Suppressed
67.6	Future control of solvents	ROG	1994		Suppressed
67.11	Future control of wood cover products	ROG	1994		Amended in 1996-1997
67.12	Operation of epoxic resins	ROG	1994		Suppressed
67.13	Confiscation of large storage and soil decontamination tanks	ROG	1993		1996-1997
67.18	Future control of marine covers	ROG	1993	Amended on 12/13/94	
67.19	Cover manufacturing and ink printing	ROG	1992	6/7/94	
67.20	Auto paint	ROG	1993		1996
67.21	Adhesive operations	ROG	1993		1996-1997
67.22	Compressed foams and plastic dila-	ROG	1993	6/7/94	

	tion				
67.23	Plastic compounds, rubber, and glass covers	ROG	1993		1996-1997
67.24	Bakelite ovens	ROG	1993	6/7/94	
69	Electricity and vapor generating boilers	NOx	1992	1/18/94	
69.2	Industrial and commercial boilers	NOx	1993	9/27/94	
69.3[1]	Stationary combustion turbines	NOx	1994	9/27/94	
69.4[2]	Internal combustion engineering of stationary sources	NOx	1995	9/27/94	
	Low NOx residential ovens	NOx	1994		1996-1997
1301[3]	Reduction from travel program for companies with more than 100 employees	All	1992	1/18/94	Suppressed
	Travel reduction from the student program	All	1993		Not scheduled
	Indirect sources program	All	1994		1996

[1] Rule 69.3. Federal measure that is adequate for the viable control of technological requirements. It can be replaced in 1996 or 1997 if necessary, by a more adequate measure of technological requirement of retrofit control.
[2] Rule 69.4. Federal measure that is adequate for technological control requirements, that would be replaced in 1996 or 1997 if necessary, by a more adequate measure of technological requirement of retrofit control.
[3] Rule 1301. That will be inoperable under the federal reclassification of ozone and the State decides to eliminate it. Therefore, the control measure is initially suppressed by RAQS.

ROG = Reactive Organic Gases.

Table 3.14 synthesizes the rules adopted or amended in 1994 that are not reflected in the 1991 RAQS. Most of the rules included in this table were adopted or amended under the federal goal requirements. However, Rule 27- *Bank credits for the reduction of mobile source emissions* and the amendments related to Rule 21, allow the conditions to adopt the following requirements that are needed by industry due to the great flexibility in the goals of New Sources (NSR).

Table 3.14. District rules adopted or amended in 1994 that are not programmed in the 1991 RAQS

Rule #	Control Measures	Pollutants	Current Adoption / Amendment date
20.9-20.10	Review of new federal sources	All	5/17/94
21	Conditions allowed	All	Amended 11/29/94
27	Bank credits for reducing mobile source emissions	All	11/29/94
67.3	Metallic parts' products and covers	ROG	Amended 11/1/94
67.4	Metallic containers, operation and closing of coils	ROG	Amended 9/27/94
67.10	Biopolymer processing and manufacturing operations	ROG	Amended 6/15/94
67.16	Graphic arts operations	ROG	Amended 6/20/94
68	Fuel burning equipment	NOx	Amended 9/20/94

1401...1425 12 rules	Title V. Operations allowed in federal sources	All	1/18/94

Non-regulated control measures in the transportation sector

The 1991 RAQS includes 6 non-regulated transport control measures (TCMs): traffic improvement, van fleet, highly occupied vehicle lanes (HOV), free parking lots and parking facilities, bicycle facilities and traffic signal improvements. TCMs reflect compliance with measures in order to continue with the implementation of efforts, especially the Regional Transportation Plan (RTP).

According to the 1994 RTP and the Regional Transportation Improvement Program (RTIP), the following were scheduled for compliance by the year 2001:

Transit Improvements: The Santee Trolley service and the trolley service from the ocean to downtown San Diego started recently. The expansion of trolley service from Downtown to Mission Valley, and to the University, are under construction. The new express bus service and several new transit stations have been scheduled for construction. Eighty-three low-emissions, compressed natural gas (CNG) buses, were purchased to replace older diesel buses that produce high emissions. The Plan was started replacing 50% of the local bus fleet and adding 30 CNG buses. More than 100 low-emissions buses are scheduled for purchase by 2001.

Van Transportation: the van program has been improved with additional funding, provided by the San Diego Governors' Association. 10 CNG fueled vans and 22 gasoline-fueled vans were purchased through this program.

HOV Routes: HOV routes were scheduled for construction along Interstate 5 (I-5) and Interstate 805 (I-805), in the direction of Manchester Avenue, by the end of the decade. The following priority would be to continue from I-5 to Ocean Zone and I-15 to Escondido.

Parking Lots and Crossing Facilities: In conjunction with the 1991 RAQS, the promotion of existing parking lots and new traffic intersections continued. Caltrans installed some parking lot services and crossing facilities, through the Regional Program for Travelers, through a computerized commuter.

Bicycle Facilities: 402 new routes were added, with an average of more than 50 miles per year. Commonly in the 1991RAQS, 25 miles are added per year.

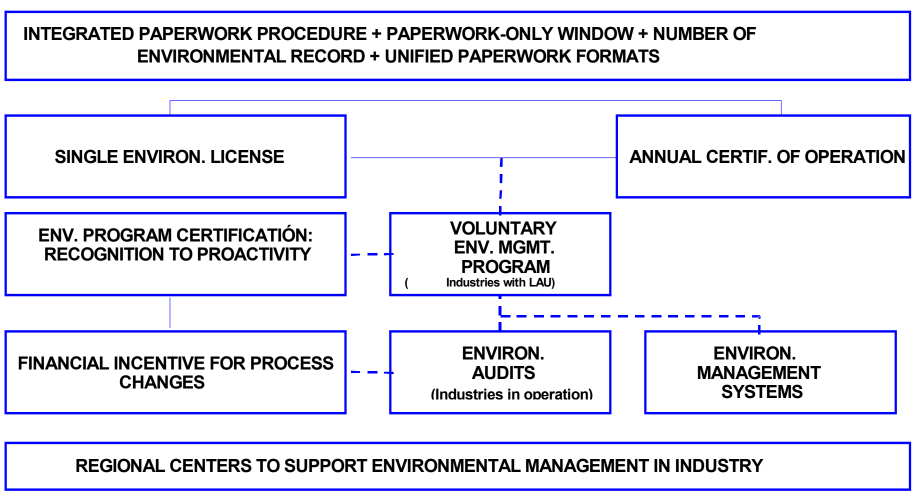
Traffic Signal Improvement: 42 traffic signals and interconnection projects were scheduled during 1995. RTP signals indicate the interconnection showing the lights over the regional arterial system.

Detailed information about RAQS can be found at:
http://www.sdapcd.co.san-diego.ca.us/aqplan/RAQS-WEB.htm.

Industrial Regulation and Environmental Management in Baja California

In Baja California, like the rest of the country, a *Direct Regulation and Environmental Management Integrated System for the Industrial Sector (SIRG)* has been developed. This system has been formulated as an efficient instrument in formulating environmental policies and has the primary objective of fostering and facilitating the coordination, as far as direct regulation of the industrial sector is referred, between INE, CNA and PROFEPA. SIRG also promotes pollution prevention and minimization using a mullet-media approach, as well developing environmental management programs, generating annual integrated information for the National Environmental Information System, and contributing to the establishment of National Environmental Certification System, homologous to that of other countries. Its long-term perspective is to achieve coordination between the three levels of government, so that both federally as well as locally regulated industry are treated as a whole.

Figure 3.8. Basic components of SIRG



SIRG has as its main predecessor the Environmental Program 1995-2000, within the framework of the new approach to environmental policy that has been defined by SEMARNAP, and it incorporates the changes that were introduced through the December 1996 reforms to the General Law of Ecological Balance and Environmental Protection. When it was conceived, the precepts of the Environmental Protection and Industrial Competitiveness Program, signed by SEMARNAP, SECOFI and CONCAMIN in July 1995, were taken into account.

Figure 3.8 shows the components of SIRG and the interrelationships between them.

SIRG, has three basic elements that are intimately related: Licencia Ambiental Única (Sole Environmental License), Cédula de Operación Anual (Annual Operation Certificate), and Programa Voluntario de Gestión Ambiental (Voluntary Environmental Management Program).

- *Sole Environmental License (LAU)* is the main component of the system. The Voluntary Environmental Management Program, a self-regulatory program to reduce industrial emissions, and other SIRG components, are developed around it. LAU is a direct regulatory instrument that integrates in a single procedure, the different environmental licenses issued by the federal authority.
- *Annual Operation Certificate (COA)*, is a follow-up instrument that must be complied with by industrial facilities, which provides information regarding emissions, discharges, and transfer of air, water and soil pollutants and waste. It also allows the evaluation of a company's environmental performance. The information obtained through the LAU and the COA will help integrate the Registry of Emissions and Pollutant Transfer (RETC), a basic component of the National Environmental Information System.
- *Voluntary Environmental Management Program (PVG),* has the main objective of favoring and fostering self-regulation in the industrial sector, emphasizing private interests in favor of productivity and competitiveness, and public interests in favor of environmental protection, based on compliance with current laws.

The following industrial sectors falling under federal jurisdiction must have an LAU: oil, petrochemical, chemical, paints and dyes, iron and steel, metallurgy, automotive, cellulose, paper, cement, lime, asbestos, glass, electric power generation, and hazardous materials treatment.

In order to be applied, SIRG requires the Integrated Paperwork Procedure, the Paperwork-Only Window, the Environmental Record Number, and the Unified Paperwork Formats.

Like the States of Querétaro and Chihuahua, INE has been promoting the State and Municipal integration of RETCs that allow authorities at the three levels of government to initiate the integrated regulation of the industrial sector.

It is important to mention that since 1994, the year when the RETC was started in Mexico, different environmental organizations have been actively involved in its implementation and consolidation in Baja California.

For example, on April 10, 1998, the Federal Official Newspaper published the Coordination Agreement that was reached between SEMARNAP (INE), SEMARNAPs Federal Delegation in the State of Baja California, the State of Chihuahua, the Municipality of Juárez, and Juárez' Municipal Board on Water and Sanitation Issues. This agreement was reached with the purpose of conducting a pilot project in Ciudad Juárez to apply SIRG principles, incorporating industries of local jurisdiction and those with federal jurisdiction. This agreement will help support decentralization and institutional strengthening of environmental management, for the benefit of the industrial sector in Ciudad Juárez.

Another objective of the project is promoting pollution prevention in the local industrial sector, through the implementation of voluntary self-regulation programs that tend to reduce pollutant emissions and waste in the source, emphasizing process technologies in pollution control equipment, and corrective actions. The National Institute of Ecology will evaluate, issue a guidance, or agree with the interested parties, on the use of these technologies in their Voluntary Environmental Management Program.

The State of Chihuahua and the Municipality of Juárez are bound under this agreement to provide information regarding emissions sources within their jurisdiction, to the National Institute of Ecology (INE) for the integration of the RETC of the municipality.

Methods to Estimate Emissions from Various Unique Sources in Mexicali, Mexico (EPA-456/R-99-002) and Emissions from Taco Street Stands (EPA-600/R-99-048)

The preliminary report titled "Mexican Emissions Inventory Methodology", prepared by Radian Corporation for the US Western Governors' Association and the Binational Air Workgroup, identifies several types of air polluting sources that may contribute significantly to the degradation of air quality in the border zone. The purpose of this study is to provide the necessary information to the appropriate agencies, in order to decide which methodologies must be used to establish emissions factors and develop emissions inventories for: 1) particulate matter less than 10 microns in diameter (PM10), hazardous air pollutants (HAPs), volatile organic compounds (VOCs) and nitrogen oxides (NOx), originating from cooking devices used by street vendors, and 2) VOC and HAP emissions originating from open lagoons and canals that store or carry wastewater.

This project has concluded and its report is available on CICAs web site at (http://www.epxa.gov/ttn/catc/cica) and INEs web site at: (http://www.ine.gob.mx).

Participating agencies included: INE for Mexico, EPA Region 9 and Imperial County Air Pollution Control District for the United States.

Intensive Air Quality Monitoring Study in California-Baja California (in progress)

The objective is to carry out a special air quality monitoring study to provide the required additional information to develop the ozone, PM and carbon monoxide studies in accordance with the plans for the California-Baja California region. Furthermore, the study will generate the data to be used for integrating the Mexican northern border region into the regional photochemical modeling study of Southern California.

In order to verify and evaluate the emissions inventory developed for Baja California, CARB will consider the information generated by the Tijuana-Rosarito-Tecate and Mexicali air-monitoring networks. The first phase of this study will provide ambient data on hydrocarbons and meteorological conditions, which will allow the use of source/receptor mathematical models to estimate the uncertainties in the emissions inventory. The second phase will provide meteorological data for the top layer of the atmosphere, as part of Southern California's ozone study. The third and fourth phases of this project will include the acquisition of equipment for emissions testing and will establish the basis for the voluntary emissions testing study in the ports of entry along the California-Baja California border. The vehicular emissions testing program will provide useful information to refine the emissions inventory for Mexicali-Imperial County and Tijuana-Rosarito-San Diego, and will provide additional information for the development of the Mobile-Mexico model.

Studies conducted in conjunction with CARB (in progress)

The following air pollution prevention and control studies have been conducted in the binational airshed, within the framework of the Border XXI Program and in conjunction with CARB.

Tijuana-Rosarito Air Quality Monitoring Network

Cooperative work between CARB and Mexico dates back to may of 1990, when some training courses were given to three technicians from INE, at CARBs laboratories in Sacramento, California.

In 1993, CARB received funding from the EPA to support the operation of the air monitoring station that was located at Instituto Tecnológico de Tijuana.

In 1995 funding was received from the EPA to establish and operate, through a contract with a private company, six air monitoring stations in Tijuana. Since then, EPA has provided additional funding to continue with the operation of the monitoring network, as well as adding hazardous air pollutant monitoring in the area.

Mobile Source Emissions Study

CARBs Mobile Source Control Division carried out an emissions measurement study during the months of July and September of 1999. This was a study to measure the emissions of vehicles crossing the border into California. The study consisted of randomly selecting approximately 1,020 vehicles, in order to determine their average emissions rates and vehicular activity. This was done with the purpose of refining the mobile source emissions inventory that is under development, and to learn the impact of the emissions from these vehicles on the California-Baja California border region. The study was carried out at the border crossings of Mexicali, Mesa de Otay and San Ysidro. The number of vehicles studied at each port of entry was proportional to the percentage of vehicles that cross the border annually at each of those ports. The percentages were 31%, 15% and 54%, respectively.

All the vehicles that participated in the study underwent the BAR90 emissions test, as well as a visual and operating inspection of their emissions control systems. A small sample of these vehicles (approximately 200) underwent the IM240 test on a dynamometer. After the IM240 test, a smaller number of vehicles (approximately 100), were equipped with a Global Positioning System (GPS) and a datalogger, with the purpose of acquiring information about the different operating patterns and the number of kilometers traveled per vehicle.

Comité de Forestación Municipal de Tijuana (Tijuana's Municipal Reforestation Committee)

Background: The Municipal Reforestation Committee, comprised by government institutions, educational institutions and members of the public, unveiled its Manual of Operations in March of 1998. This manual, based on stipulations from the National Reforestation Program (PRONARE), describes the objectives, structure, responsibilities and roles, as well as the rights and obligations of the members, and was the result of a community concern in the city of Tijuana about several problems. These problems included deforestation, the lack of programs to improve the urban image of the city, air quality problems, noise, erosion, and hillside instability problems, among others. The manual proposes the following workgroups: Technical Commission, Review Commission, Promotion and Outreach Commission, Secretary in charge of Drafting Minutes, and Treasurer.

The functions of the Municipal Reforestation Committee can be summarized as follows:

- Propose before the three levels of government, educational authorities and non-government organizations, actions that tend to improve and beautify the environment through reforestation.
- Have knowledge, analyze and cast opinions about the Delegation's projects, as well as other projects from non-government and private reforestation organizations.
- Develop the Reforestation Project for the Municipality.
- Procure the acquisition of supplementary funding to promote and conduct outreach on reforestation programs.
- Promote community involvement in urban reforestation programs.
- Act as a collegiate institution. Thus all its activities and decisions will only be valid if they are based on informed analysis that respects differences of opinion and is based on the voiced consensus of its members.

Products: The "Basic Manual for Urban Reforestation" was unveiled in January of 2000, as one of the first achievements of this Committee. The manual consists of a practical document that has the objective of contributing to the knowledge of the general public, providing basic information about urban reforestation in Tijuana.

Implementation of Methodology to Characterize Solid Suspended Particulate in the Air of the State of Baja California (in progress)

Author: Dr. César Díaz Trujillo, Research Professor in the College of Chemical Sciences and Engineering at Universidad Autónoma de Baja California (UABC).

This project is being supported by the National Council of Science and Technology (CONACYT) within the Program of Projects for the Mar de Cortés System (SIMAC), with additional support from SEMARNAP.

Objective: Determine the physical and chemical characteristics of total suspended particulate in the air of the city of Tijuana, applying instrumental methods to estimate possible interactions with the health of the general population and the environment, as well as develop zoning for the composition of particulate at the local level.

Technical contribution: A major contribution to society will be the generation of information, since currently there is no information available on the subject. Current records are scarce and there are only a few studies that have been conducted by US researchers in certain border areas of the State of California.

The product of this scientific investigation will allow us to start learning about the air quality conditions in the Municipality of Tijuana, related to this type of particulate. This type of contaminant is believed to be the main cause of a series of health problems, mainly in the respiratory system. No epidemiological studies have been conducted in this city to learn more about this problem.

A contribution of this work to technology will consist of implementing a new analytical methodology for quantifying and analyzing suspended particulate.

Tijuana-Rosarito-San Diego Air Quality Binational Alliance

This is a non-profit corporation for public benefit, which was organized with the exclusive purpose of improving the air quality and health of the citizens that reside in the Tijuana-Rosarito-San Diego airshed.

Objective:

- Offer advice to the participating entities.
- Serve as an advisory body to the Air Quality Workgroup that was established in accordance with the La Paz Agreement.
- Serve as a public forum for the discussion of air quality related issues in the binational airshed.

Air quality related goals:

- Serve as a forum for discussion of public policy.
- Foster the planning, communication and coordination between the responsible organizations.
- Follow-up closely the developments within the organizations involved.
- Obtain resources from local, state, national, and international organizations to carry out projects.
- Educate the public and promote awareness.
- Produce, promote and support programs.
- Develop joint studies and analyses related to air quality monitoring and modeling, as well as pollution prevention and abatement efforts in the airshed.
- Exchange information about aspects related to air emissions monitoring and compliance with the standards that correspond to each country.
- Conduct technical assistance, technology exchange, and training programs in fields that are relevant to air pollution prevention and reduction in the binational airshed.
- Examine the strategies to prevent air pollution in the region, including those recommendations on pollution trading programs and other economic incentives, as well as increasing the compatibility of air quality programs in the airshed, and other related issues that the Alliance may consider pertinent and which can be recommended.

Road and Transportation Regulation for the Municipality of Tijuana, B.C. (in progress)

The Municipality of Tijuana through Instituto Municipal de Planeación (IMPlan) and its Department of Regulations and Standards, has been developing the Road and Transportation Regulation for the Municipality of Tijuana since June 1999. This will serve to define the roadway design elements and lineaments that avoid adverse effects on the environment, as well as the standards to regulate the use of vegetation in roadways.

Its internal review is expected to be completed by IMPlan in the year 2000, in order to reach a consensus with the public and then turn it over to the City Council for its review and approval.

Integrated Road and Transportation Master Plan for the City of Tijuana, B.C. (in progress)

Road and transportation planning is one of the priorities of Tijuana's Municipal Administration. For that reason, starting in June 1998, the Municipality through Dirección Municipal de Planeación del Desarrollo Urbano y Ecología (currently transformed into Instituto Municipal de Planeación IMPlan) gave out for contract the Integrated Road and Trasnportation Master Plan for the city.

This plan will serve as a tool for diagnosing and planning new roads; updating, maintaining, improving existing ones; and, planning and restructuring transportation. The plan will also be used to assign new concessions, as well as promote and develop new mass transportation systems. These include road junctions, express routes, the bus system for new roads on the east side of the city, as well as the Light Train Subsystem, which is being promoted as a concession to the private sector for its construction, operation and maintenance.

The Master Plan will serve as fundamental support for defining strategies and actions concerning urban image, ecology and institutional development, through immediate, medium-term and long-term actions.

The Master Plan is currently being reviewed by IMPlan, which will then send it to the City Council for final approval.

4. AIR QUALITY

4.1. 1. Air quality standards and effects from pollutants

In 1994, the government established standards for the concentrations of air pollutants, with the purpose of providing an adequate margin of safety to protect the health of the general population and of the population at highest risk. The economic and technological aspects were not considered as determining factors in their design. The current air quality standards were published by Secretaría de Salud (the Ministry of Health) in the *Federal Official Newspaper* on December 23, 1994.

Air quality standards set maximum permissible values for the concentration of pollutants that are commonly present in urban areas. When these standards were developed, the resources and the infrastructure to conduct epidemiological, toxicological, and exposure studies, on animals as well as humans, were non-existent in Mexico. Thus standards were developed basically taking into account the criteria and standards adopted in other countries of the world. Currently, Secretaría de Salud is conducting epidemiological studies that value the dose/response relationship, between the different contaminants and the health of the population in some areas of the country, and is reviewing the standards for ozone and particulate matter. For the former, it has developed a project to update its standard contemplating a new 8-hour exposure limit, in addition to the current 1-hour exposure limit.

Air pollutants present in Tijuana-Rosarito are measured through internationally accepted standardized procedures, which provide representative values for the air quality present in Tijuana-Rosarito. Advances in technology and scientific knowledge about the effects of air pollution on human health set the stage for equipping continuous monitoring stations with far reaching remote sensors and other instruments to measure other toxic compounds.

Table 4.1 provides a summary of the current Official Mexican Standards related to ambient air quality, for ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), total suspended particles (TSP), particulate matter less than 10 microns in diameter (PM10), and lead (Pb).

US air quality standards are also provided due to the fact that the Tijuana is located along the US-Mexico border.

Table 4.1. Mexican Air Quality Standards

Pollutant	Limit Values			Official Mexican Standards
	Acute Exposure		Chronic Exposure	
	Concentration and average time	Maximum acceptable frequency	(To protect susceptible individuals)	
Ozone (O_3)	0.11 ppm (1 Hour)	Once every three years	-	NOM-020-SSA1-1993
Carbon monoxide (CO)	11 ppm (8 Hours)	Once a year	-	NOM-021-SSA1-1993
Sulfur dioxide (SO_2)	0.13 ppm (24 Hours)	Once a year	0.03 ppm (annual arithmetic mean)	NOM-022-SSA1-1993
Nitrogen dioxide (NO_2)	0.21 ppm (1 Hour)	Once a year	-	NOM-023-SSA1-1993
Total suspended particulate (TSP)	260 $\mu g/m^3$ (24 Hours)	Once a year	75 $\mu g/m^3$ (annual arithmetic mean)	NOM-024-SSA1-1993
Particulate matter less than 10µm (PM10)	150 $\mu g/m^3$ (24 Hours)	Once a year	50 $\mu g/m^3$ (annual arithmetic mean)	NOM-025-SSA1-1993
Lead (Pb)	-	-	1.5 $\mu g/m^3$ (3-month arith. Mean)	NOM-026-SSA1-1993

Source: Official Federal Newspaper, December 23, 1994.

The United States Congress issued the first amendments to the 1970 Clean Air Act, in order to establish, within a short period of time, the National Ambient Air Quality Standards (NAAQS) and the National Emissions Standards for Hazardous Air Pollutants. Data used to develop these standards was the result of occupational exposure studies and laboratory studies, and not necessarily data from environmental exposure to pollutants.

In 1997 the EPA revised its standards for ozone and PM10, changing the former to a value of 0.08 ppm in a mobile average of 8 hours, instead of one hour, and proposed the use of a new standard for particulate matter less than 2.5 microns in diameter (PM2.5). On July 18, 1997, the EPA published the reforms to these standards; the revision of the concentrations set through these standards was mainly due to the important adverse health effects that these two pollutants have on the population. US standards are, in the most part, similar to those from Mexico and are shown in Table 4.2.

The EPA estimates that, by changing the value of these standards, it will be protecting 125 million people from the adverse health effects related to air pollution, including the prevention of approximately 15 thousand premature deaths and 350 thousand cases of asthma per year.

As was mentioned earlier, in Mexico Secretaría de Salud is currently revising ozone and PM regulations to determine the suitability of modifying current standards and/or introducing new PM2.5 standards in Mexico.

In Mexico as well as the United States, air quality indexes are used to inform the population, in simple terms, about the current pollution levels. The Air Quality Metropolitan Index (Índice Metropolitano de la Calidad del Aire-IMECA – see Annex A) is used in Mexico, whereas in the United States, the Air Quality Index (AQI)[15], recently replaced the Pollutant Standard Index (PSI).

Table 4.2. Primary ambient air quality standards in the US

Pollutant	Boundary concentrations (Concentration and average time)	Compliance criterion
Ozone (O_3)	0.12 ppm* (1 hour)	Average of 1 exceedance over a 3 year period
	0.08 ppm (8 hours)	The 4th greatest daily exceedance, three year average
Carbon monoxide (CO)	9 ppm (8 hours)	Once a year
	35 ppm (1 hour)	Once a year
Sulfur dioxide (SO_2)	0.14 ppm (24 hours)	Once a year
	0.03 ppm (Annual average)	
Nitrogen dioxide (NO_2)	0.053 ppm (Annual average)	
Lead (Pb)	1.5 µg/m^3 (Quarterly average)	Once a year
Particles less than 10µm (PM10)	150 µg/m^3 (24 hours)	98% percentile of the annual distribution, 3-year average
	50 µg/m^3 (Annual average)	3-year average
Particles less than 2.5µm (PM2.5)	65 µg/m^3 (24 hours)	98% percentile of the annual distribution, 3-year average
	15 µg/m^3 (Annual average)	3-year average

Source: National Ambient Air Quality Standards, www.rtpnc.epa.gov/naaqsfin.

***Still in force in non-attainment areas, until these comply with the standard.**

Epidemiological studies conducted during the 1980s in the city of Los Angeles consistently showed that the health of the population was significantly affected by air pollution in that airshed. For that reason, the State of California proceeded to set stricter air quality standards for some parameters that were stricter than the federal standards. This change and the efforts that were undertaken to implement air quality monitoring programs and control methods, by implementing stricter regulations, mainly to decrease pollution caused by vehicular emissions, have resulted in fewer air pollution episodes in the urban areas of that State. Table 4.3 shows the current air quality standards for California[16].

Table 4.3. California Ambient Air Quality Standards

Pollutant	Limit values (Avg. Concentration and time)	Compliance criteria
Ozone (O_3)	0.09 ppm (1 hour)	Not to be exceeded
Carbon monoxide (CO)	9 ppm (8 hours)	Not to be exceeded
	20 ppm (1 hour)	Not to be exceeded
Sulfur dioxide (SO_2)	0.25 ppm (1 hour)	Not to be exceeded

[15] EPA (1999). Guideline for Reporting of Daily Air Quality-Air Quality Index (AQI). Office of Air Quality Planning and Standards. Research Triangle Park, NC 27711. EPA/454/R99-010.

[16] World Health Organization and United Nations Environment Programme (1992). Urban Air Pollution in Megacities of the World. Blackwell Publisher. U.K.

	0.04 ppm (24 hours)	Not to be exceeded
Nitrogen dioxide (NO_2)	0.25 ppm (1 hour)	Not to be exceeded
Lead (Pb)	1.5 μg/m^3 (monthly average)	Not to be exceeded o equaled
Particulate matter less than 10μm (PM10)	50 μg/m^3 (24 hours)	Not to be exceeded
	30 μg/m^3(Annual geometric average)	Not to be exceeded
Particulate matter less than 2.5μm (PM2.5)	65 μg/m^3 (24 hours)	Not to be exceeded or equaled
	15 μg/m^3 (Annual average)	Not to be exceeded or equaled

Source: California Air Resources Board (1999).

Effects of air pollutants on human health

Based on their origin, air pollutants can be classified as primary or secondary. *Primary pollutants* are those that are directly emitted into the atmosphere (nitrogen oxides, sulfur oxides, hydrocarbons, carbon monoxide, etc.). *Secondary pollutants* form in the atmosphere through photochemical reactions, hydrolysis or oxidation (ozone, peroxiacetyl nitrate, etc.).

Those pollutants can be classified as particulate or gases depending on the physical state of the material in which they are found. *Particulate* are finely divided liquids and solids that can be sedimented, including dust, smoke and ashes. *Gases,* which also include vapors, are many times invisible and sometimes cannot be detected by smell. Some of the most common gaseous pollutants include carbon monoxide, hydrocarbons, ozone, nitrogen oxides and sulfur oxides.

Unlike particulate, gases are not sedimented but rather tend to remain in the atmosphere and turn into more simple or more complex compounds, or become a part of biogeochemical cycles.

The effect of air pollutants on human health as well as the severity of the effect can vary depending on the age of the individual. Table 4.4 summarizes the effects from some pollutants, such as ozone (O_3), carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), particulate matter less than 10 microns in diameter (PM10), acid aerosols, and lead (Pb). These are broken into age groups and risk groups. Annex C expands on the effects of the pollutants listed.

Table 4.4. Health effects from air pollutants

Pollutant	**Exposed population and at-risk groups**	**Health effects**
O_3	Adults y healthy children	• Reduction in pulmonary function • Increase in air reactivity • Swelling of the lungs
	Athletes, outdoor workers	• Increase in respiratory symptoms (effects that are enhanced with exercise)
	Asthmatics and people with other respiratory diseases	• Decrease in the ability to exercise (Effects occur in conjunction with particulate matter and acid aerosols) • Increase in the number of hospitalizations

CO	Healthy adults	• Decrease in the ability to exercise
	Patients with ischemic disease	• Decrease in the ability to exercise (Increase in the number of effects including anemia or chronic lung disease) • Angina pectoris
NO_2	Healthy adults	• Increase in air reactivity
	Healthy children	• Decrease in lung function • Increase in respiratory symptoms (increase in the number of respiratory infections) (Effects are found in homes that use combustion sources)
SO_2	Adults and patients with chronic obstructive pulmonary disease	• Increase in respiratory symptoms (highly soluble gas with little long-distance penetration) • Increase in mortality an number of hospitalizations due to respiratory illnesses • Decrease in respiratory function (Observations were done at low exposure levels)
PM10	Children	• Increase in respiratory symptoms • Increase in respiratory illnesses • Decrease in pulmonary function (effects are seen in conjunction with SO_2)
	Chronic effects	• Excess of mortality
	Asthmatic	• Increase in exacerbation of asthma
Acid aerosols	Healthy adults	• Alteration of the mucoceles
	Children	• Increase in the number of respiratory illnesses (effects are seen in conjunction with ozone and particulate matter)
	Asthmatics and others	• Decrease in pulmonary function (increase in the number of hospitalizations)
Pb	Children	• Alteration of neurological function
	Adults	• Increase in blood pressure(associated with lead levels in gasoline)

Source: Dirección General de Salud Ambiental, SSA, 1999.

Likewise, Table 4.5 shows some industrial chemical agents and their toxicological effects.

Table 4.5. Toxicological classification of industrial chemical agents

Classification	Chemical agent
Respiratory irritants	Sulfuric acid, ammonia.
Simple suffocants	Propane butane.
Chemical suffocants	Chlorhydric acid and sulfhydric acid
Anaesthetics and narcotics	Xylene, cumene
Neurotoxics	N-hexane, toluene, mercury and manganese
Nefrotoxics	Cadmium, silver
Hematotoxics	Nitrobenzene, aniline, benzene
Ostheotoxics	Fluorhydric acid, cadmium
Hepatotoxics	Carbon tetrachloride, beryllium
Dermatotoxics	Chrome, nickel
Carcinogens	Asbestos, benzene
Teratogenics	Methylmercury, lead

Spermatotoxics	Dibromocloropropane, clordecone
Immunotoxics	Dioxines, polychlorinated biphenyls

Due to the importance and use of insecticides that are still being used in crops, the following is a description of the main compounds used in Mexico.

Insecticides

The main active ingredients of the 10 insecticides that were most frequently used in Mexico during 1995 are: methylic parathion, metamidofos, endosulfan, clorpirifos, monocrotofos, carburan, carbaryl, malathion, methonile and profenofos. Generally, there are three types of insecticides: 1) botanic, 2) organic phosphates or carbamato colinesterase inhibitors (parathion, malathion, demeton, etc.), and 3) chlorinated hydrocarbons (derived from chlorobenzene –DDT, DDD, TDE, DFDT, neotrane, DMC and dilan-; benzene hexachloride; and polycyclic chlorinated hydrocarbons –chlordane, heptachlor, aldrin, mirex, dieldrin, endrin, isodrin and metoxichlor).

Hydrocarbonated insecticides were introduced in 1938 and it has been proven that the residue from a single application remains active in an open surface for periods fluctuating between 2 and 12 months. As far as the human toxicity that is produced by DDT and related chlorobenzenes, it can be said that they cause a generalized stimulation of the central nervous system that is characterized by a sequence of events, depending on the degree of intoxication: vomiting, parestesia, irritability, lack of response to auditive stimuli and other types of stimuli, tremors, convulsions and death by respiratory paralysis. Recovery from acute intoxication can take two or more months.

Table 4.6 shows the historical registry of poisoning by plagicides during the period between 1964 and 1995.[17]

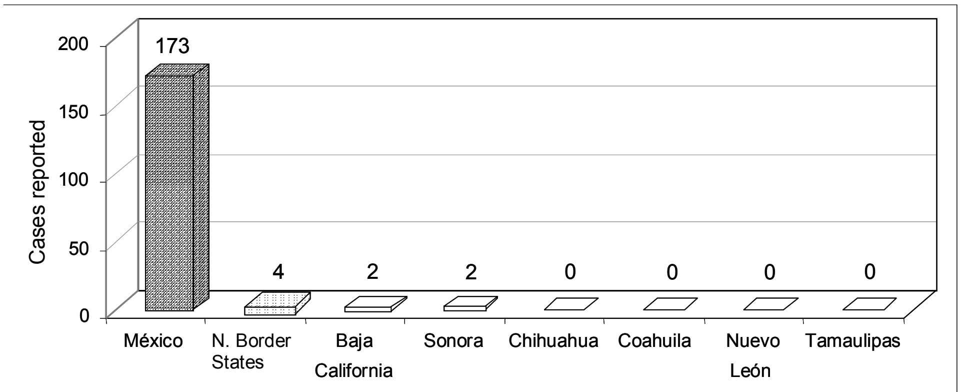
Table 4.6. Poisoning by plagicides in the northern border

Year	State-Municipality	# of poisonings	$ of deaths	Observations
1967	Tijuana, B.C.	559	16	Wheat flour contaminated with parathion during transport.
1970	Mexicali, B.C.	59	4	Agricultural workers during the farming of cotton with organophosphated and organochlorinated plagicides.
1974	Coahuila-Durango	847	4	Inhalation of plagicides, type not specified.
1983	Chihuahua (Sahuayo)	24	8	Parathion (contamination during tortilla consumption)
1995	Coahuila	113	NR	Worker poisoning

[17] IMSS (1996). Beneficios y Riesgos en el uso de Plaguicidas en México. Su impacto en la Salud Pública y Desarrollo Agropecuario, con sus Consecuencias Toxicológicas en el Presente y en el Futuro.

NR = not reported.

Figure 4.1. Cumulative cases of poisoning by plagicides
Mexico and northern border states (1995)



Source: SSA, 1996. Sistema Único para la Vigilancia Epidemiológica.

In 1995, a total of 173 cases of plagicide poisoning were reported[18]. Of those, 2.3% (4) occurred in the northern border states. Of the six border states, only Baja California and Sonora recorded two cases each. The same source indicates that by January 31, 1996 (only the first four weeks of the year), 107 cases of plagicide poisoning had been reported around the country. This is 58% of the total number of cases reported in 1995.

By that time, four cases had been reported in the northern border states; one in Baja California and three in Chihuahua. The latter had not reported any cases in 1995.

Herbicides

> The main active ingredient of the 10 most frequently used herbicides in Mexico during 1995 are: 2,4-D; paraquat; atrazine; isopropilam salt of g; 2,4-D amine; diuron; ametrine; triafluoraline; clortal dimetril.

2,4-D and its byproducts. The interest in clorofenoxi herbicides and their byproducts (2,4,5,-T) comes from an episode during the Vietnam war where these products were widely used to destroy crops (rice) and weeds in the jungle. The so-called "agent orange" of some manufacturers, contained a pollutant, 2,3,7,8-dibenzodioxin-tetraclorate, a substance of highly lethal acute toxicity which is by far the most powerful teratogenic (capable of producing fetal malformations)

[18] Secretaría de Salud (1996). Sistema Único de Vigilancia Epidemiológica, Rev. No. 6, Vol. 13, semana del 14 al 10 de febrero de 1996.

agent in existence. These agents also cause respiratory tract irritation and alterations in pulmonary function.

Paraquat. This is a herbicide that requires sunlight to produce any effect. It is highly toxic and can cause death at a dose of 4 milligrams per kilogram of body weight. At high doses it causes pulmonary edema, interstitial pulmonary fibrosis and consequent respiratory malfunction, and death.

Recommendations on public health and epidemiological oversight of the population

The measurement of air quality in Tijuana-Rosarito has identified high pollution levels for ozone, particulate matter less then 10 microns in diameter and nitrogen dioxide. Even though these concentrations are not as high as those found in other cities around the country, they could pose a future potential risk for the health of the population.

Unfortunately, there is not enough information to evaluate the harm, if any, that is being caused by air pollution in Tijuana-Rosarito. For that matter, it is necessary to establish an epidemiological oversight program associated with air pollution that will allow the availability of permanent and up-to-date information about the health status of the population.

An oversight program of this kind will allow us to learn more about the pathologies and symptoms related with air pollutants, both during days with low pollutant levels as well as days where there might be environmental contingencies.

Table 4.7 lists a series of recommendations and measures to prevent health damage caused by air pollutants.

Table 4.7. Recommendations to oversee and prevent health damage caused by air pollutants

Health measures
1. Establish an oversight system for health effects. 2. Conduct epidemiological studies. 3. Disseminate measures that contribute to the abatement of air pollutants. 4. Disseminate preventive measures in the population.
Individuals at higher risk due to exposure to pollutants
1. Children. 2. Elderly. 3. Individuals with heart disease. 4. Individuals with pulmonary and bronchial pathology. 5. Smokers.
Recommendations for the general population and at-risk groups
1 Consume 5 portions of previously washed vegetables and dry fruit per day. 2. Avoid smoking or being nearby smokers. 3. During the winter, remain indoors closing air passages; wear adequate clothing; do not light portable ovens to heat up enclosed areas; avoid sudden changes in temperature; and, pay special attention to children and the elderly in light of any respiratory infection (insignificant as it may seem.) 4. Drink lots of fluids.
General control measures for pollution sources
1. Improvement and replacement of motor vehicle fuels. 2. Improvements in motor vehicle technology. 3. Incorporation of anti-pollution technologies in the industrial and service sectors. 4. Cost-effective instruments to abate pollution. 5. Industrial and vehicular inspection and oversight. 6. Creation of environmental norms.

Source: Dirección General de Salud Ambiental, SSA, 1998.

Effects on the ecosystem

Air pollutants also have adverse effects on vegetation; they damage wooded areas and decrease the productivity of agricultural fields. Damage is mainly due to the effects from gases, particulate, acid rain and fog, and photochemical oxidants. An important characteristic of this type of activity is that their impact goes beyond the local scale, affecting vast regions, which at times cross the borders of the country generating those pollutants.

Air pollutants affect atmospheric conditions causing poor visibility, fog and precipitation, a reduction in solar radiation, and alterations in temperature and wind distribution. Currently, the possible effects of some air pollutants (for example, carbon dioxide and particulate) on global climate changes are being analyzed.

The most evident effect of air pollution on the atmosphere is a reduction in visibility, which is the result of the light absorption and dispersion caused by gaseous and particulate molecules. The absorption of certain light wavelengths by gaseous and particulate molecules is often responsible for the different tonalities in the atmosphere. However, light dispersion is the main phenomenon that is responsible for the deterioration of visibility.

In addition to this effect, air pollution affects urban climates with an increase in the formation of fog and a decrease in the reception of solar radiation. It has been observed that the frequency of fog formation is greater in cities than in the countryside, in spite of the fact that air temperature tends to be higher and relative humidity tends to be lower in the cities than in the countryside. The explanation of this behavior lies in the fog forming mechanism. For example, with high concentrations of sulfur dioxide, sulfuric acid droplets formed by the oxidation of dioxide, serve as the condensation nuclei for the formation of fog. In addition to this phenomenon, high precipitation has been linked to high concentrations of particulate matter.

4.2. Meteorological Characteristics

According to Jáuregui (1981)[19], the climate in Tijuana and its surrounding region is determined by its proximity to the ocean and by the position and intensity of the North Pacific semipermanent anticyclonic cell. In general, it can be established that the climate in Tijuana is dry maritime, of Mediterranean type, with winter rains that are concentrated in the months of November through April. During this period, 91% of the total annual precipitation (203 mm) in the region occurs. During the summer, clear skies generate abundant sunlight, which rises the temperature above 26 ºC at noontime. On the other hand, during the winter, maritime polar air masses, along with a greater frequency of cloudy days, cool down the climate in the region.

Weather systems

With respect to weather systems that have the greatest influence on the climatological conditions of the Tijuana region, the same author mentions the following:

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[19] Jáuregui, O.E., 1981. Climatología de Difusión de la Ciudad de Tijuana, B.C. Boletín del Instituto de Geografía. Universidad Nacional Autónoma de México. Número 11. México, D.F.

- The semipermanent North Pacific anticyclone

The pressure gradient and, as a consequence, the wind intensity in the Tijuana region is determined by the intensity of the North Pacific anticyclone, to the west, as well as its position relative to the thermal low located in the east, in the northeastern end of Mexico and southern Arizona.

During the winter this thermal low is very weak, whereas the Pacific anticyclone is less intense than in the summer, even though it gets closer to the continent (and toward the south). The displacement of the anticyclone toward the south allows the frontal systems to penetrate even more into the northeastern area of Mexico. These cold fronts that sweep through the coast of the Baja California Peninsula, Sonora, and Arizona, carry during the cold season cloudiness and precipitation in decreasing amounts as it moves to the south of the region. In Tijuana, these are the synoptic systems that produce almost the entirety of the annual precipitation. During the summer, the anticyclone intensifies at the same time that it moves to the northeast, getting farther way from the coast. The northernmost direction of the anticyclonic cell and its intensity during this season keeps the frontal systems from moving through the coastline, causing low precipitation in Tijuana during the summer.

- Tropical cyclones

The cyclonic vortexes that originate in the Eastern Pacific Intertropical Convergence Zone, in front of the coast of Central America, affect exceptionally the northern end of Baja California during the summer. However, the erratic nature of these disturbances explains the huge variability in rainfall during the summer months in the study area.

- The warm anticyclonic cell of the Great Airshed (Rocky Mountains)

This type of migratory anticyclone, which can have a cold or warm core, has a seven or ten-day frequency during the winter in Southern California and Northern Baja California. Once the cold front passes, the sky clears up and the subsidence that follows the cold front frequently causes thermal inversions in the higher levels of the atmosphere. The blue skies that prevail then, induce a high loss of heat due to radiation, in the long winter nights. This is evidenced by the formation of a surface inversion. This surface inversion reaches its maximum intensity at dawn, and in the middle of the winter it can persist until noontime.

- The cold anticyclone over the large airshed

This is a cold migratory anticyclone that is centered over the Rocky Mountains. The anticyclonic flow produces northeasterly winds that descend from the Rockies toward the southern California coast. Heating due to the descent of these winds can be observed between 24 and 36 hours after he front passes over the coast. When they get near the coast, these dry winds meet with the breeze in the afternoon, producing a convergent flow.

- Frontal systems

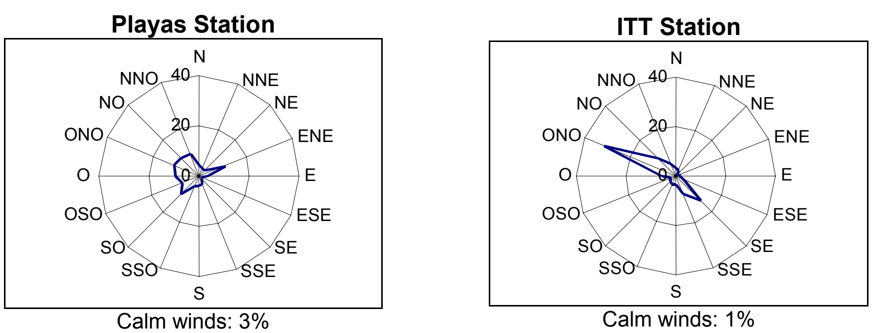
As was mentioned earlier, these cold fronts are the main systems that produce precipitation as they move south. They move in an almost west-east direction in the Tijuana-San Diego region, producing the largest amount of clouds and precipitation in coastal areas, where they are accompanied by moderate winds from the west. When it is a strong front, it produces rain in the mountains to the east and strong winds to the west.

Wind roses and general air circulation patterns

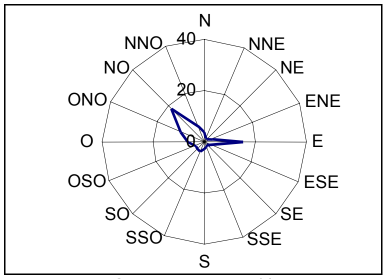
Following is a brief meteorological analysis that was conducted using data compiled through the Air Quality Monitoring Network in Tijuana, during 1998. That analysis was complemented with information obtained through a bibliographic search.

Figure 4.2 shows the surface wind roses that were obtained at the Instituto Tecnológico de Tijuana (ITT), Rosarito, La Mesa and Playas stations of the Tijuana-Rosarito air monitoring network.

Figure. 4.2. Wind roses for the Tijuana-Rosarito monitoring stations, 1998
(Percentage and direction)

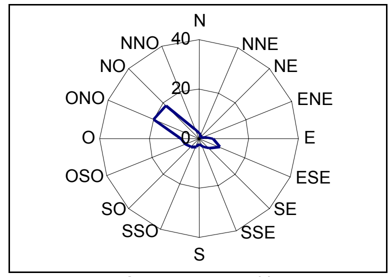


Rosarito Station



Calm winds: 13%

La Mesa Station



Calm winds: 2%

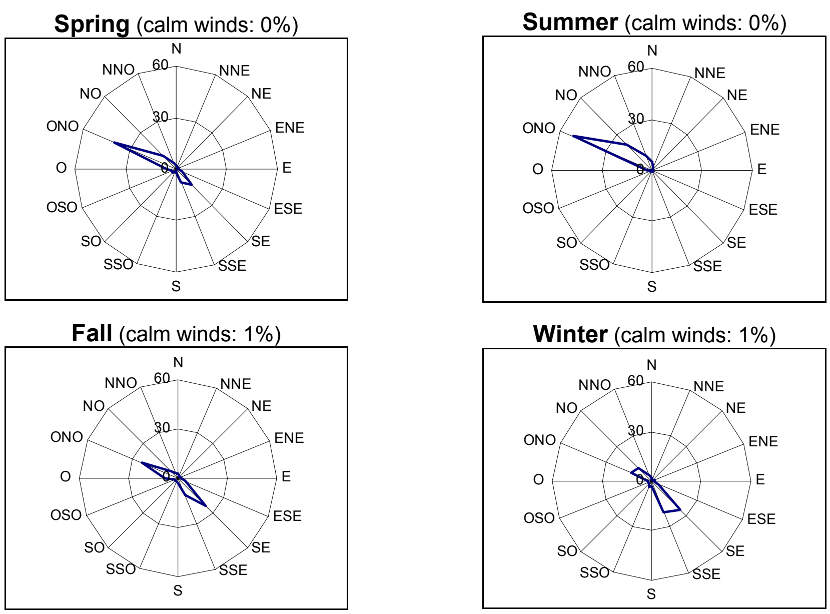
____Frequency %

The following conclusions can be drawn from analyzing the above:

- Wind behavior at the Playas station is slightly different from the other stations as far as prevalence of northwestern winds, since northwesterly and southwesterly winds flow with pretty much the same frequency at this station. This could be due to the topographic effect on surface winds. This monitoring station is directly affected by coastal streams, is located in flat terrain to the west (1 km from the coastal line), only 5 meters above sea level, and is surrounded from the northeast to the south by a coastal range.
- At all the monitoring stations, including the Playas station, the prevailing wind direction throughout the year comes form the northwestern section, specifically from the north-northwest, northwest, and west-northwest, since the frequency of occurrence of winds from these directions represents at least 30% of the total frequency at each station.
- At the ITT and La Mesa stations, the second most prevailing wind direction is from the southeast sector, particularly in the east-southeast, southeast and south-southeast directions. The frequency of occurrence of southerly winds at these monitoring stations is 26 and 19 % respectively.
- At the Rosarito station, the second most prevailing wind direction was from the east with a 15% total frequency. At the Playas station, the second most prevailing wind direction is from the east-northeast (11%) and from the southwest (10%). This last fact is evidently due to the presence of the coastal range, which surrounds the Playas Station from the northeast to the south.
- Calm winds (those with velocity less than or equal to 0.5 m/s), occurred with much greater frequency at the Rosarito station (13%). This was probably due to problems with the operation of the monitoring equipment. This idea is supported by the fact that during the period between August and December the percentage of calm winds was very high, oscillating between 20 and 30%, whereas in the previous months that percentage was always less than 10%. At the other stations this frequency was even lower. However, the staff in charge of operating the air quality monitoring network in Tijuana has not been able to confirm this assumption.

Figure 4.3 the surface wind behavior during the different seasons of the year at the ITT station. The months of January, April, July, and October, were considered typical months for winter, spring, summer and fall, respectively. This figure seeks to illustrate the seasonal wind behavior in Tijuana during 1998, since in general, it is representative to the pattern that was observed at the other monitoring stations. However, later in this chapter we will mention some particular trends that were observed at these stations. It can also be observed that, during the spring and summer, the wind flow is noticeably from the northwest and the west-northwest (from ocean to land), mainly due to the pressure gradient that is originated by the North Pacific semipermanent anticyclone and to the thermal contrast between the sea water and the coast, which are greater during this time of the year. Fall seems to be a transition period, since southeasterly and northwesterly winds occur with practically the same frequency. This is probably due to the attenuation of the North Pacific anticyclone. Finally, southeasterly and south-southeasterly winds prevail during the winter. According to Jáuregui (1981), this is both due to the attenuation of the semipermanent North Pacific anticyclone as well as to the thermal low which is almost imperceptible during this time of the year.

Figure 4.3. Surface wind behavior during the different seasons of the year in Tijuana-Rosarito (ITT monitoring station, 1998)

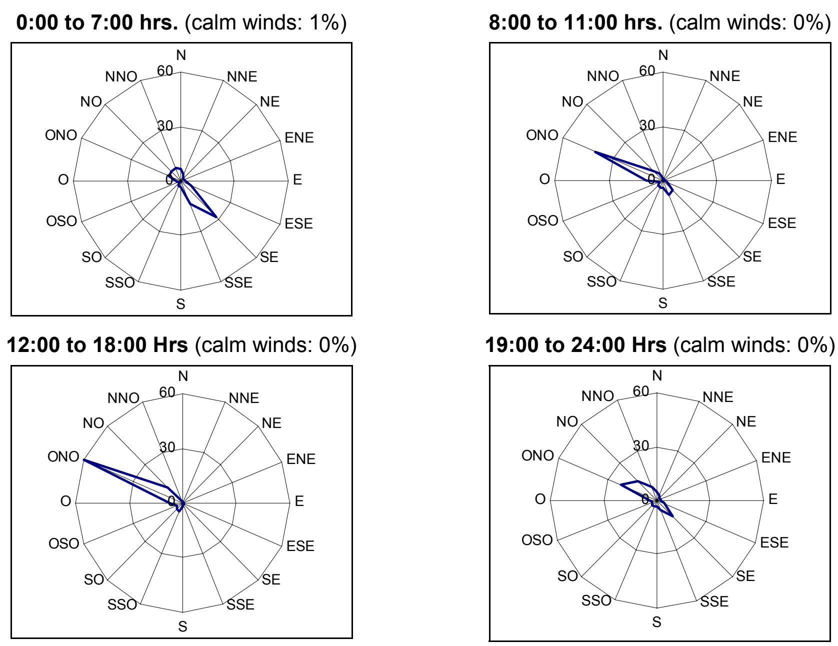


____Frequency %

The following can be said about the differences that exist between the previously described wind pattern and that which was observed at the remaining monitoring stations: a) during spring, fall and winter, the Playas and Rosarito monitoring station show an important east-northeast and east component respectively; even though they generally adjust to the previous description, and; b) during the summer, all the monitoring stations clearly show a noticeable northwest and west-northwest flow, with the exception of the Playas station where the flow originates almost with the same frequency from the north-northwest and south-southwest directions.

Figure 4.4 shows the annual average hourly behavior of surface wind at the ITT monitoring station. This figure illustrates the wind behavior throughout the day in Tijuana during 1998, since in general, it is representative of what was observed at the other monitoring stations. It can be observed that between 8:00 and 18:00 hours there is a clearly prevailing pattern of winds from the sea (from the northwest and west-northwest), representing up to 60% of the total frequency from 12:00 to 18:00 hours. Between 0:00 and 7:00 hours, the prevailing wind comes from the southeast and east-southeast directions, jointly representing up to 42% of the total frequency. Finally, between 19:00 and 24:00 hours, even though northwesterly winds remain more frequent, southeasterly flow starts to gain importance. Thus we can consider this a transition period.

Figure 4.4 Annual average hourly behavior of surface winds in Tijuana-Rosarito (ITT monitoring station, 1998)



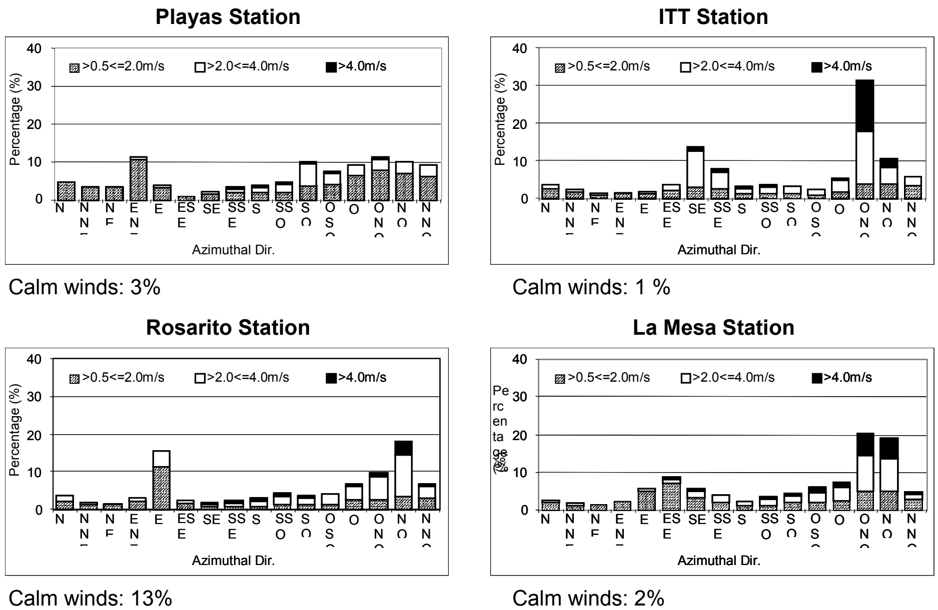
____Frequency %

It is important to mention that, even though the previous figure is being used to illustrate what happens with surface wind throughout the Tijuana-Rosarito area, it is important to point out certain patterns that were particular to the Rosarito and Playas monitoring stations. At the Rosarito station, during the period between 0:00 and 7:00 hours, the prevailing winds were from the east, rather than the southeast. At the Playas monitoring station, between 12:00 and 18:00 hours, the prevailing wind was from the north-northwest to southwest directions with relatively the same frequency, and between 0:00 and 7:00 hours the prevailing winds were east-northeast. This is probably due to the effect from the coastal range surrounding the area where this monitoring station is located.

It is convenient to highlight that the diurnal wind pattern that was just describes is basically determined by the topography of this zone and its proximity to the sea. For example, we notice that in the absence of a sharp regional barometric gradient, the cold air that descends during the night to the bottom of the Tijuana River Valley manifests itself by a southeasterly wind component, since the river is oriented along a southeast-northwest axis, whereas the thermal contrast between the sea water and the coast determines the establishment of an air flow directed to the ground (in this case from the northwest), that is generally accentuated after noon. These northwesterly winds occur, as was mentioned before, throughout the year. However, this pattern occurs more often during the summer, when ground heating in the Tijuana region is greater due to the absence of clouds, which is caused by the intensification of the North Pacific semipermanent anticyclonic cell.

Finally, as far as wind velocity, it can be highlighted that the most frequent intensities at the Playas and La Mesa stations, fall under 2 m/s. In fact, the frequency of occurrence of wind velocities below 2 m/s (including calm winds) at these two stations, was up to 50% of the time. At the ITT and Rosarito stations the most frequent wind speeds fell in the range between 2.1 and 4 m/s, representing up to 46% of the total occurrence (Figure 4.5).

Figure 4.5. Prevailing wind in Tijuana-Rosarito 1998
(Direction and velocity - Percentage of occurrence)



The monitoring stations where winds with an intensity higher than 4 m/s occurred most frequently were ITT and La Mesa. This was particularly true when the prevailing wind directions were from the northwest and west-northwest, when wind velocities reached close to 10 m/s. This situation is probably due to the fact that these stations are located in flat terrain, at an elevation between 130 and 120 meters above sea level, respectively. Because of this, the wind circulates freely without slowing its intensity from the effect of a rugged topography, as is the case at the Playas and Rosarito monitoring stations.

Temperature

The hottest months of the year in Tijuana, for 1996, were April through August, when monthly average maximum temperatures exceeded 30°C. For the coldest months, which are January through March, the monthly minimum average temperatures were below 9°C. As far as monthly average temperatures are concerned, the maximum temperatures oscillated between 28°C (February) and 39°C (September and October), and the minimum temperatures oscillated between 3°C (January) and 16°C (July and August).

The temperature behavior for 1997 was similar to that of the previous year, since the monthly average for the maximum temperatures was above 32°C and that for the minimum temperatures fell below 8ºC.

The temperatures for both years were similar, with both the high temperature as well as the low temperature periods, coinciding both years. It is important to point out that in this area, the extreme maximum and minimum temperatures for these two years were 39°C (August 1997) and 3°C (January of both years), respectively (Figure 4.6).

Figure 4.6. Monthly temperature in Tijuana-Rosarito, 1997
(Average value of maximum and minimum daily temperatures)

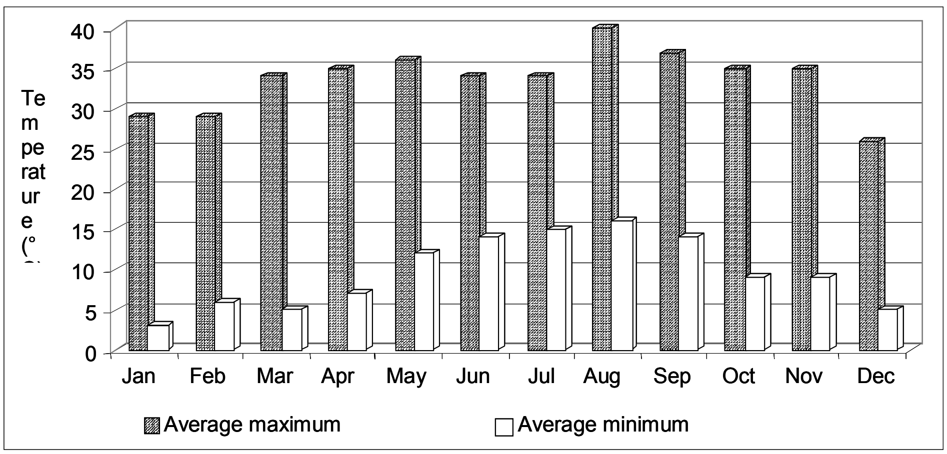
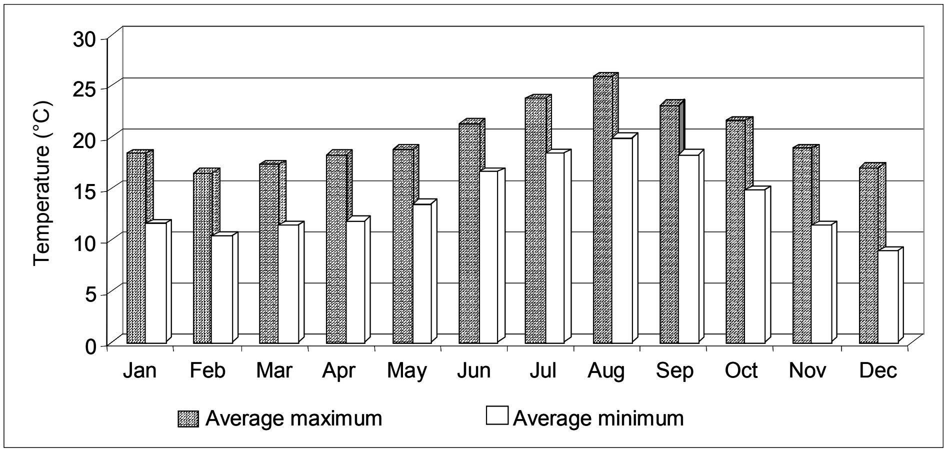


Figure 4.7 shows that, in 1998, the hottest months of the year were June and October, with an average monthly value exceeding 21ºC for the maximum temperatures. By contrast, the coldest months were November and February, with a monthly average below 12ºC for the minimum temperatures.

The monthly average of maximum temperatures oscillated between 16.5ºC in February and 26ºC in August. On the other hand, the monthly average of minimum temperatures varied between 9ºC (December) and 20ºC (August). These numbers illustrate the thermal oscillation that occurred throughout the year, and from one year to the next.

In reference to the extreme maximum and minimum temperatures for 1998, it can be highlighted that the maximum temperature was 34ºC, recorded at the ITT station in the month of August, whereas the minimum temperature was 3.7ºC, recorded at La Mesa station in December.

Figure 4.7. Monthly temperature in Tijuana-Rosarito, 1998
(Average values of maximum and minimum daily temperatures)



Precipitation

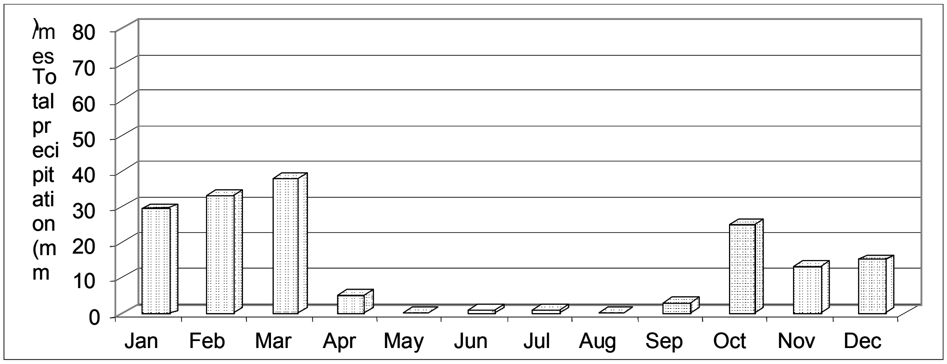
According to Jáuregui[20], the rainy season in Tijuana begins in November and extends through April. Precipitation during these months is between 30 and 40 mm/month. In general, precipitation shows a frontal pattern, with only 4 to 6 days of considerable rain. The synoptic frontal systems produce almost the entirety of the annual precipitation in Tijuana-Rosarito. During the summer, the North Pacific anticyclone is intensified, resulting in an increase in the pressure gradient in the northern part of the state, keeping the frontal systems from moving along the coast. This causes very low precipitation in the region during the summer, with the rains that exceptionally occur at the end of this season being associated with the North Oriental Pacific tropical cyclones, that rarely set course toward the Tijuana-Rosarito region.

Figures 4.8 and 4.9 show the precipitation behavior in the zone during 1996 and 1997. This data was obtained from Comisión Nacional del Agua (National Water Commission).

Figure 4.8 shows total precipitation by month for 1996. In general terms, it can be seen that there is little precipitation, with the greatest concentration occurring during the first months of the year (i.e., January, February and March), with 27, 33 and 38 mm/month, respectively. The driest period corresponds to the months of May through August.

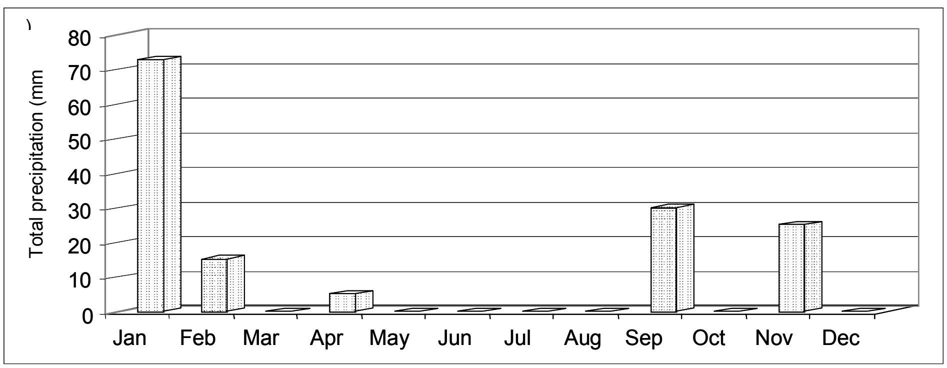
[20] Jáuregui, O.E. (1981). Climatología de Difusión de la Ciudad de Tijuana, B.C. Boletín del Instituto de Geografía. Universidad Nacional Autónoma de México. Número 11. México, D.F.

Figure 4.8. Total Precipitation in Tijuana-Rosarito, 1996



As shown in Figure 4.9, during 1997 precipitation occurred only in five months of the year; January, February, April, September and November, with 73, 15, 6, 30 and 24 mm/month, respectively.

Figure 4.9. Total Precipitation in Tijuana-Rosarito, 1997



Thermal inversions

Normally, air temperature decreases at higher elevations. When this process is inverted, it is said that there is a thermal inversion. Dilution capacity is a function of the vertical thermal gradient in the planetary layer (the first kilometer). In general, air is stratified at night due to ground cooling, through space radiation. Surface temperature inversions are formed under these conditions. The transfer of cold air at night to the lower sections of the Tijuana River watershed reinforces surface inversion. Once the ground begins to heat up after sunrise, surface air temperature gradually rises until the inversion disappears or is "burned out" a little before noon. Turbulent wind conditions prevail during these hours of mid-day, when a dry adiabatic-like gradient is established. Pollutants that are emitted during these hours are diluted in a layer whose depth depends on the maximum surface temperature. This layer is known as the "maximum mixing layer."

Once the westerly light winds mechanism has been established, pollutants traveling to the northwest in the afternoon hours converge at the southern end of the urban area of San Diego and are then transported to Tijuana by reverse flow.

Jáuregui[21], used radiosonde data from the North Island Station in San Diego, locate some 20 kilometers from Tijuana, to analyze the behavior of thermal inversions. Table 4.8, show the monthly frequency of inversions whose base is below 700 and 500 meters, and at the surface. Surface inversions have a greater frequency during the cold season.

During the first hours of the morning, pollutants in Tijuana tend to be transported to the northwestern part of the city, in the direction of San Ysidro, California. During this period, air stability restricts the dilution of contaminants. According to information collected by Jáuregui, surface inversion occurs at night, an almost permanent characteristic in Tijuana that causes vertical dispersion to be almost always restricted. On the other hand, inversions at 500 and 700 meters are more frequent in the summer. The greater incidence of surface inversions in the winter indicates that this is the time of the year when the least favorable conditions for pollutant dispersion occur in Tijuana. The incidence of inversions is reduced drastically starting in the month of April, with this condition remaining almost through the end of August.

The prevalence of westerly breezes during most of the day, and the relative absence of inversions, favors diffusion and pollutant transport during the hot season. However, the elevated frequency of inversions with a base between 500 and 700 meters in the summer, indicates that the dilution of impurities cannot penetrate any deeper than these levels. The cooling of surface air layers begins to prevail around the month of September, consequently increasing the frequency of inversions. Low elevation inversions are frequent in the area during the summer, restricting the dispersion of pollutants beyond an altitude of 600 meters.

Table 4.8. Monthly cumulative frequency of inversions with a base below 700 and 500 meters in the surface, at North Island Station, San Diego, at 7 a.m.(1) and 7 p.m.(2) (U.S.W.B. T.P. 54, 1965)

Height from the base (m)	**J**		**F**		**M**		**A**		**M**		**J**	
	1	2	1	2	1	2	1	2	1	2	1	2
700	66	51	68	43	49	46	28	42	43	57	46	64
500	65	45	64	41	44	39	19	31	27	40	28	43
Sup.	57	23	56	19	27	15	2	1	3	2	1	2

Height from the base (m)	**J**		**A**		**S**		**O**		**N**		**D**	
	1	2	1	2	1	2	1	2	1	2	1	2
700	78	93	79	93	73	84	71	78	71	63	73	53

[21] Jáuregui, O.E. (1981). Climatología de Difusión de la Ciudad de Tijuana, B.C. Boletín del Instituto de Geografía. Universidad Nacional Autónoma de México. Número 11. México, D.F.

500	47	76	56	80	54	69	56	68	68	53	69	51
Sup.	3	5	3	2	15	18	24	17	48	26	61	31

Source: Jáuregui, O.E. (1981). Climatología de Difusión de la Ciudad de Tijuana, B.C. Boletín del Instituto de Geografía. Número 11. Universidad Nacional Autónoma de México. México.

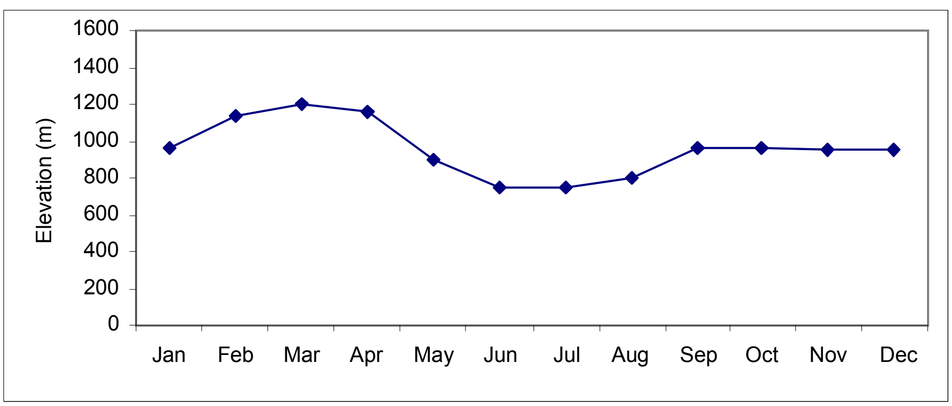
Mixing layer height

The mixing layer height is the region within the atmosphere where pollutants are dispersed. The value associated with this height (which goes from the ground surface to the point where it becomes stable, or where the first thermal inversion is found), varies as a function of atmospheric stability, depending on air temperature and wind velocity.

Jáuregui points out in his study on climatology of diffusion in the City of Tijuana that the San Diego County Air Pollution Control District (APCD) had recorded the mixing layer height for several years using a wind profiler. Figure 4.10 shows the maximum monthly variation for the mixing layer height in San Diego, for 1976.

San Diego's APCD and downtown Tijuana are at approximately the same distance from the ocean. Therefore, the mixing layer heights recorded in San Diego should be similar for Tijuana.

Figure 4.10. Maximum mixing layer height in San Diego, Cal., 1976



Source: Jáuregui, O.E. (1981). Climatología de Difusión de la Ciudad de Tijuana, B.C. Boletín del Instituto de Geografía. Número 11. Universidad Nacional Autónoma de México. México.

This figure shows that the minimum mixing layer height was reached in the summer (approximately 800 meters), probably due to the intensification of the North Pacific semipermanent anticyclonic cell. During the rest of the year, the mixing layer height varied between 900 and 1,200 meters.

4.3. Air quality diagnostic

Following is a description of the air quality diagnostic for the region, incorporating the information from 5 monitoring stations in Tijuana and one in Rosarito (known as a whole as the *Tijuana Monitoring Network*).

The current active phase of the air monitoring system in Tijuana began in November of 1995, with the installation, configuration, and equipment operation acceptance tests. Monitoring began in the second semester of 1996, within the Border XXI Program cooperative framework, with resources from EPA and CARB, and SEMARNAPs involvement.

The monitoring network consists of six stations, four of which continuously measure the concentrations of O_3, NO_2, SO_2 and CO, as well as temperature, relative humidity, wind speed and wind direction. TSP and PM10 samples are collected manually at these four stations every sixth day. Only TSP and PM10 samples are collected at the two remaining stations. The six stations are: Instituto Tecnológico de Tijuana (ITT), Rosarito, La Mesa, Playas, Centro de Salud (SSA), and Colegio de la Frontera (COLEF). This monitoring network is currently operated and financed by CARB. The different activities involved in the operation of the network are in charge of a US company (TEAM-TRACER), with the support from local academic institutions of higher education. SEMARNAPs state delegation has been in charge of supervising project development, with technical assistance from INE.

According to the bilateral agreements, the transfer of responsibilities will begin the second semester of the year 2000. After that, the Mexican government and other Mexican institutions will be fully responsible of operating the network. With respect to the equipment, 80% of it was provided by US agencies and the remaining equipment was provided by INE. Data generated through the operation of the monitoring network are transferred directly by radio signals to CARBs headquarters, where the preliminary evaluation is conducted. Data is subsequently sent to the AIRS system, where validation is performed in accordance with EPA approved quality assurance methodologies. Finally, data is sent to INE and CICA every quarter, and posted on the internet.

Monitoring network configuration

The following is a brief description of each of the monitoring stations that make up the network.

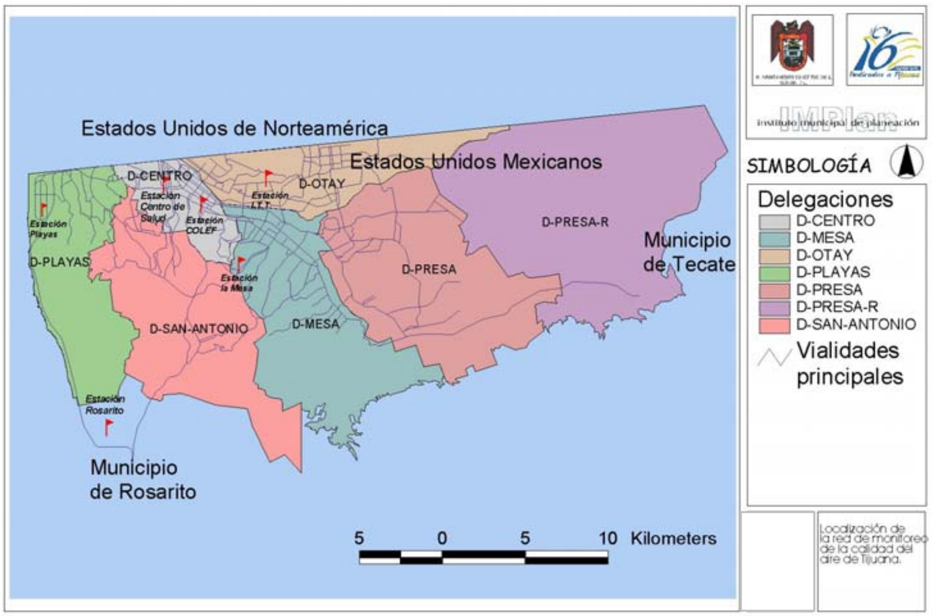
The ITT station is located at Instituto Tecnológico de Tijuana, on Calzada Tecnológico s/n, Fraccionamiento Tomás Aquino. The station is at an elevation of 130 meters above sea level. Its geographic coordinates are 32° 31' 53" North latitude and 116° 59' 10" West longitude. This area of the city is characterized for having a flat topography (it is on the crest of a Mesa), and its soil use is predominantly residential and commercial. The industrial zone is located five kilometers east of this station, whereas the city airport is located two kilometers to the northwest. This monitoring station has the following analytical equipment to measure pollutant concentrations: DASIBI 3008 analyzer to determine CO concentrations, THERMO 43 for SO_2, API 200A for NOx, API400 for O_3, GMW 2000H for TSP and WEDDING for PM10.

The Rosarito station is located at Escuela Primaria Federal Pedro Moreno, on calle J. Amaro s/n, Fraccionamiento Machado. The station is at an elevation of 10 meters above sea level. Its geographic coordinates are 32° 20' 36" North latitude and 117° 03' 21" West longitude. The topography of this area is slightly tilted, rising to the east, even though there are no hills. The ocean is only 2 kilometers to the west. Soil use is residential and industrial. The Rosarito power plant is located relatively close to this monitoring station. This station has the following analytical equipment to measure pollutant concentrations: DASIBI 3008 analyzer to determine CO concentrations, THERMO 43 for SO_2, API 200A for NOx, API400 for O_3, GMW B/M2360 for TSP and WEDDING for PM10.

The La Mesa station is located in the facilities of a High School, on Calle Cajemé s/n, about 120 meters above sea level. Its geographic coordinates are 32° 29' 52" North latitude and 116° 58' 37" West longitude. Soil use is mainly residential. The intersection between Lázaro Cárdenas Avenue and Díaz Ordaz Boulevard is approximately one kilometer to the northeast of this station. The monitoring booth has the following analytical equipment to measure pollutant concentrations: DASIBI 3008 analyzer to determine CO concentrations, THERMO 43 for SO_2, API 200A for NOx, API400 for O_3, GMW 76-100 for TSP and WEDDING for PM10.

The Playas station is located at Centro de Bachillerato Técnico (CBATIS 146), on Avenida Parque Baja California, lote 751, Sección El Dorado, Playas de Tijuana, at an elevation of 5 meters above sea level. Its geographic coordinates are 32° 30' 50" North latitude and 117° 06' 56" West longitude. The topography of the zone is flat to the west (1 kilometer to the sea) and there is a mountain range that surrounds the station, running from the northeast to the south. Soil use is residential and there are no important emissions sources in the proximity of this station. This station has the following analytical equipment to measure pollutant concentrations: DASIBI 3008 analyzer to determine CO concentrations, THERMO 43 for SO_2, API 200A for NOx, API400 for O_3, GMW 2000H for TSP and WEDDING for PM10.

Figure 4.11. Location of air quality network monitoring stations in Tijuana-Rosarito



The Centro de Salud (SSA) station is located on Avenida de la Constitución s/n, in a lot where the elevation above sea level is 46 meters. Its geographic coordinates are: 32° 31' 33" North latitude and 117° 02' 19" West longitude. Topography in this zone is flat with a slight slope rising from north to south. Soil use is commercial and residential. This station is only equipped with manually operated samplers to measure TSP (GRASEBY BM2360) and PM10 (WEDDING).

The COLEF station is located in the facilities of Colegio de la Frontera, on Blvd. Abelardo L. Rodríguez 2925, Zona del Río, at an elevation of 5 meters above sea level. Its geographic coordinates are: 32° 31' 07" North latitude and 117° 00' 40" West longitude. The topography in this zone is flat, within the Tijuana River watershed. Soil use is mostly for commercial purposes. This station, like the one located at Centro de Salud, is only equipped with manually operated samplers to measure TSP (GRASEBY BM2360) and PM10 (WEDDING).

Table 4.9. Location of monitoring stations in Tijuana-Rosarito

Station	Zone	Address	Monitored Parameters	Meteorological Parameters
ITT	Northeast	Calzada Tecnológico s/n	O_3, CO, SO_2, NO_2, TSP and PM10	Temperature, wind direction and wind speed.
Rosarito	Southeast	Calle J. Amaro s/n	O_3, CO, SO_2, NO_2, TSP and PM10	Temperature, wind direction and wind speed.
La Mesa	Southeast	Calle Cajemé s/n	O_3, CO, SO_2, NO_2, TSP and PM10	Temperature, wind direction and wind speed.

Playas	Northeast	Av. Parque Baja California, lote 751	O_3, CO, SO_2, NO_2, TSP and PM10	Temperature, wind direction and wind speed.
Centro de Salud (SSA)	Northeast	Av. de la Constitución s/n	TSP and PM10	
COLEF	Central	Blvd. Abelardo L. Rodríguez 2925	TSP and PM10	

The monitoring equipment is continuously calibrated and, as was mentioned earlier, the information obtained is validated using EPA approved quality control methods.

Air quality trends

The following is a description and analysis of the air quality information that was generated through the air quality monitoring network during 1997 and 1998.

Table 4.10 shows the percentage and number of days when the 100 and 150 IMECA point levels were either reached or exceeded during 1997 and 1998. The air quality standard was reached or exceeded only 1% of the time (4 days) during 1997 and the 150 IMECA points level was never reached by any pollutant. It is important to clarify that the Table shows four days when the 100 IMECA points level was reached or exceeded, even though in the middle of the table two exceedances are reported for the ozone standard and three for the PM10 standard. This is due to the fact that both standards were exceeded on the same day in one occasion. This happened on October 31. Likewise, we must not forget that PM10 samples are collected once every six days. Therefore, the total number of days when the standard was exceeded in 1997 could have been up to 15.

During 1998, the percentage of days when at least one of the air quality standards was exceeded was 2% (7 days of the year). The 150 IMECA points level was not reached or exceeded this year either. The number of times when the 100 IMECA points level was exceeded for PM10 was greater this year than in the previous one, and in 1998 there was one exceedance of the NO_2 standard.

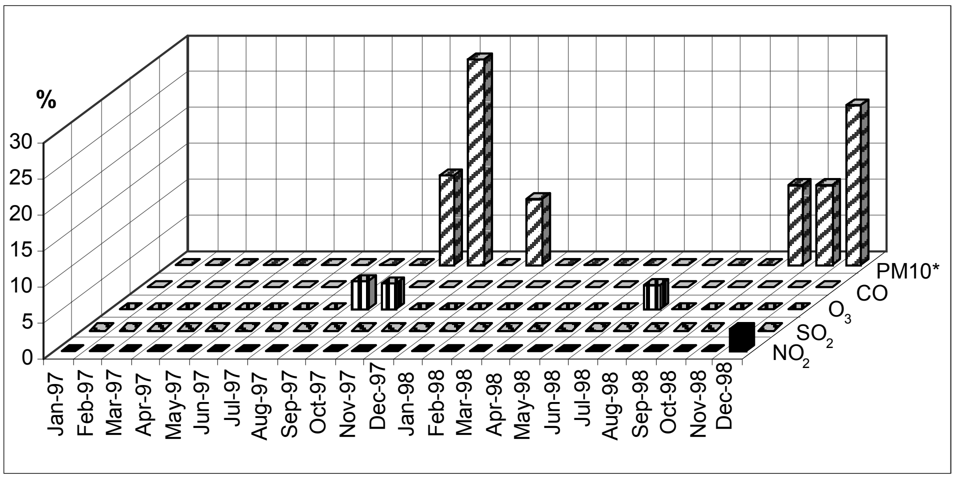
Table 4.10. Percentage and number of days with values equal to or greater than 100 and 150 IMECA points in Tijuana-Rosarito, 1997-1998

	1997					**1998**				
	>=100		**>=150**		**Total number of days with data**	**>=100**		**>=150**		**Total number of days with data**
	%	**No.**	**%**	**No.**		**%**	**No.**	**%**	**No.**	
O_3	1.1	3	0	0	268	0.3	1	0	0	365
PM10*	3.8	3	0	0	78	5.5	5	0	0	91
CO	0.0	0	0	0	271	0.0	0	0	0	365
NO_2	0.0	0	0	0	297	0.3	1	0	0	365
SO_2	0.0	0	0	0	250	0.0	0	0	0	361
General	1.2	4	0.0	0	322	1.9	7	0.0	0	365

* Percentage and number of samples.

Figure 4.12 shows the percentage of days and the number of samples per month when the air quality standards were exceeded during the period under consideration. This figure shows that PM10 exceedances occurred at the end of the fall and beginning of the winter, with November and December showing the largest percentage of exceedances. Exceedances of the ozone standard occurred both in the summer as well as the fall (July, September and October). There was one exceedance of the nitrogen dioxide air quality standard in December 1998, whereas no exceedances were reported for sulfur dioxide and carbon monoxide during the study period.

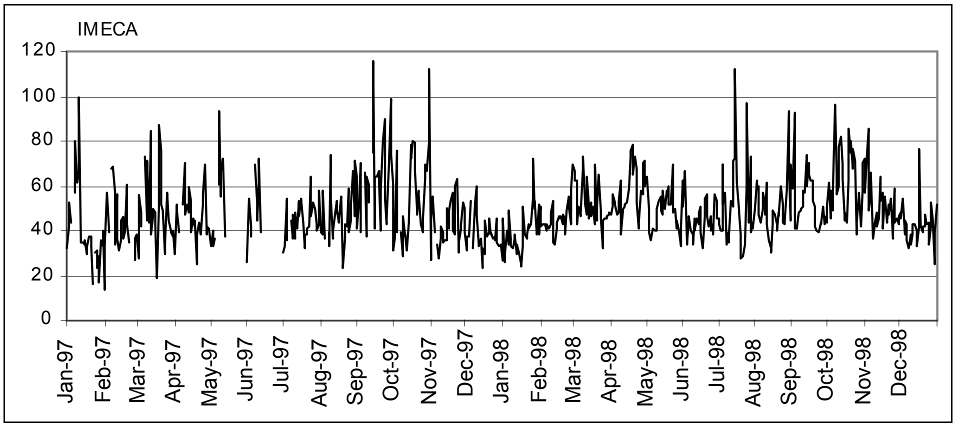
Figure 4.12. Percentage of days when the 100 IMECA points level was reached or exceeded by month and by pollutant in Tijuana, 1997-1998



* Percentage of samples.

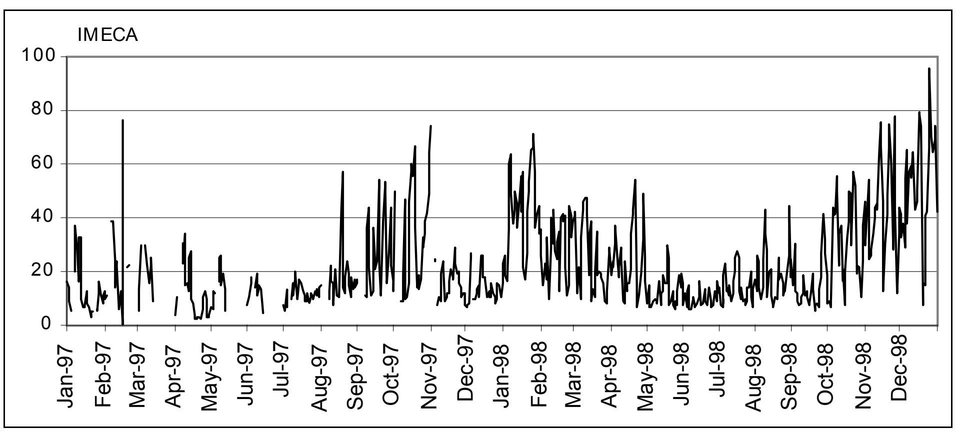
Figure 4.13 shows the IMECA maximum daily value for ozone from January 1997 to December 1998. It can be seen that the maximum values recorded were 116 IMECA points in September of 1997 and 112 IMECA points in October of 1997 and July of 1998. Likewise, there were four other days when the 100 IMECA points level was almost reached.

Figure 4.13. IMECA maximum daily value for ozone in Tijuana-Rosarito, 1997-1998



In reference to the trend for the maximum daily IMECA concentrations for carbon monoxide, Figure 4.14 shows that this pollutant did not exceed 100 IMECA points in 1997 and 1998. However, in December of 1998 there was a value that was close to that level (96 IMECA points). During the rest of the year, the maximum concentrations were below 80 IMECA points. In 1997 the maximum concentration was 76 IMECA points, which occurred in the month of February.

Figure 4.14. Maximum daily IMECA for CO in Tijuana-Rosarito, 1997-1998



In reference to nitrogen dioxide, Figure 4.15 illustrates the behavior of the maximum daily concentrations during the study period. It can be seen that, in general, the maximum concentrations tend to remain below 60 IMECA points, and the 100 IMECA points level was reached in only one occasion (December 1998). In 1997 the maximum concentration was 83 IMECA points, which was recorded in the month of September.

Figure 4.15. Maximum Daily IMECA Level for NO_2 in Tijuana-Rosarito, 1997-1998

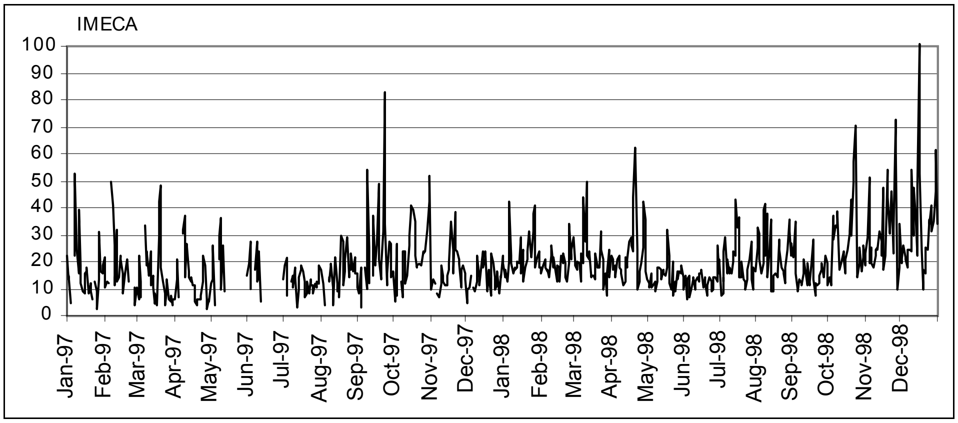
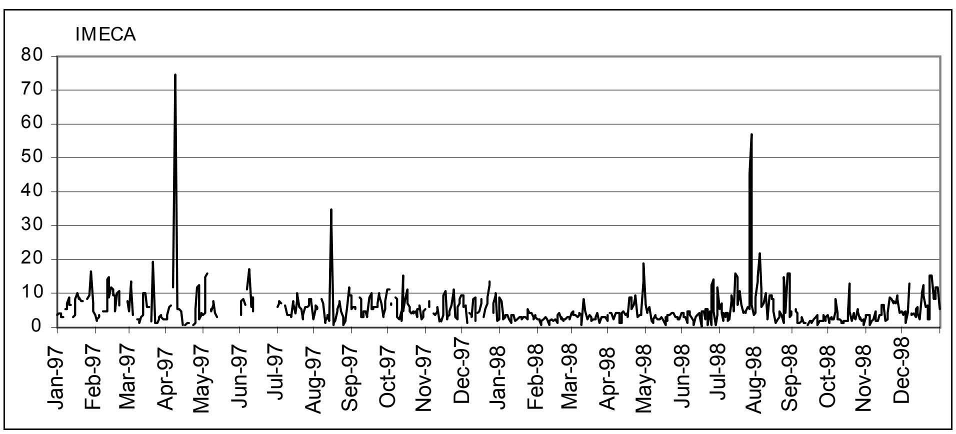


Figure 4.16 shows the behavior of the maximum daily IMECA concentrations for sulfur dioxide in 1997 and 1998. It can be observed that the maximum recorded concentrations are, in general, lower than 20 IMECA points. During the study period, the maximum concentration recorded for this pollutant was 75 IMECA points, in the month of April 1997. In 1998 the maximum daily concentrations were, in general terms, even lower in 1997.

Figure 4.16. Maximum Daily IMECA Levels for SO_2 in Tijuana, 1997-1998

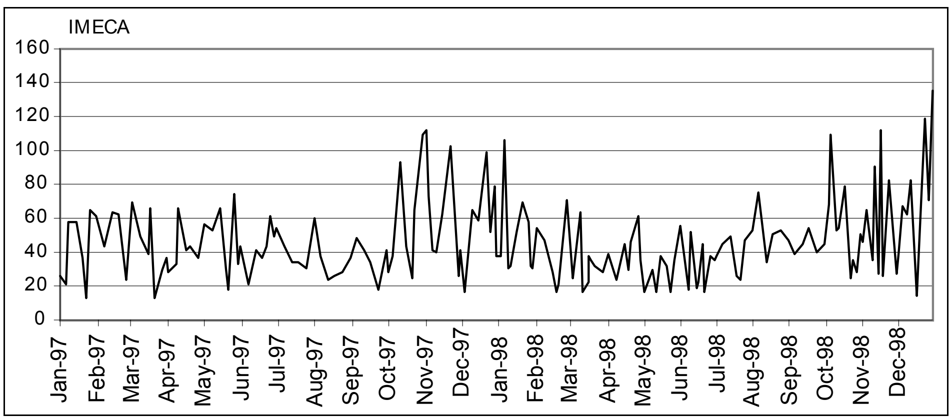


The annual average for this pollutant in 1997 was 0.005 ppm, and in 1998 it was 0.003 ppm. These values are significantly lower than the annual standard, which is 0.03 ppm for the arithmetic mean.

Figure 4.17 illustrates the trend of the maximum IMEC values recorded for PM10, during the same period. For this case, it is important to notice that PM10 samples are not collected daily, but rather every sixth day. Therefore, the number of records observed in this graph is less than that for the other pollutants. This figure shows that the PM10 standard was exceeded during eight sampling days, three times in 1997 and eight times in 1998. The highest concentrations were 119 and 136 IMECA points, and both were recorded in December 1998. The maximum concentration in 1997 was 112 IMECA points and it was recorded in November.

The PM10 annual average for 1997 was 56 μg/m^3 and for 1998 it was 52 μg/m^3. These two values are slightly higher than the annual air quality standard for this pollutant, which is 50 μg/m^3.

Figure 4.17. Maximum IMECA concentrations for PM10 in Tijuana-Rosarito, 1997-1998

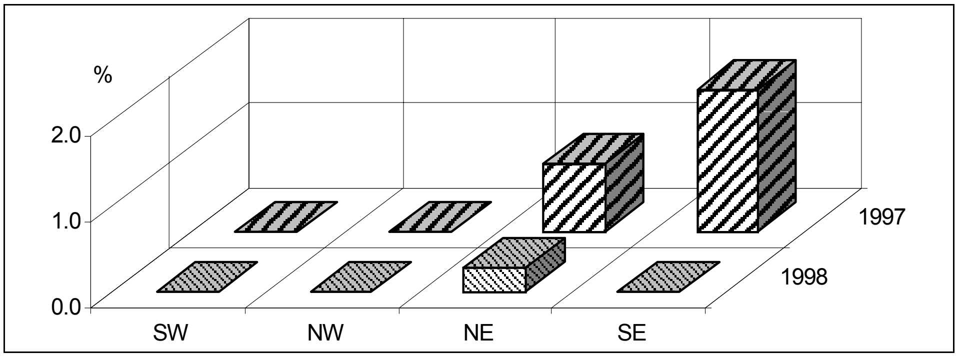


Pollutant Behavior by Zone

Keeping in mind that not all five pollutants are measured at every monitoring station, the following illustrates the spatial behavior of ozone, nitrogen dioxide, particulate matter (PM10), which were the three pollutants that recorded exceedances of their air quality standard in the 1997-98 period.

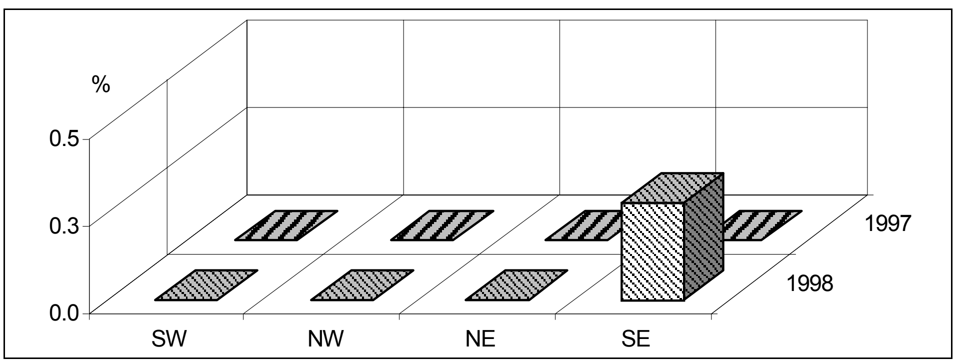
Figure 4.18 shows the percentage of days when the standard for ozone was exceeded in the different zones of the city. It can be seen that only the southeastern and northeastern zones recorded exceedances of the ozone standard, with the frequency of exceedances being greater in the southeastern zone. Likewise, it can be seen that, in 1998, there was a decrease in the number of exceedances in both zones, with respect to 1997.

Figure 4.18. Percentage of days when the ozone standard was either reached or exceeded in the different zones of Tijuana-Rosarito, 1997-1998



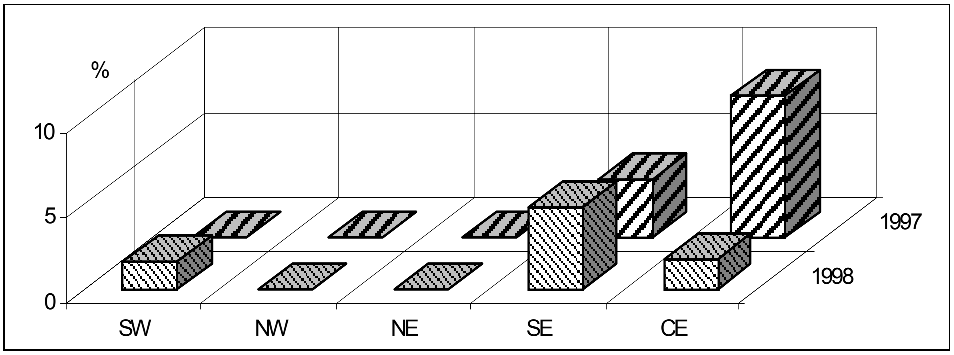
As far as NO_2 is concerned (Figure 4.19), there was only one exceedance and this occurred in the month of December 1998, in the southeastern part of the city.

Figure 4.19. Percentage of days when the NO_2 standard was either reached or exceeded in the different zones of Tijuana-Rosarito, 1997-1998



Finally, Figure 4.20 shows the percentage of samples that exceeded the PM10 standard, by zone, during the study period. In general, it can be seen that this pollutant exceeded its standard with greater frequency in the southeastern zone. However, it can also be highlighted that, in 1998, a higher percentage of exceedances was recorded in the same zone with respect to the previous year. In the central zone of the city the percentage of exceedances was greater in 1997, whereas the southwestern zone only recorded exceedances in 1998. Finally, in the northwestern and northeastern zones the concentrations recorded always were below the standard.

Figure 4.20. Percentage of samples that exceeded the PM10 standard in the different zones of Tijuana-Rosarito, 1997-1998



Seasonal behavior

Figure 4.21 the variation in the monthly average of hourly concentrations for ozone, with the idea of identifying some kind of seasonal behavior. In general, the trends for this pollutant throughout the year are similar at the four monitoring stations, and whereas the highest monthly averages in 1997 occurred in different stations, in 1998 these occurred consistently at the Rosarito station. On the contrary, the lowest monthly averages in 1997 occurred at ITT, and in 1998 at La Mesa. In reference to the seasonality shown by this pollutant it can be observed that the highest monthly averages, at all four monitoring stations and during the two years of the study, happened in the periods from March to May, and from September to October (i.e., spring and fall).

Figure 4.21. Monthly average of hourly concentrations for ozone by monitoring station in Tijuana-Rosarito, 1997-1998

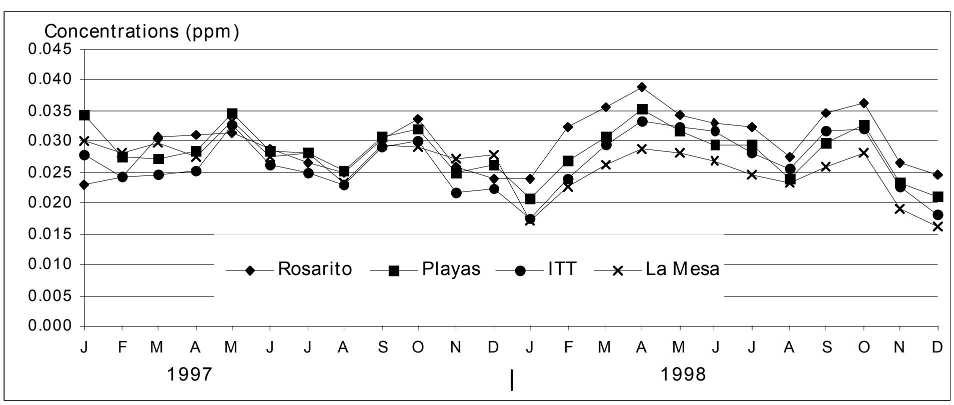


Figure 4.22 shows the monthly average concentrations for carbon monoxide. La Mesa is the monitoring station where the highest concentrations of this pollutant were recorded. It is possible that this is due to the CO vehicular emissions that are recorded at the intersection between Lázaro Cárdenas Avenue and Díaz Ordaz Boulevard, which is located about one kilometer to the northeast of the monitoring station. At the remaining stations, carbon monoxide shows a similar seasonal behavior, with a tendency for displaying the highest average monthly values between the months of October and December, covering the cold months of the year. This is particularly evident in 1998.

Figure 4.22. Monthly average of hourly concentrations for CO by monitoring station in Tijuana-Rosarito, 1997-1998

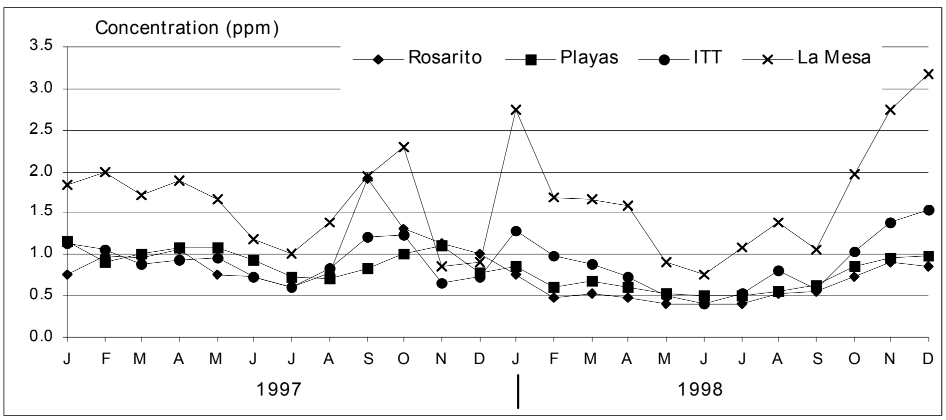


Figure 4.23 shows the monthly averages recorded for PM10 at the six monitoring stations. It shows that the highest average concentrations occur at the end of the fall and beginning of the winter (October and December.) Similarly, it can be highlighted that in 1997 the highest average values consistently occurred at the monitoring station in La Mesa, whereas in 1998, the highest average values occurred at the station in Rosarito. It is important to mention that the Rosarito station only has information for 1998.

It is likely that the fact that the highest monthly averages for PM10 were recorded at the La Mesa and Rosarito stations responds to the type of emissions sources that are found in their proximity. For example, there is a power plant near the Rosarito station, whereas the intersection between two heavily traveled avenues (Lázaro Cárdenas and Díaz Ordaz Boulevard) is only one kilometer to the northeast of La Mesa station.

Figure 4.23. Monthly average of hourly PM10 concentrations by monitoring station in Tijuana-Rosarito, 1997-1998

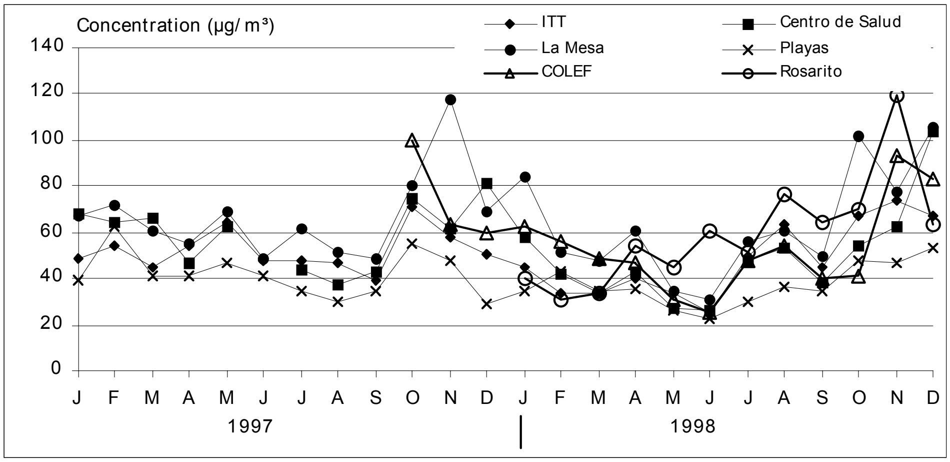
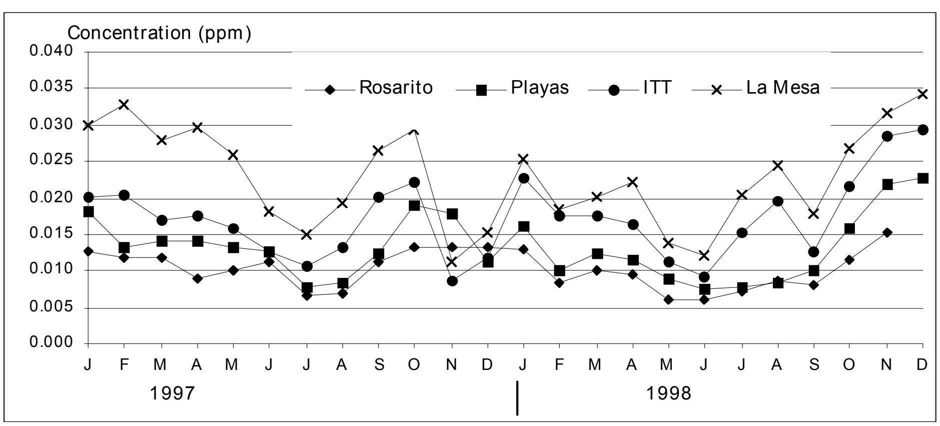


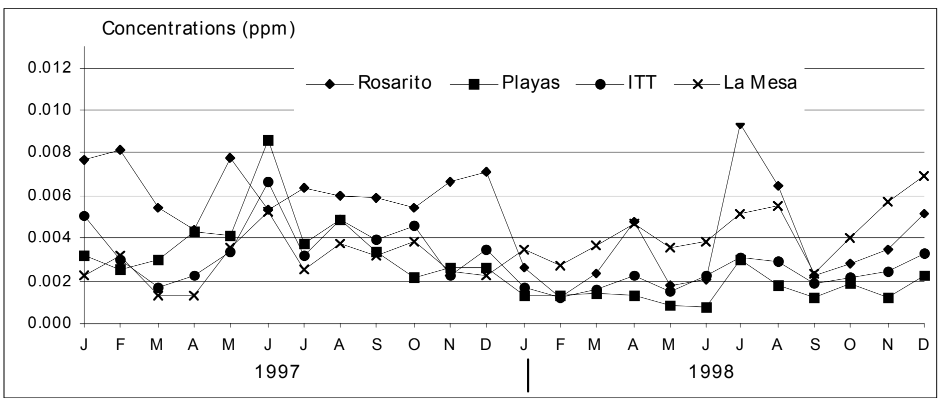
Figure 4.24 shows the monthly average concentrations for nitrogen dioxide, highlighting that the noticeably higher averages are recorded consistently at the La Mesa monitoring station. Evidently, as is the case for carbon monoxide, this can be due in large part to the effect of the emissions of vehicles that travel through the intersection that was previously mentioned. It can also be seen that, in general, the trends at all the monitoring stations are similar throughout the two years of the study and that, in 1997, the highest values at all the stations were recorded in the months of January and October, whereas in 1998, the highest values at all the stations were recorded in the months of January, November, and December.

Figure 4.24. Monthly average of hourly concentrations of NO_2 by monitoring station in Tijuana-Rosarito, 1997-1998



Finally, Figure 4.25 shows the average monthly behavior for sulfur dioxide in 1997 and 1998. It can be seen that, in general, the average monthly concentrations were lower in 1998 than in 1997, at all four stations. Likewise, it can be seen that, the highest average values occur with more frequency at the Rosarito station. This was more evident in 1997 than in 1998. This is likely a reflection of the impact of the emissions from the power plant that is locate at close proximity from the monitoring station. In reference to the seasonality of this pollutant, it can be observed that the highest averages during the study period, and at all the monitoring stations, occurred in the summer (June-July) and the winter (December-January.)

Figure 4.25. Monthly average of hourly concentrations for SO_2 by station in Tijuana-Rosarito, 1997-1998

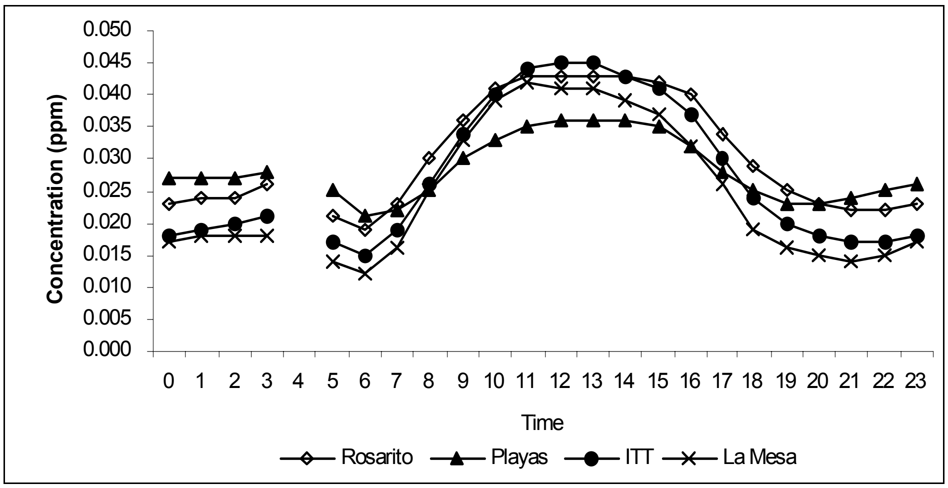


Hourly behavior for ozone and nitrogen dioxide

The concentration of a pollutant measured at ground level at a determined location varies as a function of a series of factors of the urban dynamics (vehicular flow intensity, industrial and commercial activities, among others), the daily cyclic meteorological conditions and their seasonal variation, as well as the physical and chemical characteristics of the pollutants themselves. The following is a description of the average hourly behavior in 1997 and 1998 for ozone and nitrogen dioxide at the four monitoring stations were these pollutants are measured, since they presented exceedances of their air quality standards during the study period.

Figure 4.26 shows that between 0:00 and 8:00 hours the average hourly concentrations for ozone remain below 0.03 ppm. These concentrations begin to rise around 9:00 hours, reaching their maximum values between 11:00 and 16:00 hours. This is the time of the day when we receive the largest amount of solar radiation and when the highest temperatures occur. This generates the most favorable conditions for the formation of this pollutant. After 16:00 hours, the average concentrations for ozone tend to decrease significantly, until they reach concentrations that are similar to those recorded in the morning hours. This behavioral pattern is similar in all the monitoring stations.

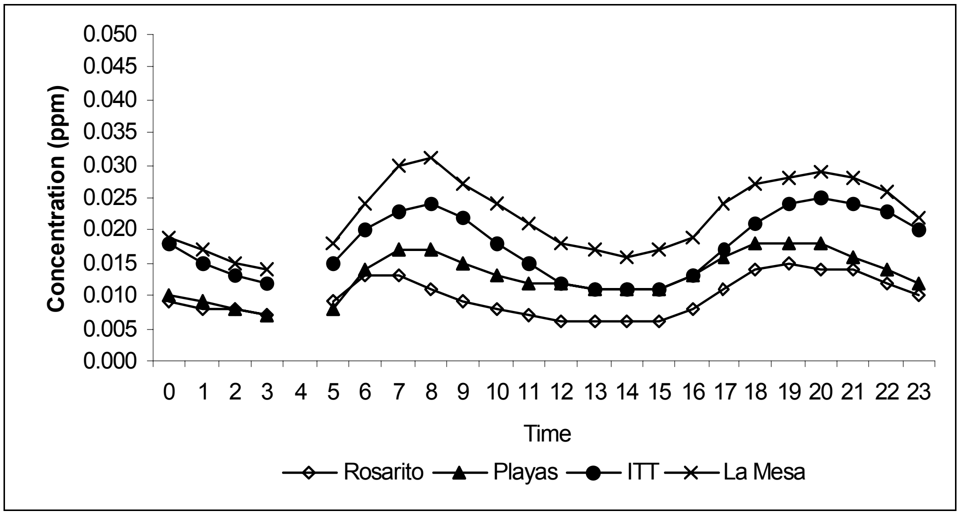
Figure 4.26. Average hourly variation for ozone by monitoring station in Tijuana-Rosarito, 1997-1998.



On the other hand, it can be highlighted that the highest average O_3 concentrations tend to occur at the Rosarito and ITT stations, whereas the lowest average concentrations are recorded at La Mesa. The Playas station shows the highest average concentrations in the morning and afternoon hours, and then these concentrations decrease more gradually than at the other stations.

In reference to the average hourly trends that were observed for NO_2 during the 1997-1998 period, Figure 4.27 reveals that the average hourly concentrations for this pollutant at all four stations were low, showing a clearly defined and characterized daily trend, due to the fact that there are two periods during the day when the highest concentrations are recorded. These two periods are between 6:00 and 8:00 hours and between 18:00 and 21:00 hours, corresponding to the peak vehicular circulation associated with people driving to and from work and school. On the other hand, shows in a very consistent manner that the highest concentrations of NO_2 ,throughout the day, are recorded at the La Mesa monitoring station, whereas the lowest concentrations occur at the Rosarito station.

Figure 4.27. Average hourly variation for NO_2 by monitoring station
in Tijuana-Rosarito, 1997-1998



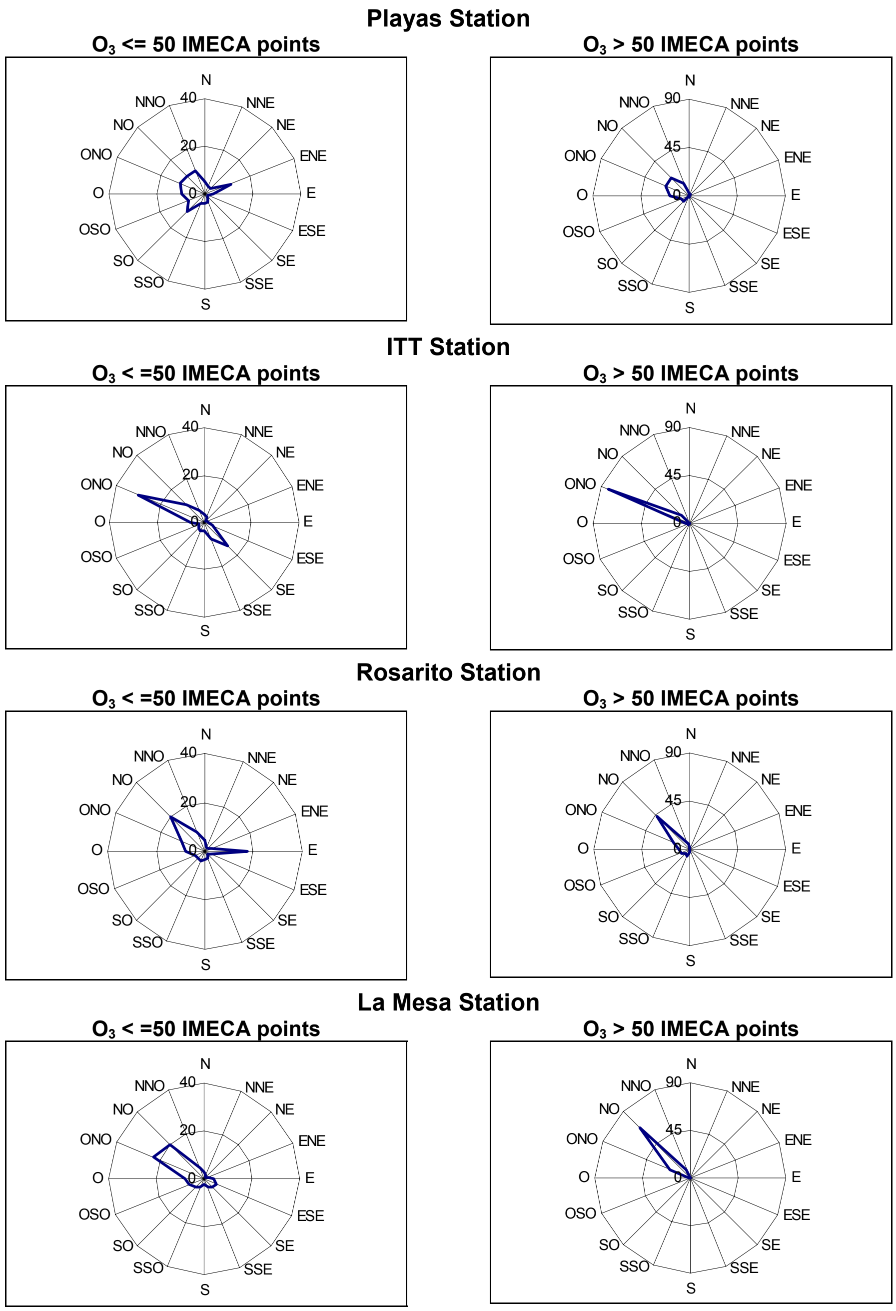
Wind roses for pollutants

Figure 4.28 presents a series of graphs showing the percentage of occurrence of ozone concentrations that are equal to or less than 50 IMECA points, for each wind direction at the different wind monitoring stations during 1998. In order to develop these graphs, only data for those hours where information was reported for both wind direction and ozone concentration was used. Furthermore, data showing “calm winds” (winds with an intensity equal to or less than 0.5 m/s) was eliminated.

The same figure shows that when ozone concentrations were less than or equal to 50 IMECA points, the prevailing wind direction at all four monitoring stations was from the west-northwest to north-northwest. The second most important direction varies a little bit from station to station, but it can be from the east to south-southeast directions.

On the other hand, it can be highlighted that when ozone concentrations exceeded 50 IMECA points, the wind at all the monitoring stations consistently came from the northwest and west-northwest directions. This is particularly noticeable at the ITT, Rosarito and La Mesa monitoring stations.

Figure 4.28. Frequency of occurrence of ozone concentrations by wind direction in Tijuana-Rosarito, 1998.



____Frequency %

Air quality in San Diego

The San Diego County Air Pollution Control District, publishes documents with the purpose of making its achievements and programs known to the general public[22].

In the San Diego area, air emissions have their origin in motor vehicles and industries (nitrogen dioxides and reactive hydrocarbons). The air pollution problem is enhanced with the presence of a thermal inversion layer, which traps pollutants and keeps them from rising. This layer occurs at an elevation of approximately 2,000 feet, during the months of May through October, favoring high concentrations of ozone.

In San Diego, 57% of the days exceed the state's air quality standards, mainly due to pollutant transport from the Los Angeles area. The remaining 43% comes from locally generated emissions.[22]

During 1997 there was only one exceedance of the federal standard for ozone. This was attributed to pollutant transport from the Los Angeles airshed. Likewise, no air quality advisories have been issued in San Diego since 1991. By contrast, in 1990 the federal standard was exceeded 87 days, of which 60 were attributable to pollutant transport and the remaining 27 to local emissions.

The California State ozone standard is also more stringent than the federal standard. This has led to a considerable improvement in ozone concentrations. In 1981, there were 192 exceedances of the state standard, 101 of which were due to pollutant transport and 91 due to local emissions. By contrast, in 1997 there were 43 exceedances, 28 of which were due to pollutant transport and the remaining 15 due to local emissions.

In reference to carbon monoxide, in 1997 there were no exceedances of the federal or state standards. Neither the federal nor the state 8-hr standard for CO has been reached since 1990. In 1995, CARB redesignated San Diego County as an attainment area for the state standard of carbon monoxide. In June 1998, EPA also redesignated this area as attainment for the federal standards of this pollutant.

Nitrogen dioxide did not exceed the federal or state standards in 1997. San Diego County has not exceeded the federal standards for nitrogen dioxide in its annual average and the one-hour state standard was exceeded only three days since 1978; once each in 1981, 1987 and 1988.

[22] San Diego Air Pollution Control Board (1997). Annual Report. Air Quality in San Diego County.

With respect to PM10, its standards have not been exceeded since 1987, when they were established, even though the state standard, which is more stringent, was exceeded at Mesa de Otay Station in 1997.

Sulfur dioxide is not a problem in San Diego, since there are no industries associated with this pollutant. There have never been any violations to the federal or state standards for SO_2. For that reason, San Diego County has been designated as an attainment area for SO_2.

There is a 24-hour standard for sulfates, which is 25 $\mu g/m^3$. This standard was exceeded for the first time in fourteen years on May 16, 1997, when a concentration of 26.71 $\mu g/m^3$ was recorded. The source of this exceedance was attributed to the Rosarito Power Plant, whose fuel source will be switched to natural gas.

The federal and state standards for lead were made the same in 1997. The federal standard has not been exceeded since 1980 and the state standard since 1987. San Diego County is considered as “not designated” by the federal government and as an attainment area by the state government.

Conclusions regarding air quality in Tijuana-Rosarito

Due to the fact that this analysis was done using information for only two years (1997 and 1998), the trends that were observed cannot be considered fully representative of the behavior of pollutants in this region. However, the following conclusions can be established regarding air quality in Tijuana-Rosarito during this study period:

- The frequency of exceedance of any of the air quality standards was less than 6% of the sampling days and none of the pollutants ever reached 150 IMECA points during the 1997-1998 study period.

- The standard for ozone was exceeded four times during the study period (three times in 1997 and once in 1998). The maximum recorded value during this period was116 IMECA points, in September of 1997.

- It was observed that whenever the levels for ozone were less than or equal to 50 IMECA points, the prevailing wind was from west-northwest to north-northwest, as well as from the east to south-southeast, with similar frequencies. On the other hand, when concentrations exceeded 50 IMECA points, the prevailing wind was from the northwest and west-northwest.

- The standard for nitrogen dioxide was exceeded one during the study period. This exceedance occurred in December, 1998 when the concentration of this pollutant reached 100 IMECA points.

- The air quality standard for particulate matter PM10 was exceeded a total of eight times (three in 1997 and five in 1998). This was the standard that was exceed most often. These exceedances could occur anywhere between 14 and 20 times per year with PM10 continuous monitoring. During this two-year study, all violations occurred in the period between the months of October and January.

- Carbon monoxide and sulfur dioxide did not exceed their respective air quality standards during this period.

- In reference to pollutant behavior by zone, it can be observed that the ozone standard is exceeded most frequently in the southeastern zone of the city, followed by the notheast zone. There were no violations to the ozone standard any anywhere else in the city. Nitrogen dioxide presented only one exceedance, which was recorded in the southeastern zone. Finally, the PM10 standard was exceeded in the northeast, central and southeast parts of the city. In 1997, the central zone was where most of the exceedances occurred, whereas in 1998 most exceedances occurred in the southeastern part of the city.

- The monitoring station with the largest number of violations to air quality standards is La Mesa, followed by ITT and COLEF.

The situation in Tijuana-Rosarito confirms that the main air quality problem in the region is related to PM10, followed by ozone.

5. EMISSIONS INVENTORY

The air emissions inventory is a strategic tool for air quality management in the region. It allows us to learn the type of pollutant (SO_2, NOx, PM10, CO, HC), and the volume of that pollutant produced by each sector or emissions source (industrial, services, transportation; private vehicles, power plants, unpaved streets, etc.). Based on this emissions inventory it is possible to assess the impact from some of the actions included in the Program. The following is a description of the energy balance for fuels and the estimation of emissions in Tijuana-Rosarito for the year 1998.

5.1 Energy balance

The level of economic activity in a city can be expressed, among others, in terms of fuel consumption. There are several studies that show a significant correlation between the gross domestic product and energy demand. The way in which this energy demand impacts air quality depends, to a large extent, on the energy balance. That is, the balance that results from the volumes, types and characteristics of fuels used in homes, as well as the industrial, commercial, service, and transportation sectors; homes; and on the technological condition of industrial facilities and the vehicular fleet.

Table 5.1 shows a summary of the energy balance for Tijuana-Rosarito, taking into account the main economic sectors and the different types of fuel that are more widely used. These data were obtained using the net calorific power[1] of each type of fuel, as published in the 1997 National Energy Balance, as well as fuel consumption data provided by Pemex Refinación and Pemex Gas, and Petroquímica Básica. A common unit of measure for fuel consumption is adopted to establish a direct comparison within the energy balance between the different types of fuel consumed in Tijuana-Rosarito.

This Table highlights the large consumption of heavy industrial fuel for industrial use and magna gasoline for vehicular use. Globally, it can be seen that the largest consumption comes from the industrial sector, with a little more than 44%, followed by the transportation sector with close to 41%, and the services sector with almost 15%.

[1] Calorific power.- the amount of heat released by a fuel during the combustion process.

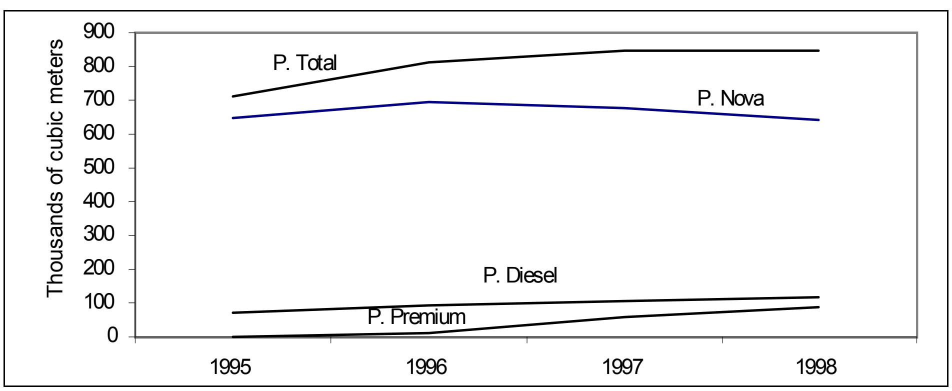
Table. 5.1. Annual energy consumption by sector in the Tijuana-Rosarito area (% with respect to total consumption*), 1998

Fuel	Transportation	Industrial	Services	Total
Magna Gasoline	30.6			30.6
Premium Gasoline	4.2			4.2
Pemex Diesel	6.0			6.0
Industrial Diesel		3.8		3.8
Heavy industrial fuel		40.6		40.6
L.P. Gas			14.8	14.8
Total	**40.8**	**44.4**	**14.8**	**100**

* Annual total consumption: 69 X 10^9 mega joules, equivalent to 2,100,946 cubic meters of gasoline.
Source: INE, 1999, with information from PEMEX Refinación, PEMEX Gas and Petroquímica Básica and the National Energy Balance, 1997.

Given that heavy industrial fuel for industrial use involves, at the same time, the greatest energy demand as well as the most significant percentage of sulfur dioxide emissions, it is important to take consider overload trends in the airshed if there is an increase in the use of this type of fuel. Therefore, it is necessary to look for cleaner alternatives for fuel supply. There is also a great demand of gasoline for vehicular use. Given that motor vehicles contribute the largest percentage of pollutant emissions in this area, it is necessary to look for alternatives in order to increase energy efficiency and perhaps improve the quality of fuels used, as well as improve emissions control technologies and roadway lay-up.

Figure .5.1. Evolution of vehicular fuel consumption in Tijuana-Rosarito, 1995-1998



Source: INE 1999, with information from PEMEX Refinación.

Figure 5.1 shows the evolution of annual vehicular fuel consumption in Tijuana-Rosarito from 1995 to 1998, revealing an increasing trend due to increases in Premium gasoline and diesel consumption. Premium gasoline consumption increased six-fold with respect to consumption in 1995 and during this same period Pemex Diesel consumption almost doubled.

Seventy-six percent of the annual total consumption of vehicular fuels (848 thousand cubic meters), consists of Pemex Magna gasoline (Figure 5.2) and its distribution shows a constant trend throughout the year. Distribution of leaded gasoline (Nova) stopped in September 1996 at the same time that commercial distribution of Pemex Premium gasoline started in this border zone.

As far as industrial and service fuels are concerned, their annual consumption was 1.18 million cubic meters. Most of this consumption corresponds to heavy industrial fuel, representing 59%, followed by natural gas with 35%, and Industrial Diesel with 6% (Figure 5.3).

Figure . 5.2. Vehicular fuel consumption in Tijuana-Rosarito, 1998 (percentage)

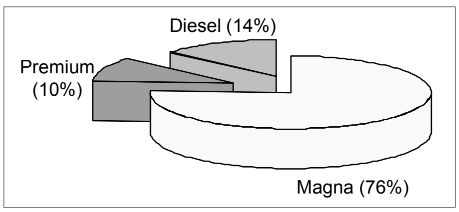
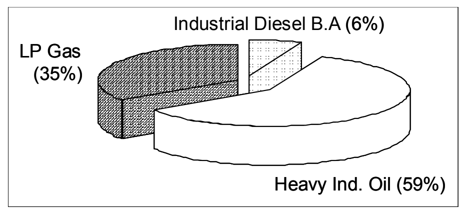


Figure . 5.3 Industrial and service fuel consumption in Tijuana-Rosarito, 1998 (percentage)



5.2. Fuel characteristics

The quality of fuels consumed in Tijuana is regulated by NOM-ECOL-086-1994 (Published in the Official Federal Newspaper on December 2, 1994). This standard establishes the specifications for environmental protection that must be met by the liquid and gaseous fossil fuels that are used in fixed and mobile sources along the Northern Border Zone. It is important to mention that this standard does not establish any standards for Pemex Premium gasoline, since this type of gasoline was not produced in Mexico at the time this standard was published.

Gasoline sold in Tijuana is transported from the Salina Cruz Refinery in Oaxaca, like Pemex Diesel, Industrial Diesel, and Heavy industrial fuel.

A study commissioned by the US National Research Council considers that an improvement in fuel quality can offer positive results for air quality in urban zones (Calvert *et al*, 1993).[23] Particularly, it is believed that the most promising changes that can take place in gasoline quality from the environmental viewpoint consist of a decrease in sulfur content and Reid Vapor Pressure. Sulfur reduction improves the efficiency of the catalytic converter and a decrease in Reid Vapor Pressure has a di-

[23] Calvert, J.G.; Heywood, J.B.; Sawyer, R.F.; Seinfield, J.H. (1993). Science, vol. 261, p.37. Citado en el Programa para Mejorar la Calidad del Aire en el Valle de México 1995-2000.

rect effect on the decrease of evaporative emissions. They also recommend decreasing the content of olefins as well as the T_{90} value, that is, the temperature at which 90% of the gasoline is distilled. The addition of oxygenated compounds is beneficial when trying to maintain the octane and reduce the level of carbon monoxide. However, this action appears not to offer any benefits with respect to ozone reduction.

These observations indicate the need to conduct specific studies and analyses to define the specifications and quality of gasoline for a determined area, so that a balance is achieved in terms of the cost-benefit.

Table 5.2. Comparison of specifications and typical values of unleaded Mexican and US gasoline

	P. Magna	**Regular**		**P. Magna**
	ZFN* NOM-086-1994	**USA** ASTM D4814 1993**	**CARB*** June 1996**	**Tijuana Typical value in 1998**
Reid Vapor Pressure, pi	7.8 – 13.5	7.8 max. Denver	6.8 Max	9.7
10% distills @ °C (maximum): 50% distills @ °C: 90% distills @ °C (maximum): Final boiling temperature, °C:	55 – 70 77min 185 – 190 225	70 77 – 121 190 225	93 max 143	53.2 111.0 171.7.4 213..2
Sulfur, % by weight (maximum)	0.10	0.10	0.003	0.088
Lead, kg/m³ (maximum)	0.0026	0.013		0.00026
Number of highway octane, (R+M)/2 (minimum)	87.0	87.0	87.0	87.2
Aromatics, % volume (maximum)	ND	-	22	30.9
Olefins, % volume (maximum)	ND	-	4	12.0
Benzene, % volume (maximum)	ND	-	0.8	1.7
Oxygen, % by weight	ND	-	2 min	ND

Notes: * Standard published in the Federal Official Newspaper on December 2, 1994.
** US Regular Gasoline. *** California's Regular. ND = Value not available.

Table 5.2 shows some US federal specifications for Regular gasoline and those currently in place in the State of California. Typical values reached by different properties of Pemex Magna in Tijuana during 1998 are also included in this table.

It can be inferred that Pemex Magna gasoline complied with the specifications from NOM-086-ECOL-1994 for the Northern Border Zone (ZFN) during 1998, and that some of its characteristics are comparable to those of US Regular gasoline. Gasoline from California has more strict parameters that US Regular and Mexican gasoline with respect to the percent distillation, vapor pressure and sulfur content. In the case of gasoline in the ZFN, NOM-086 does not establish reference values for the content of olefins, aromatics and benzene, but for these parameters California's gasoline also has stricter values.

In some US cities such as El Paso, Texas, a program has been implemented to reduce volatile organic compounds (VOCs) evaporative emissions, by using low

RVP gasoline (the maximum value is 7psi) during the period from June to September of every year. Such measure is beneficial when trying to reduce ozone levels. NOM-086 specifies that, for Magna gasoline in the Border Zone, RVP will vary throughout the year with respect to the type of volatility of the zone. For example, the lowest RVP value (7.8 psi) occurs during the period from May to September, whereas in November, December, January, February and March, the highest value (13.5 psi) occurs. California gasoline must comply with an RVP specification no greater than 6.8 psi.

As far as oxygen content in gasoline is concerned, the Mexican standard does not specify any value for this parameter and the Salina Cruz, Oaxaca refinery does not report one. In the city of El Paso gasoline is oxygenated during the winter season (with ethanol) with a minimum content of 2.7% O_2 by weight, with the purpose of improving combustion and decreasing carbon monoxide emissions. At the same time, gasoline in Cd. Juárez is oxygenated to close to 1.5% by weight using MTBE, from November to March of every year, since 1999. In the case of California, an oxygen content no less than 2% by weight is specified.

Table 5.3. Specifications for Mexican diesel with low sulfur content

Property	**Diesel Sin**		
	Mexico NOM-086* 1994	**ZMVM Typical value in 1997****	**Salinas Cruz Ref. Typical value in 1997**
10% distills @ ºC (maximum):	275	223	209
90% distills @ ºC (maximum):	345	335	338
Water and sediment, % by volume (maximum):	0.05	0.010	ND
Ashes, % by weight (maximum):	0.01	0.001	ND
Ramsbotton carbon, % by weight (maximum):	0.25	0.080	0.09
Sulfur, % by weight (maximum):	0.05	0.03	0.04
Cetane index (minimum):	48	55	53.6
Viscosity, (SU), seconds	32 – 40	ND	ND
Aromatics, % by volume	30	27.5	24.1

Note: * Standard published in the Federal Official Newspaper on December 2, 1994.
** Through March, ND = Parameter not available

As far as Pemex Diesel fuel is concerned, it easily complies with Mexican specifications, with an average sulfur content of 0.04% by weight. This parameter is slightly higher than that for Pemex Diesel distributed in Mexico City in 1997, which was 0.03% by weight (see Table 5.3).

With respect to industrial fuels, heavy industrial fuel (industrial oil) must show a maximum sulfur content no greater than 4%, as established in NOM-086, starting on January 1998. Heavy industrial fuel that was distributed in Tijuana during 1997 complied with this standard, with an average sulfur content of 3.8% by weight.

Table 5.4. Mexican heavy industrial fuel specifications

Property	**Heavy industrial fuel**	
	Mexico NOM-086* 1994	**Salina Cruz Ref. Typical value, 1997**
Specific Weight (20/4 ^{0}C)	ND	1.001
Viscosity SSF (50^{0}C)	475-550	530.6
Sulfur (% by weight)	4	3.8
Water and Sediment, (% by volume):	1.0 max.	0.063
Temp. Infl. (^{0}C)	66 min.	99.6
Temp. Drain. (^{0}C)	15 max.	12.2
Ashes (% by weight)	ND	0.045
Vanadium (ppm)	ND	347.8
Nickel (ppm)	ND	67.0
Sodium (ppm)	ND	2.1
Asphaltenes (% by weight)	ND	14.2
Conradson Carbon(% by weight)	ND	15.39
Kinematic Viscosity	1008-1166	1125

Note: * Standard published in the Federal Official Newspaper on December 2, 1994.
ND = Parameter not available

With respect to the use of gas, in 1998, only liquefied petroleum gas (LP gas) was consumed in Tijuana. This type of fuel must comply with the characteristics and composition indicated under NOM-086 (see Table 5.5). It can be observed that this standard does not establish a minimum content for propane.

Table 5.5. LP Gas* Specifications

Property	**Liquefied Petroleum Gas**
	NOM-086* 1994
Vapor pressure exceeds atmospheric pressure @ 37.8 ^{0}C (kPa, lb/pulg^2)	551 (80) minimum 1379 (200) maximum
95% distills @: (^{0}C)	2 maximum
Ethane (% volume)	2 maximum
Pentane (%volume)	2 maximum
Evaporation residue of 0.100 dm^3 (cm^3)	0.05 maximum
Specific weight @ 20/4^{0}C	Inform
Copper plate corrosion, 1 hour @ 37.8 ^{0}C	Maximum #1 Standard
Total sulfur (kg/ton)	0.140 maximum
Free water	Nothing

* Standard published in the Federal Official Newspaper on December 2, 1994.

5.3. 1998 Emissions Inventory

In order to develop this Program, the detailed emissions inventory of Tijuana and Rosarito was integrated as part of the Border XXI Program's Binational Air Quality Workgroup activities. The resources to develop the emissions inventory were granted by the EPA through the WGA, as part of the tasks of the Project to Develop an Emissions Inventory Methodology for Mexico. In this project it was contemplated to prove this methodology in Mexican cities. Dames & Moore, an American consulting firm was contracted to accomplish this task. In turn Dames & Moore sub-contracted the service of a Mexican company, Ecodes, to develop the emissions inventory of the municipalities of Tijuana, Rosarito and Tecate. The approximate cost of this project was 250 thousand dollars. At the time this document was drafted, the initial consolidated results obtained by the Mexican consultant for this emissions inventory were available. These results will undergo the QA/QC process , first by the American consultant and then by INE. For that reason, the results presented in this document are "preliminary".

Tables 5.6 and 5.7, and Figure 5.4 show the volume and percentage of emissions generated by source type and by pollutant. It is estimated that more than 465 thousand tons of criteria pollutants are emitted every year, of which 74% correspond to the transportation sector, 8% to the industrial sector, 17% to the services sector, and soils and vegetation contribute a little less than 1%. Tables 5.8 and 5.9 shows the emissions generated in desegregated form, by type of industrial category, and source subcategory.

Table 5.6. 1998 preliminary emissions inventory of Tijuana-Rosarito (ton/year)

Sector	PM10	SO_2	CO	NOx	TOG*	Total	%
Industry	3,299	21,633	617	3,501	8,329	37,379	8.0
Services	23,563	7,626	17,157	1,649	31,304	81,299	17.4
Transportation	1,214	949	281,917	23,501	36,908	344,489	74.0
Soils and vegetation	1,273			145	1,195	2,613	0.6
T O T A L	29,349	30,208	299,691	28,796	77,736	465,780	100.0

Table 5.7. 1998 preliminary emissions inventory of Tijuana-Rosarito (ton/year)
(percentage by weight by pollutant)

	PM10	SO_2	CO	NOx	TOG*
Industry	11.2	71.6	0.2	12.2	10.7
Services	80.3	25.3	5.7	5.7	40.3
Transportation	4.1	3.1	94.1	81.6	47.5
Soils and vegetation	4.4			0.5	1.5
Total	100.0	100.0	100.0	100.0	100.0

* TOG: Total Organic Gases

Table 5.8. 1998 preliminary desegregated emissions inventory of Tijuana-Rosarito (ton/year)

Source type	**PM10**	**SO_2**	**CO**	**NOx**	**TOG**
Industry					
Energy Generation	1,043	21,268	340	3,104	122
Chemical Industry	NS	NS	NS	NS	105
Metallic minerals	18	2	205	1	35
Non-metallic minerals	25	NS	7	12	212
Vegetable and animal products	NS	NS	NS	1	4
Wood and by-products	3	50	NS	5	4
Food consumer products	20	163	46	279	19
Clothing industry	NS	NS	1	4	27
Various consumer products	9	146	8	52	1,334
Metallic products	1	1	3	6	476
Medium-life consumer products	2,180	3	6	31	3,646
Long-life consumer products	NS	NS	NS	1	1,441
Fuel storage, handling and sales	NS	NS	1	5	904
Services					
Industrial, commercial combustion	429	7,616	106	887	20
Residential combustion	6	NS	26	190	7
Locomotives	4	10	18	150	8
Airplanes	NE	NS	298	194	84
Border crossings	NS	NE	16,500	219	1,693
Bus terminals	NS	NS	10	7	2
Industrial surface coating	NA	NA	NA	NA	1,550
Car body paint	NA	NA	NA	NA	1,017
Architectural surface coating	NA	NA	NA	NA	2,531
Road/traffic paint	NA	NA	NA	NA	48
Industriual surface cleaning (degreasing)	NA	NA	NA	NA	3,960
Dry cleaners	NA	NA	NA	NA	727
Graphic arts	NA	NA	NA	NA	715
Asphalt application	NA	NA	NA	NA	3,342
Commercial and domestic solvent use	NA	NA	NA	NA	5,462
Fuel commercialization and distribution	NA	NA	NA	NA	2,482
Airplane refueling	NA	NA	NA	NA	1
LP Gas distribution	NA	NA	NA	NA	7,391
Bakeries	NA	NA	NA	NA	170
Construction	286	NA	NA	NA	NA
Charbroiling operations	74	NE	NE	NE	65
Pesticide application	NA	NA	NA	NA	NS
Cattle feed lots	546	NA	NA	NA	NA
Agricultural tilling	16	NA	NA	NA	NA
Wastewater treatment	NA	NA	NA	NA	12
Wildfires	12	NE	109	NE	10
Structural fires	6	NA	90	2	7
Paved roads	4,324	NA	NA	NA	NA
Unpaved roads	17,860	NA	NA	NA	NA
Transportation					
Private vehicles	84	406	130,638	7,037	16,431
Taxi cabs	24	118	38,142	2,053	4,798
Pick-up trucks	68	328	99,064	5,394	13,092
Gasoline-fueled passenger trucks	2	9	3,645	249	429
Diesel-fueled passenger trucks	390	26	2,142	3,191	521
Gasoline-fueled freight trucks	2	9	3,633	241	431
Diesel-fueled freight trucks	642	43	3,602	5,297	870
Motorcycles	2	10	1,051	39	336
Soils and vegetation					
Wind erosion	1,273	NA	NA	NA	NA
Vegetation	NA	NA	NA	145	1,195

Total	29,349	30,208	299,691	28,796	77,736

NA = Not applicable NE = Not estimated NS = Not significant

Table 5.9. 1998 Preliminary Emissions Inventory (percentage by weight by pollutant)

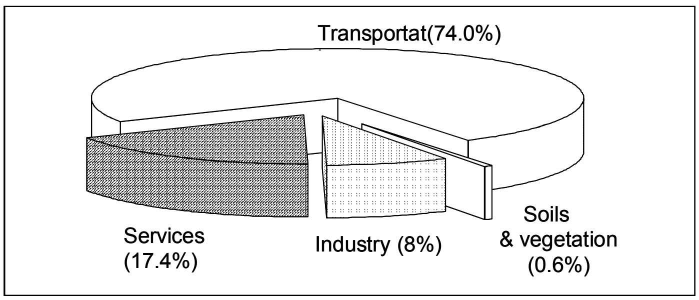
Source type	**PM10**	**SO2**	**CO**	**NOx**	**TOG**
Industry					
Energy generation	3.6	70.4	0.1	10.8	0.2
Chemical Industry	NS	NS	NS	NS	0.1
Metallic minerals	NS	NS	NS	NS	NS
Non-metallic minerals	NS	NS	NS	NS	0.3
Vegetable and animal products	NS	NS	NS	NS	NS
Wood and by-products	NS	0.2	NS	NS	NS
Food consumer products	NS	0.5	NS	1.0	NS
Clothing Industry	NS	NS	NS	NS	NS
Various consumer products	NS	0.5	NS	0.2	1.7
Metallic products	NS	NS	NS	NS	0.6
Medium-life consumer products	7.4	NS	NS	0.1	4.7
Long-life consumer products	NS	NS	NS	NS	1.9
Fuel storage, handling and sales	NS	NS	NS	NS	1.2
Services					
Indiustrial, commercial combustion	1.5	25.2	NS	3.1	NS
Residential combustion	NS	NS	NS	0.7	NS
Locomotives	NS	NS	NS	0.5	NS
Airplanes	NE	NS	0.1	0.7	0.1
Border crossings	NS	NE	5.5	0.8	2.2
Bus terminals	NS	NE	NS	NS	NS
Industrial surface coating	NA	NA	NA	NA	2.0
Car Body Painting	NA	NA	NA	NA	1.3
Architectural surface coating	NA	NA	NA	NA	3.3
Road/Traffic paint	NA	NA	NA	NA	0.1
Surface cleaning in the industrial sector (degreasing)	NA	NA	NA	NA	5.1
Dry cleaners	NA	NA	NA	NA	0.9
Graphic arts	NA	NA	NA	NA	0.9
Asphalt application	NA	NA	NA	NA	4.3
Commercial and domestic solvent use	NA	NA	NA	NA	7.0
Fuel commercialization and distribution	NA	NA	NA	NA	3.2
Airplane refueling	NA	NA	NA	NA	NS
LP Gas distribution	NA	NA	NA	NA	9.5
Bakeries	NA	NA	NA	NA	0.2
Construction	1.0	NA	NA	NA	NA
Charbroiling operations	0.3	NE	NE	NE	0.1
Pesticide application	NA	NA	NA	NA	NS
Cattle feed lots	1.9	NA	NA	NA	NA
Agricultural tilling	0.1	NA	NA	NA	NA
Wastewater treatment	NA	NA	NA	NA	NS
Wildfires	NS	NE	NS	NE	NS
Structural fires	NS	NA	NS	NS	NS
Paved roads	14.7	NA	NA	NA	NA
Unpaved roads	60.9	NA	NA	NA	NA
Transportation					
Private cars	0.3	1.3	43.6	24.4	21.1
Taxi cabs	0.1	0.4	12.7	7.1	6.2
Pick-up trucks	0.2	1.1	33.1	18.7	16.8
Gasoline-fueled passenger trucks	NS	NS	1.2	0.9	0.6
Diesel-fueled passenger trucks	1.3	0.1	0.7	11.1	0.7
Gasoline-fueled freight trucks	NS	NS	1.2	0.8	0.6
Diesel-fueled freight trucks	2.2	0.1	1.2	18.4	1.1
Motorcycles	NS	NS	0.4	0.1	0.4
Soils and vegetation					
Wind erosion	4.3	NA	NA	NA	NA

Vegetation	NA	NA	NA	0.5	1.5
Total	100	100	100	100	100

NA = Not applicable NE = Not estimated NS = Not significant

Analyzing the previous tables, it is observed that the industrial sector contributes 71% of the SO_2 emissions, 11% of the PM10 emissions, and 12% of the NOx emissions. The services sector emits 40% of the TOG and 80% of the PM10 emissions. The transportation sector generates 82% of the NOx, 47% of the TOG and 94% of the CO emissions. The soils sector emits 4% of the total PM10 emissions.

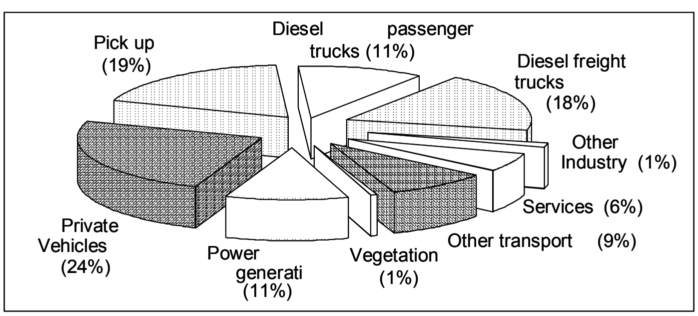
Figure 5.4. Contribution to total emissions by sector



The following is an analysis of the emissions contribution for PM10, TOG and NOx, since these are the pollutants that exceed the air quality standards and are involve in ozone formation.

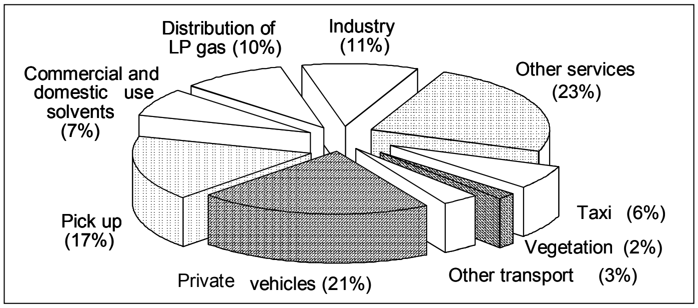
If we make an analysis of the contribution from all the sources that integrate the emissions inventory, it is concluded that, with respect to nitrogen oxide, diesel-fueled freight and passenger trucks generate 18% and 11% of this type of emissions respectively. Furthermore, 24% of NOx emissions are generated by private cars, 19% by pick-up trucks, 11% by electric power generation, and 9% by other types of transportation (Figure 5.5).

Figure 5.5. Annual NOx Contribution NOx by type of source



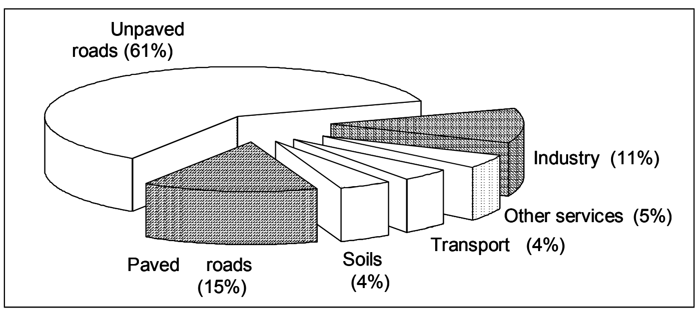
Similarly, it is observed that private cars contribute 21% of TOG emissions, pick-up trucks contribute 17%, taxi cabs 6%, commercial and domestic solvent use 7%, LP gas distribution 10%, other services 23%, and industry 11% (Figure 5.6).

Figure 5.6. Annual TOG contribution by type of source



As far as PM10 is concerned, it is observed that paved and unpaved roads contribute 76% of the emissions of this type of pollutant, industry contributes 11%, all other services 5%, and transportation and soils contribute 4% each (Figure 5.7).

Figure 5.7. Annual PM10 contribution by type of source

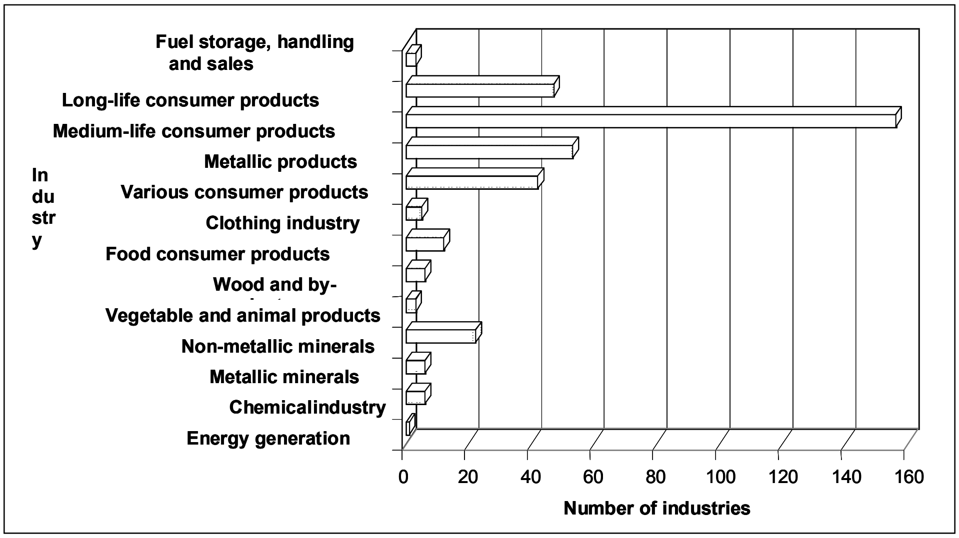


Industry

In Tijuana-Rosarito it is estimated that there are approximately 2,205 manufacturing industrial establishments. Most of these correspond to the micro and small industry, whereas only 12% correspond to medium and large industry.

In order to develop the emissions inventory, the information gathered from 362 companies was integrated. Of these, 351 are located in Tijuana and 11 in Rosarito. Thirteen industrial categories were identified, of which 42% correspond to medium-life consumer products, followed by metallic products with 15%, long-life consumer products with 13%, various consumer products with 12%, and the remaining categories account for 18% of the industrial establishments (Figure 5.8).

Figure 5.8. Number of establishments by industrial category in Tijuana-Rosarito



As was indicated, the inventory of emissions generated by the industrial sector was generated applying the methodology that was developed for Mexico[24]. In order to accomplish this, information submitted to SEMARNAPs Delegation in Baja California by companies that fall under federal jurisdiction, and included in their Annual License of Operation, was used. Furthermore, information included the 1997 and 1998 records submitted by companies under state jurisdiction to Baja California's General Direction of Ecology was used for this purpose.

Based on this emissions inventory, it is concluded that the total amount of emissions generated by the industrial sector in Tijuana-Rosarito is 37,000 tons/year. Approximately 58% of these emissions correspond to SO_2. This is because of the power plants that are located in this area and which consume large volumes of heavy industrial oil (heavy industrial fuel). It has been contemplated to substitute 50% of this fuel with natural gas in the second half of this year, with the remaining 50% consisting of heavy industrial fuel with 2% sulfur content. According to data contained in the emissions inventory for this area, there are very few companies that use large capacity combustion processes and the other fuels used by the industrial sector are diesel and LP gas, in small amounts.

[24] Radian-Semarnap, (1997). Mexico Emissions Inventory Program Manuals, Volume IV Point Source Inventory Development.

As far as PM10 is concerned, the industrial sector generates 3,299 ton/year of the emissions of this pollutant, of which 61% are emitted by the medium-life consumer products category and 32% by the electric power generation sector. Likewise, this activity contributes with 89% of the industrial NOx emissions, followed by the food consumer products category, with 8%.

Of particular importance are total organic gas (TOG) emissions, because in the Tijuana-Rosarito region most industrial establishments are maquiladoras that use a large volume of solvents. On one hand, these contribute to ozone formation and on the other hand they can present risks from toxicity. TOG emissions from this sector amount to 8,000 tons/year, of which 43% are generated by medium-life consumer products, 17% by long-life consumer products, 16% by various consumer products, 11% by fuel storage, handling and distribution, and the rest by other categories.

Figure 5.9. Industrial Sector Contribution to TOG Emissions by Category

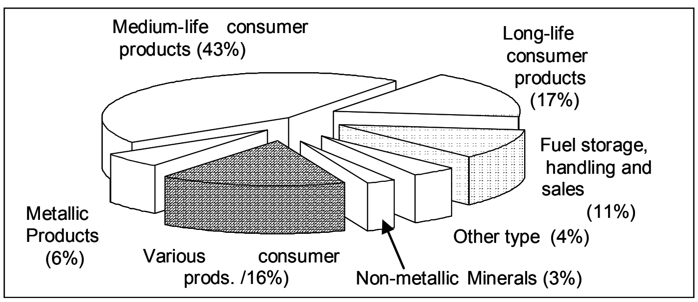


Table 5.10 shows 8 groups of companies according to the level of emissions indicated in the second column. An analysis of NOx and TOG emissions shows that group A, which includes all other groups, consists of the 195 companies whose individual emissions levels are greater than 2 tons/year. Group B, which includes the subsequent, consists of the 171 establishments whose individual emissions levels are greater than 3 tons/year, and so on.

Table 5.10. Distribution of companies in Tijuana-Rosarito according to the volume of NOx and TOG emissions (ton/year)

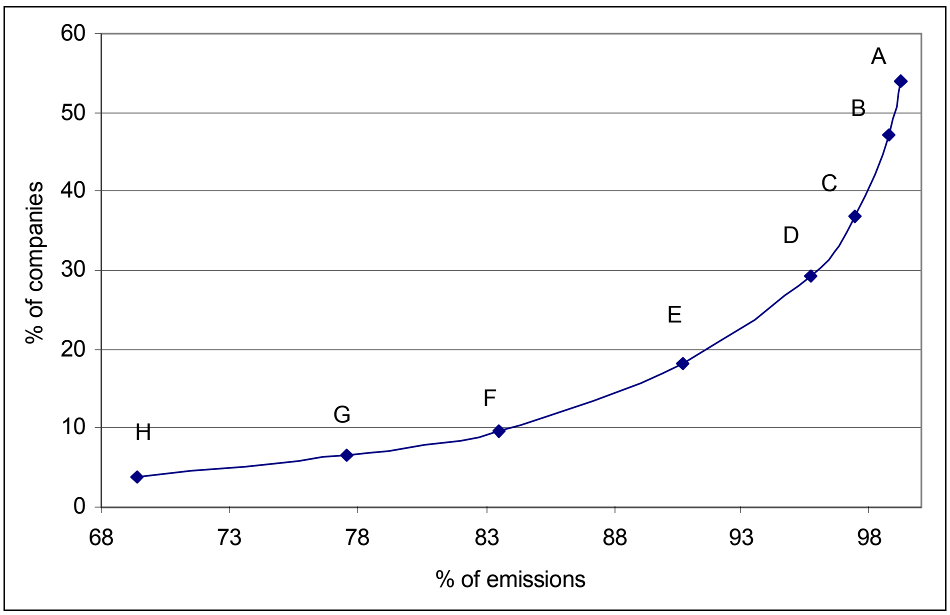
Group	Emissions strata (ton/year)	# of establishments	% of establishments with respect to the total	Emissions (ton/year) NOx	TOG emissions (ton/year) TOG	NOx + TOG Emissions	% emission with respect to the total NOx + TOG of the sector
A	>2	195	53.9	3,485	8,254	11,739	99.2
B	>3	171	47.2	3,480	8,199	11,679	98.7
C	>5	133	36.7	3,467	8,059	11,526	97.4
D	>10	106	29.3	3,438	7,887	11,325	95.7
E	>20	66	18.2	3,422	7,300	10,722	90.6
F	>40	35	9.7	3,416	6,459	9,875	83.5

G	>80	24	6.6	3,381	5,795	9,176	77.6
H	>120	14	3.9	3,379	4,832	8,212	69.4

Total number of companies in database:	362
Total NOx emissions ton/year	3,501
Total HC emissions ton/year	8,329
Total (HC + NOx) emissions, ton/year	11,830

This way of organizing the information contained in this table, allows us to observe that the 195 companies in the A stratum represent a volume of 11,739 tons/year of ozone precursors, which corresponds to 99% of the total emissions generated by the industrial sector. Using the same line of reasoning, it can be observed that it is enough to include the 66 companies that emit more than 20 tons/year (group E), to cover 91% of the total HC and NOx emissions produced by the industrial sector in Tijuana-Rosarito.

Figure 5.10. TOG and NOx emissions contribution from the industrial sector



The Lorenz Curve in Figure 5.12 shows a slanted distribution for the emission of ozone precursors generated by the industrial sector (very few companies contribute large amounts of pollution). Point A, represents the 195 establishments that generate 99% of the emissions of ozone precursors. The remaining 1% of the precursors corresponds to emissions generated by the remaining 46% of the establishments; that is, 167 establishments.

If we expand the previous analysis and incorporate SO_2, PM10 and CO emissions, it can be observed that the same 195 establishments generate 57% of the total emissions from the industrial sector (see Table 5.11). This type of analysis provides elements for implementing the appropriate programs that lead to industrial emissions reduction, such as high pollution episodes, fuel improvement and technological updates of the industrial plant.

Table 5.11. Distribution of companies in Tijuana-Rosarito according to the volume of total emissions of PM10, SO_2, CO, NOx and TOG.

Group	Emission Strata (ton/year)	No. of companies	% of companies with respect to the total	PM10	SOx	CO	NOx	TOG	Total emission (ton/year)	% of emissions with respect to the sector
A	>2	195	53.9	1,929	2,846	4,684	3,485	8,254	21,199	56.7
B	>3	171	47.2	1,907	2,837	4,678	3,480	8,199	21,102	56.5
C	>5	133	36.7	1,894	2,832	4,677	3,467	8,059	20,929	56.0
D	>10	106	29.3	1,893	2,823	4,675	3,438	7,887	20,716	55.4
E	>20	66	18.2	1,887	2,814	4,672	3,422	7,300	20,095	53.8
F	>40	35	9.7	1,880	2,739	4,655	3,416	6,459	19,149	51.2
G	>80	24	6.6	1,875	2,664	4,653	3,381	5,795	18,368	49.1
H	>120	14	3.9	1,239	1,813	4,633	3,379	4,832	15,897	42.5

Total number of companies on the database	362
Total emissions ton/year	37,379

Area Sources

Area source inventories group together the emissions from numerous and disperse emissions sources of similar type, which individually emit small amounts of pollutants within a specific category. For the case of Tijuana-Rosarito, the emissions that were inventoried correspond to the commercial and services sectors, roadways and other activities. Some of the activities that were inventoried include industrial, commercial and residential combustion; hotels; restaurants; public baths; micro-industries that consume small volumes of fuel; solvent use; fuel storage, transportation and distribution; small commercial sources; and, border crossings.

The commercial and services sector is important due to the large number of establishments that exist in Tijuana-Rosarito, since it is a zone of medium population density which is one of the ten most populated cities in Mexico. This implies the necessity to have available the entire spectrum of services and commercial establishments to meet the basic needs of the population. Individually, people generate small amounts of pollutants but, when taken as a whole, the emissions generated by the population are important especially when referring to PM10 and TOG.

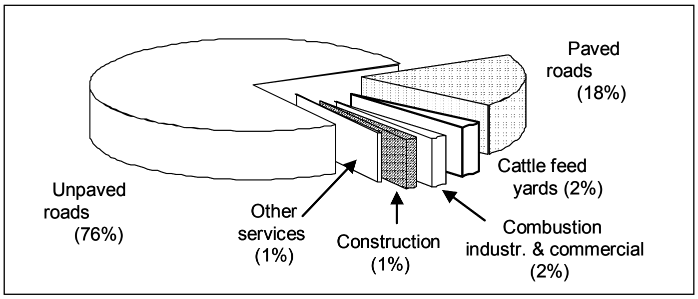
As mentioned earlier, the methodology developed for México[25] was used for the development of the Tijuana-Rosarito area source inventory, using the most reliable methods recommended for emissions calculations. Depending on data avail-

25 Radian-Semarnap (1997). Mexico Emissions Inventory Program Manuals, Volume V- Area Source Inventory Development.

ability for the different categories, the most widely used methods were the application of emissions factors and mechanical models.

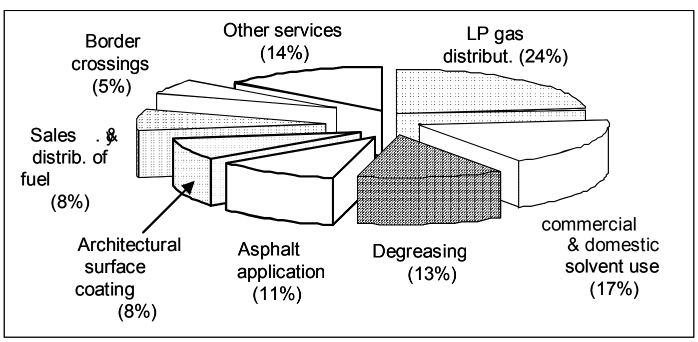
PM10 emissions from area sources are 23,563 tons/year, mainly generated by unpaved roads or streets (76%). This is due to the fact that 40% of the streets in Tijuana lack pavement and in Rosarito 95% of the streets are unpaved. Another 18% of this pollutant are generated by the re-suspension of particles caused by vehicular traffic circulating on paved roads. Large amounts of dirt are dragged onto paved roads during the rainy season due to the topography of the area. This dirt is deposited on streets located in the lower part of the city (Figure 5.11).

Figure 5.11. Contribution to PM10 emissions by area source sub-category



Another pollutant that is generated in significant amounts by area sources are TOGs, mainly from the distribution of LP gas (24% of the emissions), commercial and domestic solvent use (17%), degreasing of parts (13%) and asphalt application (11%).

5.12. TOG emissions contribution by area source subcategories



Soils and Vegetation

The first estimates of emissions generated by soils and vegetation in Tijuana-Rosarito were developed for this inventory and they can be used to design reforestation and soil stabilization programs in this region.

Soil emissions depend on several factors. Some of the most important factors considered include: the type of soil (for this region it has a sandy-silty texture); precipitation (an average of 300 mm per year); and, wind speeds (these vary depending on the time of the year and range between 3 and 4 meters per second.)

Obviously, the pollutant that is emitted by soils is PM10, and the main source of soil erosion is the wind. Due to the fact that the city is located in a zone where the climate is dry and mild, with a large surface covered with small plants, the types of soil favor PM10 emissions from the effect of the wind. Due to the low amount of precipitation recorded in this region, this is not an important factor that decreases soil emissions. The zones that have been identified as contributors to this pollutant include the open spaces without ground cover that surround the city, as well as unpaved roads and barren lots within the city. It is estimated that soil erosion contributes a little more than 4% of the PM10 emissions.

It is important to mention that in order to integrate the Tijuana-Rosarito emissions inventory, the total organic gas emissions generated by the vegetation were calculated. These are estimated to be 1,195 tons/year.

Transportation

Fuel consumption by motor vehicles constitutes the main source of pollutant emissions in Tijuana-Rosarito. In order to calculate the emissions generated by the transportation sector the model known as MOBILE5-Juárez,[26,27] was applied, modifying to suit the vehicular fleet and characteristics of the region. This model was used to estimate the emission factors for NOx, TOG and CO, and the model was run for every month of the year, due to substantial variation in the maximum and minimum temperature. In order to calculate SO_2 emissions, the materials balance technique was used, considering fuel sulfur content, and for particulate, international emissions factors were used.

The transportation sector generates 344,000 tons of pollutants annually, of which 282,000 tons correspond to carbon monoxide, 37,000 tons to total organic gases, 23,000 tons to nitrogen oxides, 1,000 tons to sulfur dioxide, and 1,200

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[26] Radian-Semarnap (1997). Mexico Emissions Inventory Program Manuals, Volume VI-Motor Vehicle Inventory Development.

[27] Texas Natural Resource Conservation Commission (1994). Cd. Juárez Mobile5 Data Collection.

tons to PM10. Given the environmental problems and the level of development that is required to structure the environmental plans and programs for Tijuana-Rosarito, it is necessary to always update the emissions from these sources as much as possible.

Roadways

Tijuana-Rosarito borders to the north with the United States; to the east with the municipalities of Tecate and Ensenada; to the south with the municipality of Ensenada and the Pacific Ocean; and, to the west with the Pacific Ocean and the United States.

Table 5.12shows that there are six main roads of access to the municipality of Tijuana. The average daily traffic flow on cost-free and toll roads to Ensenada and the cost-free road to Tecate-Mexicali is greater than 5,500 vehicles. On the toll road to Tecate-Mexicali the traffic flow is greater than 1,500 vehicles. The greatest average daily traffic flow occurs in the international ports of entry (Puerta Mexico and Otay), and it exceeds 45,000 vehicles per day.

Table 5.12. Access roads to Tijuana-Rosarito

Freeway Access	Direction	Length (km)
Toll-Free Freeway to Ensenada	Southwest	16.68
Toll Freeway to Ensenada	Southwest	21.54
Toll Freeway Tecate-Mexicali	Southeast	8.65
Toll-Free Freeway Tecate-Mexicali	East	6.85
Puerta México International Port of Entry	North	0.73
Otay International Port of Entry	Northeast	1.47

Source: Plan de Desarrollo Urbano del Centro de Población Tijuana PDCPT, 1998.

Table 5.13 describes the main roadways in the urban zone. The ones that show congestion are Calzada Lázaro Cárdenas, which is converged by Blvd. Díaz Ordaz and the east and west freeways; Blvd. Insurgentes, south freeway and the highway to the airport. This roadway has an average daily traffic flow greater than 25,000 vehicles and rush hour speeds range between 5 and 10 km/h. This roadway has the worst traffic congestion, since it is the axis that communicates the city from east to west.

Agua Caliente Boulevard along with Díaz Ordaz Boulevard connect the downtown area with the east side of the city, cutting across practically the entire city, showing an average daily traffic count greater than 25,000 vehicles. The most congested area is in the intersection between 5 and 10, where rush hour speeds range between 10 and 15 km/h and speeds at other times of the day range between 30 and 40 km/h.

Table 5.13. Main Roadways in Tijuana-Rosarito

Name	Orientation	Kilometers
Ave. Revolución	N – S / S – N	1.53
Blvd. Aguascalientes	NW – SE	3.72
Blvd. Salinas	E – W / W – E	1.85
Blvd. Federico Benítez	E – W / W – E	6.8
Blvd. Díaz Ordaz	E – W / W – E	7.5
Highway to Playas	E – W / W – E	6.82
Calle Segunda	W – E	2.32
Calle Tercera	E – W	2.09
Ave. Internacional	E – W / W – E	4.06
South freeway	N – S / S – N	10.59
Blvd. Fundadores	N – S	5.88
Ave. Paseo de los Héroes	E – W / W – E	4.39
Western freeway	E – W	8.99
Eastern freeway	W - E	7.31
Tijuana–Ensenada toll-free road	N – S	16.68
Blvd. Cuauhtémoc East	W – E	5.92
Blvd. Cuauhtémoc West	E – W	1.07
Blvd. Aeropuerto	E – W / W - E	6.35
Blvd. Defensores de Baja California	E – W	1.77
Blvd. Tecnológico	E – W	2.77
Blvd. Universidad	E – W	1.96
Acceso Otay–Buena Vista	E – W	2.79
Blvd. Las Américas	N – S	1.21
Blvd. Lázaro Cárdenas West	N – S	5.15
Blvd. Lázaro Cárdenas East	S – N	2.79
Blvd. Insurgentes	E – W / W – E	10.91
East freeway	E – W	7.39
Calle 9	E – W / W - E	3.0
Highway to Presa	N – S	3.5
Toll-free road to Tecate	E – W	8.65
Blvd. Industrial	E – w	4.38
Blvd. Bellas Artes	E – W / W - E	4.67
Tijuana – Tecate toll road	E – W	6.85
Blvd. Héroes de la Independencia	NE-SW	11.45
Blvd. Manuel J. Clouthier	N – S	6
Tijuana – Ensenada Scenic Road	N – S	21.54

Source: ECODES, SP, based on the plan provided by Instituto Municipal de Planeación (IMPLAN, 1999)
Symbols: N.- North, S.- South, E.- East y W.- West

The east and west freeways have an average daily traffic flow that exceeds 20,000 vehicles. Average speeds for rush hour traffic range between 40 and 50 km/h, whereas normal hour speeds range between 60 and 80 km/h. There is a congested zone in the intersection between the eastern freeway and Calzada Lázaro Cárdenas. Average speeds during rush hour at this intersection range between 10 and 15 km/h.

Calle Segunda and its extension, which connects the central and eastern zones of the city, is congested with collective transportation vehicles along most of its path. The average daily traffic flow is greater than 25,000 vehicles. Rush hour traffic speeds range between 10 and 15 km/h and normal hour traffic speeds range between 25 and 40 km/h.

Paseo de los Héroes Avenue has an average daily flow greater than 20,000 vehicles. Rush hour speeds range between 10 and 15 km/h, whereas normal hour speeds range between 20 and 35 km/h. There is a congestion zone at the circle where the monument of the Californias is located.

At the urban level, the study area shows a radial type roadway structure, with the city being the point of convergence. The main roadways that distribute traffic toward its different points of destination are the northern freeway, the southern freeway and Blvd. Insurgentes. The two first roadways form a complete loop along with Avenida Internacional, the eastern and western freeways, and Calzada Lázaro Cárdenas. The access roads coming from the city of Ensenada converge directly into this loop and those from the city of Tecate converge into Blvd. Insurgentes and Blvd. Díaz Ordaz, along with the road to the Dam.

As was mentioned earlier, the zone with greatest congestion is comprised by Calzada Lázaro Cárdenas, which is part of the aforementioned loop. The problem is generated due to the roadways that converge into this road at crossways and intersections. Furthermore, the location of the bus terminal has an impact of this traffic congestion.

Vehicular fleet

The vehicular fleet officially registered in Tijuana-Rosarito in 1998 was 373,955 vehicles[28], most of which come from the United States where they are imported from at relatively lower prices than domestic vehicles. Occasionally, these vehicles have mechanical problems and their emissions control devices are in poor condition.

The ease to acquire used vehicles has had as a consequence an accelerated increase in the vehicular fleet, as well as the proliferation of older models with tampered or mutilated electronic and fuel injection systems, and anti-pollution systems. These conditions make them more polluting than newer vehicles. On the other hand, the city does not yet have a vehicular emissions program that could serve to induce a corrective action for this situation.

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[28] Secretaria de Planeación y Finanzas, Centro SCT 02. 1998.

Table 5.14. Vehicular fleet in Tijuana

Classification	# of vehicles	%	Veh/km/day	veh/km/year
Private Cars	260,996	71.9	30	10,950
Taxi Cabs	7,125	2.0	320	116,800
Pick-up trucks	79,533	21.9	80	29,200
Gasoline-fueled passenger trucks	1,380	0.4	131	47,815
Diesel-fueled passenger trucks	2,219	0.6	320	116,800
Gasoline-fueled freight trucks	1,258	0.3	131	47,815
Diesel-fueled freight trucks	8,490	2.3	131	47,815
Motorcycles	2,187	0.6	80	29,200
Total	363,188	100.0	1,223	446,395

Sources: Compiled with information from Secretaria de Planeación y Finanzas. Sistema de Control Vehicular, 1996; Centro SCT02. Departamento de Autotransporte Federal 1998.

Table 5.15. Vehicular fleet in Rosarito

Classification	# of vehicles	%	Veh/km/day	veh/km/year
Private Cars	7,901	73.3	10	3,650
Taxi Cabs	460	4.3	60	21,900
Pick-up trucks	613	5.7	40	14,600
Gasoline-fueled passenger trucks	12	0.1	70	25,550
Diesel-fueled passenger trucks	20	0.2	70	25,550
Gasoline-fueled freight trucks	227	2.1	50	18,250
Diesel-fueled freight trucks	1,204	11.2	50	18,250
Motorcycles	330	3.1	40	14,600
Total	10,767	100.0	390	142,350

The distribution by vehicle type used for the calculations in this inventory show that the highest percentage corresponds to private vehicles, mostly imported, which have a 9:1 ratio with respect to vehicles manufactured in Mexico.[29] Tables 5.14 and 5.15 show the vehicular fleet classification for Tijuana-Rosarito and the average vehicle-kilometers-traveled, obtained with information from 1998.

As can be seen in the previous table, the category with the largest percentage of vehicles in Tijuana-Rosarito is comprised by private cars, with 72% of the units; followed by pick-up trucks with 21% of the units; and diesel-fueled heavy duty trucks, with 3%. Public transportation as a whole accounts for only 1% of the total number of vehicles (3,631 units).

Table 5.16 shows the variation in gasoline and diesel consumption in 1997-98. A decrease in the use of Magna gasoline can be observed. This is due to the price difference between Mexican and US gasoline. Since gasoline is less expensive in the United States, many people cross the border only to fill up their tank.

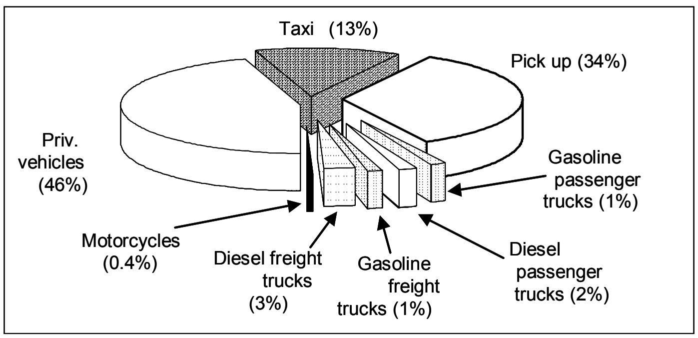
[29] Numbers obtained from “Reporte de Estadísticas Vehiculares por Municipio, INEGI, 1996”.

Table 5.16. Vehicular fuel consumption (m^3/year)

Fuel	1997	1998	1996-1997 Variation
Magna	676,635	643,558	Sales decreased by 5%
Premium	59,191	88,787	Sales increased by 33%
Diesel	108,516	116,061	Sales increased by 6.5%

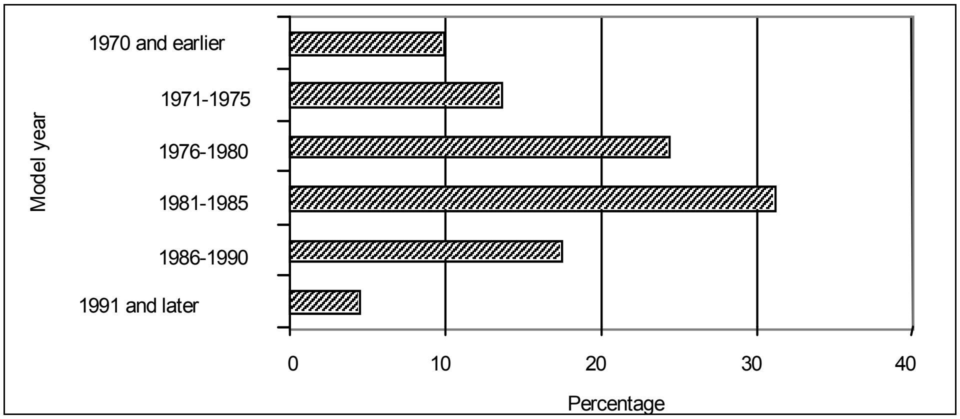
As far as emissions generated by the transportation sector are concerned, Figure 5.13 shows that 45% of these emissions are generated by private cars, 31% by pick-up trucks, 13% by taxi cabs, and the remaining 11% by all other vehicles.

Figure 5.13. Emissions generated by vehicle type



Age distribution of the vehicular fleet in the city of Tijuana shows that approximately 30% of the units are 1981-1985 models, almost 25% correspond to 1976-1980 models, and less than 5% are post-1991 models. In 1996, 95% of the vehicular fleet was comprised of 1990 and older models (see Figure 5.14). This means that only a small percentage of the vehicles are recent models.

Figure 5.14. Age of the vehicular fleet



San Diego Emissions Inventory

Table 5.17 shows the 1996 desegregated emissions inventory for San Diego.

Table 5.17. 1996 Emissions inventory for San Diego (ton/year)

Source Type	PM10	SO_2	CO	NOx	HC
Combustion					
Energy generation (combustion)	99	298	928	2618	199
Cogeneration	133	0	696	862	795
Industry and manufacture (combustion)	66	66	265	1127	265
Food and agricultural processes	99	66	4,806	0	298
Industrial processes					
Industrial processes	1,160	0	33	33	1,624
Area sources					
Commercial and service combustion	33	398	166	530	33
Residential combustion	2,552	99	18,526	1,458	2,486
Fuel Refining and commercialization	0	0	0	0	21,310
Locomotives	0	0	66	696	33
Commercial use of solvents	0	0	0	0	7,722
Consumer products	0	0	0	0	6,231
Airplanes	563	66	5,932	2,182	1,193
Other non-road mobile equipment	796	1,624	37,643	9,612	4,607
Painting and related processes	0	0	0	0	1,094
Construction and demolition	0	0	0	0	10,672
Wildfires	3,480	0	22,338	331	2,154
Architectural surface coating & related proc-	0	0	0	0	3,977
Degreasing	0	0	0	0	1,326
Dry cleaners	0	0	0	0	1,061
Asphalt application	0	0	0	0	397
Consumer products					
Pesticides and fertilizers	0	0	0	0	862
Agricultural tilling	132	0	0	0	6,827
Waste disposal and burning	558	0	2,916	66	52,729
Paved roads	0	0	0	0	10,009
Unpaved roads	0	0	0	0	5,733
Fugitive dust	0	0	0	0	99

Source Type	PM10	SO_2	CO	NOx	HC
Utility equipment	33	0	19,620	33	1,425
Fires	33	0	298	0	33
Other miscellaneous processes	795	0	0	0	762
Transportation sector					
Private vehicles	464	166	239,948	22,769	30,921
Pick-up trucks	199	66	100,719	13,853	12,362
Light-duty trucks	33	0	9,587	2,121	1,624
Gas-fueled light trucks for heavy-duty	66	33	6,927	2,121	530
Gas-fueled medium trucks for heavy-duty	0	0	3,844	696	232
Diesel-fueled light trucks for heavy-duty	99	99	928	1,094	166
Diesel-fueled medium trucks for heavy-duty	199	133	1,922	2,486	365
Diesel-fueled heavy trucks for heavy-duty	597	298	5,236	8,153	994
Motorcycles	0	0	1,591	166	365
Diesel-fueled urban buses	0	33	66	563	66
Total	*3,208*	*828*	*393,602*	*54,121*	*126,104*

Source: www.arb.ca.gob/emisinv/emsmain/emsmain.htm.

This inventory is not comparable to the one developed for Tijuana-Rosarito, due the fact that they were estimated for different years and using information and methods that are not at all similar. However, it can be concluded that, in general terms, PM10 and SO_2 emissions are greater in the Mexican cities.

The joint binational studies will allow us, in the future, to have a harmonized regional inventory, at least in terms of methodology. The degree of certainty will allow us to confirm the contents of this chapter.

6. PROGRAM OBJECTIVES, GOALS AND GENERAL STRATEGIES

6.1. Objectives

General Objective:

The main objective of the Tijuana-Rosarito Air Quality Program is to point out the actions aimed at protecting the health of the population, and to prevent and control air pollution generated by emissions sources, through the coordinated actions between the three levels of government.

Specific objectives:

- Reduce pollutant emissions generated by motor vehicles,
- Reduce emissions generated by industry, and commercial and service establishments,
- Reduce particulate matter emissions generated by unpaved roads, barren lots and unvegetated areas,
- Promote the use of public transportation to reduce private vehicle use,
- Develop interinstitutional coordination mechanisms for designing policies by sector, that allow the integration of environmental and urban planning in the Municipalities of Tijuana and Rosarito,
- Strengthen public awareness and involvement around environmental protection actions,
- Enhance the technical-scientific knowledge of the processes that condition the behavior of air pollutants, in order to support the actions proposed by the Program, and incorporate others that have not been considered,
- Develop mechanisms that foster private sector involvement through economic incentives, including international support for required projects and studies.

6.2. Goals

The general goal of this program is to gradually reduce the emissions generated until compliance with air quality standards is achieved, within the period from the year 2000 to 2005.

6.3. Actions and Strategies

The Program to Improve Air Quality in Tijuana-Rosarito proposes five work areas, each of which brings together specific actions focused on compliance with the proposed objectives and pollutant emissions reduction. These areas include the following:

- Industry, commerce and services
- Urban and transportation management
- Ecological recovery
- International research and agreements
- Public involvement.

Different actions are proposed for each of these areas, the goals, directly responsible parties, other participants, and some of the required management mechanisms are identified for each area.

6.3.1. Industry, Commerce and Services

1. *Emissions regulation for potentially polluting companies through the issuance of environmental licenses, permits and authorizations.*

Objective: Avoid the establishment of companies in the region that cannot comply with the environmental laws and reduce the emissions generated by polluting companies already in operation.

Justification: The geographic location of Tijuana and Rosarito makes them attractive for the installation of industries, commerce and services. According to the emissions inventory of the industrial sector the most representative pollutants are sulfur dioxide (with 58% of the emissions for the sector), followed by hydrocarbons (22%), nitrogen oxides and PM10 (9% each). According to the available data, there are some establishments that use heavy industrial oil (combustoleo) and diesel for fuel, where it is necessary to promote the installation of pollution control devices to reduce gas and PM10 emissions, and to provide incentives for the use of cleaner fuels.

Goal: Implement control and oversight mechanisms that allow for the regulation of industry, commerce and services. Put into practice programs that are geared toward the reduction of pollutant emissions based on the results of the emissions inventory.

Directly responsible parties: Municipal, State, and Federal governments in their respective legal capacities.

Other participants: Industrial, Commercial and Services sectors.

Management mechanisms: At the municipal level, create the Municipal Department of Ecology and issue Environmental Regulations for the city of Tijuana. Reach agreements with the sectors involved with the purpose of reducing pollutant emissions. Develop mechanisms to have fiscal incentives that foster the implementation of these activities.

2. Implement a vapor recovery program at storage terminals and gas stations.

Objective: Install vapor recovery systems at gas stations and service stations.

Justification: Volatile organic compounds are considered ozone precursors. These compounds are considered primary pollutants in Mexico as well as the United States. Data obtained from the air quality monitoring network show ozone as one of the compounds that show exceedances in the region.

Goal: Agree on acquiring and testing phase zero and one vapor recovery systems at storage terminals and gas station tanks, and promote the installation of phase two systems in 100% of the service stations located in Tijuana and Rosarito.

Directly responsible parties: State Government and Pemex.

Parties responsible for follow-up: Tijuana and Rosarito Municipal Governments y SEMARNAP.

Other participants: Consejo Intermunicipal de Vigilancia de Calidad del Aire (Intermunicipal Council on Air Quality Oversight), service station owners.

Management mechanisms: Reach an agreement with Pemex to develop a vapor recovery program at fuel storage terminals and service stations.

3. Develop a Municipal Emissions Registry.

Objective: Identify and record all pollutant emissions sources that fall under municipal jurisdiction.

Justification: The municipal emission source registry is the first step to evaluate pollutant transfer, as well as to develop environmental compliance indicators and indexes for the region. The Municipal Governments of Tijuana and Rosarito, supported by the emissions inventory and by the creation of their respective Ecology Departments, will be able to start developing their own registry of emissions sources that fall under municipal jurisdiction.

Goal: Record in the short-term all commercial and service drafts that fall under municipal jurisdiction, both existing as well as new.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government, Commercial and Service Sectors, Chambers and Associations.

Management mechanisms: Transfer of authority from the State to the municipalities for handling commercial and service drafts.

4. Evaluate the implementation of a Registry of Pollutant Emissions and Transfer (RETC) in Tijuana-Rosarito.

Objective: Identify the needs and opportunities that would arise from the development of this type of registries.

Justification: The application of corrective measures requires the prior evaluation of the status of pollutants and of the mechanisms that are involved in the dispersion of pollutants. This way, each level of government can assume the responsibilities and mechanisms that will help prevent adverse health effects on the population. This will also lead to homologation of responsibilities between facilities that fall under federal jurisdiction and those under local jurisdiction.

In order to accomplish this, it is necessary to have reliable information on emissions sources, which can currently be obtained through the RETC for companies under federal jurisdiction. It is necessary for the Tijuana-Rosarito RETC to include a list of substances that reflects the local situation, and that the information that is generated be accessible to the public in as much detail as possible for each emissions source.

Goal: Establish a RETC with annual information on pollutant emitters, provided by facilities that fall under federal and state jurisdiction, as well as other sources of pollution.

Directly responsible party: State Government.

Other participants: Tijuana and Rosarito Municipal Governments, SEMARNAP, Non-Government Organizations and Academic Institutions.

Management mechanisms: Reach an agreement between the three levels of government to implement the RETC.

5. Strengthen the inspection and oversight of industrial, commercial and service establishments.

Objective: Strengthen the inspection and oversight of industrial, commercial, and service facilities through the enforcement of existing rules and standards.

Justification: In order for current air quality regulations to be effective and to standardize the criteria employed, it is necessary for the State and Municipal Governments to update their regulation in order to comply with the new General Law of Ecological Balance and Environmental Protection and make them more efficient. In the same manner, SEMARNP will continue overseeing sources with federal jurisdiction in order to ensure compliance with current standards.

Goal: Establish a permanent program of compliance with Official Mexican Standards related to air quality and air pollution sources.

Directly responsible parties: Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP.

Management mechanisms: Strengthen inspection and review programs of current standards.

6. Develop a program of Volatile Organic Compounds (VOCs) emissions reduction

Objective: Evaluate the level of environmental compliance and decrease VOC emissions in the industrial sector, through the Emissions Control State Program and the Inspection and Oversight Program.

Justification: Implementing a program that evaluates the magnitude of the problem and promotes a change of raw materials or the installation of control equipment for their reduction is necessary, given that the industrial branch of the manufacture of electronic components uses large amounts of solvents for cleaning assembly parts,. The State Government, based on the emissions inventory, will be able to specify the number of industries that will be included in this program.

Goal: Evaluate in the short-term with the industrial sector the implementation of a voluntary environmental audit program and to reduce VOCs.

Establish a voluntary environmental auditing program in facilities that fall under federal and state jurisdiction.

Directly responsible parties: State Government and SEMARNAP.

Other participants: Tijuana and Rosarito Municipal Governments and Industrial Sector.

Management mechanisms: Agree on the environmental auditing program with the industrial sector to promote the reduction of VOC emissions and development of an Official Mexican Standard for VOC emissions by INE.

6.3.2. Urban and transportation Management

1. Establish the Vehicle Emissions Testing Program in the Municipality of Ti-

juana

Objective: Reduce vehicular emissions generated by freight and passenger public transportation vehicles, as well as private vehicles, through a mandatory Vehicle Emissions Testing Program.

Justification: According to estimates included in the emissions inventory, motor vehicles are the greatest contributors of carbon monoxide and hydrocarbon emissions. In the case of Tijuana and Rosarito, the vehicular fleet has an average age that is greater than 15 years and more than 90% of the vehicles come from the United States. These vehicles have had their emissions control systems modified, in addition to the fact that emissions increase with lack of maintenance. Currently, the Tijuana plans to develop a Vehicular Emissions Testing Program which will be part of the Municipal Regulations on Ecology.

Goal: Reduce emissions generated by motor vehicles circulating in the Municipality of Tijuana.

Start with the first phase of the Vehicle Emissions testing Program, including official vehicles belonging to the City Government and Municipal Public Transportation.

Add a vehicular emissions testing program as a requirement for the municipal transportation vehicle maintenance program.

Reduce up to 30% the emissions generated by gasoline and diesel vehicles.

Develop in a medium-term a mandatory Vehicular Emissions Testing Program for the City of Rosarito.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government, Ministry of Communication and Transportation, Chambers of Commerce, Transportation Sectors.

Management mechanisms: Promote collaboration agreements with the transportation sector and with the owners of used car lots, to implement the Vehicle Emissions Testing Program.

2. Strengthen vehicular inspection in the importation of used vehicles

Objectives: Promote and request that the importation of used vehicles complies strictly with the law and with local regulations on that subject.

Justification: Currently, the importation of vehicles does not comply to a large extent with current environmental. Compliance with and oversight of standards for the importation of motor vehicles in both countries will be promoted before the Ministry of the Treasury and Public Credit (SHCP) and the Ministry of Commerce and Industrial Development (SECOFI).

Goal: Establish the basis for environmental regulation on the importation of motor vehicles in the Tijuana border zone.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government, SEMARNAP, SHCP, SECOFI, and Customs Officials.

Management mechanisms: Promote before SHCP and SECOFI the enforcement and compliance with used vehicle importation standards.

3. Integrate vehicular inspection with vehicle maintenance programs

Objectives: Strengthen vehicular inspection systems that are geared toward maintaining the vehicular fleet in good operating condition, through the creation of mechanical inspection standards and programs.

Justification: According to data reported by The Organization for Cooperation and Economic Development (OCDE), the World Bank and the United Nations Organization for Industrial Development (ONUDI), a vehicle in that is in poor condition can emit 100 times more pollutants than a modern vehicle that receives routine maintenance. The implementation of actions that are geared toward promoting the appropriate use of a vehicle and its proper maintenance, are measures that must be incorporated into the maintenance programs that are currently done for public transportation vehicles. However, expanding these programs to other sectors requires establishing improvement, compliance and fiscal standards designed for the region, that originate from the emissions inventory and aim toward the implementation of policies for the improvement of transportation systems.

Goal: Compatibility between maintenance programs and air pollution prevention actions, operational controls and standards.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government and Transportation Sector.

Management mechanisms: Incorporate formal schemes that allow the use of new, inexpensive auto parts, or used parts in good working condition, that simplify and make vehicle maintenance less costly. Consider standards to appropriately regulate the use of these parts.

4. Study different alternatives for mass transportation and vehicular fleet renewal

Objectives: Develop medium and long-term joint strategies to improve the quality of transportation in the city of Tijuana.

Justification: Within the environmental diagnostic of the Roadway and Transportation Master Plan for Tijuana (which has not yet been published), it is established that air quality is the factor that receives the greatest impact from the deficiencies in the roadway and urban transportation system. This diagnostic indicates that the main problems affecting air quality are related to the rugged topography of the city, the type of roadway layout, the lack of roadway links and an excess of traffic control systems. On the other hand, the circulation of heavy-duty vehicles in the central area of town, is a factor that contributes mainly on the traffic congestion problems that frequently occur in the main arteries throughout the city.

Goal: As a long-term scenario, a commuter train project has been considered for the city of Tijuana. This will create an efficient alternative for mass transportation, reducing the use of private vehicles.

In the short-term, the Vehicular Inspection Program for Tijuana, anticipates implementing incentive programs for the improvement of transportation, incorporating credit support for the acquisition of new units, as well as actions to recycles the old units.

Establish an agreement with the maquiladoras to provide mass transportation for their employees and mandatory emissions inspection of freight vehicles.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government, Transportation Sector, and Industrial Sector.

Management mechanisms: Develop agreements with vehicle parts suppliers to offer special prices for car shops and carriers. Develop agreements with SHCP and SECOFI to offer credit opportunities for carriers.

5. Implement a campaign for issuing warnings to visibly polluting vehicles

Objective: Reduce the circulation of visibly polluting vehicles in the cities of Tijuana and Rosarito.

Justification: Currently, in the cities of Tijuana and Rosarito there are visibly polluting vehicles, for which there are no specific regulations. The implementation of the Municipal Emissions Testing Program and related regulations in the city of

Tijuana, foresee mechanisms for testing visibly polluting vehicles, as well as the procedures to warn the individual, involving the community in this Program through the Volunteer Inspector figure.

Goal: Establish in the short-term a campaign to warn visibly polluting vehicles and a widespread outreach campaign.

Achieve full community involvement and compliance with the Program.

Implement a program to warn visibly polluting vehicles in the city of Rosarito.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government and NGOs.

Management mechanisms: Start outreach campaigns for the Vehicular Emissions Testing Program in the city of Tijuana with the purpose of creating awareness about the importance of tune-ups and emissions testing as a preventive measure to help reduce pollution generated by motor vehicles.

6. Develop an integrated study of roadways and transportation

Objective: Conduct an integrated study of roadways and transportation that will serve as the basis for designing mass mobilization programs that reduce emissions and the use of private vehicles.

Justification: The municipal government is conducting a roadway and transportation study in Tijuana. This study marks the beginning of work that is geared toward improving the roadway and transportation system in the city of Tijuana. The study identifies the current problems and establishes a series of proposals geared toward improving travel times and routes for the creation of new routes. Likewise, it seeks to favor the fast movement of motor vehicles and thus the reduction of pollutant emissions generated through this means.

Goal: Conduct a quantitative evaluation of the emissions generated by the transportation sector. This evaluation would allow us to set complete scenarios for scheduling priority work, which will be determined in the more advanced stages of planning and will be based on a cost-benefit evaluation of actions such as: installing traffic lights at intersections; eliminating circles or squares with streets converging on them; traffic signals; construction of road links; paving of access roads; underpasses and overpasses; and, broadening of lanes to favor the rapid movement of vehicles and emissions reduction. It will be necessary to evaluate the local economy to sustain the incorporation of the different emissions controls schemes, in order to avoid limiting economic growth.

Directly Responsible Party: Tijuana Municipal Government.

Other participants: Instituto Municipal de Planeación de Tijuana, State Government, and Transportation Sector.

Management mechanisms: Coordination between the three levels of government to designate resources to accomplish the different strategies considered in this Program.

7. Induce new growth patterns, soil use and public transportation schemes

Objective: Revert the current tendency of vehicular fleet growth through the induction of new growth, soil use and public transportation patterns.

Justification: Studies conducted by the California Department of Transportation confirm that the current cost of vehicle-generated air pollution in the region is about two billion dollars a year. Although some of these costs are recoverable through fiscal mechanisms, such as gasoline taxes, most of them are currently being covered by the general public.

Goals: Increase accessibility to transportation considering soil use redensification, prioritizing public transportation, and promoting non-motorized means of transportation to reduce excessive motor vehicle use.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government, SEMARNAP and SHCP.

Management mechanisms: Promote the use of public transportation in future urban developments. Negotiate with SHCP the design and application of fiscal schemes that promote the reduction of private vehicles. Negotiate finance mechanisms to improve the public transportation system.

6.3.3. Ecological Recovery

1. Promote the use of a different type of fuel by the Federal Electric Power Commission (CFE)

Objective: Reduce emissions generated by the Rosarito power plant.

Justification: Based on the emissions inventory developed for Tijuana-Rosarito, the power plant located in Rosarito is highly polluting due to the use of combustoleo as fuel.

A gas pipeline is currently being installed in order to switch the plant to natural gas. In order to accomplish this, the burners in the two units with largest capacity will have to be modified with the purpose of making combustion more efficient. Furthermore, combustoleo with less than 2% sulfur content by weight will continue being used in the other units.

Goal: Reduce PM10 and SO_2 emissions in the short-term.

Directly responsible parties: Energy Ministry (SE) and Federal Electric Power Commission (CFE).

Other participants: State Government and SEMARNAP.

Management mechanisms: SEMARNAP in coordination with the Energy Ministry and the Federal Electric Power Commission will be in charge of supervising the progress in the switch over from combustoleo to natural gas at this power plant.

2. Agree with PEMEX on the supply of oxygenated gasoline with low RVP

Objective: Reduce the emissions generated by the vehicular fleet during the summer and winter months.

Justification: The Tijuana-Rosarito area consumes an average of 732 thousand cubic meters of gasoline per year. Most of this gasoline is supplied by PEMEX through its Salina Cruz refinery in Oaxaca. More than 88% is Magna gasoline with an average Reid Vapor Pressure (RVP) of 9.7 lb/in^2, and 12% is Premium gasoline with RVP between 7.8-9.0 lb/in^2 during the entire year. Fuel is imported from the United States in very few occasions. This type of gasoline is not oxygenated. It is necessary to request that PEMEX evaluates the appropriateness of supplying ecological fuels with low RVP for the summer and oxygenated for the winter, due to the climatological conditions of this region. This would help reduce the emissions generated by the vehicular fleet.

Goal: Reduce hydrocarbon and carbon monoxide vehicular emissions.

Directly Responsible Party: Pemex.

Other participants: Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP.

Management mechanisms: Have the state and municipal government follow-up on the agreements between SEMARNAP and PEMEX with the purpose of developing compliance calendars to reach the desired objective.

3. Development of a Municipal Reforestation Program and Regulations and follow-up of the paving programs

Objective: Reduce dust and PM10 emissions generated by soil erosion and unpaved streets.

Justification: According to data reported by the air quality monitoring network, it can be seen that, in the city of Tijuana, PM10 air quality standards were exceeded. These exceedances are linked to the fact that approximately 50% of the streets in Tijuana are unpaved. These streets are eroded daily with the circulation of vehicles. During the rainy season, water drags dirt and deposits it on paved streets. At the end of the rainy season all the dirt that has been deposited on paved streets is emitted into the air as dust by the passing vehicles.

For this reason, the three levels of government and the Municipal Reforestation Committee, founded on June 27, 1997, will evaluate a large scale reforestation program for the city, in order to solve the problem generated by unvegetated areas. Fast-growing vegetation that can easily adapt to the type of soil and climate of the region will be considered for this purpose.

Goal: Reduce in the medium-term, and according to the numbers reported in the emissions inventory, the generation of dust and PM10 particles. Conduct a program of priorities to consider for paving based on air quality monitoring data and on the identification of areas of greater conflict in the region.

Directly responsible parties: Tijuana and Rosarito Municipal Governments, Comité de Forestación Municipal de Tijuana.

Other participants: State Government, SEMARNAP, NGOs, Academic and Research Institutions, general population.

Management mechanisms: Promote social programs for street paving in coordination with the Federal government, to request the donation of asphalt. Designate ecological preservation areas within the city, in accordance with the Municipal Regulations on Ecology and the State Planning Law.

4. Develop a program of financial incentives for individuals, institutions and organizations that develop programs to prevent and control air pollution

Objective: Encourage the use of emissions control technologies through the award of financial incentives and other economic instruments.

Justification: Authorities from the three branches of government will orchestrate a program to promote and award financial incentives to individuals, institutions, or organizations that develop initiatives to reduce air pollution. This will serve as an incentive, for those who are interested, to propose programs and reduce their pollutant emissions in a cost-effective manner. For this purpose, information on existing programs will be provided through the treasury authorities and development organizations.

Goal: Grant financial incentives to those engaged in air pollutant emissions reduction.

Directly responsible parties: SHCP and SEMARNAP.

Other participants: Tijuana and Rosarito Municipal Governments and State Government.

Management mechanisms: Develop a collaboration agreement between SHCP, INE and SEMARNAP.

6.3.4. Research and International Agreements

1. Local Operation of the Air Quality Monitoring Network

Objective: Continue with the air quality monitoring effort in the Tijuana-Rosarito region.

Justification: The air quality monitoring network began operating permanently in the second semester of 1996, with the use of resources from EPA and CARB. These two agencies have expressed their desire to transfer operation of this network to Mexican authorities. The need of funding to maintain the network has prompted Federal authorities to seek the necessary mechanisms for maintaining the air quality monitoring network in the region, for the benefit of both countries. Site and equipment infrastructure for the monitoring network represents an investment of approximately 1 million dollars. It is estimated that the cost of operating the network is about 800 thousand pesos per year.

Goal: Develop a local plan of operation for the monitoring stations in Tijuana-Rosarito, in coordination with research institutions and institutions of higher education in Tijuana. This plan should include the evaluation and selection of potential additional monitoring sites, setting local parameters of compliance, the creation of a new administrative and management area for the program, and the development of a local data collection and management system.

Transfer the operation of the Air Quality Monitoring Network to the municipal authorities of Tijuana.

Reach formal agreements of financial support for the operation of the Monitoring Network with authorities from the Mexican and US federal governments, authorities from the states of California and Baja California, and the Municipal government.

Directly Responsible Party: Tijuana Municipal Government.

Other participants: State Government, SEMARNAP, EPA and CARB.

Management mechanisms: Carry out the Air Monitoring Network transfer agreement from SEMARNAP, EPA and CARB to the Municipalities. Financial and technical support, as well as personnel training should be included in this agreement.

2. Review periodically the emissions inventory

Objective: Have a reliable emissions inventory that can be used as the basis for designing control measures to reduce emissions from the different sectors.

Justification: The emissions inventory for any city is a dynamic instrument that needs to be updated periodically. For this Program, one of the immediate activities that are being conducted by the National Institute of Ecology (INE) with EPA resources channeled through WGA, is a detailed emissions inventory. Based on this inventory several pollution prevention and control measures were designed. This inventory must be updated at least every other year.

Goal: Have a reliable instrument to aid in decision-making.

Directly responsible parties: State Government and SEMARNAP.

Other participants: Tijuana and Rosarito Municipal Governments, Academic and Research Institutions.

Management mechanisms: The State Government and SEMARNAP must reach a coordinated agreement with the purpose of periodically updating the emissions inventory. Due to the dynamic growth of the region, this updates must be done at least every other year, in order for the inventory to serve as a basic instrument for controlling air pollution.

3. Consolidate a program of epidemiological oversight associated with air pollution

Objective: Availability of permanent and updated information regarding the health condition of the population of Tijuana-Rosarito, through an epidemiological oversight program.

Justification: Environmental and health authorities, and the community in general, need to have permanent information available about the effects on health from the environment. This information is important in the decision-making process and to consistently apply the Program to Improve Air Quality in Tijuana-Rosarito. The activation of this monitoring system should lead to the development of the necessary information to learn and evaluate the harm and adverse effects on human health, and thus focus efficiently on appropriate prevention, protection and care measures.

As part of the epidemiological monitoring program, health authorities in coordination with other competent authorities, will conduct outreach activities to inform the population in a timely manner about the preventive and corrective measures that must be followed to avoid the health effects originating form exposure to pollutants.

Goal: Have in place an epidemiological monitoring system that can be used permanently and for critical air pollution episodes.

Directly responsible parties: Tijuana and Rosarito Municipal Governments, and State Government.

Other participants: SEMARNAP, SSA, ISESALUD, Academic and Research Institutions.

Management mechanisms: Carry out a coordinated agreement between the three levels of government to follow-up on the results of the Monitoring Network with the purpose of implementing follow-up and information strategies to the population.

4. Reach agreements with institutions of higher education to conduct air pollution related studies

Objectives: Reach agreements with research institutions and institutions of higher education about conducting air pollution related studies.

Justification: Currently, the cities of Tijuana and Rosarito have been the object of some specific studies related to environmental pollution. Research institutions such as Universidad Autónoma de Baja California (UABC) and Instituto Tecnológico de Tijuana (ITT), among others, have conducted work related to this subject. It is necessary to support and carry put this type of projects.

Goal: Reach agreements to conduct studies to prevent and reduce air pollution.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government and SEMARNAP.

Management mechanisms: Authorities at the three levels of government must support and promote research studies conducted by the different institutions with the purpose of preventing and controlling air pollution in the region.

5. Reach agreements with international institutions to conduct air pollution related studies

Objectives: Agree with international institutions on the completion of special studies and the funding of those studies.

Justification: The cities of Tijuana and Rosarito have been the subject of studies funded by international organizations, one of which is the development of an emissions inventory. In the same manner, support has been received for the installation and operation of an air quality monitoring network. It is necessary to sign specific agreements with the international institutions that have supported these initiatives. Those institutions include: EPA, CARB, WGA, CICA and the World Bank, among others.

Goal: Negotiate agreements to obtain the resources to conduct studies to prevent and reduce air pollution.

Directly responsible parties: Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP.

Other participants: Academic and research institutions.

Management mechanisms: Negotiate work and funding agreements with international institutions that are interested in conducting environmental work.

6. Strengthen the actions of the Border XXI Program

Objective: Strengthen the joint efforts that are being undertaken by the Border XXI binational air quality workgroup in the Tijuana-Rosarito-San Diego airshed.

Justification: Continuity will be given to a series of binational efforts that were initiated under the framework of the Border XXI Program. Some of these activities include the operation of the air quality monitoring network and the development of an emissions inventory.

Goal: Obtain the support from the governments of both countries to conduct studies, programs and activities that allow us to reduce and control air emissions.

Directly responsible party: SEMARNAP.

Other participants: Tijuana and Rosarito Municipal Governments and State Government, EPA, CARB and San Diego County.

Management mechanisms: Organize work and follow-up meetings to learn about the progress in the different areas of the Program.

6.3.5. Public Involvement

1. *Prompt the involvement of the San Diego-Tijuana-Rosarito Airshed Binational Air Quality Alliance.*

Objective: Continue with the follow-up of the air quality proposed actions, for evaluation and suitability.

Justification: The Binational Air Quality Alliance (a non-profit organization for public benefit) was organized with the exclusive purpose of improving air quality and the health of the people who reside in the San Diego-Tijuana-Rosarito airshed, to advice different organizations and, at the Council's discretion, to serve as advisors to the Air Quality Workgroup that was established in accordance with the Binational Agreement, signed in La Paz, Baja California, in 1983. Furthermore, it serves as a public forum for the discussion of air quality related subjects in the airshed.

A local group to aid with the follow-up to the propose actions related to air quality is necessary. This group must focus on the specific needs of the Tijuana–Rosarito region. Of greater importance is the evaluation of achievements. These should be put into perspective by the different sectors involved and, particularly, non-government organizations.

Goal: Form a local group to follow-up and evaluate the proposed actions of the Air Quality Program, the progress of the different State and Federal programs, as well as the Border XXI Program, in conjunction with all interested non-government organizations. This local group could be made up of groups such as the Binational Alliance, the Federal, State and Municipal Governments.

Directly responsible parties: Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP.

Other participants: NGOs.

Management mechanisms: The different government groups must promote the convenience of the involvement of, and support to non-government organizations and other parties interested in air quality pollution prevention and control in the region.

2. Develop an environmental awareness and education program for the Tijuana-Rosarito region

Objectives: Create awareness in order to drive people to contribute in the prevention and control of air pollution, developing social programs and environmental education programs.

Justification: The municipal governments in coordination with agencies from other levels of government and academic institutions must promote an environmental education program with the different social groups. This type program is necessary to promote knowledge about environmental pollution prevention and control, since it is not only the responsibility of the authorities, but rather it should be the sum of the efforts from all the community members. In order to accomplish this, it is necessary to draft agreements with universities and academic institutions about the preparation of these topics. Also, authorities will promote the training of their staff with specialized courses about environmental topics for all different levels and work areas so that the Program is viewed as an integrated effort.

Goal: Consolidate a Social Involvement and Environmental Education Program.

Directly responsible parties: Tijuana and Rosarito Municipal Governments.

Other participants: State Government, Academic and Research Institutions, NGOs and Private Sector.

Management mechanisms: Coordination with the Municipalities in order to develop a program with the involvement from the State government, academic and research institutions, and NGOs supported by the private sector for the funding and implementation of these actions.

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ANNEX A. AIR QUALITY MONITORING AND METROPOLITAN INDEX

Monitoring

Air pollutant monitoring methods

Standardized techniques and procedures published as Official Mexican Standards (NOMs), are used to measure pollutant concentrations in the air, with the availability of equivalent reference methods. Reference methods are more precise and selective but, for some pollutants, their use is only practical in the laboratory but not in the field. For this reason, equivalent methods that are feasible for field use, in addition to being permanent and reliable, are used to provide the appropriate precision and selectivity under ambient conditions. The following Table summarizes the principles considered by the methods used for measuring air pollutant concentrations.

Table A.1. Air pollutant measurement methods

Pollutant	Reference Method	Equivalent Method
SO_2	Pararrosanillin (manual)	Fluorescence (automatic)
CO	Infrared Photometry (automatic)	None
O_3	Chemoluminescence (automatic)	UV Photometry (automatic)
NOx	Chemoluminescence (automatic)	Wet Chemistry
PST	High volume sampling (manual), includes Pb	None
PM10	High volume sampling (manual)	Beta attenuation (automatic)

Description of methods

Sulfur dioxide: The reference method for determining SO_2, is the wet chemistry process developed by West and Gake, known as the “pararrosanillin process”. A volume of air passes through the bubbler at a constant and controlled flow rate, during a set period of time. The bubbler contains an absorbing solution that retains molecules from the pollutant and reacts with the solution components. At the end of the sampling period, generally 24 hours, the solution is transported to the laboratory to be analyzed using colorimetry. The larger the concentration of SO_2, the more intense the color of the solution, which varies from light pink to purple.

The equivalent method is a fully automated process. Even though it is not as accurate as the reference method, it offers acceptable precision and consistency. In this case, the ability of SO_2 to absorb UV light and release it as fluorescent light is utilized. The intensity of the fluorescence is directly proportional to the concentration of SO_2. The entire process takes place under controlled conditions, inside an analyzer.

Carbon monoxide: This pollutant is measured taking advantage of its ability to absorb infrared light when exposed to an optical path where this type of energy is displaced. The measurement takes place inside a chamber equipped with a device that detects the different variations of infrared light and, it calculates the concentration of this pollutant through the use of an electronic processor. This is the only method that is recognized for continuous monitoring of CO in ambient air.

Ozone: In order to measure ozone concentrations in ambient air, the reference method involves a chemical reaction between ozone and ethylene, which is provided specifically inside a specially designed chamber containing optical devices. These optical devices catch the light signals resulting from this reaction. These light signals are amplified and turned into an electrical signal that is proportional to the concentration of ozone in the air sample.

The equivalent method uses the property of ozone to absorb a portion of an ultraviolet light beam directed through an optical path, confining an air sample containing the pollutant. The variations in light intensity that are detected in the system are associated with ozone concentrations.

Nitrogen dioxide: This pollutant is measured through the reaction that takes place, inside a specially designed and conditioned chamber, between NO_2 and ozone, which is generated in excess by the same instrument. As a result of this reaction there is an emission of a variable number of photons, depending on the concentration of the pollutant that enters the chamber as one of the components of the air sample. The photon current is amplified and turned into voltage in order to be interpreted.

Some alternative methods include a few wet chemistry techniques, which are not widely used in practice due to a large diversity of factors of error that accumulate when used on the field.

Total suspended particles and PM10 particles: The high volume method is used in order to collect samples of the solid matter that floats in ambient air. This method consists of passing an air flux at a high rate of speed, through a teflon filtering medium, which retains particles with aerodynamic diameters between 0.1 and 100 micrometers. This method requires keeping a constant flow and knowing the total volume of air sampled during a 24-hour period, which is the amount of time that is usually recommended for this type of sample. It is also necessary to know the weight of the filter before and after the sample is collected. In order to do this the filter is conditioned for 24 hours in a chamber, where temperature and relative humidity are controlled. After determining the mass of the material, the sample becomes susceptible to undergoing physical and chemical analyses to determine the content of lead and other heavy metals, as well as sulfates and nitrates.

This same method is used to collect samples of total suspended particles and PM10, using a different kind of head in the sampler to separate the fine from the coarse particles.

Quality assurance and quality control (QA/QC) of the measurements

In order to evaluate the quality of the analytical results obtained from an air pollutant monitor, it is necessary to conduct audits during all the phases of the monitoring process. An audit program must contemplate the following activities:

- Calibration.
- Zero span and subsequent adjustments.
- Review of the data that results from testing.
- Preventive and/or corrective maintenance.

Calibration

The calibration of monitoring equipment consists of determining the instrument's response to known concentrations and adjusting it to the corresponding curve. Calibration is done at the time of installation and activation of the monitor, as well as during its operation:

- In time intervals not greater than three months from the most recent calibration or audit.
- Immediately after an interruption of more than three days in the operation of an analyzer.
- After any repair involving the replacement of one or more major components.
- When physically moving the analyzer from one place to another.
- Whenever there is evidence of a significant lack of precision in the analyzer.

Zero and span checks

These checks are a key component of quality assurance and quality control programs that apply to continuous monitors of gaseous pollutants and are useful to:

- Indicate when it is necessary to adjust the analyzer to its zero and/or span levels.
- Provide the criteria for deciding when an instrument must be calibrated.
- Establish the basis for making the decision to invalidate data that are generated by the monitor.

Zero and span checks must be done at least once every other week or more often, if the instrument's performance calls for it.

Air Quality Metropolitan Index

An air quality index weighs and transforms the concentrations of a set of pollutants into a non-dimensional number that indicates the level of pollution present in a determined location and can be easily understood by the public.

The procedure to manipulate the concentrations of pollutants, with the objective of obtaining a significant number, basically depends on the algorithm used, particularly on the index. The problem faced by those who develop air quality indicators consists in determining how to weigh the effects of pollutants.

Among the different indexes used around the world, a certain number of weight factors has been proposed, the most acceptable being the one that considers air quality standards as the basis for determining the effects from pollutants. That approach has been used in developing the following indexes: PINDEX, Oak Ridge Air Quality Index (ORAQI), Mitre Air Quality Index (MAQI), Extreme Value Index (EVI), Pollutant Standard Index (PSI).

In 1975, Thom and Ott researched all the air pollution index structures being used in the US and Canada, as well as those mentioned in the literature, in order to compare and evaluate more than 50 different types. They developed a system to classify indexes and, using that system, they identified the optimal characteristics that should be considered by the PSI index. That index was later modified and adopted by the US government.

The PSI includes 6 air pollutant variables {CO, NO_2, O_3, PST, SO_2 and the product of PST x SO_2}, it uses segmented linear functions to calculate sub-indexes, incorporating a simple form of the maximum permissible concentrations set by the government, and calculating the "Maximum Mode". This consists of reporting only the sub-index of the highest resulting pollutant. The sub-indexes utilize the US primary air quality standards, episode criteria, and significant damage levels as their break points.

The PSI system is based (in part), on pollution levels set as federal episode criteria (i.e. concentrations associated with alert, danger and emergency levels). These are not totally based on purely scientific information but rather, they are recommended to direct actions to reduce air pollution in metropolitan areas, in the short term.

Table A.2. PSI Descriptive Categories

Good	0 – 50
Moderate	51 – 100
Unhealthy	101 – 199
Very unhealthy	200 – 299
Harmful	300 or more

In Mexico, based on the bibliographic review that took place prior to defining air quality indexes, the decision was made to use an approach that would include air quality standards as well as significant harm levels, as the basis for measuring the effects from pollutants. Instead of using an approach that is solely based on air quality standards, IMECA uses a more realistic approach, allowing the use of measurement factors that change according to different pollution levels and also allows the generation of daily air quality reports.

The Metropolitan Air Quality Index (IMECA), is based on the use of segmented linear functions, similar to those used by PSI. Thus we must not forget that the segmented linear functions used by this system correspond to the US primary air quality standards, episodic criteria, and significant harm levels. When IMECA was first developed, there were no Official Mexican Standards for air quality, episodic criteria, or significant harm. However, this was overcome through the development of break points based on local information, using the same philosophy that was used for defining PSI.

The variables that were selected to be included in the air quality index were the same as those for PSI, taking into consideration the information available in Mexico. Those variables include CO, O_3, NO_2, PST, PM10 and SO_2.

The equation that defines IMECA can be expressed in the following manner:

$$IMECA = \max (I_1, I_2, I_3, \ldots ,I_n)$$

Where $I_1, I_2, I_3, \ldots ,I_n$ are individual sub-indexes for each of the pollutants. The sub-indexes are calculated using segmented linear functions based on the break-point values included in the following Table:

Table A.3. IMECA break points

IMECA	PST (24 hr) µg/m³	PM10 (24 hr) µg/m³	SO_2 (24 hr) Ppm	NO_2 (1 hr) ppm	CO (8 hr) Ppm	O_3 (1 hr) Ppm
100	260	150	0.13	0.21	11	0.11

200	546	350	0.35	0.66	22	0.23
300	627	420	0.56	1.1	31	0.35
400	864	510	0.78	1.6	41	0.48
500	1000	600	1.00	2.00	50	0.60

Air quality is considered to be unsatisfactory if the IMECA value is between 101 and 200, poor between 201 and 300; and, very poor if it is above 300.

IMECA reports the maximum mode and its descriptive terms are based on the short-term threshold effects and on significant harm levels. When IMECA was first developed, the Air Quality Criteria values published on November 29, 1992 were used to set the 100 level. The concentrations for the 200, 300 and 400 IMECA values were arrived at dividing the interval between the air quality criterion and the level of significant harm (IMECA 500 value), into 4 equal parts. Correlation studies were conducted to determine the break points for particulate measurements, and thus the PM10 sub-index was developed.

The substitution of the 1982 air quality criteria with the Official Mexican Standards on December 24, 1994, resulted in an update of the air quality metropolitan index with the new values.

Table A.4 shows a list of health effects at different IMECA levels along with some recommendations that are suggested to avoid further harm. This table highlights the fact that children and the elderly are the most affected groups by air pollution episodes.

Table A.4. Health effects at different IMECA levels and some recommendations to prevent them

IMECA level	Possible health effects	Preventive type measures
0 to 100	• No negative effects are present in the health of the population. • All individuals can perform all types of physical activities.	• At this level, non-preventive type measures are necessary.

101 to 250	• Conjunctivitis or headaches in any group of the population. • People who suffer from heart or pulmonary disease reactivate the symptoms of their illnesses. • Nursing children, the elderly and smokers, show dysfunction of the respiratory and cardiovascular system, as well as an increase in respiratory frequency, shortness of breath, and palpitations. • The generally healthy population shows adverse effects such as itchy eyes, headaches, increase in respiratory function, shortness of breath and palpitations, especially when performing an intense physical activity.	• At this level, general behaviors conducive to low exposure to air pollutants must be adopted, especially by the population at-risk or with greater susceptibility, such as children, the elderly, pregnant women and individuals with chronic heart disease and chronic pulmonary disease. Adopting the following measures is recommended for the population as a whole: > Avoid exposure to polluted air. > Do not perform intensive outdoor exercises or physical activities. > Remain indoors for the duration of the high pollution episode.
251 a 350	• Nursing children, the elderly, and smokers, can show the symptoms described in the previous level, in addition to inflammatory alterations (coughing, expectoration, and bronchial spasms) in their respiratory system. • The generally healthy population can show dysfunction of the respiratory and cardiovascular system, such as an increase in cardiac and respiratory frequency, shortness of breath and palpitations, especially when performing outdoor exercises or physical activities.	• Starting at this level of pollution, the following measures are recommended for the population as a whole, and especially for higher risk groups: > Avoid exposure to polluted air. > Do not perform outdoor exercises or physical activities. > Remain indoors for the duration of the high pollution episode. > Avoid additional damage to the respiratory system. > Avoid smoking and exposure to smoke from tobacco. > Avoid abrupt changes in temperature. > Decrease contact with individuals that present signs of respiratory infection.
351 and up	• Starting at this level of pollution, some investigative reports indicate the possibility that: > Individuals with chronic heart disease or pulmonary disease will reactivate their basic illness. > Nursing children, the elderly and smokers, will show inflammatory type alterations in their respiratory system (coughing, expectoration, and bronchial spasms). > The generally healthy population is at risk of showing inflammatory type alterations in their respiratory system, even without performing any outdoor exercise or physical activity.	• Reinforce the body's natural defense mechanisms through: > Abundant ingestion of liquids, preferably natural fruit juices. > Consume lots of fruit and vegetables. • Timely medical attention. • Susceptible individuals must see a doctor if they show signs of reactivation of their illnesses. • Masks, air purifiers or oxygen inhalers are not scientifically-proven protective measures in the presence of rising levels of air pollution, and their discriminatory use may result in a higher risk for the susceptible groups. • Be aware of the recommendations from the National Health System Institutions, through the media.

ANNEX B. AIR QUALITY SUMMARY TABLES FOR TIJUANA-ROSARITO, 1997-1998

Table B.1. Percentage and number of days with concentrations greater than or equal to 100 and 150 IMECA points by zone, 1997-1998

Northwest (Playas and Centro de Salud)

	1997					1998				
	>=100		>=150		Total days with data	>=100		>=150		Total days with data
	%	No.	%	No.		%	No.	%	No.	
O_3	0.0	0	0.0	0	147	0.0	0	0.0	0	349
PM10*	0.0	0	0.0	0	65	0.0	0	0.0	0	73*
CO	0.0	0	0.0	0	165	0.0	0	0.0	0	361
NO_2	0.0	0	0.0	0	151	0.0	0	0.0	0	358
SO_2	0.0	0	0.0	0	116	0.0	0	0.0	0	236

*samples

Northeast (Instituto Tecnológico)

	1997					1998				
	>=100		>=150		Total days with data	>=100		>=150		Total days with data
	%	No.	%	No.		%	No.	%	No.	
O_3	0.8	1	0.0	0	123	0.3	1	0.0	0	365
PM10*	0.0	0	0.0	0	60*	0.0	0	0.0	0	60*
CO	0.0	0	0.0	0	139	0.0	0	0.0	0	365
NO_2	0.0	0	0.0	0	123	0.0	0	0.0	0	335
SO_2	0.0	0	0.0	0	137	0.0	0	0.0	0	207

*samples

Central (COLEF)

	1997					1998				
	>=100		>=150		Total days with data	>=100		>=150		Total days with data
	%	No.	%	No.		%	No.	%	No.	
O_3	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM
PM10*	9.1	1	0.0	0	11	1.8	1	0.0	0	56*
CO	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM
NO_2	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM
SO_2	SM	SM	SM	SM	SM	SM	SM	SM	SM	SM

*samples

SM: No Measurements

Southwest (Rosarito)

	1997					1998				
	>=100		>=150		Total days with data	>=100		>=150		Total days with data
	%	No.	%	No.		%	No.	%	No.	
O_3	0.0	0	0.0	0	287	0.0	0	0.0	0	348
PM10*	SM	SM	SM	SM	SM	1.7	1	0.0	0	60
CO	0.0	0	0	0	272	0.0	0	0.0	0	355
NO_2	0.0	0	0.0	0	287	0.0	0	0.0	0	307
SO_2	0.0	0	0.0	0	248	0.0	0	0.0	0	224

*samples.

Southeast (La Mesa)

	1997					1998				
	>=100		>=150		Total days with data	>=100		>=150		Total days with data
	%	No.	%	No.		%	No.	%	No.	
O_3	1.7	2	0.0	0	119	0.0	0	0.0	0	365
PM10*	3.4	2	0.0	0	58	4.8	3	0.0	0	62
CO	0.0	0	0.0	0	136	0.0	0	0.0	0	365
NO_2	0.3	1	0.0	0	120	0.3	1	0.0	0	363
SO_2	0.0	0	0.0	0	82	0.0	0	0.0	0	246

*samples.

Table B.2. Maximum monthly IMECA value by zone and pollutant (1997)

	O_3	PM10*	CO	NO_2	SO_2
Southwest	99	SM	76	48	75
Northwest	100	99	34	43	20
Northeast	109	75	41	51	12
Southeast	116	112	67	83	12
Central	SM	65	SM	SM	SM

*samples SM: No Measurements

Table B.3. Maximum monthly IMECA value by zone and pollutant (1998)

	O_3	PM10*	CO	NO_2	SO_2
Southwest	96	112	28	27	57
Northwest	76	82	30	36	12
Northeast	112	70	55	54	14
Southeast	97	136	96	100	15
Centro	SM	119	SM	SM	SM

*samples SM: No Measurements

Table B.4. Maximum monthly IMECA value by pollutant (1997)

	O_3	PM10*	CO	NO_2	SO_2
January	100	65	41	52	17
February	69	63	76	49	18
March	87	70	56	48	19
April	71	65	35	37	75
May	93	75	26	37	45
June	72	61	26	28	17
July	64	55	28	21	37
August	74	60	64	30	34
September	116	48	54	83	11
October	112	93	67	52	21
November	63	112	34	38	22
December	60	99	30	24	17

*samples

Table B.5. Maximum monthly IMECA value by pollutant (1998)

	O_3	PM10*	CO	NO_2	SO_2
January	72	106	71	42	9
February	69	17	44	34	4
March	73	63	48	50	8
April	78	61	54	62	19
May	69	37	30	32	6
June	66	55	16	26	14
July	112	50	27	43	57
August	94	76	45	41	22
September	93	54	41	35	5
October	96	109	57	70	13
November	85	112	78	73	9
December	76	136	96	100	15

*samples

ANNEX C. HEALTH EFFECTS FROM POLLUTANTS

Ozone (O_3)

Ozone is the main photochemical oxidant present in the atmosphere, along with peroxiacetyl nitrate, alkyl nitrates, and other compounds. In nature, ozone is one of the main components of the chemical make-up of the stratosphere and has the important function of protecting the earth's surface from solar ultraviolet radiation. However, the presence of ozone in the lower layer of the atmosphere (known as the troposphere), where most living organisms develop, is due to the photochemical reactions that transform hydrocarbons and nitrogen oxides.

Even though O_3 is a very unstable pollutant, destroyed as easily as it is formed, it has been proven that, regardless of its brief stay, it causes irritation in the respiratory system, coughing, phlegm, breathing pain, and inflammation of the lung tissue, reducing its ability to respond to foreign agents. Furthermore, it reduces lung capacity, mucocilliar capacity, weakening the natural defenses of the respiratory system. Also, it has been proven that respiratory illnesses are more prevalent among children who are exposed to ozone. Likewise, it has been observed that during periods of environmental contingency with high ozone concentrations, there is a noticeable increase in school absences in pre-school and elementary school-age children (Romieu, 1995).[1]

Gong[2] believes that ozone also causes problems in healthy people, since it makes breathing more difficult while working and exercising, and it causes general respiratory irritation. Furthermore, it can scar the lungs causing permanent damage. It is thought that irritation symptoms tend to disappear with repeated exposure to ozone. However, this "attenuation of the response" is not something positive, since the fact that there are no obvious reactions to the exposure, does not mean that the body has adapted to it. There is evidence to support the fact that the pulmonary lesion remains even during attenuation.

A significant problem with ozone pollution is the fact that the lungs do not stop developing until a person turns 18. Therefore, lungs that are not fully developed suffer early damage that can increase the risk of contracting a respiratory illness in the adult years.

Particulate Matter (TSP, PM10 and PM2.5)

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[1] Romieu, I. (1995). Effects of urban air pollutants on emergency visits for childhood asthma in Mexico City. Am. J. Epidemiol.

[2] Gong, H. M. (1987). "Effects of ozone on exercise performance". Journal of Sports Medicine and Physical Fitness.

Some behaviors that lead to particulate matter pollution include the destruction of vegetation, which in turn causes erosion; fires; some dust generating industrial processes; and, human activities requiring the burning of fuels such as coal, firewood, and petroleum byproducts. The inadequate disposal of garbage and fecal matter are also important sources of emissions of microorganisms, cysts, spores, pollen, etc. that stick to dust. With this in mind, it is necessary to tackle these problems directly to reduce the pollution generated by suspended particles.

Depending on their size, particles can float or form sediments. Particles that are constantly floating are known as total suspended particles (TSP).

Particles with a diameter less than, or equal to 10 µm are known as breathable particles or PM10, and can be formed by aerosols, dust, metals, combustion products, or microorganisms such as protozoa, bacteria, virus, fungi, and pollen, that can cause different kinds of illnesses. When particles are inhaled they are not always expelled by the body's defense systems, thus causing problems in the respiratory system.

Particulate matter contamination can cause, in the short and long-term, a reduction in lung function, which contributes to the incidence of respiratory illnesses and premature death.

Exposure to PM10 has generated a great deal of concern during the last several years, because more studies have been published that reveal a significant link between PM concentration in ambient air, and mortality and morbidity. Consistently, many studies have revealed a 3% increase in daily mortality for every 10 $\mu g/m^3$ of PM10 above the standard. The most significant link appears to be with cardiopulmonary and lung cancer. Of special concern is the fact that there does not appear to be a minimum concentration at which adverse health effects become undetected.

The link between mortality and air pollution tends to be stronger when PM2.5, also known as fine particles or breathable fraction particles, is used for comparison purposes. These particles penetrate deeper into the respiratory system and thus are more damaging to human health. Because of their size (light wavelength location), they interfere with light dispersion contributing to poor visibility. Approximately 40% of these particles become embedded in the bronchi and alveoli, causing acute respiratory symptoms, including severe pain and coughing. PM2.5 can be directly emitted into the atmosphere or it can form in the atmosphere through photochemical reactions and physical processes.

Lead (Pb)

Lead is not only naturally discharged into the environment, (i.e., through soil erosion and volcanic eruptions), but also through anthropogenic processes. In the latter case, it occurs during the extraction, smelting and refining of non-ferrous minerals, and fossil fuel combustion. The latter is the main source of emissions into the atmosphere, since an increase in the concentration of lead in the atmosphere is largely due to the introduction of lead organic compounds, such as gasoline additives. In Mexico, at the end of 1997, leaded gasoline sales were discontinued.

Lead generated by motor vehicle fuels is associated with particles less than 1 μm in diameter. These particles can easily reach the inner portion of the lungs, where lead is introduced into the blood stream. Once in the blood stream, lead invades all the body tissues and organs, becoming embedded in the bones, liver, cerebral cortex and kidneys, as well as the brain and fatty tissue. The main human body systems that are affected by lead poisoning include the hematopoietic system, renal system, central nervous system, and the peripheral nervous system.

Symptoms of chronic intoxication become evident through the absorption of oxides, carbonates and other soluble compounds in water through the digestive tract. There is evidence to support the fact that children with high lead concentrations in their blood stream show restricted mental development and a higher incidence of behavioral problems. These effects are attributed to the irreversible inhibition in the development of the nervous system. Acute intoxication is usually caused by the inhalation of lead tetraethyl, which is highly volatile and lyposoluble. Symptoms of acute intoxication may include diarrhea, colic, nausea, vomiting, weariness, sleeplessness, convulsions and headaches (California Air Resources Board, 1983).[3]

Airborne lead is very important because it is a source of exposure through inhalation for living organisms. Like other pollutants, it is transported by the wind to other regions, and is deposited in the soil, water and vegetation.

Hydrocarbons (HC)

Hydrocarbons are chemical compounds that contain carbon and hydrogen in their chemical structure. Many gasoline components and petroleum byproducts are hydrocarbons. These react with nitrogen oxides, through photochemical reactions, to form peroxiacetyl and ozone, among other compounds.

Some types of hydrocarbons are toxic, others are not, and many of them do not have a significant potential to cause adverse health effects. However, since they contribute to ozone formation, they are considered important pollutants.

Aromatic hydrocarbons are potential carcinogenic agents. Some studies indicate that these hydrocarbons are formed during the incomplete combustion of almost any organic material, including fat, meat, coffee, sugar, rubber, and cigarette smoke.

[3] California Air Resources Board (1983). "How Air Pollution Demages Health".

Anthropogenic sources of hydrocarbons may vary widely. The transportation industry is responsible for a large part of these emissions, whereas fuel consumption by stationary sources occupies a secondary position. Finally, we find different processes such as agricultural practices and garbage dumps, which also contribute to the generation of these pollutants.

Transportation is considered the major source of hydrocarbon emissions into the atmosphere, due to the incomplete combustion in motor vehicle engines. Likewise, evaporative emissions during the loading and unloading of fuel at gas stations or in large storage containers also contribute to the emissions of hydrocarbons into the atmosphere.

Hydrocarbons include volatile organic compounds (VOCs) such as benzene, xylene, toluene, ethylbenzene, propane, and aldehydes, among others, which are important precursors to the formation of ozone and other oxidants. Volatile organic compounds are of special concern due to their high toxicity in humans. Mexico lacks a continuous, widespread air quality program for VOCs, and it has not established an air quality standard for these pollutants. In the United States, even though VOC measurements are taken in different cities, these do not constitute by themselves an air quality parameter, due to the diversity of species, toxic properties and high reactivity. Even though there are some difficulties in establishing standards for VOCs, some of these toxic pollutants such as benzene, formaldehyde, acetaldehyde, and 1,3-butadiene should be periodically analyzed to identify and prevent potential environmental health problems.

Carbon monoxide (CO)

Carbon monoxide is a colorless, flavorless and odorless gas, which is chemically inert under normal conditions. Carbon monoxide is not harmful in low concentrations. However, when present in concentrations exceeding the standard, this pollutant can seriously affect the metabolism of the respiratory system, due to the high affinity of hemoglobin toward this compound.

CO emissions in an enclosed area can cause death through cardiac arrest or asphyxiation. This is because CO absorption increases with its concentration in the environment, an increase in the time of exposure, and an increase in physical activity. Exposure to low levels of CO can also cause health damage when individuals are taking medications, consume alcoholic beverages or live at high elevations.

Some studies show that CO concentrations found in micro-environments, such as sidewalks that are adjacent to streets that carry large volumes of traffic, or inside vehicles, are much greater than those found at fixed, continuous monitoring stations. This means that even though the standard is not exceeded at those stations, there can be a considerable number of individuals exposed to hazardous levels of this pollutant. This was supported by two intensive studies conducted by the US Environmental Protection Agency, in Denver and Washington, D.C. (Akland *et al*, 1985).[4]

Sulfur oxides (SOx)

Sulfur dioxide (SO_2) is a colorless, non-flammable and non-explosive gas, with a very strong odor, and is highly soluble in water. It can remain in the atmosphere from 2 to 4 days. During this time it can be transported for thousands of kilometers forming sulfuric acid, which then precipitates as acid rain in another region, distant from its source.

Sulfuric acid, sulfur dioxide, and sulfate salts irritate the mucous membrane and the respiratory tract. They can even cause chronic illnesses of the respiratory system, such as bronchitis and emphysema.

The harmful effect of sulfur oxides increases in an environment where there is a high concentration of suspended particles. Sulfur dioxide and sulfuric acid paralyze the cilia of the respiratory tract, allowing dust particles containing sulfur compounds to penetrate the lungs. This may cause serious harm and even death. It has been confirmed that the acid component of particulate matter was involved in the mortality episodes of the 1940s and 50s in London, England.

In plants, SO_2 causes irreversible tissue damage, especially during sunny days. On the other hand, sulfuric acid attacks building materials such as marble, quarry, lime, and mortar. A large number of monuments, buildings, sculptures, and churches have deteriorated because of this. Sulfuric acid also damages fabrics such as cotton, linen, rayon, and nylon. Libraries also have a problem with this compound, since it makes paper turn yellow. The same compound causes leather items to dry up and metals to corrode.

Fossil fuels containing sulfur are the main source of sulfuric oxide emissions. Therefore, fixed sources that consume fuel with a high sulfur content are the main cause of sulfur emissions into the atmosphere.

Air pollution has global and regional effects; it is not only restricted to large cities. Acid rain is an example of this. Acid rain originates when sulfur oxide and nitrogen oxide emissions react with water vapor; with the help of solar light they turn into sulfuric acid and nitric acid. These compounds are deposited on the earth's surface as aerosols and particles (dry deposition) or as rain, hail and dew (wet deposition). Pollutants can be emitted from one point and remain there for days, until the wind

[4] Akland, G.G.; Hartwell, T.D.; Johnson, T.R.; Whitmore, R.W. (1985). "Measuring human exposure to carbon monoxide in Washington, D.C., and Denver, Colorado, during the winter of 1982-1983". Environ. Sci. Technol. 19: 911-918.

carries them for a long distance, and then fall in areas that can be impacted according to the sensitivity of the ecosystem.

Nitrogen oxides (NOx)

Nitrogen forms seven different types of oxides, two of which, nitric oxide (NO) and nitrogen dioxide (NO_2), are important air pollutants. NOx are formed during combustion and are the product of atmospheric nitrogen oxidation or the oxidation of organic oxygen from fuel. In the first case, NOx formation is enhanced as temperature rises. As a result of this, NO and NO_2 production is also a function of the air/fuel ratio in the mixture. Nitrogen dioxide can form nitric or nitrous acid with the presence of water. Both can be precipitated with rain or combine with ammonia in the atmosphere to form ammonium nitrate.

Nitric oxide, like carbon monoxide, can mix with hemoglobin in the bloodstream reducing its capacity to transport oxygen.

Nitrogen oxide irritates the alveoli. Occupational health studies show that this gas can be fatal in high concentrations. Unlike ozone, NO_2 can be more abundant indoors than outdoors. This is due to the fact that one of the sources of this contaminant is LP gas as well as industrial burners and ovens that use the same type of fuel.

Nitrogen oxides, along with hydrocarbons, generate secondary type pollutants known as photochemical pollution, whose main component is ozone (O_3). Nitrogen oxides are mainly produced by industrial fuel transport and consumption, as well as power generation.

Benzene

Benzene is a compound that has been classified by the International Agency for Cancer Research as a Group 1 carcinogen, meaning that there is sufficient scientific evidence to prove a positive relationship between exposure to that toxic compound and developing cancer. More specifically, it has been found that workers who are exposed to benzene have a greater probability of developing acute leukemia than the general population. Likewise, it is known that benzene has hematological and immunological effects, as well as effects on the nervous system.

Environmental exposure studies conducted in Los Angeles, revealed that the main source of exposure to benzene are cigarettes (39%), and the main source of benzene in the atmosphere are motor vehicle emissions (82%), and the loss of hydrocarbon vapors while driving, and while distributing, storing and dispensing gasoline. Even though gasoline sold in Mexico has a relatively low benzene content (less than 2% in the metropolitan zones), its toxicity and the large volume of gasoline consumption make it necessary to install monitoring stations and conduct exposure studies. These studies can help develop a human health risk assessment to reveal the percentage of the population in the Tijuana-Rosarito airshed that is exposed to high concentrations of this hydrocarbon.

Formaldehyde

Formaldehyde can be emitted by motor vehicles or be produced by photochemical reactions in the atmosphere. Formaldehyde emissions generated by vehicles are increased with the use of oxygenated gasoline.

The fact that formaldehyde causes eye, nose and throat irritation, as well as coughing, nausea, and other respiratory symptoms has been well documented. Formaldehyde has been associated with lung and nasopharyngeal cancer mainly in individuals that work in the environmental field. Exposure to formaldehyde must be reduced not only because of its carcinogenic effect, but also because of its potential effect for causing tissue damage. Some recent epidemiological studies on formaldehyde suggest that the threshold for damage to the tissue is 1.0 Fg/m^3; however, it is difficult to make a formal risk assessment of its carcinogenic effect due to the limited amount of data currently available (Wark and Warner, 1994).[5]

Polycyclic Aromatic Hydrocarbons (PAH)

PAHs are a group of chemical compounds formed during the incomplete combustion of wood and other fossil fuels. Concentrations of these compounds can be fairly high in the emissions from diesel-fueled vehicles. One of the best known PAHs is benzo-α-pyrene. These compounds can be absorbed in the intestines and the lungs.

There is sufficient experimental evidence to suggest that PAHs are mutagenic and carcinogenic. Specific studies indicate that those individuals who are exposed to PAHs in the work environment are at a greater risk of developing cancer. More specifically, it has been found that truck drivers and messengers are at a greater risk of developing bladder cancer (Wark and Warner*,* 1994).[5]

[5] Wark, K. y Warner, C. (1994). Contaminación del Aire, Origen y Control. Limusa Noriega Editores, México D.F.

ANNEX D. SUMMARY OF THE CALCULATION OF EMISSIONS REDUCTIONS, INVESTMENTS AND COSTS

The following is a summary of the calculations that were performed to determine emission reductions, as well as the cost and investment necessary to achieve those reductions. Estimates are presented only for those control measures where these parameters could be quantified. The number associated with each measure is the same number used in Chapter Six.

I. INDUSTRY, COMMERCE AND SERVICES

1. Regulate emissions in potentially polluting companies through the issuance of environmental licenses, permits and authorizations.

Emissions:

There are 19 companies that consume heavy industrial fuel (combustóleo), which can incorporate certain reductions by using a different fuel or control equipment. The emissions generated by these companies amount to 1,442 ton/year of SO_2.

In order to reduce emissions in these facilities, the use of emissions control equipment such as gas cleaners, is recommended. These can reduce sulfur dioxide emissions by at least 50%. Thus the following emissions reduction would be achieved:

SO_2 Reduction: 1,442– 721 = 721 ton/year

Costs: This action took into account a cost of US$1,400/ton of sulfur dioxide emissions reduction.

2. Implement a vapor recovery program at storage terminals and gas stations.

Emissions: Currently, 2,482 tons/year of TOG are generated. A 90% reduction in emissions of this type is expected through the installation of vapor recovery equipment at 83 service stations.

TOG Reduction = 2,482 ton/ year x 0.90 =2,238 tons/year.

Costs: A cost of US$30,000 per station is assumed for vapor recovery.

II. URBAN AND TRANSPORTATION MANAGEMENT

1. Start the Vehicle Emissions Program in the Municipality of Tijuana.

Emissions: Studies conducted in the ZMVM reveal that, when vehicles that are found in the worst possible operating conditions receive a complete tune-up (change of spark plugs, check carburetor, check timing, check spark plug cables, change filters, etc.), an approximate 30% emissions reduction is achieved for PM10, CO, NOx, and HCs, in gasoline-fueled vehicles. If we assume a 50% compliance with the vehicle emissions testing program, we arrive at the reductions shown in Tables D.1 through D.4. Likewise, if we assume the same rate of compliance for diesel vehicles, considering a 30% emissions reduction for all pollutants, the resulting reductions are those shown in Tables D.5 through D.8.

Table D.1. PM10 reductions for gasoline-fueled vehicles

Vehicle type	**PM10 Emissions (tons/year)**	**Applicable PM10 Emissions**	**% reduction**	**Reduction (tons/year)**
Private cars	84	42	30	13
Taxi cabs	24	12	30	4
Pick-up trucks	68	34	30	10
Passenger trucks	2	1	30	1
Light-duty freight trucks	2	1	30	1
Total	**180**	**90**		**29**

Table D.2. CO reductions for gasoline-fueled vehicles

Vehicle type	**CO Emissions (tons/year)**	**Applicable CO Emissions**	**% reduction**	**Reduction (tons/year)**
Private cars	130,638	65,319	30	19,596
Taxi cabs	38,142	19,071	30	5,721
Pick-up trucks	99,064	49,532	30	14,860
Passenger trucks	3,645	1,822	30	547
Light-duty freight trucks	3633	1,816	30	545
Total	**275,122**	**137,560**		**41,269**

Table D.3. TOG reductions for gasoline-fueled vehicles

Vehicle type	**TOG Emissions (tons/year)**	**Applicable TOG Emissions**	**% reduction**	**Reduction (tons/year)**
Private cars	16,431	8,215	30	2,465
Taxi cabs	2,053	1,026	30	308
Pick-up trucks	13,092	6,546	30	1,964
Passenger trucks	429	214	30	64
Light-duty freight trucks	431	215	30	65
Total	**32,436**	**16,216**		**4,866**

Table D.4. NOx reductions for gasoline-fueled vehicles

Vehicle type	**NOx Emissions (tons/year)**	**Applicable NOx Emissions**	**% reduction**	**Reduction (tons/year)**
Private cars	7,037	3,518	30	1,055

Taxi cabs	2,053	1,026	30	308
Pick-up trucks	5,394	2,697	30	809
Passenger trucks	249	124	30	37
Light-duty freight trucks	241	120	30	36
Total	**14,974**	**7,485**		**2,245**

Table D.5. PM10 Reductions for diesel vehicles

Vehicle type	**PM10 Emissions (tons/year)**	**Applicable PM10 Emissions**	**% reduction**	**Reduction (tons/year)**
Passenger trucks	390	195	30	59
Freight trucks	642	321	30	96
Total	**1032**	**516**		**155**

Table D.6. CO reductions for diesel vehicles

Vehicle type	**CO Emissions (tons/year)**	**Applicable CO Emissions**	**% reduction**	**Reduction (tons/year)**
Diesel-fueled passenger trucks	2,149	1,074	30	322
Diesel-fueled freight trucks	3,602	1,801	30	540
Total	**5,751**	**2,875**		**862**

Table D.7. TOG Reductions for diesel vehicles

Vehicle type	**TOG Emissions (tons/year)**	**Applicable TOG Emissions**	**% reduction**	**Reduction (tons/year)**
Diesel-fueled passenger trucks	521	260	30	78
Diesel-fueled freight trucks	870	435	30	131
Total	**1391**	**695**		**209**

Table D.8. NOx Reductions for diesel vehicles

Vehicle type	**NOx Emissions (tons/year)**	**Applicable NOx Emissions**	**% reduction**	**Reduction (tons/year)**
Diesel-fueled passenger trucks	3,191	1,595	30	479
Diesel-fueled freight trucks	5,297	2,648	30	794
Total	**8,488**	**4,243**		**1,273**

Costs: It was considered that 181,011 gasoline-fueled vehicles and 5,966 diesel-fueled vehicles underwent emissions testing. For gasoline-fueled vehicles it was assumed that all of them have a carburetor and require a lesser tune-up, with an average cost of US$100 per unit. For diesel- fueled vehicles a US$800 tune-up cost per unit was considered. The estimated cost includes the emissions testing cost.

4. Study different alternatives for mass transportation and for the renewal of the vehicular fleet.

Emissions: Passenger public transportation vehicles emit a total of 10,605 tons/year of pollutants, whereas freight public transportation vehicles emit a total of 14,770 tons/year. In order to calculate emissions reductions, we assumed the renewal of at least 30% of these vehicles, resulting in 3,353 freight vehicles and 1,089 passenger vehicles, which would take place during the next 5 years. The emissions generated by each vehicle type, according to the emissions inventory, were taken as the basis for these calculations:

Table D.9. Emissions generated by passenger and freight public transportation vehicles

Vehicle Type	**Pollutants (tons/year)**				
	PM10	**SO_2**	**TOG**	**CO**	**NOx**
Gasoline-fueled buses	2	9	429	3,645	249
Diesel-fueled buses	390	26	521	2,142	3,191
Gasoline-fueled freight trucks	2	9	431	3,633	241
Diesel-fueled freight trucks	642	43	870	3,602	5,297

A 30% reduction was applied to the previous emissions. This reduction helps us obtain the numbers presented in Table D.10.

Table D.10. Emissions reduction in passenger and freight public transportation vehicles

Vehicle Type	**Pollutants (tons/year)**				
	PM10	**SO_2**	**TOG**	**CO**	**NOx**
Gasoline-fueled buses	0.6	3	129	1,094	75
Diesel-fueled buses	117	8	156	643	957
Gasoline-fueled freight trucks	0.6	3	129	1.090	72
Diesel-fueled freight trucks	193	13	129	1,081	1,589
Total reductions	**311.2**	**27**	**543**	**3,908**	**2,693**

Costs: The estimated cost of this measure is US$167 million, considering a cost of US$30,000 to renew each passenger vehicle and US$40,000 to renew each freight truck.

III. ECOLOGICAL RECOVERY

1. Prompt a change in the type of fuel used at the Federal Electric Power Commissions (CFE).

Emissions: This control measure consists of changing 50% of the fuel used at the Federal Electric Commission's (CFEs) power plant. Currently, the plant uses industrial fuel oil (combustóleo) with 2% sulfur content by weight. We are aiming at reducing the use of this fuel by 50%, replacing it with natural gas.

Combustóleo emissions consist of 1,043 tons/year of PM10, 21,267 tons/year of SO_2, 339 tons/year of CO, 3,099 tons/year of NOx and 70 tons/year of TOG. Emissions reductions resulting from the combined use of combustóleo and natural gas are as follows:

- PM10 Reduction: 1,043-525 = 520 tons/year
- SO_2 Reduction 21,267-10,633 = 10,634 tons/year
- NOx Reduction 3,099-1,649 = 1,450 tons/year.
- CO Reduction 339-194 = 145 tons/year
- TOG Reduction 70-39 = 31 tons/year

Costs: costs were not calculated.

2. Develop a municipal program and regulation on reforestation and follow-up of the paving programs.

Three actions can be undertaken in order to reduce particulate matter (PM10) emissions generated by soils:

Reforestation creating windbreak barriers in the peripheral zone of the city and preservation of wooded areas

Emissions: PM10 emissions generated by the wind in open-space areas with eroded soil amount to 1,273 tons/year. Considering that there are 40,000 hectares of barren areas in the City of Tijuana and Rosarito, and considering that only 20% of this area will be reforested, PM10 emissions can be reduced by 254 tons/year.

Costs: An estimated cost of $US1,000 per forested hectare.

Application of soil stabilizers for PM10 emissions control in unpaved roads and barren areas

Emissions: In order to calculate emissions reduction through soil stabilization in unpaved roads, we used a vehicular traffic emissions contribution of 17,860 tons/year in unpaved roads. Also, it was considered that the soil in 20% (200 hectares) of the unpaved roads would be stabilized, resulting in 90% emissions reduction in those areas. Therefore, total emission from unpaved roads would be reduced by 18%, or 3,186 tons/year of particulate matter (PM10.)

Costs: A cost of US$1,500 per ton of PM10 reduction was estimated.

Intensify a road paving program

Emissions: It was considered that there are 797 hectares of unpaved surface area in Mexicali and that vehicular traffic accounts for 17,860 tons/year of PM10 emissions. If the emissions reduction achieved from soil stabilization (3,186 tons/year) is subtracted from this number, we are left with 14,674 ton/year of PM10 emissions. This implies that paving 20% of the streets will reduce PM10 emissions by 2,935 ton/year.

Costs: An estimated cost of $US 5,000 per ton of particulate matter emissions reduction through paving was calculated.

Table D.11. Summary of emissions reductions and costs associated with some of the Program's measures

Action	Tons/year of pollutant reduction					Cost in Millions of Dollars
	PM10	SO_2	CO	NOx	TOG	
Regulate emissions in potentially polluting companies through the issuance of environmental licenses, permits and authorizations.	NE	721	NE	NE	NE	1.0
Implement a vapor recovery program at storage terminals and gas stations.	NA	NA	NA	NA	2,238	2.5
Start the vehicle emissions program in the municipality of Tijuana	184	NA	42,131	3,515	2,173	6.6
Study different alternatives for mass transportation and for the renewal of the vehicular fleet	311	27	3,908	2,693	543	167
Prompt a change in the type of fuel used at the Federal Electric Power Commissions (CFE)	520	10,634	145	1,450	31	NE
Development of a municipal program and regulation on reforestation and follow-up of the paving programs	6,375	NA	NA	NA	NA	19.7
Total	**7,390**	**11,382**	**46,184**	**7,658**	**4,985**	**198.8**
Percent reduction with respect to total emissions	**25**	**38**	**15**	**27**	**6**	

ANNEX E. TECHNICAL LINEAMENTS OF A VEHICULAR EMISSIONS TESTING PROGRAM

E.1. Introduction

Information collected through Tijuana-Rosarito's air quality monitoring network indicates that the air quality standards for nitrogen dioxide (NO_2), ozone (O_3), and particulate matter less than 10 microns in diameter have been exceeded in recent years. Furthermore, it is a known fact that the main pollutants emitted by internal combustion engines are: CO, NOx, HC, SOx, carbon particles and heavy metals, such as lead when gasoline contains lead compound-based additives. Some pollutants such as NOx and HC, are precursors of photochemical oxidants such as O_3. The vehicular fleet in Tijuana-Rosarito consists of approximately 370 thousand vehicles, with estimated daily emissions of 666 tons of CO, 100 tons of total organic gases and 60 tons of NOx. This is the equivalent of approximately 340 thousand tons of annual pollutant emissions, representing 78% of all atmospheric emissions in Tijuana-Rosarito.

Likewise, there are other factors that contribute to vehicular emissions such as: the use of inadequate fuels, the number of vehicles in circulation, inefficient vehicle maintenance, tampered emissions control systems, and inefficient or insufficient public transportation, among others.

Based on this information, we can assert that motor vehicles in Tijuana-Rosarito represent one of the main sources of air quality degradation, thus making it necessary to promote control measures that lead to a decrease in vehicular emissions.

In Mexico, there has been progress as far as controlling the most important atmospheric pollutants in urban areas. Currently, there are 30 Official Mexican Standards, related to industrial and vehicular atmospheric pollution control.

Motor vehicles play an important role in the degradation of air quality, particularly when the concentration of certain pollutants exceeds a particular standard. Some of these standards establish maximum permissible levels for air pollutants emitted by vehicular exhaust, as well as the procedure for certifying the emission levels of air pollutants, commonly known as vehicle emissions testing. This consists of measuring vehicle emissions with gas analyzers.

The following is an outline of the legal aspects that can be used as the basis for implementing a vehicle emissions testing program in Tijuana-Rosarito, and an illustration of a series of technical elements that this program might take into account. This information was adapted from the Air Quality Management Program for Ciudad Juárez, which shares several characteristics with Tijuana-Rosarito as far as the condition of its vehicular fleet. However, the time has come for local and state government authorities to clearly define the emissions testing program.

E.2. Legal basis for vehicle emissions testing

The Political Constitution of the United Mexican States establishes in Article 4 a person's right to health protection and requires assurance of a satisfactory air quality for the well being of the population and ecological balance.

At a national level, the legal framework for air quality management is the General Law of Ecological Balance and Environmental Protection (LEGEEPA), with its accompanying Air Pollution Prevention and Control Regulation.

On February 29, 1992 the Ecological Law and Regulation for the State of Baja California came into effect. The contents of this document are in accordance with those of LEGEEPA. In Title Two, Chapter I, Section V, Article 19, of this State Law, the following are listed as the City Councils' responsibilities:

XI. Establish and operate emissions testing systems to comply with the technical ecological standards of maximum permissible emissions of pollutants into the atmosphere, by sources that fall under municipal jurisdiction.

XII. Apply the appropriate transit and roadway measures to keep motor vehicle emissions into the atmosphere from exceeding the maximum permissible levels determined by the applicable regulations and technical ecological standards.

XIII. Set measures for retiring motor vehicles that exceed the maximum permissible levels of emissions into the atmosphere, established by the applicable regulations and technical ecological standards.

The following is mentioned in Title Five under Environmental Protection, Chapter I, dealing with atmospheric pollution prevention and control:

Article 136. Motor vehicles that emit visible gases, smoke or dust, or whose air pollutant emission levels exceed the maximum permissible levels established under the technical ecological standards, will not be allowed to circulate.

Article 137. Car dealers must obtain proof of compliance with emissions testing prior to the sale of motor vehicles. The sale of any motor vehicle will be subject to any administrative penalties on the part of the competent municipal traffic and transportation authorities.

Article 138. The municipalities must show the administrative ability to:

I. Establish or grant the rights to establish vehicle emissions testing facilities, in such fashion that the number of these facilities is enough to readily test and monitor the performance of all registered motor vehicles currently in circulation.

II. Establish and control a quick mechanism for testing the emissions of vehicles currently owned by car dealers.

III. Develop a regulation describing the procedure for issuing emissions testing vouchers to vehicles owned by car dealers.

Article 139. Traffic and transportation authorities will require that the owner or person in possession of a motor vehicle show the vehicle emissions testing voucher prior to obtaining license plates and all other required documentation for that vehicle.

Article 140. It is the responsibility of the owner or person in possession of a motor vehicle to maintain that vehicle in good working condition, to ensure that the emissions of carbon monoxide, other gases, smoke and particulate matter, fall within the established technical ecological standards. Non-compliance with the above requirements, under any circumstances, will result in penalties to be determined by the appropriate traffic and transportation authorities.

Article 141. Owners or individuals in possession of any motor vehicle, public or private, have the responsibility of passing the emissions test once a year, with the purpose of controlling those emissions and determining all the appropriate repairs as necessary. Such testing must be done at one of the authorized facilities as determined by the local governments.

Article 142. Owners and individuals in possession of public transportation vehicles, or other vehicles used for commercial purposes, must have the emissions of those vehicles tested with the frequency established in the regulations issued by the local governments for that purpose. Such frequency must not exceed six months. Non-compliance with the above requirements will result in penalties, as established by the local competent traffic and transportation authorities.

The environmental protection regulation for the Municipality of Mexicali, Baja California, published on December 8, 1997, assigns the following responsibilities to the municipality on issues related to motor vehicle pollution prevention and control:

a) Joint participation with the State Government in formulating the regulations and programs that set the basis for conducting vehicle emissions tests in municipal jurisdiction;
b) Apply the standards related to atmospheric vehicular emissions prevention and control, not considered to fall under federal jurisdiction;
c) Establish the basis for operating vehicle emissions testing facilities, as well as to control and oversee the operation of those facilities;
d) Authorize those who comply with the requirements from the Ministry of the Environment, Natural Resources and Fisheries (SEMARNAP) and other competent authorities, to provide vehicle emissions testing services; inspect and oversee compliance with the conditions of such authorization; and, when necessary, revoke that authorization.
e) Propose to the City Council measures for retiring motor vehicles that exceed the maximum permissible limits established by the applicable regulations and standards. Also, join the Municipal Department of Public Safety in enforcing the measures that have been approved for this purpose;
f) Collaborate with the competent municipal authorities in establishing traffic flow and roadway design criteria and lineaments that will be conducive to a reduction in motor vehicle emissions.

The following conditions, among others, must be agreed upon with the Municipal Department of Public Safety and the State Finance Ministry:

- Any vehicle circulating in State public roadways must have a license plate, circulation card, vouchers and/or stickers, as proof of registration and compliance with the applicable environmental requirements.

- Show proof of compliance with vehicle emissions test.

E.3. Elements of a vehicular emissions testing program

Objectives

- Achieve the required compliance with Mexican Official Standards by limiting the emission of air pollutants for vehicles currently in circulation.
- Promote the appropriate maintenance of engines and emissions control systems in the vehicular fleet of the municipalities of Tijuana and Rosarito; and
- Incorporate permanent actions for public involvement in the Vehicle Emissions Testing Program.

Goals

- In the short term, establish an Emissions Testing Program and achieve compliance from the entire community;
- Abate the levels of HC and CO from vehicular emissions.

Testing location and frequency

Testing will be performed at facilities authorized by the Municipal Ecology Department or at the emissions testing center owned by the Municipal Government. These facilities will be located according to the needs of the population. The frequency of testing will be once a year.

Testing centers

The purpose of these centers or facilities is to officially certify the emissions levels of motor vehicles. This is achieved by using a gas analyzer for vehicular exhaust.

The technical staff will perform a visual inspection of the different devices in the vehicle, in order to determine the potential source of problems in the test results. This is done because maintenance, both of the engine as well as the emissions control system, plays an important role in the test results.

Comparison of test results is made against the parameters established under the Official Mexican Standard for maximum permissible levels of vehicular pollutants.

Infrastructure and equipment

A vehicle emissions testing facility must comply with a series of requirements, determined in accordance with technical and functional criteria:

- The minimum surface area for installing a vehicle emissions testing center will be 300 square meters and it will be used exclusively for vehicle emissions testing;
- Display the logos of both the Direction of Ecology as well as the Vehicle Emissions Testing Program in a visible billboard. The number that was assigned to the facility by the Direction of Ecology should appear next to these logos, along with Official Mexican Standard NOM-041-ECOL-1999 that establishes the maximum permissible limits, the devices to be inspected, and the total, official service fee;
- The testing center must be equipped with the following public service areas:

  a.- Vehicle reception and visual inspection area b.- Measurement and analysis area

c.- Payment area

d.- Restroom and public service area.

- The area to be used for testing and diagnostics will have a total of 30 m² for each piece of equipment used at the center. This is based on the minimum surface area required for handling any vehicle. This area cannot be used for any other purpose;
- Access to testing or diagnostic areas will be exclusively for this purpose.
- The decision to approve the proposed facility will be based on pictures of the proposed facility and its corresponding plan. The plan must indicate the area that will be occupied by the emissions testing center, the public reception office, restroom, parking area, access to the facilities from the road, as well as the surrounding structures and nearby streets.
- The facility must be equipped with gas analyzers to determine the concentration of hydrocarbons, carbon monoxide, carbon dioxide and oxygen in the exhaust gases of the vehicle, set at 90 bars and authorized by the Municipal Department of Ecology.
- This equipment must have a total measuring scale between 0 and 10% by volume, for carbon monoxide; 0 a 2000 ppm, for hydrocarbons; 0 to 16% by volume, for carbon dioxide; and 0 to 22% by volume, for oxygen.
- The analyzer must be designed to handle continuous heavy work for a minimum period of 8 hours per day.

Procedure for establishing an emissions testing center

A request to create a vehicle emissions testing center must comply with the following requirements:

a) The format of the request to establish a vehicle emissions testing center can be obtained from the Municipal Department of Ecology;
b) Once the request has been received, the Department of Ecology will develop the appropriate response, determining whether or not the facility will be authorized.

The owners of the vehicle emissions testing and diagnostic facilities must submit a copy of all the requested documents to the Department of Ecology, as well as the agreement reached with the City Council, which will be valid for two years. This agreement may be renewed.

Only the owners of the vehicle emissions testing centers, or authorized staff carrying a notarized letter, can apply for renewal of the agreement before the

Municipal government. The Department of Ecology must have knowledge of this request.

The number of devices to be used in the vehicle emissions testing center will be included in the request, along with the brand, serial number, and other technical information regarding the equipment.

The authorization to renew the agreement granted by the Department of Ecology to the emissions testing and diagnostic centers, can only be transferred to another individual if that individual complies with all the established requirements.

Technical staff

All vehicle emissions testing centers must have qualified technical staff to operate the testing equipment and follow the proper procedures. For this reason, all technical staff must obtain a certificate of accreditation, asserting that they have received the proper training for handling the emissions testing equipment.

It is the facility owner's responsibility to provide technical training to all staff in charge of operating the testing equipment, as well as making sure that their accreditation is kept current.

The Municipal Department of Ecology will request all emissions testing centers to submit the proper documentation for authorized personnel, reserving the rights to make this request as often as it deems it necessary. This is done with the objective of verifying the certification and validity of the training received by all the staff hired to provide this service.

The certificates or vouchers of accreditation for all the emissions testing technicians must always be displayed in plain view, must not have any erasures or amendments, and can be issued by any official educational institution in the country, or by any technical school in Tijuana-Rosarito.

Emissions measurement procedure

The authorized vehicle emissions testing centers must have signs indicating the current vehicle emissions standards, in accordance with NOM-047 (reproduced in Annex H), considering the dimensions indicated in previous paragraphs. Visibly polluting vehicles cannot be tested.

The information about the vehicle and its owner must be recorded. All information will be entered into a database, which will be requested and compiled by staff from the Department of Ecology.

The hours of operation for all vehicle emissions testing centers must cover a 10-hour period per day, from Monday through Saturday. This schedule can be modified only with prior approval from the Municipal Department of Ecology.

Testing method

The static test will be the method of choice for this mandatory program. It will apply to all vehicles that are powered by gasoline, liquefied petroleum gas, natural gas, or other alternate fuels (NOM-047-ECOL-1993).

The static test consists of three stages: a visual smoke inspection, a cruise-speed test, and a slow-speed idle test.

For the visual smoke inspection the tachometer of the testing equipment is connected to the ignition system of the vehicle. The engine is run at 2,500 $\pm$ 250 revolutions per minute. If black or blue smoke emissions are observed, and if these emissions remain for more than 10 seconds, the test must be stopped. In this case, the maximum permissible limits established by the corresponding Official Mexican Standard are exceeded.

For the cruise-speed test, a probe is placed in the tailpipe, making sure that it is perfectly secured. The engine is run at 2,500 $\pm$ 250 revolutions per minute, for at least 30 seconds.

For the slow-speed idle test, the engine is decelerated to the speed specified by the manufacturer, which will not exceed 1,100 revolutions per minute during a period of at least 30 seconds.

Visual inspection of the vehicle prior to the test

The conditions that must be met by the vehicle in order to undergo the testing procedure specified by the Official Mexican Standard are the following:

- The technician performing the test must inspect the manufacturer installed emissions components and design elements to ensure compliance with the applicable emissions control standards, making sure that these components have not been:

  a) Removed from the emissions control system of the vehicle
  b) Tampered to keep the emissions control system from working properly
  c) Replaced with a component that was not sold by the manufacturer for this purpose
  d) Replaced with a component that does not have the ability of being connected to other emissions control components
  e) Disconnected, even though the element is present and mounted correctly in the vehicle.

- The technician must ensure that the tailpipe of the vehicle is in perfect operating condition and that it does not have any other exits in addition to the one from the original design, which may cause dilution of exhaust gases or a leak of those gases.

- The visual inspection will be aimed at the following devices:

  a) Tailpipe (not defective, not noisy, not perforated)
  b) Air filter
  c) Gasoline tank cap
  d) Oil tank (cap and level rod)
  e) Carburetor (free of gasoline leaks and spills)
  f) Thermometer with normal operating temperature
  g) Vacuum hoses connected and in good working condition
  h) Engine water hoses in good condition
  i) Cables in good condition
  j) Activated carbon filter
  k) Housing ventilation
  m) Hot air admission system
  n) PCV valve
  o) EGR valve.

For vehicles equipped with double exhaust systems, the test must be done on each of those systems. The result will be the average of the readings recorded for each exhaust system.

The testing equipment is to be handled exclusively by the assigned technician. The technician must operate this equipment in accordance with the instructions in the manufacturer's manual. The technician must calibrate the equipment according to the instructions and specifications included in this procedure, removing any foreign matter and/or water or moisture that may accumulate in the filters and probes.

Analysis of results

A vehicle passes emissions when none of the values recorded during the tests, at slow speed, idling, and at cruise speed, exceed the maximum permissible levels established by the corresponding Official Mexican Standard.

Based on these results, the technician will give a simple explanation to the user regarding the test results. If the vehicle fails the test, the driver will receive guidance on authorized diagnostic centers where he can be given a better explanation about the necessary adjustments and repairs, with the purpose of having the necessary improvements done within the period of time authorized for a second test.

Recommendations for users of the emissions testing service

The owner or driver taking a vehicle in for testing must:

- Present the circulation card, provisional circulation permit, or invoice letter;
- Present the vehicle in good working condition, with all additional equipment and accessories installed as specified by the manufacturer;
- Make sure that the test is conducted in compliance with official standards;
- Demand the emissions certificate and placement of the sticker in a visible location, in case the vehicle passes the test, keeping the voucher, since this will be required for the next emissions test.

Supervision of the operation and maintenance of emissions testing centers

For the purpose of supervision, the gas analyzing equipment must have an identification plate affixed to the outside of the unit, including: model, serial number, manufacturer name and address, electric power requirements, and voltage limits while operating the equipment.

The compilation of technical data from the testing and diagnostic equipment will be done on a monthly basis. The operators in charge of compiling this information will make an attempt to optimize time and effort.

During inspection visits, the work area and testing equipment will be inspected in the following manner:

- Probe, handle, and pipette: These components must not be altered, perforated, or cracked. The probe will undergo a leak test by closing the end of the pipette.
- In-line filters: their usage capacity must not allow more than 20 ppm with a flow of 7 cubic feet per hour.
- Tri-filter: this is the primary filter and the mesh filters, which must be completely clean. Furthermore, the container, the lids, and the cover must not have any leaks.
- Tongs and connection: the cables and connection to the card must not be patched or stuck together.
- Electrical installation: physical ground, voltage regulator and three-prong outlet.
- Keyboards: all the keys, including all characters, must be working correctly.
- Printing tape: legible and full lines.
- Microswitches: these must be in good condition, connected and working.

Calibration of the gas analyzer

The owner of the emissions testing center must calibrate the equipment with the frequency specified by the manufacturer. This calibration can be conducted using the test gas. The test gas must have a precision of $\pm$ 2% of the indicated concentration, guaranteed by the manufacturer.

The equipment must be calibrated to obtain the calibration curves as established by Mexican standards.

Vehicles that must be tested

Two types of facilities will be used for vehicle emissions testing:

- The first type will be exclusively dedicated to testing the emissions of public use vehicles, passenger or freight transportation vehicles, government vehicles, school buses and company vehicles used to transport employees, as well as gasoline and diesel-fueled vehicles destined for any type of service (municipal government owned testing center).
- The second type of emissions testing centers will be dedicated to all gasoline-fueled private vehicles, vehicles used by diplomatic and international organizations, motorcycles, and other vehicles not considered under the previous paragraph.

New vehicles of any type must be certified by the same distributing agency, before they are delivered and put in circulation.

Used imported and domestic vehicles that are for sale must have passed the vehicle emissions test. Imported vehicles in particular, must fully comply with the decree of Monday, February 21, 1994, published in the Official Federal Newspaper, in reference to the conditions for the importation of used motor vehicles that are destined to remain permanently within the Mexican northern border region.

The owner of the vehicle must have a document certifying that the vehicle to be imported complies with the technical requirements of maximum permissible pollution in its country of origin. In order to accomplish this, it is necessary for Tijuana Border Customs to oversee and comply with this requirement.

All car dealers, and service and repair shops, are prohibited from disconnecting or tampering with any emissions control devices.

Test fees and duties

The Municipal Department of Ecology will establish the fees. Those fees must be visibly displayed in all vehicle emissions testing stations.

In other Mexican States, the test fees for 1999 were the equivalent of three days pay at the minimum wage for the Federal District, plus tax; with the exception of federal testing centers, where the fee is the equivalent to five days pay at the current minimum wage, plus tax.

The owner of a vehicle that fails the first test will have the right to an additional test, free of charge, as long as the vehicle is brought back to the same facility where it failed the initial test.

When a vehicle fails the emissions test, the owner will have thirty days from the date of the initial test to have the vehicle re-tested and pass emissions. If the vehicle is not brought in for re-testing, or if it fails again, the owner will receive the applicable penalty.

Proof of testing

The ecological stickers and emissions testing certificates will serve as proof of compliance with the vehicle emissions test.

E.4. Proposal of strategies for the vehicle emissions testing program

The following strategies are presented as an example for achieving the objectives of the program. These strategies seek to include the shared responsibility of the parties involved.

Vehicle emissions testing program at maquiladoras and other large companies

The maquiladora industry and other large companies in Tijuana-Rosarito currently provide employment to more than 100,000 people. This is why it is so important to establish a coordinated proposal with the Maquiladora Association and other Industrial Associations, to implement the vehicle emissions testing program.

Every participating company will reach an agreement with the municipality, through the Department of Ecology, regarding its involvement in the required vehicle emissions testing program.

The important aspects to be considered for the involvement of each company in this program are the following:

a) Knowledge of the vehicular fleet operated by its employees, as well as those vehicles that are for official use of the company. This is done with the objective of determining the amount of time that will be required for the authorized emissions testing center to test the emissions of all the vehicles from a specific facility.
b) Companies involved in this program must establish their own calendar for the participation of their employees.
c) It is important for companies to consider the need for financial support or incentives that may be requested by their employees, in case their vehicles are in poor condition and require repairs related to their emissions control devices.

Only those vehicle emissions testing centers equipped with two or more testing bays can participate in this program. The participating facilities must inform the Department of Ecology, in writing, about the days and times when they will offer their services.

The measures to be considered will be decided jointly by the Department of Ecology, the company, and the Emissions Testing Centers' Association.

Mechanical education for car drivers

Another strategy is to release information through the media, about the importance of this program in improving vehicle maintenance and that of their emissions control devices, with the purpose of reducing air pollution levels derived from mobile sources.

This educational component of the program will address vehicle inspection and maintenance in detail, and will discourage the mutilation of emissions control devices. Car drivers will be warned about inspection operations to be conducted by the corresponding authorities, and will alert them about the purchase or sale of vehicles that lack emissions control devices, or are equipped with emissions control devices that are not in working condition. This strategy considers enlisting the services of an emissions control specialist to conduct outreach on this subject.

E.5. Authority and oversight

As mentioned in the initial paragraphs outlining this program, it is essential that the corresponding authorities, in this case the Department of Ecology and the Department of Public Safety, inspect and oversee compliance with the program requirements.

E.6. Resources for conducting outreach

The Department of Ecology will be in charge of conducting outreach efforts in support of the vehicle emissions testing program. Likewise, the Department of Ecology must have access to the different communications media: radio stations, printed information, and television stations.

ANNEX F. MEXICAN AIR QUALITY STANDARDS

The Air Pollution Prevention and Control Regulation, included in the “General Law of Ecological Balance and Environmental Protection”, points out in article 7, fraction IV that it is SEMARNAPs responsibility to set the standards “to be certified by the competent authority, for the concentration of the different pollutants generated by particular sources.” To that effect, SEMARNAP has issued the following standards for environmental monitoring, fixed source emissions, fuel characteristics, and mobile source emissions:

Table F.1. Fixed sources

Official Mexican Standard	**Maximum permissible levels for atmospheric emissions**
NOM-039-ECOL-1993	Sulfur dioxide and trioxide, and sulfuric acid mist in sulfuric acid production plants.
NOM-040-ECOL-1993	Solid particles and control of fugitive emissions generated by cement plants.
NOM-043-ECOL-1993	Solid particles.
NOM-046-ECOL-1993	Sulfur dioxide, sulfur trioxide mist, and sulfuric acid, in dodecylbenzenesulfonic acid production plants.
NOM-051-ECOL-1993	Industrial oil used in fixed sources in the Mexico City Metropolitan Area (ZMCM).
NOM-075-ECOL-1995	Volatile organic compounds from the process of oil-water separators in oil refineries.
NOM-085-ECOL-1994	Smoke, total suspended particles, sulfur oxides, nitrogen oxides and fixed sources that utilize fossil fuels.
NOM-092-ECOL-1995	Gasoline vapor recovery system requirements for service and self-serve stations located in the Valley of Mexico.
NOM-093-ECOL-1995	Laboratory efficiency for gasoline vapor recovery systems in service stations and self –serve stations.
NOM-097-ECOL-1995	Particulate matter and nitrogen oxides from glass manufacturing processes across the country.
NOM-105-ECOL-1996	Total suspended particles and total reduced sulfur compounds generated by the manufacture of cellulose.
NOM-121-ECOL-1997	Volatile organic compounds (VOCs) generated by paint operations in the automobile industry as well as the method to calculate their emissions.
NOM-123-ECOL-1997	Maximum permissible limits for volatile organic compounds (VOCs) in the manufacture of air-dried solvent-based paints and for domestic use, and the procedures for determining their content in paints and recoating solvents.

Table F.2. Fuel Characteristics

Official Mexican Standard	Specifications for:
NOM-086-ECOL-1994	Liquid and gaseous fossil fuels used in fixed and mobile sources.

Table F.3. Mobile Sources

Official Mexican Standard	Maximum permissible levels for pollutant emissions
NOM-041-ECOL-1999	Emission of polluting gases generated by the exhaust of gasoline-fueled vehicles in circulation.
NOM-042-ECOL-1999	Unburned hydrocarbons, carbon monoxide, nitrogen oxides, evaporative hydrocarbons generated by the exhaust of gasoline and gas fueled vehicles in plant.
NOM-044-ECOL-1993	Hydrocarbons, carbon monoxide, nitrogen oxides, total suspended particles and smoke opacity generated by diesel vehicles in plant.
NOM-045-ECOL-1996	Smoke opacity in diesel-fueled vehicles in circulation.
NOM-047-ECOL-1993	Equipment characteristics and measuring procedures for testing the pollutants generated by gasoline, LP gas, and natural gas fueled vehicles.
NOM-048-ECOL-1993	Hydrocarbons, carbon monoxide and smoke generated by gasoline or gasoline-oil powered motorcycles.
NOM-049-ECOL-1993	Equipment characteristics and measuring procedure for testing pollutants in gasoline and gasoline-oil fueled motorcycles.
NOM-050-ECOL-1993	Polluting gas emissions generated by vehicles that use LP gas or natural gas.
NOM-076-ECOL-1995	Polluting gas emissions generated by new vehicles with gross weight greater than 3,857 kilograms.
NOM-077-ECOL-1995	Equipment characteristics and measuring procedures for testing opacity levels in diesel-fueled motor vehicles.

Table F.4. Environmental monitoring

Official Mexican Standard	Measurement and equipment calibration method for determining concentrations
NOM-034-ECOL-1993	Carbon monoxide.
NOM-035-ECOL-1993	Total suspended particles.
NOM-036-ECOL-1993	Ozone.
NOM-037-ECOL-1993	Nitrogen dioxide.
NOM-038-ECOL-1993	Sulfur dioxide.

ANNEX G. MEXICAN VEHICLE EMISSIONS STANDARDS

Vehicle emissions testing in Mexico is covered by two Official Mexican Standards. The first one, NOM-041-ECOL-1999, published in the Federal Official Newspaper on June 24, specifies the maximum permissible limits for exhaust gases. The second one, NOM-047-ECOL-1993, published in the Federal official newspaper on October 22, establishes the characteristics of the vehicle emissions test procedure. These two standards are reprinted in the following pages.

NOM-041-ECOL-1999

JULIA CARABIAS LILLO, Minister of the Environment, Natural Resources and Fisheries, based on article 32 Bis fractions I, II, IV and V of the Federal Public Administration Law; Article 5 fractions V, and XIX; Article 6; Article 7 fractions III and XIII; Article 8 fractions III and XII; Article 9; Article 36; Article 37 Bis; Article 111 fraction IX; Article 112, fractions V, VII, X and XII; Article 113; Article 160; and, Article 171 of the General Law of Ecological Equilibrium and Environmental Protection; Article 7 fractions II and IV; Article 46; and Article 49 of its Air Pollution Prevention and Control Regulation; Article 38 fraction II; Article 40 fraction X; Article 41; Article 45; Article 46; and, Article 47 of the Federal Law of Meteorology and Standardization, and

Considering

That in compliance with Fraction I, Article 47 of the Federal Law of Meteorology and Standardization, NOM-041-ECOL-1999 was published on March 8, 1999 in the Federal Official newspaper, as a Project. That standard establishes the maximum permissible limits for exhaust emissions from gasoline-powered vehicles. It allows 60 days for the interested parties to submit their comments to the National Advisory Committee on Standardization for Environmental Protection, located on Avenida Revolución 1425, Mezzanine planta alta, Colonia Tlacopac San Ángel, C.P. 01040, Delegación Álvaro Obregón, in Mexico City.

That during the term referred to in the previous paragraph, the Regulatory Impact Statement conducted under the terms in Article 45 of the aforementioned legal order, was available to the public at the Committee's headquarters.

That according to Fractions I and II of Article 47 of the Federal Law on Meteorology and Standardization, the comments submitted by the interested parties regarding the project in question, were analyzed at the Committee's headquarters, making all the necessary changes. A response to those comments, as well as the changes, were published in the Official Federal Newspaper on June 23, 1999.

That having complied with the protocol established by the Federal Law on Meteorology and Standardization for the development of Official Mexican Standards, the National Advisory Committee for Environmental Protection, in session on May 28, 1999, approved the current Official Mexican Standard, NOM-041-ECOL-1999. This standard establishes the maximum permissible limits for gases emitted from the tailpipe of gasoline-powered vehicles in circulation. This new standard replaces NOM-041-ECOL-1996, published in the Official Federal Newspaper on February 25, 1997. Taking into consideration all of the above, I issue the following

Official Mexican Standard NOM-041-ECOL-1999, establishing the maximum permissible limits for the emission of polluting gases generated by the exhaust of gasoline-fueled motor vehicles.

Index

1. Objective and field of application.
2. References.
3. Definitions.
4. Specifications.
5. Level of conformity with international standards and lineaments, and with Mexican standards taken as the basis for its development.
6. Bibliography
7. Observance of this standard.

1. Objective and field of application

This Official Mexican Standard establishes the maximum permissible limits for the emission of hydrocarbons, carbon monoxide and oxygen. It also establishes minimum and maximum dilution levels, procedures for measuring nitrogen oxides, and must be observed by all gasoline-powered motor vehicle operators around the country, as well as those in charge of operating all authorized emissions testing centers. An exception to this are those vehicles with gross vehicular weight less than 400 kilograms, motorcycles, tractors for agricultural use, and machinery used in the construction and mining industries.

2. References

Mexican Standard NMX-AA-23-1986, Environmental Protection-Air Pollution Terminology, published in the Official Federal Newspaper on July 15, 1986.

Official Mexican Standard NOM-047-ECOL-1993, establishing the equipment characteristics and measurement procedures for the testing of pollutant emissions generated by all motor vehicles in circulation that run on gasoline, liquefied petroleum gas, natural gas, or other alternate fuels. This standard, published in the Official Federal Newspaper on October 22, 1993, contains the nomenclature in terms of the Agreement through which 58 Official Mexican Standards were updated. This agreement was published on November 29, 1994.

3. Definitions

3.1. Model year

The period from the start of production of certain type of motor vehicle and the 31st of December of the calendar year when the manufacturer designs the model in question.

3.2. For the purpose of this standard motor vehicles are defined and classified in the following manner:

3.2.1. Passenger vehicle (VP)

An automobile, or similar vehicle, with the exception multiple use or utility vehicles and trailers, designed for transporting up to 10 people.

3.2.2. Light-duty trucks (CL1)

Light-duty trucks (group 1) with gross vehicular weight of up to 2,722 kg and test weight (PP) of up to 1,701 kg.

3.2.3. Light-duty trucks (CL2)

Light-duty trucks (group 2) with gross vehicular weight of up to 2,722 kg and test weight (PP) greater than 1,701 and up to 2,608 kg.

3.2.4. Light-duty trucks (CL3)

Light-duty trucks (group 3) with gross vehicular weight greater than 2,722 and up to 3,856 kg and test weight (PP1) of up to 2,608 kg.

3.2.5. Light-duty trucks (CL4)

Light-duty trucks (group 4) with gross vehicular weight greater than 2,722 and up to 3,856 kg and test weight (PP1) greater than 2,608 and up to 3,856 kg.

3.2.6. Medium-duty truck

A motor vehicle with gross vehicular weight greater than 3,856 and up to 8,864 kg.

3.2.7. Heavy-duty truck

A motor vehicle with gross vehicular weight greater than 8,864 kg.

3.2.8. Motor vehicle

Ground transportation, self-propelled freight or passenger vehicle, that uses the public roadways.

3.2.9. Multiple use or utility vehicle

A motor vehicle designed for the transportation of persons and/or products, with or without a chassis, or having special equipment for occasional off-road use. For testing purposes, these will be classified in the same manner as light-duty trucks.

3.2.10. Vehicle in circulation

A motor vehicle circulating in public roadways.

3.3. Testing center

The facility or location established or authorized by the competent authorities for measuring pollutant emissions generated by motor vehicles in circulation.

3.4. Gases, listed as follows:

3.4.1. Total hydrocarbons (HC).
3.4.2. Carbon monoxide (CO).
3.4.3. Oxygen (O_2).
3.4.4. Carbon dioxide (CO_2).
3.4.5. Nitrogen oxides (NOx).

3.5. Engine

A group of mechanical components that convert fuel into kinetic energy to self-propel a motor vehicle. A specific engine is set apart from others based on its disposition, distance between the center of its cylinders, type of fuel, as well as the number of pistons and displacement volume.

3.6 Gross vehicular weight (PBV)

The maximum weight in kilograms specified by the manufacturer for a particular vehicle. It is equivalent to the nominal vehicle weight added to its maximum load capacity, when the fuel tank is filled to its nominal capacity.

3.7. Mexico Valley Metropolitan Zone (ZMVM)

The area including the 16 political delegations of the Federal District, and the following 18 municipalities of the State of Mexico: Atizapán de Zaragoza, Coacalco, Cuautitlán Izcalli, Cuautitlán de Romero Rubio, Chalco de Covarrubias, Chimalhuacán, Ecatepec de Morelos, Huixquilucan, Ixtapaluca, La Paz, Naucalpan de Juárez, Nezahualcoyotl, San Vicente Chicoloapan, Nicolás Romero, Tecámac, Tlanepantla de Baz, Tultitlán and Valle de Chalco Solidaridad.

4. Specifications

4.1 The specification of the maximum permissible levels of vehicular exhaust emissions for all gasoline-fueled vehicles circulating across the country, with the exception of item 4.2 of this Official Mexican Standard.

4.1.1. The maximum permissible levels for the emission of exhaust gases from passenger vehicles in circulation, as a function of the year-model, are presented in Table 1 of this Official Mexican Standard.

Table 1

Model-Year of the Vehicle	Hydrocarbons	Carbon monoxide	Oxygen (Max.)*	Dilution	
				Min.	Max.
	(HC) (ppm)	(CO) (% Vol.)	(O_2) (% Vol.)	($CO + CO_2$) (% Vol.)	
1986 and earlier	500	4.0	6.0	7.0	18.0
1987-1993	400	3.0	6.0	7.0	18.0
1994 and later	200	2.0	6.0	7.0	18.0

* Vehicles of any model-year with an air pump as part of the original equipment have a maximum oxygen limit of 15% by volume.

4.1.2. The maximum permissible levels for the emission of exhaust gases from multiple use or utility vehicles, light-duty trucks CL.1, CL.2, CL.3 and CL.4, medium and heavy-duty trucks in circulation, as a function of the year-model, are presented in Table 2 of this Official Mexican Standard.

Table 2

Model-Year of the vehicle	Hydrocarbons	Carbon monoxide	Oxygen (Max.)*	Dilution	
				Min.	Max.
	(HC) (ppm)	(CO) (%Vol.)	(O_2) (%Vol.)	($CO + CO_2$) (% Vol.)	
1985 and earlier	600	5.0	6.0	7.0	18.0
1986-1991	500	4.0	6.0	7.0	18.0
1992-1993	400	3.0	6.0	7.0	18.0
1994 and later	200	2.0	6.0	7.0	18.0

* Vehicles of any model-year with an air pump as part of the original equipment have a maximum oxygen limit of 15% by volume.

4.2. The specification of the maximum permissible levels of vehicular exhaust emissions for vehicles that circulate in the Mexico Valley Metropolitan Zone (ZMVM).

4.2.1. The maximum permissible limits for the emission of hydrocarbons, carbon monoxide, oxygen, and the minimum and maximum dilution limits for the exhaust of gasoline-fueled passenger vehicles, as a function of the year-model, are established in Table 3 of the Official Mexican Standard.

Table 3

Model-Year of the Vehicle	**Hydrocarbons**	**Carbon Monoxide**	**Oxygen (Max.)***	**Dilution**	
				Min.	**Max.**
	(HC) (ppm)	(CO) (% Vol.)	(0_2) (% Vol.)	($CO + CO_2$) (% Vol.)	
1990 and earlier	300	3.0	6.0	7.0	18.0
1991 and later	200	2.0	6.0	7.0	18.0

* Vehicles of any model-year with an air pump as part of the original equipment have a maximum oxygen limit of 15% by volume.

4.2.2. Table 4 of this Official Mexican Standard establishes the maximum permissible limits for the emission of hydrocarbons, carbon monoxide, oxygen, and the minimum and maximum dilution limits for the exhaust of gasoline-fueled passenger vehicles, light-duty trucks CL1, CL2, CL3 and CL4, multiple use or utility vehicles, medium and heavy-duty trucks in circulation, regardless of their model-year, which are used as taxi cabs, collective transportation vehicles, mini-buses, and all types of public transportation, with local, federal and/or metropolitan plates.

Table 4

Type of Vehicle	**Hydrocarbons**	**Carbon monoxide**	**Oxygen * (Max.)**	**Dilution**	
				Min.	**Max.**
	(HC) (ppm)	(CO) (% Vol.)	(0_2) (% Vol.)	($CO + CO_2$) (% Vol.)	
Taxis, Collective, Minibuses and all types of passenger public transportation	100	1.0	6.0	7.0	18.0

- Vehicles of any model-year with an air pump as part of the original equipment have a maximum oxygen limit of 15% by volume.

4.2.3. The maximum permissible limits for the emission of hydrocarbons, carbon monoxide, oxygen, and the minimum and maximum dilution limits for the exhaust of gasoline-fueled passenger vehicles, light-duty trucks CL1, CL2, CL3 and CL4, multiple use or utility vehicles, medium and heavy-duty trucks in circulation, as a function of the year-model, with local and/or federal plates, except those covered under item 4.2.2, referred to earlier, are established in Table 4 of this Official Mexican Standard.

Table 5

Model-Year of the Vehicle	**Hydrocarbons**	**Carbon monoxide**	**Oxygen (Max.)***	**Dilution**	
				Min.	**Max.**

	(HC) (ppm)	(CO) (% Vol.)	(0_2) (% Vol.)	$(CO + CO_2)$ (% Vol.)	
1993 and earlier	350	3.0	6.0	7.0	18.0
1994 and later	200	2.0	6.0	7.0	18.0

* Vehicles of any model-year with an air pump as part of the original equipment have a maximum oxygen limit of 15% by volume.

4.3. The State Governments, in coordination with the Municipalities and in accordance with the applicable legal dispositions, when deemed necessary, will have the ability to apply the maximum permissible limits for emissions, established in Tables 3, 4 and 5 of this Official Mexican Standard.

4.4. 1999 and 2000 year-model vehicles that comply with the maximum permissible limits in the factory, as established in Table 3 of the current Official Mexican Standard NOM-042-ECOL-1999, can be exempted from emissions testing for a period of up to two years after their acquisition, and in accordance with the legal dispositions issued by the respective federal and local authorities. Starting with year-model 2001, vehicles can obtain this and other benefits as determined by the aforementioned authorities.

4.5. Testing protocol

4.5.1. The testing protocol for measuring gasoline-fueled motor vehicle exhaust emissions is established by Official Mexican Standard NOM-047-ECOL-1993, referred to in item 2 of this Official Mexican Standard.

4.5.2. In the Mexico Valley Metropolitan Zone, the dynamic test referred to in the Official Mexican Standard that was cited in the previous paragraph must be used to quantify emissions. An exception to this are those vehicles described by their manufacturer as inoperable in the dynamometer. Nitrogen oxides should also be measured as reference only.

4.5.3. A vehicle is considered to have passed the emissions test when it has complied with the prior inspection (visual inspection) and the smoke test, and none of the readings recorded during the slow-speed (Ralenti) test and the cruise-speed test exceed the limits established in this Official Mexican Standard.

5. Degree of conformity with international standards and lineaments, and with the Mexican standards that were taken as the basis for its development

5.1 There are no equivalent standards. The provisions of domestic character that exist in other countries do not contain the technical and legal elements and precepts included in this Official Mexican Standard. Furthermore, no other Mexican standards were used in its development.

6. Bibliography

6.1. Code of Federal Regulations 40, Parts 86 to 99, revised July 1994, USA.

6.2. Code of Regulations for the State of California, United States of America, (Title 16, Ch. 33).

7. Observance of this standard

7.1. Oversight of compliance with the Official Mexican Standard in question corresponds to the Ministry of the Environment, Natural Resources and Fisheries (SEMARNAP), through the Federal Attorney's Office for the Protection of the Environment (PROFEPA), and the Federal District, State and Municipal governments, within the scope of their corresponding jurisdiction.

7.2. Any violations to this standard will be penalized under the terms outlined by the General Law of Ecological Balance and Environmental Protection, under its Air Pollution Prevention and Control Regulation and other applicable legal requirements.

7.3. The current Official Mexican Standard must be displayed in a visible location at all the authorized emissions testing centers.

7.4. The current Official Mexican Standard will enter into effect 60 days after its publication in the Official Federal Newspaper.

7.5. The current Official Mexican Standard cancels out the Emergency Official Mexican Standard NOM-EM-127-ECOL-1998, published in the Official Federal Newspaper on December 28, 1998 and its extension notice. It also repeals NOM-041-ECOL-1996, which establishes the maximum permissible limits of polluting gas emissions generated by the exhaust of gasoline-powered motor vehicles in circulation. That standard was published in the Official Federal Newspaper on February 25, 1997.

Federal District of Mexico, July 9, 1999.

THE SECRETARY OF THE ENVIRONMENT, NATURAL RESOURCES AND FISHERIES

JULIA CARABIAS LILLO

....

NOM-047-ECOL-1993

Official Mexican Standard NOM-047-ECOL-1993, establishing the equipment characteristics and the measurement procedure for testing the level of pollutant emissions generated by motor vehicles in circulation that use gasoline, liquefied petroleum gas, natural gas, or other alternate fuels.

SERGIO REYES LUJAN, Chairman of the National Institute of Ecology, based on article 32 fraction XXV of the Federal Public Administration Law; Article 5 fraction VIII, Article 6 last paragraph, Article 8 fractions II and VII, Article 9 part A fraction II, Article 36, Article 43, Article 111 fraction IV, Article 160, and Article 171 of the General Law of Ecological Balance and Environmental Protection on the subject of Air Pollution Prevention and Control; Article 38 fraction II, Article 40 fraction X, Article 41, Article 43, Article 46, Article 47, Article 52, Article 62, Article 63 and Article 64 of the Federal Law on Meteorology and Standardization; First and Second Articles of the Agreement through which authority is delegated to the Assistant Secretary of Housing and Real Estate, and to the Chairman of the National Institute of Ecology to issue Official Mexican Standards in the subject of housing and ecology, respectively, and

Considering

That motor vehicles in circulation that run on gasoline, liquefied petroleum gas, natural gas, or other alternate fuels, generate air emissions that adversely affect air quality, make it necessary to establish a protocol for measuring these pollutants, as well as the required equipment characteristics to conduct these measurements, with the objective of preserving the ecological balance and protecting the environment.

That having complied with the protocol established by the Federal Law on Meteorology and Standardization for the development of Official Mexican Standards, the

Chairman of the National Advisory Committee on Standardization for Environmental Protection ordered the publication of the Official Mexican Standard NOM-PA-CCAT-010/93, that establishes the equipment characteristics and measurement procedures for testing the levels of pollutant emissions generated by gasoline-fueled motor vehicles in circulation. This standard was published in the Official Federal Newspaper on June 23, 1993, with the object of giving the opportunity to the interested parties to submit their comments to the Advisory Committee.

That the National Commission on Standardization determined during its July 1, 1993 session that this standard, which was originally identified as NOM-PA-CCAT-010/93, will be identified as NOM-047-ECOL-1993, from now on.

That during the ninety-day term starting on the date of publication of that Official Mexican Standard, the analyses referred to in Article 45 of the legal order were available to the public for review.

That within the same term, the interested parties submitted their comments regarding the proposed standard. The National Advisory Committee on Standardization reviewed these comments, and the appropriate changes were incorporated. The Ministry of Social Development, through the National Institute of Ecology, published the answers to the public comments in “Gaceta Ecológica”, Volume V, October 1993 Special Edition.

That the Ministry of Commerce and Industrial Development and the Ministry of Energy, Mines and Quasi-State Industry, expressed their conformity with the contents and issuance of the current Official Mexican Standard.

That upon prior approval from the National Advisory Committee on Standardization for Environmental Protection, in session on September 23, 1993, I have considered of benefit to issue the following:

Official Mexican Standard NOM-047-ECOL-1993, that establishes the equipment characteristics and the measurement procedures for testing the levels of pollutant emissions generated by motor vehicles in circulation that use gasoline, liquefied petroleum gas, natural gas, and other alternate fuels.

Preface

The following entities were involved in the development of this Official Mexican Standard:

MINISTRY OF SOCIAL DEVELOPMENT
- National Institute of Ecology (INE)

- Federal Attorney's Office for the Protection of the Environment (PROFEPA)

MINISTRY OF ENERGY, MINES AND QUASI-STATE INDUSTRY
- Subministry of Energy

MINISTRY OF COMMUNICATION AND TRANSPORTATION

MINISTRY OF HEALTH
- General Bureau of Environmental Health

MINISTRY OF COMMERCE AND INDUSTRIAL DEVELOPMENT

GOVERNMENT OF THE STATE OF MEXICO
- Ministry of Ecology

NATIONAL CHAMBER OF THE TRANSFORMATION INDUSTRY (CANACINTRA)

PATRONAL CONFEDERATION OF THE MEXICAN REPUBLIC

FEDERAL DISTRICT DEPARTMENT

- General Bureau of Environmental Projects

NATIONAL POLYTECHNICAL INSTITUTE

MEXICAN PETROLEUM (PEMEX)
- Industrial Safety, Environmental Protection and Energy Savings Audit
- Environmental Protection and Energy Savings Administration
- Pemex-Gas and Petroquímica Básica
- Environmental Protection and Safety Administration

ASOCIACION NACIONAL DE PRODUCTORES DE AUTOBUSES, CAMIONES Y TRACTOCAMIONES, A.C. (NATIONAL ASSOCIATION OF BUS, TRUCK AND TRACTOR TRAILER MANUFACTURERS)

ASOCIACION NACIONAL DE PRODUCTORES DE AGUAS ENVASADAS, S.A. DE C.V. (NATIONAL ASSOCIATION OF BOTTLED WATER PRODUCERS)

ASOCIACION NACIONAL DE LA INDUSTRIA AUTOMOTRIZ, A.C. (NATIONAL ASSOCIATION OF THE AUTOMOBILE INDUSTRY)

KENWORTH OF MEXICO, S.A. DE C.V.

MERCEDES BENZ OF MEXICO

1. Objective

This Official Mexican Standard establishes the equipment characteristics and measurement methods for the testing of pollutant emissions generated by motor vehicles in circulation, equipped with engines that run on gasoline, liquefied petroleum gas, natural gas, or other alternate fuels. The maximum permissible levels for these pollutants are determined by the corresponding Official Mexican Standard.

2. Field of Application

This Official Mexican Standard must be complied with when establishing and operating vehicular emissions testing centers.

3. References

NMX-AA-23 Terminology.

4. Definitions

4.1. Automobile

A motor vehicle designed for transporting up to 10 people.

4.2. Light-duty truck

A motor vehicle with or without chassis, designed for transporting goods or more than 10 people, and having a gross vehicular weight ranging between 2,727 and 7,272 kilograms.

4.3. Testing Center

A facility or premise that has been established or authorized by the competent authorities to measure the emissions of vehicles in circulation.

4.4. Standard gas

The gas or mixture of gases of known concentration (certified by the manufacturer) used for the calibration of air pollutant measuring equipment and to certify its calibration.

4.5. Cruise speed

The operating condition of a vehicle when its transmission is set to neutral, the engine is running and undergoing acceleration, and no external load is being applied.

4.6. Slow speed idle

The operating condition of a vehicle when the engine is running, there is no acceleration, and the number of revolutions per minute falls within the range specified by the manufacturer.

4.7. Otto cycle engine

A set of mechanical components that transform heat energy into kinetic energy through the discontinuous combustion of a fuel-air mixture in one or more chambers whose volumes have been modified for the movement of pistons or rotors. The combustion process is initiated by an external source of ignition.

4.8. Gross vehicular weight

The real weight of the motor vehicle expressed in kilograms, added to the weight of its maximum load capacity, as specified by the manufacturer, and to the weight of its full tank.

4.9. Static test

The test conditions for a vehicle, consisting of slow-speed idle and cruise speed as specified by this standard.

4.10. Dynamic test

The test conditions for a vehicle, consisting of slow-speed idle and cruise speed, as specified by this standard.

4.11. Normal operating temperature

The temperature reached by the engine and the drive train of the vehicle after it has been in operation for at least 10 minutes, or when the engine oil temperature has reached 60 degrees centigrade.

4.12. Commercial vehicle

A motor vehicle with or without a chassis, used for transporting goods or more than 10 people, and having a gross vehicular weight of up to 2,727 kilograms.

4.13. Multiple use or utility vehicle

A motor vehicle used for transporting goods or up to 10 people, and having a gross vehicular weight of more than 2,727 kg.

4.14. Motor vehicle

A land transportation vehicle used in public roadways, for freight or passengers, which is self-propelled.

4.15. Vehicle in circulation

A motor vehicle used in public roadways.

4.16. Intensive use vehicle

4.16.1. A motor vehicle for public use, used for transporting passengers or freight;

4.16.2. Motor vehicles that provide services to federal public administration entities and agencies, and to the governments of the Federal District, federal entities, and municipalities;

4.16.3. Motor vehicles assigned for commercial use, used for commercial transactions or as a work instrument;

4.16.4. Motor vehicles that provide service to employees and for school use; and

4.16.5. Motor vehicles that have been converted to use liquefied petroleum gas, natural gas, or other alternate fuels, used to provide any type of service.

4.17. Mexico City Metropolitan Zone

The area comprised by the 16 Political Delegations within the Federal District, and the following 17 municipalities of the State of Mexico: Atizapán de Zaragoza, Coacalco, Cuautitlán de Romero Rubio, Cuautitlán Izcalli, Chalco de Covarrubias, Chimalhuacán, Ecatepec, Huixquilucan, Ixtapaluca, La Paz, Naucalpan de Juárez, Nezahualcóyotl, San Vicente Chicoloapan, Nicolás Romero, Tecámac, Tlalnepantla and Tultitlán.

5. Specifications

5.1. The methods used for measuring the emissions generated by motor vehicles in circulation that use gasoline, liquefied petroleum gas, natural gas, or other alternate fuels, are specified below:

5.1.1. Tailpipe emissions

The static test must be used, except in the Mexico City Metropolitan Zone, where the dynamic test must be used for automobiles, commercial vehicles and light vehicles, classified as intensive-use vehicles.

5.1.2. Evaporative emissions

In the Mexico City Metropolitan Zone, the method that must be applied for motor vehicles that use gasoline or other alternate liquid fuels and have a threaded gasoline tank cap, is the fuel tank cap test.

A cap seal test must be conducted to measure the pressure drop in inches of water, according to the limits set by the corresponding standard.

5.1.3. Dates when the above tests will enter into effect

The dates when the aforementioned tests will enter into effect in the Mexico City Metropolitan Zone, are shown in Table 1.

Table 1

Type of test	Used to measure	Year of application in vehicle for:	
		Intensive use	Non-intensive use
Static test	HC, CO, O_2 and Dilution	N/A	Immediate
Dynamic test using Dynamometer with constant load	HC, CO, O_2 and Dilution	Immediate	1997
Fuel tank cap seal	Leaks	1995	1995
Dynamic test using Dynamometer with variable load	HC, CO, O_2, NOx and Dilution	1999	N/A

5.2. Test equipment preparation.

The equipment must be prepared before proceeding with the measurements.

The technician must do the following:

5.2.1. Operate the equipment according to the manufacturer’s specifications.

5.2.2. Operate the equipment according to the manufacturer’s specifications and in accordance with this standard.

5.2.3. Remove any foreign matter and/or water or moisture accumulated in the filters and the probe.

5.3. Visual Inspection of the vehicle prior to the test.

5.4. The vehicle must meet the following requirements in order undergo the testing procedure specified by this standard:

5.4.1. The technician must check to make sure that the manufacturer installed emissions components and other design elements that have been installed in the vehicle to comply with the applicable emissions control standards have not been:

5.4.1.1. Removed from the emissions control system.

5.4.1.2. Tampered with to keep the emissions control system from working properly.

5.4.1.3. Replaced with a component that was not sold by its manufacturer for that kind of use.

5.4.1.4. Replaced with a component that cannot be connected to other emissions control components.

Disconnected, even though the component is still present and mounted correctly in the vehicle.

5.4.2. The technician must ensure that the exhaust pipe of the vehicle is in perfect operating condition and that it does not have any additional exits to those in its original design, which my cause the dilution or leak of exhaust gases.

5.4.3. The following devices must be in good condition and working properly:

Air filter, oil tank cap, fuel tank cap, crankcase oil level, crankcase ventilation system, activated carbon filter, and engine and tank connecting hoses.

5.5. Test preparation of the vehicle

The vehicle must be prepared before starting the test. The technician must:

5.5.1. Make sure that the choke's manual control is not on.

5.5.2. Make sure that the vehicle's accessories are turned off. These include the lights and A/C.

5.5.3. Make sure that the engine runs at its normal operating temperature.

5.5.4. For automatic transmission vehicles, make sure that the vehicle is set to Park or Neutral. For semiautomatic or manual transmission, make sure that the vehicle is set to neutral and the clutch is not being pressed.

6. Measurement procedures

6.1. Static test method

The static test method is a procedure for measuring hydrocarbons, carbon monoxide, carbon dioxide and oxygen emissions as they exit the tailpipe of a motor vehicle that runs on gasoline, liquefied petroleum gas, natural gas, or other alternate fuel.

The static test procedure consists of three phases: visual smoke inspection, cruise speed test, and slow speed idle test.

6.1.1. Visual smoke inspection test

6.1.1.1. The tachometer of the testing equipment must be connected to the ignition system of the vehicle. The vehicle is run at 2,500 ± 250 revolutions per minute for at least 30 seconds. If black or blue smoke is emitted continuously for more than ten seconds, the test must be stopped and the maximum permissible limits are considered exceeded. This test should not last more than one minute.

6.1.1.2. Blue smoke emissions indicate the presence of oil in the combustion system and black smoke emissions indicate an excess of unburned fuel. Therefore, any of the two indicate high emission levels of hydrocarbons and other pollutants.

6.1.2. Cruise speed test

The testing probe must be inserted into the tailpipe according to the manufacturer's specifications, making sure that the probe is perfectly in place. The engine is run at 2,500 ± 250 revolutions per minute for at least 30 seconds. After 25 consecutive seconds under these operating conditions, the technician must record the average readings that appear in the display of the analyzer during the next five seconds. This test cannot last more than one minute.

6.1.3. Slow-speed idle test

The engine of the vehicle is decelerated to the idle speed specified by the manufacturer, which will not be greater than 1100 revolutions per minute. This rate must be maintained for at least 30 seconds. After 25 consecutive seconds under these operating conditions, the technician must determine the average readings that appear in the display of the analyzer during the next five seconds, and record those values. This test cannot last more than one minute.

6.1.4. Analysis of Results

A vehicle passes this test when none of the values registered in the readings for the slow-speed idle test and the cruise-speed test exceed the maximum permissible levels specified by the applicable standard.

For vehicles equipped with a double exhaust system, the test must be conducted for each system, using the average of the readings recorded in each system as the emissions value for each of the pollutants.

6.2. Method for dynamic test with constant load

The dynamic test with constant load is another procedure for measuring the emissions of hydrocarbons, carbon monoxide, carbon dioxide and oxygen as they exit the exhaust pipe of motor vehicles in circulation that run on gasoline, liquefied petroleum gas, natural gas, or other alternate fuels.

The dynamic test method with constant load consists of three stages. A visual smoke inspection, a dynamic test with load, and a slow-speed idle test.

6.2.1. Visual smoke test

6.2.1.1. This test must be conducted with the engine running at 2,500 ± 250 revolutions per minute for at least 30 seconds. If black or blue smoke is emitted continuously for more than ten seconds, testing must be stopped, and the maximum permissible limits are considered exceeded. This test should not last more than one minute.

Blue smoke emissions indicate the presence of oil in the combustion system and black smoke emissions indicate an excess of unburned fuel. Therefore, any of the two indicate high emission levels of hydrocarbons and other pollutants.

6.2.2. Preparation for the dynamic test:

6.2.2.1. The motorized wheels of the vehicle must be placed over the dynamometer's rollers, securing the vehicle to prevent its movement, in accordance to the to the instructions for the dynamometer.

6.2.2.2. The testing probe must be inserted into the tailpipe, in accordance with the equipment instructions, making sure that the probe is securely placed.

6.2.2.3. The technician must determine the load and speed to be applied to the vehicle in accordance with Table 2.

Table 2

Number of Cylinders, Speed and Load to be Applied

No. of cylinders	Roller Speed (km/h)	Applied load (bhp)
4 or less	40	2.8 - 4.1
5 – 6	40	6.8 - 8.4
7 or more	40	8.4 - 10.8

6.2.3. Dynamic test

With the vehicle running, it is accelerated in second or third gear (choosing the gear that allows for stable operating conditions of the vehicle, without forcing the engine), until the vehicle reaches the specified roller speed. If the vehicle is equipped with automatic transmission the test will be done in second gear.

The load of the dynamometer is adjusted according to the values stipulated in Table 2 and the vehicle is run under normal operating conditions for a minimum of 30 seconds. After 25 consecutive seconds under these operating conditions, the technician must determine the average readings that appear in the display of the analyzer during the next five seconds, and record those values. This test must not last more than one minute.

If a vehicle cannot reach the specified speed or maintain the load specified in Table 2, or if the vehicle design does not allow the use of a dynamometer, the static test procedure must be applied.

6.2.4. Slow-speed idle test

The engine of the vehicle is decelerated to the idle speed specified by the manufacturer, which will not exceed 1100 revolutions per minute, with the transmission placed in neutral. This speed must be maintained for a minimum of 30 seconds. After 25 consecutive seconds under these operating conditions, the technician must determine the average readings that appear in the display of the analyzer during the next five seconds, and record those values. This test must not last more than one minute.

6.2.5. Analysis of results

A vehicle passes this test when none of the values registered in the readings for the slow-speed idle test and the dynamic test exceed the maximum permissible levels specified by the applicable Official Mexican Standard.

For vehicles equipped with a double exhaust system, the test must be conducted for each system, using the average of the readings recorded in each system as the emissions value for each of the pollutants.

6.3. Fuel tank cap test

6.3.1. The measurement procedure consists of a seal test for the cap mounted onto a testing device, using the appropriate size collar. The device is pressurized to the pressure specified in Table 3 and, once the specified pressure is reached, the pressure drop in inches of water during the period specified in the same Table, is measured.

6.3.2. Analysis of Results

A vehicle passes the test whenever there is not a leak that results in a pressure drop greater than the established limit.

The permissible limits for maximum pressure drop for motor vehicles in circulation that run on gasoline or other alternate liquid fuels, are established in Table 3.

Table 3. Limits as a function of the Test Procedure

Model-year of the vehicle	Type of test	Initial pressure (pulg. H_2O)	Maximum pressure drop	
			(inch H_2O)	in seconds
All	Fuel tank cap seal	14 ± 0.5	2.0	20

7. Data recording

The testing center must record the test results in a magnetic medium so these can be sent to the authorities whenever requested.

The minimum data required are:

7.1. Information about the center

Description	Format	Characters
Certificate Number	N	8
Center number	N	3
Test Date	F	6
Test time	A	5
Type of verification	A	1

7.2. Information about the owner of the vehicle

Description	Format	Characters
Name	A	25
Address	A	25
Colonia	A	15
Zip Code	N	5
Delegation or municipality	N	3
State	N	2

7.3. Information about the Vehicle

Description	Format	Characters
Odometer reading	N	7
Model year of the vehicle	N	2
City where it was registered	A	10
License plates	A	7
Class	N	2
Type of fuel	N	1
Brand	N	3
Sub-brand	A	8
Type of service	N	2
Number of cylinders	N	1
Fuel feed	N	1

7.4. Information about the Test

Description	Format	Characters
Test Sequence	A	1

Description	Format	Characters
HC slow-speed idle	N	4
CO slow-speed idle	N	4
CO_2 slow-speed idle	N	4
O_2 slow-speed idle	N	4
RPM slow-speed idle	N	4
HC cruise-speed or dynamic test	N	4
CO Cruise-speed or dynamic test	N	4
CO_2 Cruise-speed or dynamic test	N	4
O_2 Cruise-speed or dynamic test	N	4
NO Cruise-speed or dynamic test	N	4
RPM Cruise-speed or dynamic test	N	4

7.5. Results of the verification

Description	Format	Characters
Test sequence	A	1
HC slow-speed idle	N	4
CO slow-speed idle	N	4
CO_2 slow-speed idle	N	4
O_2 slow-speed idle	N	4
RPM slow-speed idle	N	4
HC Cruise-speed or dynamic test	N	4
CO Cruise-speed or dynamic test	N	4
CO_2 Cruise-speed or dynamic test	N	4
O_2 Cruise-speed or dynamic test	N	4
NO Cruise-speed or dynamic test	N	4
RPM Cruise-speed or dynamic test	N	4
Exhaust emissions	A	1
(Approved, Not approved)		
Cap seal	A	1
(Approved, Not approved)		

Format key: N = Numeric A = Alphanumeric F = Date

8. Equipment specifications

The devices used for the measuring vehicular emissions must comply with the following specifications:

8.1. Gases to be analyzed

8.1.1. The analyzer used during the dynamic test must determine the concentration of hydrocarbons, carbon monoxide, carbon dioxide, nitrogen oxides and oxygen in the exhaust of the vehicle.

8.1.2. The analyzer used during the static test must determine the concentration of hydrocarbons, carbon monoxide, carbon dioxide, and oxygen in the exhaust of the vehicle.

8.2. Measurement scale

8.2.1. The total measurement scale must be between 0 and 10% by volume, for the case of carbon monoxide; 0 to 2000 ppm, for hydrocarbons; 0 to 4000 ppm for nitrogen oxides; 0 to 16% by volume for carbon dioxide; and, 0 to 22% by volume, for oxygen.

8.2.2. The resolution of the scale must be 1 ppm for HC and NO; 0.01% for CO, and 0.1% for CO_2 and O_2.

8.3. Precision, Noise and Replication

8.3.1. The analyzer must comply with the following requirements of accuracy in its readings:

Gas	Range	Precision	Noise	Replication
HC (ppm)	0- 400	±12	6	8
	401-1000	±30	10	15
	1001-2000	±80	20	30
CO (%)	0-2.00	±0.06	0.02	0.03
	2.01-5.00	±0.15	0.06	0.08
	5.01-9.99	±0.40	0.10	0.15
CO_2 (%)	0- 4.0	±0.60	0.20	0.30
	4.1-14.0	±0.50	0.20	0.30
	14.1-16.0	±0.60	0.20	0.30
NO (ppm)	0-1000	±32	16	20
	1001-2000	±60	25	30
	2001-4000	±120	50	60
O_2 (%)	0-10.0	±0.5	0.3	0.4
	10.1-22.0	±1.3	0.6	1.0

Noise is defined as the average difference obtained between peaks from a lone source for a period of 20 seconds.

Replication is determined during 5 successive measurements from the same source.

8.3.2. Response time must not be greater than 8 seconds in order to achieve 90% of the final stabilized reading and must not be greater than 12 seconds in order to achieve 95% of the final stabilized reading.

8.3.3. During the entire work time stability must be less than ± 3%.

8.3.4. The period of stability must be less than 10 minutes after start-up.

8.3.5. The tachometer must have the capability of measuring the number of revolutions per minute (RPM) with a precision of ± 3% .

8.4. Build

8.4.1. The analyzer must be designed to support continuous heavy use for a minimum of eight hours per day.

8.4.2. The analyzer must have a ID plate attached to its outer surface, including: model, serial number, manufacturer's name and address, electric power requirements, and voltage limits during operation.

8.4.3. Must be airtight in all its connections.

8.4.4. Its controls must be accessible to the operators.

8.4.5. The analyzer readings must not be affected by nominal voltage variations of ± 10%.

8.4.6. The internal attachments that are in contact with the test gas must be corrosion resistant and have devices or traps for eliminating or reducing particulate matter and water, with the purpose of avoiding modifications that may affect the analysis of gases. The container used for water removal must be made of clear material, have the ability of being drained and easily dismounted for cleaning.

8.4.7. The external attachments consist of a probe, with a length greater than 3 meters and less than 9 meters, flexible enough to allow its handling.

8.4.8. The local authorities may establish additional specifications for the analyzer, with the object of improving the reliability of results and safety in the handling of certificates and stickers, when applicable.

8.5. Routine Calibration

The calibration of the analyzers must be done with standard gas every third day or according to the manufacturer's specifications. The standard gas must have a guaranteed precision in the mixtures of ± 2% of the indicated concentration.

8.6. Calibration Check

Calibration of the analyzers must be done in a calibration laboratory that is accredited by the Ministry of Commerce and Industrial Development, under the terms specified by the federal Law on Meteorology and Standardization. The analyzers must be calibrated every three months, under normal operating conditions, independent from the calibrations that are done every time one of its parts is replaced, or it undergoes maintenance or repairs.

8.6.1. In order to determine whether the analyzer is perfectly calibrated, measurements must be collected using three different standard gases of known concentration (with a precision of 1%). These gases must be introduced into the device using a normal testing probe.

8.6.2. Three measurements must be collected with each standard gas. The average values of the three readings obtained for each of the pollutants are recorded in the record sheet. A calibration curve is traced in the graphing sheet (Annex 1) using these values, and then it is compared with the representative curve that is shown in the same sheet. The deviation between these two curves must be less than 10% .

8.7. Dynamometer Specifications

As far as the dynamometer is concerned, it must have the appropriate rollers to support the motorized wheels of vehicles being tested, allowing for their continuous rotation. The power generated by the engine of the vehicle that passes from the tires to the rollers, must be transmitted to an energy-absorbing device. The load can be established by the physical characteristics of the design of the energy absorption unit or by an automatic control. The frame and the sets of rollers must be placed in such a way that they allow any make of vehicle to be easily placed on the rollers, in order to test them in a leveled position. A platform between the rollers and the roller brakes will allow quick access and exit to and from the dynamometer. The dynamometer design must allow for the safe testing of front-wheel drive vehicles.

8.7.1. Dynamometer capabilities

8.7.1.1. Test repetitiveness must fall within a 2% tolerance for a given vehicle and a given speed.

8.7.1.2. Short stability periods at a constant speed must not have a power variation that is greater than 0.5 H.P. during the test.

8.7.1.3. The load capacity of the rollers must handle a weight of at least 3500 kilograms.

8.7.1.4. Each roller must have a minimum diameter of 20.32 cm. (8"). The rollers must be spaced in such a way that the radius of the tire, which is 33.02 cm. (13"), must have a contact of at least 50° and not greater than 63°, measured from the center of the axis of the tire to the center of the axis of the rollers. The rollers must not provide a contact surface that is less than 243.84 cm. (96") wide.

8.7.1.5. The speed indicators must be in kilometers or their functional equivalent, using a single scale with a length that is not less than 19 cm. (7.5"), and they must show from 0 to 95 km/h.

8.7.1.6. The dynamometer must have its own calibration unit.

The current Official Mexican Standard must be displayed in a visible location in the public and authorized private emissions testing centers.

9. Oversight

9.1. The Federal, state, and municipal governments (when applicable), are the authorities in charge of enforcing compliance with the current Official Mexican Standard.

10. Penalties

10.1. Non-compliance with the current Official Mexican Standard will be penalized according to the Air Pollution Prevention and Control Regulation included in the General Law of Ecological Balance, and all other legal orders.

11. Bibliography

11.1. Code of Federal Regulations, Vol. 40, 1991, USA.

11.2. California Code of Regulations, United States of America. Title 16 Chapter 33

12. Conformity with international standards

12.1 This official Mexican standard does not conform to any international standard.

13. Effect

13.1. The current Official Mexican Standard will come into effect the day after it is published in the Official Federal Newspaper, with the exception of the requirement of calibration testing included under item 10.6, which will come into effect on January 3, 1994.

13.2 The Agreement overseeing the issuance of Ecological Technical Standard NTE-CCAT-013/89 published in the Official Federal Newspaper on June 7, 1989, is repealed.

Issued in Mexico City, Federal District, on October 18, 1993. Sergio Reyes Luján, Chairman of the National Institute of Ecology.

ANNEX 1

Record sheet to verify the quality of measurement form the analyzers

Testing Center ____________________ No. _____________________________
Address________________________ Col.______________________________
Pol. Del. or Munic. _____ Tel.______________ RFC _______________________
Equipment Brand_______________________ Serial No.____________________
Place of certification ____

Measurement	**Recorded readings**					
	High			**Low**		
	CO	**HC**	**CO_2**	**CO**	**HC**	**CO_2**
First						
Second						
Third						
Average value						
Concentration of standard gas						

Calibration curves

Hydrocarbons (HC, PPM)				

Standard gas

Carbon monoxide (CO, % Vol)				

Standard gas

Test Date ____

Next Test Date ____

Name and signature of the technician _________________________________

ANNEX H. 1983 LA PAZ AGREEMENT

A formal joint effort between The United States and Mexico to protect and improve the environment along the border area began in 1983. That year, both countries signed the *Agreement between the United States of America and the United Mexican States on Cooperation Regarding the Protection and Improvement of the Environment in the Border Area*, also known as “La Paz Agreement”.

This agreement outlines the main objectives regarding border environmental cooperation, establishes a mechanism to draft further agreements, annexes, technical actions, as well as hold high level meetings and special technical meetings to promote and foster cooperation between the two countries. Likewise, it established formal communication procedures between the two countries and ordered the appointment of National Coordinators to direct and supervise the implementation of this Agreement.

The La Paz Agreement regulates a framework of cooperation between US and Mexican authorities to prevent, reduce and eliminate air, water and soil pollution sources along a 100-kilometer wide border zone on either side of the international border. This Agreement sets the general guidelines that must be applied in the specific projects mentioned in its five technical annexes. Air quality issues are addressed by Annex IV, which is known as the *"Agreement between the United States of America and the United Mexican States on Cooperation Regarding Transboundary Air Pollution caused by Copper Smelters Along their Common Border";* and Annex V, known as the *"Agreement between the United States of America and the United Mexican States on Cooperation Regarding International Transport of Urban Air Pollution".*

The La Paz Agreement and its Annexes IV and V are reproduced in the following pages.

AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT IN THE BORDER AREA

The United States of America and the United Mexican States,

RECOGNIZING the importance of a healthful environment to the long-term economic and social well being of present and future generations of each country as well as of the global community;

RECALLING that the Declaration of the United Nations Conference on the Human Environment, proclaimed in Stockholm in 1972, called upon all nations to collaborate to resolve environmental problems of common concern;

NOTING previous agreements and programs providing for environmental cooperation between the two countries;

BELIEVING that such cooperation is of mutual benefit in coping with similar environmental problems in each country;

ACKNOWLEDGING the important work of the International Boundary and Water Commission and the contribution of the agreements concluded between the two countries relating to environmental affairs;

REAFFIRMING their political will to further strengthen and demonstrate the importance attached by both Governments to cooperation on environmental protection and in furtherance of the principle of good neighborliness;

Have agreed as follows:

Article 1

The United States of America and the United Mexican States, here in after referred to as the Parties, agree to cooperate in the field of environmental protection in the border area on the basis of equality, reciprocity and mutual benefit. The objectives of the present Agreement are to establish the basis for cooperation between the Parties for the protection, improvement and conservation of the environment and the problems which affect it, as well as to agree on necessary measures to prevent and control pollution in the border area, and to provide the framework for development of a system of notification for emergency situations. Such objectives shall be pursued without prejudice to the cooperation, which the Parties may agree to undertake outside the border area.

Article 2

The Parties undertake, to the fullest extent practical, to adopt the appropriate measures to prevent, reduce and eliminate sources of pollution in their respective territory which affect the border area of the other. Furthermore, the Parties shall cooperate in the solution of the environmental problems of mutual concern in the border area, in accordance with the provisions of this Agreement.

Article 3

Pursuant to this Agreement, the Parties may conclude specific arrangements for the solution of common problems in the border area, which may be annexed thereto. Similarly, the Parties may also agree upon annexes to this Agreement on technical matters.

Article 4

For the purposes of this Agreement, it shall be understood that the "border area" refers to the area situated 100 kilometers on either side of the inland and maritime boundaries between the Parties.

Article 5

The Parties agree to coordinate their efforts, in conformity with their own national legislation and existing bilateral agreements to Address problems of air, land and water pollution in the border area.

Article 6

To implement this Agreement, the Parties shall consider and, as appropriate, pursue in a coordinated manner practical, legal, institutional and technical measures for protecting the quality of the environment in the border area. Forms of cooperation may include: coordination of national programs; scientific and educational exchanges; environmental monitoring; environmental impact assessment; and periodic exchanges of information and data on likely sources of pollution in their respective territory which may produce environmentally polluting incidents, as defined in an annex to this Agreement.

Article 7

The Parties shall assess, as appropriate in accordance with their respective national laws, regulations and policies, projects that have significant impacts on the environment of the border area, that appropriate measures may be considered to avoid or mitigate adverse environmental effects.

Article 8

Each Party designates a national coordinator whose principal functions will be to coordinate and monitor implementation of this Agreement, make recommendations to the Parties, and organize the annual meetings referred to in Article 10, and the meetings of the experts referred to in Article 11. Additional responsibilities of the national coordinators may be agreed to in an annex to this Agreement. In the case of the United States of America the national coordinator shall be the Environmental Protection Agency, and in the case of Mexico it shall be the Secretaría de Desarrollo Urbano y Ecología, through the Subsecretaría de Ecología.

Article 9

Taking into account the subjects to be examined jointly, the national coordinators may invite, as appropriate, representatives of federal, state and municipal governments to participate in the meetings provided for in this Agreement. By mutual agreement they may also invite representatives of international governmental or non-governmental organizations who may be able to contribute some element of expertise on problems to be solved.

The national coordinators will determine by mutual agreement the form and manner of participation of non-governmental entities.

Article 10

The Parties shall hold at a minimum an annual high level meeting to review the manner in which this Agreement is being implemented. These meetings shall take place alternately in the border area of Mexico and the United States of America. The composition of the delegations which represent each Party, both in these annual meetings as well as in the meetings of experts referred to in Article 11, will be communicated to the other Party through diplomatic channels.

Article 11

The Parties may, as they deem necessary, convoke meetings of experts for the purposes of coordinating their national programs referred to in Article 6, and of preparing the drafts of the specific arrangements and technical annexes referred to in Article 3.

These meetings of experts may review technical subjects. The opinions of the experts in such meetings shall be communicated by them to on the national coordinators, and will serve to advise the Parties technical matters.

Article 12

Each Party shall ensure that its national coordinator is informed of the activities of its cooperating agencies that are carried out under this Agreement. Each Party shall also ensure that its national coordinator is informed of the implementation of other agreements concluded between the two Governments concerning matters related to this Agreement. The national coordinators of both Parties will present to the annual meetings a report on the environmental aspects of all joint work conducted under this Agreement and on implementation of other relevant agreements between the Parties, both bilateral and multilateral.

Nothing in this Agreement shall prejudice or otherwise affect the functions entrusted to the International Boundary and Water Commission, in accordance with the Water Treaty of 1944.

Article 13

Each Party shall be responsible for informing its Border States and for consulting them in accordance with their respective constitutional systems, in relation to matters covered by this Agreement.

Article 14

Unless otherwise agreed, each Party shall bear the cost of its participation in the implementation of this Agreement, including the expenses of personnel who participate in any activity undertaken on the basis of it. For the training of personnel, the transfer of equipment and the construction of installations related to the implementation of this Agreement, the Parties may agree on a special modality of financing, taking into account the objectives defined in this Agreement.

Article 15

The Parties shall facilitate the entry of equipment and personnel related to this Agreement, subject to the laws and regulations of the receiving country. In order to undertake the monitoring of polluting activities in the border area, the Parties shall undertake consultations relating to the measurement and analysis of polluting elements in the border area.

Article 16

All technical information obtained through the implementation of this Agreement will be available to both Parties. Such information may be made available to third parties by the mutual agreement of the Parties to this Agreement.

Article 17

ARTICLE 17Nothing in this Agreement shall be construed to prejudice other existing or future agreements concluded between the two Parties, or to affect the rights and obligations of the Parties under international agreements to which they are a party.

Article 18

Activities under this Agreement shall be subject to the availability of funds and other resources to each Party and to the applicable laws and regulations in each country.

Article 19

The present Agreement shall enter into force upon an exchange of Notes stating that each Party has completed its necessary internal procedures.

Article 20

The present Agreement shall remain in force indefinitely unless one of the Parties notifies the other, through diplomatic channels, of its desire to denounce it, in which case the Agreement will terminate six months after the date of such written notification. Unless otherwise agreed, such termination shall not affect the validity of any arrangements made under this Agreement.

Article 21

This Agreement may be amended by mutual agreement between the two Parties.

Article 22

The adoption of the annexes and of the specific arrangements provided for in Article 3, and the amendments thereto, will be effected by an exchange of Notes.

Article 23

This Agreement supersedes the exchange of Notes, concluded on June 19, 1978 with the attached Memorandum of Understanding between the Environmental Protection Agency of the United States and the Subsecretariat for Environmental Improvement of Mexico for Cooperation on Environmental Programs and Transboundary Problems.

DONE in duplicate, in the city of La Paz, Baja California, Mexico, on the 14th of August of 1983, in the English and Spanish languages, both texts being equally authentic.

ANNEX IV. TO THE AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION FOR THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT IN THE BORDER AREA

AGREEMENT OF COOPERATION BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES REGARDING TRANSBOUNDARY AIR POLLUTION CAUSED BY COPPER SMELTERS ALONG THEIR COMMON BORDER

PREAMBLE

The Government of the United States of America and the Government of the United Mexican States ("Mexico'), ("the Parties"),

Recognizing public concern for health and environmental damage resulting from air pollution caused by copper smelters along their common border;

Taking note that such public concern led to consultations between the Parties in the framework of their Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area of 1983 ("the 1983 Agreement");

Taking note also with satisfaction that such consultations led to the taking by each of the Parties, in their respective territories, of measures which will yield an improvement of the air quality in the border area;

Recognizing that the decision in the United States to close the Phelps Dodge copper smelter in Douglas, Arizona, by January 15, 1987, will constitute a significant contribution to the protection of the environment in the border area;

Recognizing also that the efforts already in progress in Mexico to establish a high efficiency plant for the processing of sulfur dioxide to sulfuric acid, in the Mexicana de Cobre La Caridad copper smelter in Nacozari, Sonora, by June 1, 1988, will constitute a significant contribution to the protection of the environment in the border area;

Considering the importance for the Parties to ensure the implementation of the above described measures, as well as the need to contemplate the adoption of other measures to further protect and improve air quality from activities by copper smelters in the border area;

Reaffirming Principle 21 of the 1972 Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm, which provides that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction;

Desirous to cooperate effectively to protect public health and welfare from the effects of air pollution caused by copper smelters in the border area; and

Recalling that Article 3 of the 1983 Agreement provides that the Parties may conclude specific arrangements for the solution of common problems in the border area as annexes to that Agreement,

Have agreed as follows:

Article I
Emissions Reduction Measures

1. The United States undertakes to ensure that in the event that the Phelps Dodge copper smelter in Douglas, Arizona, recommences smelting after January 15, 1987, or that any other copper smelter is established in its side of the border area in the future, such smelter will be subject upon commencement of smelting operations to the taking of effective measures necessary to ensure that sulfur dioxide emissions shall not exceed .065 percent by volume during any six-hour period.

2. In the United States other existing copper smelters in its side of the border area, whether currently operating or not, will continue to be subject to effective control measures necessary to protect the environment from sulfur dioxide emissions, as provided by applicable state and federal law.
3. Mexico undertakes to ensure that operations of the Mexicana de Cobre la Caridad copper smelter in Nacozari, Sonora, after 1 June 1988, or the establishment of any other copper smelter in its side of the border area in the future, will upon commencement of operations be subject to the taking of effective measures necessary to ensure that sulfur dioxide emissions shall not exceed .065 percent by volume during any six-hour period. Until that date, the Nacozari smelter will continue operating at a maximum average sulfur dioxide emissions limit that does not exceed any ambient concentration up to 0.13 parts per million during any twenty-four hour period.
4. Mexico undertakes to ensure that any future expansion of the smelting capacity of the Compañía Minera de Cananea copper. smelter in Cananea, Sonora, will be subject, at the time of commencement of such expanded operations, to the taking of effective measures to ensure that sulfur dioxide emissions shall not exceed .065 percent by volume during any six-hour period.
5. For the purpose of determining compliance with the .065 emissions limitation established in this Annex:
   a) Six-hour average sulfur dioxide concentrations shall be, calculated and recorded daily for the four consecutive six-hour periods of each operating day, beginning at 12 a.m.
   b) Each six-hour period shall be contiguous one-hour average sulfur dioxide concentrations.
   c) One-hour average emissions concentrations shall be computed from four or more data points equally spaced over each one-hour period.
6. The Parties shall endeavor to take, subject to the availability of resources, any other appropriate interim emissions reduction measures intended to protect public health and welfare from air pollution caused by copper smelters in the border area.

Article II
Emissions Monitoring, Record Keeping and Reporting Systems

1. Any copper smelter that, in accordance with this Annex, will be required to comply with the emissions limitation of .065 percent by volume during any six-hour period, shall install, operate and maintain continuous emissions monitoring, record keeping and reporting systems, on the following bases:
   d) For the purpose of monitoring emissions of sulfur dioxide, the monitoring system shall he installed, calibrated and maintained by the owner or operator of any copper smelter to which this Article applies, with zero and span checks to be performed daily and a quality assurance program.
   e) For the purpose of record keeping, all records of emissions shall be kept for two years following the dates of such emissions, as well as:
      i) other information to be kept on file may include continuous monitoring system, monitoring device and performance testing measurements, all continuous monitoring system or monitoring device calibration checks adjustments or maintenance performed on these systems or devices, and all other information that the competent national authority may require be kept.
      ii) the smelter owner or operator shall be required to keep a monthly record of the total smelter charge.
      iii) The copper smelter owner or operator shall be required to submit to the competent national authority, on a quarterly basis, written reports of sulfur dioxide emissions that exceed .065 percent by volume during any six-hour period as well as the following information:
         - The magnitude of any emissions which exceed .065 percent by volume during any six-hour period, and the date and time of commencement and completion of each time period of these emissions.
         - Specific identification of each six-hour period in which emissions exceed .065 percent by volume during startup, shutdown or malfunctions of the smelter, the nature and

cause of any malfunction, if known, and the corrective actions taken.
- The date, time, and duration of each period during which the continuous monitoring system was inoperative, except for zero and span checks, and the nature of the system repairs or adjustments.

2. The emissions monitoring, record keeping and reporting systems referred to in paragraph 1 of this Article, are aimed at availing each Party with adequate information to enable it to undertake whatever practicable measures are regarded as appropriate, or to enable the Parties to cooperate to that end, and in no way shall such resulting information be interpreted so as to alter the commitments of the Parties specified in Article I of this Annex or in any of its other provisions.
3. The Parties shall consult in order to find effective means of cooperation, to ensure the most immediate means for the prompt and full implementation of the provisions in this Article.

Article III
Air Monitoring Devices

The Parties shall continue to consult each other concerning their existing air monitoring devices located in the border area, and will continue to cooperate to enhance effective monitoring.

Article IV
Workgroup of Technical Experts

1. The Parties confirm the binational body established by the First Annual Meeting of National Coordinators, in the spirit of Article 11 of the 1983 Agreement, of technical experts known as the U.S.-Mexico Air Quality working Group ("Working Group"). The working Group shall be co-chaired by officials who shall be appointed by and report to the United States and Mexican Coordinators ("National Coordinators") as provided for under Article 8 of the 1983 Agreement. The Working Group shall meet on a regular basis and shall include participation, as appropriate or necessary, of state and local officials from both countries.
2. The Working Group shall meet at least once every six months to review progress in abating smelter pollution in the border area, as contemplated by this Annex and, if necessary, to make findings on additional corrective measures for recommendation to the National Coordinators. The Working Group shall submit all its recommendations and its evaluation of the Parties' compliance with the terms of this Annex in a bi-annual report to the National Coordinators. The National Coordinators shall, by mutual agreement, implement such recommendations as they deem appropriate.
3. The National Coordinators shall forward all Working Group reports to the respective Foreign Ministries in each country, namely, the Department of State, in the case of the United States, and the Secretariat of External Relations, in the case of Mexico, and shall recommend, taking into account Working Group reports, such additional action as may be needed to further the objectives of this Annex.
4. The Parties shall, consistent with their respective domestic legislation and regulations, exchange information and data on copper smelters in their respective border states, and also ensure that the Working Group is provided with complete information, including atmospheric and emissions monitoring data in the border area and other information either existing or which may become available as a result of this Annex.

Article V
Legislative Authority

The Parties will promote legislative authority, as may be necessary, to provide for the abatement of transboundary air pollution caused by copper smelters. The Parties shall continue to consult with respect to these matters.

Article VI
Effect on Other Instruments

5. Nothing in this Annex shall be construed to prejudice other existing or future agreements concluded between the Parties, or affect the rights or obligations of the Parties under international agreements to which they are Party.
6. The provisions of this Annex shall, in particular, not be deemed to prejudice or otherwise affect the functions entrusted to the International Boundary and Water Commission, in accordance with the 1944 Treaty on the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande.

Article VII
Appendices

Any appendices to this Annex may be added through an exchange of diplomatic notes and shall form an integral part of this Annex.

Article VIII
Amendments

This Annex, and any appendices added hereto, may be amended by mutual agreement of the Parties through an exchange of diplomatic notes.

Article IX
Review

The Parties shall meet at least every two years from the date of entry into force of this Annex, at a time and place to he mutually agreed upon, in order to review the effectiveness of its implementation and to agree on whatever individual and joint measures are necessary to improve such effectiveness.

Article X
Entry into Force

This Annex shall enter into force upon an exchange of diplomatic notes between the Parties stating that each Party has completed its necessary internal procedures.

Article XI
Termination

This Annex shall remain in force indefinitely, unless one of the Parties notifies the other in writing through diplomatic channels of its desire to terminate it, in which case the Annex shall terminate six months after the date of such written notification.

Unless otherwise agreed, such termination shall not affect the validity of any agreements made under this Annex.

IN WITNESS WHEREOF the undersigned, being duly authorized by their respective Governments, have signed this Annex.

DONE at Washington, in duplicate, this twenty-ninth day of January, 1987, in the English and Spanish languages, both texts being equally authentic.

For the Government of the United Mexican States	For the Government of the United States of America

ANNEX V. TO THE AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT IN THE BORDER AREA.

AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING INTERNATIONAL TRANSPORT OF URBAN AIR POLLUTION.

The Government of the United States of America ("the United States") and the Government of the United Mexican States ("Mexico") ("the Parties"),

Recognizing that health and environmental damage may result from emissions of air pollutants in urban areas;

Realizing that the transport of air pollutants occurs from border cities of the United States to border cities of Mexico and from border cities of Mexico to border cities of the United States;

Seeking to ascertain the magnitude of such air pollutant transport and the physical mechanisms facilitating this transport;

Realizing that certain adjacent areas in the United States and in Mexico fail to meet their countries' respective ambient air quality standards for various pollutants;

Seeking to ensure a reduction in air pollution concentrations for the benefit of their citizens living in urban areas along the United States-Mexico border;

Reaffirming Principle 21 of the 1972 Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm, which provides that States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or areas beyond the limits of national jurisdiction;

Recognizing that Article 3 of the Agreement between the Parties on Cooperation for the Protection and Improvement of the Environment in the Border Area of 1983 ("the 1983 Agreement") provides that the Parties may conclude specific arrangements for the solution of common problems in the border areas as annexes to that Agreement,

Have agreed as follows:

Article I
Definitions

1. "Study area" means each specific geographic area of urban air pollution concern, which the Parties agree to subject to the requirements of this Annex, as listed in the appendices to this Annex.
2. "Selected pollutants" means those air contaminants chosen by the Parties for each "study area", as listed in the appendices to this Annex.
3. "Major stationary source" means any stationary source with emissions greater than 97 metric tons (100 tons) per year for which there is a specific air pollution control standard in force, any other source with emissions greater than 243 metric tons (250 tons) per year, and any other stationary source which the Parties mutually so designate for the purposes of this Annex.
4. "Air pollution control standards" means technologically achievable limits for controls on air pollution emissions from stationary sources (e.g., New Source Performance Standards and Límites de Emisión para Fuentes Nuevas).
5. "Ambient air quality standards" means critical ambient levels of air pollutants (e.g., the National Ambient Air Quality Standards and la Norma Mexicana de Calidad del Aire).
6. "Mobile sources" means automotive, bus or truck vehicles, off-road vehicles, waterborne vessels, and aircraft.
7. "Area sources" means all emitters of air contaminants other than major stationary sources and mobile sources.

8. "Industrial classification" means a system of classifying various industrial activities by organizing them into comparable types (e.g., the Standard Industrial Classification (SIC) Code and the Sistema Nacional de Información de Fuentes Fijas (SNIFF)).
9. "Emission point type" means the small-scale source of pollutant release, namely stack, fugitive, volume, or line.

Article II
General Obligations

1. For each study area, the Parties shall detail in their respective territory the magnitude of emissions of selected pollutants and the name, type, and location of each source of pollution, if it is a major stationary source.
2. For each study area, the Parties shall identify in their respective territory the nature and magnitude of control requirements, if any, for each major stationary source needed to conform to the air pollution control standards applicable to that source type and shall identify relatively simple and quickly initiated controls and/or changes in management practice to reduce air pollution from each major stationary source not meeting applicable air pollution control standards.
3. For each study area, the Parties shall estimate in their respective territory the emissions of the selected pollutants due to the activities of all mobile and area sources.
4. The Parties shall issue a joint report incorporating their findings under (1), (2), and (3) above within six months of making such findings.
5. Each Party shall, in its territory, perform ambient monitoring of common selected pollutants and meteorological parameters in each study area in such a way as to ascertain the pollution concentrations arising from each separate urban area and those concentrations due to the interaction of pollutants originating from both urban areas.
6. Each Party shall issue reports at agreed-upon intervals of time, but not longer than yearly intervals, detailing the results of monitoring carried out under (5) above.
7. Each Party shall, in its territory, perform monitoring to the extent necessary to successfully support the use of a state-of-the-art mathematical air modeling analysis. The Parties shall perform the modeling analysis in order to assess accurately the effect of changes in emission levels from each source type within the study area on the ambient concentrations of the related pollutants within the study area.
8. Monitoring in each study area will continue for a period of two years from the commencement Of each study, at which Point the Parties will decide whether further monitoring is desired.

Article III
Compiling air pollution emissions inventories and information about sources as outlined in Article II

1. For the Purposes Of Article II, each Party shall compile air Pollution emission inventories and source information with respect to its territory.
2. The emission inventories shall be based upon emission factors that are mutually acceptable to both Parties.
3. Each Party shall list the emissions of each major stationary source in its territory in mutually agreed-upon conventional units of measure with the source's address and industrial classification; for each separate emission point in the major stationary source, each Party shall list the emissions, latitude and longitude, emission point type, stack diameter, stack height, stack gas exit velocity, stack gas exit temperature, width, length, and height, where applicable.
4. Utilizing the information obtained under (2) and (3) above, each Party shall identify those major stationary sources in its territory that do not meet applicable air Pollution control standards for each selected pollutant. For all such sources, the Parties shall, based upon site visits and/or good engineering practice: (a) identify the type and extent of Pollution control equipment which would be required to bring each such source into conformity with applicable air pollution control standards for each selected pollutant; and (b) identify relatively simple and quickly initiated controls and/or changes in management practice to reduce air pollution from each such source. The Parties shall also identify the approximate percentage of emissions reduction of each selected pollutant that would result from such controls and/or changes in management practice. Participants designated by one Party for agreed site visits in the territory of the other Party shall have the status of observers.

Article IV
Performance of monitoring and modeling as outlined in Article II

1. For the purposes of Article II, each Party shall perform the tasks related to monitoring and modeling with respect to its territory.
2. Each Party shall, in its territory, locate and operate monitors in each study area in numbers sufficient to fulfill the goals of this Annex to assess ambient concentrations of the selected pollutants.
3. Each Party shall, in its territory, locate and operate meteorological stations in numbers sufficient to fulfill the goals of this Annex; these stations shall monitor for the following parameters on a continuous basis: wind speed, wind direction, and temperature.
4. All details relating to the nature, number and placement of the monitoring devices used in (2) and the Parties shall, mutually agree upon (3) above.
5. Analysis associated with monitoring and quality assurance shall be conducted in a manner mutually agreed upon by the Parties.
6. The state-of-the-art mathematical modeling analysis shall be either a dispersion modeling analysis or a receptor modeling analysis or both, as mutually agreed upon by the Parties; supplementary analyses may be authorized by mutual consent of the Parties.

Article V
Harmonization of standards

In order to make more effective the implementation of this Annex, the Parties shall jointly explore ways to harmonize, as appropriate, their air pollution control standards and ambient air quality standards in accordance with their respective legal procedures.

Article VI
Protection of confidential information

The Parties shall adopt procedures to protect the confidentiality of proprietary or sensitive information conveyed pursuant to this Annex, when such procedures do not already exist..

Article VII
Effect on other instruments

Nothing in this Annex or its appendices shall be construed to prejudice other existing or future agreements concluded between the Parties, or affect the rights or obligations of the Parties under international agreements to which they are party.

Article VIII
Implementation

Implementation of this Annex is dependent upon the availability of sufficient funding.

Article IX
Appendices

Appendices to this Annex may be added through an exchange of diplomatic notes and shall form an integral part of this Annex.

Article X
Amendments

This Annex, and any appendices added hereto, may be amended by mutual agreement of the Parties through an exchange of diplomatic notes.

Article XI
Review

The National Coordinators under the 1983 Agreement or their designees shall meet at least every year from the date of entry into force of this Annex, at a time and place to be mutually agreed upon, in order to review the effectiveness of its implementation and to agree on whatever individual and joint measures are necessary to improve such effectiveness.

Article XII
Entry into force

This Annex shall enter into force after signature when each Party has informed the other through diplomatic note that it has completed the internal procedures necessary for the Annex to enter into force.

Article XIII
Termination

This Annex shall remain in force indefinitely, unless one of the Parties notifies the other in writing through diplomatic channels of its desire to terminate it, in which case the Annex shall terminate six months after the date of such written notification.

IN WITNESS WHEREOF the undersigned, being duly authorized by their respective Governments, have signed this Annex.

Done in the City of Washington DC, in duplicate, this third day of October, 1989 in the English and Spanish languages, both texts being equally authentic.

By the Government of the United Mexican States	By the Government of the United States of America

APPENDIX

ANNEX V. TO THE AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT IN THE BORDER AREA.

AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING INTERNATIONAL TRANSPORT OF URBAN AIR POLLUTION.

For the purposes of Annex V, the Parties agree to define Study Area "A" as:

El Paso County, Texas; that part of the State of New Mexico that is both south of latitude 32 degrees 00 minutes North and east of longitude 106 degrees 40 minutes West; and that part of the State of Chihuahua that is both north of latitude 31 degrees 20 minutes North and east of longitude 106 degrees 40 minutes West.

For Study Area "A', the Parties agree to define as selected pollutants the following: ozone, nitrogen oxides, non-methane hydrocarbons, carbon monoxide, sulfur dioxide, particulate matter, and lead.

The Mexican Foreign Ministry salutes the United States Embassy and makes reference to Diplomatic Note # 0521 of May 7, 1996, containing several proposals related to the appendices to Annex V of the Agreement between the United States of America and the United Mexican States on Cooperation regarding the Protection and Improvement of the Environment in the Border Area, signed in La Paz, B.C., August 14, 1983 ("La Paz Agreement"). These proposals were the result of negotiations on the subject between the two federal governments, and are mentioned in the Note from the Embassy.

The Ministry agrees with the revision of the text in paragraph 3 and 5, Article I, Annex V, so it reads as presented in Annex A of the note.

Concerning the additional proposals from the United StatesEmbassy, the Foreign Ministry agrees to eliminate Annex V as it exists in its current form, replacing it with six new appendices included here as Annex "B". Thus the Foreign Ministry agrees to the formation of a Air Quality Improvement Joint Advisory Committee for the Ciudad Juárez, Chihuahua / El Paso, Texas/ Doña Ana County, New Mexico airshed; and that Appendices 2 to 6 define the geographic areas of the study, to be identified with the letters "A" through "E".

In accordance with Article IX of Annex V, the Mexican Foreign Ministry states that the Note proposed by the United States Embassy on May 7, 1996, and the current Note of response, constitute an agreement between the two governments that will take effect on this date.

The Mexican Foreign Ministry thanks the United States Embassy for its timely attention to this matter.

Mexico, D.F., May 7, 1996.

To the Embassy of the United States of America

Annex "A"

Article I
Definitions

3. "Major stationary source" refers to any stationary source whose emissions exceed 91 metric tonnes (100 tons) per year and for which there is a specific air pollution control measure in place, and any other stationary source mutually agreed upon by the Parties, to fulfill this agreement.

5. "Ambient air quality concentrations" refer to the critical concentrations of pollutants in the air (e.g., Normas Oficiales Mexicanas de Calidad del Aire and the National Ambient Air Quality Standards").

Annex "B"

APPENDIX 1

ANNEX TO THE AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING THE PROTECTION AND IMPROVEMENT OF THE ENVIRONMENT IN THE BORDER AREA.

AGREEMENT BETWEEN THE UNITED STATES OF AMERICA AND THE UNITED MEXICAN STATES ON COOPERATION REGARDING INTERNATIONAL TRANSPORT OF URBAN AIR POLLUTION.

Recalling that in the preamble to Annex V the Parties affirm their intention to ensure a reduction in air pollution concentrations for the benefit of their citizens living in the urban areas along the United States-Mexico border; and

Recognizing the importance of the participation of the local communities in carrying out the efforts to achieve this objective;

The Parties, having decided to establish a Joint Advisory Committee for the Improvement of Air Quality (hereinafter "The Committee") in the Ciudad Juarez, Chihuahua/El Paso, Texas/Doña Ana County, New Mexico Air Basin (hereinafter "air basin");

Have agreed as follows:

Definition

The air basin is defined as the geographic area that includes El Paso County, Texas, and those parts of Doña Ana County, New Mexico and the metropolitan are of Ciudad Juarez, Chihuahua that are within 100km of the border.

Objective

The Committee is established for the purpose of developing and presenting recommendations to the Air Work Group established under the La Paz Agreement regarding strategies for the prevention and control of air pollution in the air basin;

Scope of Activities

The Committee may develop recommendations for the Air Work Group on:

a) The joint development of studies and analyses on air quality monitoring and modeling, and air pollution prevention and abatement strategies in the air basin;
b) Exchanges of information on air quality matters such as air quality data, air emissions data, and data on compliance with each Party's air standards;
c) Technical assistance programs, technology exchanges, and training in areas relevant to preventing and reducing air pollution in the air basin;
d) Environmental education and outreach programs for the general public relevant to preventing and reducing air pollution in the air basin;
e) Exploring strategies to prevent and reduce air pollution in the air basin, including recommendations on emissions trading and other economic incentives as well as improving the compatibility of air quality programs in the air basin; and
f) Such other air quality improvement issues as the Committee may deem to be pertinent to the air basin and as may be recommended by the Parties.

The Parties will provide a guidance document to the Committee detailing more specific subject areas, which the Committee should consider. This guidance document may be updated periodically by the Parties.

The recommendations may include analyses of the estimated costs, and possible financial sources, to implement the recommendations. The recommendations may also address the availability of technology and training necessary for their implementation.

Structure and Organization

The Committee will consist of 20 individuals, ten of whom are to be selected by each Party, in close consultation with state and local governmental officials and the public in the air basin.

The ten U.S. representatives invited to serve on the Committee will include (i) one representative of the federal government; (ii) one representative from each of the governments of the States of Texas and New Mexico; (iii) one representative from local government in El Paso, Texas; (iv) one representative from local government in Doña Ana County, New Mexico; and (v) five persons, residing in the air basin, who are not employed by federal or any state or local government. At least one of these five persons will be a representative of the business community and at least one will be a representative of a non-governmental organization, a major portion of whose activities concerns air pollution.

The ten Mexican representatives invited to serve on the Committee will include (i) one representative of the National Institute of Ecology (INE-SEMARNAP) ; (ii) one representative of the Federal Attorney for Environmental Protection (PROFEPA); (iii) one representative of the federal health and welfare agency (SSA) ; (iv) one representative of the environmental authorities of the State of Chihuahua ; (v) one representative of the environmental authorities of the Municipality of Ciudad Juarez; and (vi) five Mexican citizens, residing in Ciudad Juarez, who are not employed by federal, state, or local government. At least one of these five persons will be a representative of the private sector, at least one will be a representative of a non governmental organization, a major portion of whose activities concerns air pollution, at least one will be a representative of the academic institutions of Ciudad Juarez, and at least one will be a representative of the Consulting Council for Sustainable Development in the Northern Region.

One federal representative from each side will preside over the Committee. The Committee will make decisions by consensus.

The Committee will establish it own rules of procedure, subject to approval by the Parties. Meeting of the Committee will generally be open to the public.

The Air Work Group will consider the recommendations of the Committee and inform the Committee of any action taken pursuant to such recommendations.

The recommendations of the Committee will not be binding on the Air Work Group or the Parties.

Review and Termination

The Parties will periodically review the implementation of this Appendix.

This Appendix will remain in force indefinitely, unless one of the Parties notifies the other in writing through diplomatic channels of its intention to terminate it or Annex V, in which case the Appendix shall terminate six months after the date of such notification.

ANNEX I. GLOSSARY OF TERMS

North American Environmental Cooperation Agreement. This agreement, signed in 1993, sets forth the commitment between the governments of Mexico, the United States, and Canada, to improve environmental conditions. It was derived from the North American Free Trade Agreement.

La Paz Agreement. Pact signed in 1993 between Mexico and the United States regarding cooperation for the protection and improvement of the environment along the border region.

Aerobiological. Microorganism that lives suspended in the air.

Aerosol. Colloidal suspension of liquid or solid particles in the atmosphere. This name has also been given to some products that are applied through aspersion and are used as propellants. For example, chlorinated hydrocarbons, such as freon. It is also defined as the mixture of particles less than 3 micrometers in diameter suspended in the atmosphere.

Tune-up. Set of actions necessary to maintain in optimal operating condition the combustion system of vehicles that use internal combustion.

Traffic Count. Record of the number and type of vehicles passing through a particular location on a given road, during a set period of time.

Ambient Air. Open space atmosphere.

Alkanes. Saturated hydrocarbons formed exclusively by carbon and hydrogen.

Allergens. Substance that is usually foreign to the body which, upon entering the body, is capable of inducing harm to the immune system or causing changes in the biochemical synthesis of the nutrients or introduce a new substance that is capable of negating or interfering with its chemical characteristics.

Alkenes. Unsaturated organic compounds with one or more double links.

Alkynes. Unsaturated organic compounds with one or more triple links.

Environment. Set of physical, chemical and biological elements, (natural or artificial, induced by humans), favoring the existence, transformation and development of organisms.

Anaerobic. Environmental condition referring to life or the vital process that occurs in the absence of oxygen, or under low partial pressure of this element.

Annex IV of the La Paz Agreement. Cooperation agreement between Mexico and the United States regarding transboundary air pollution caused by copper smelters throughout the border region.

Annex V of the La Paz Agreement. Cooperation agreement between Mexico and the United States regarding international transport of urban air pollution throughout the border region.

Anthropogenic. Relative to humans; of human origin. It can be applied to ideas that are excessively centered on human problems, putting aside the effects, problems and harm that humans cause to the environment.

Metropolitan Area. Land mass including the political-administrative unit of the central city and other surrounding communities that share certain urban characteristics with the central city, such as job sites, residential areas, space for agricultural and industrial activities, and which maintain a direct, continuous, intense, and reciprocal socioeconomic relationship with the central city.

Aromatic Compounds. Family of cyclic hydrocarbons with the following general formula: $C_6H_{6-n}X_n$. They are characterized by a closed cyclic chain of hexagonal shape, known as the benzenic ring, as well as three double links in their structure. These compounds, like some paraffinic hydrocarbons, are considered toxic compounds due to their insolubility in water, their long presence in the environment and difficult biodegradation.

Atmosphere. Air layer surrounding the earth and extending about 100 km above the earth crust. This physical structure consists of a mixture of 78% nitrogen, 21% oxygen and 1% various gases, including argon, neon, carbon dioxide and water vapor, among other inorganic compounds.

Self-regulation. Setting voluntary measures with the purpose of achieving better environmental performance in the industrial sector, where lower environmental compliance standards than those written in rule are achieved or accepted.

Energy Balance. The amount of energy distributed or consumed by the various production, service and transport sectors.

Benzene. The simplest olefinic hydrocarbon consisting of a closed cyclic chain.

Sulfur Dioxide (SO_2). Pollutant produced during the combustion process of fuels containing sulfur. Emissions from this pollutant originate mainly from industry.

Carbon Dioxide (CO_2). Inorganic gas consisting of two molecules of oxygen and one molecule of carbon. This gas is colorless, odorless and has no flavor; it is produced by human respiration and by the burning of fossil fuels.

Nitrogen Dioxide (NO_2). Pollutant generated when nitrogen contained in fuels and in the air is oxidized through a combustion process.

Butane. Saturated paraffinic hydrocarbon composed of four carbon atoms and ten hydrogen atoms.

Boiler. Pressurized industrial equipment used to generate vapor.

Environmental Quality. Set of unaltered physical, chemical and biological conditions, natural to the environment.

Fuel Quality. Technical specifications of the physical and chemical characteristics of fuels, that define the potential for polluting.

Air Quality. Pollutant concentration in ambient air.

Carcinogen. Chemical, physical, or biological agent capable of causing abnormal, disorderly, and potentially unlimited growth of cells in a tissue or an organ.

Cephalea. Headache.

Cyclone. Device that works through inertial and gravitational force used for the control of particulate matter.

Climate. The set of meteorological phenomena characterizing the average atmospheric conditions of a given point on earth during a minimum period of ten years. The main climatic elements are temperature, rainfall, seasonality, and other factors such as prevailing winds, relative humidity, sunlight, atmospheric pressure, and cloudiness.

Clorofluorocarbons (CFCs). Gases used as propellants in aerosols. Once released they can reach the stratosphere, where the chlorine they contain reacts with ozone, reducing the volume of the protective layer of the latter

Fossil Fuels. Inorganic compounds such as mineral carbon, oil ad gas, thus known because they are derived from the remains of plants and animals that inhabited the earth before humans appeared in our planet.

Clean Fuels. Inorganic compounds used as fuels and containing less than 2% sulfur by weight, or generating pollutant emissions that are negligible. (For example: compressed natural gas, methanol, ethanol, liquefied oil gas, etc.).

Combustion. Fast oxidation process of inorganic materials accompanied by energy release in the form of heat and light.

Incomplete Combustion. Insufficient oxidation occurring when oxygen or time available in the process are less than necessary, producing carbon monoxide (CO), which is a gas known for its toxicity in living organisms.

Joint Advisory Committee. Binational workgroup consisting of 20 members, 10 from each country (Mexico and the United States), representing the Industrial sector, the Academic sector, Non-Government Organizations, the three levels of government (Federal, State and Municipal) and the general public. Its objective is to issue recommendations on measures and actions to improve air quality in the region that covers Ciudad Juárez-El Paso-Doña Ana County.

Volatile Organic Compounds. These include a wide group of individual substances such as hydrocarbons (alkanes, alkenes and aromatics), halogenated compounds (e.g trichloroethylene) and oxygenated compounds (alcohols, aldehydes and ketones). All these are organic compounds of carbon and have enough volatility to occur as vapors in the atmosphere.

Concentration. Relative amount of a specific substance mixed with another substance that is usually larger. For example: 5 parts per million of carbon monoxide in the air. It can also be expressed as the weight of the material in minor proportion found within a volume of air or gas; this is expressed in micrograms of the pollutant per cubic meter of air.

Contamination/Pollution. The presence of matter or energy whose nature, location, or quantity, produce undesirable environmental effects. In other terms, it is the alteration made or induced by humans to the physical, biological, chemical, and radiological integrity of the environment.

Contaminant/Pollutant. Substance or element that, when incorporated and set in motion in the atmosphere, water, soil, plants, animals, or any other element of the environment, alters or modifies its composition, affects health, or hinders its use as a resource.

Air Contaminant/Air Pollutant. Substance in the air that, in high concentrations, can cause damage to humans, animals, plants or materials. It can include almost any natural or artificial compound that is susceptible to being transported through the air. These pollutants are found in the form of solid, liquid, gaseous, or combined particles. They are generally classified in the compounds that are emitted directly from the pollutant source or primary pollutants, and compounds that are produced in the air by the reaction of two or more primary pollutants or by their reaction with natural compounds that are found in the atmosphere.

Criteria Pollutants. Concentration conditions for certain air pollutants known to be hazardous to human health and constituting the main air quality parameters. In the international arena there are seven criteria pollutants: ozone, carbon monoxide, total suspended particles, PM10, sulfur dioxide, nitrogen oxide and lead.

Environmental Contingency. Condition of risk characterized by the presence of high concentrations of criteria pollutants in the air, derived from human activities or natural phenomena. These concentration may be harmful to human health, as well as affect the ecosystems.

Emission Controls. A set of measures that tend to cause a reduction in air pollutant emissions.

Catalytic Converter. Device used to lower air pollution by removing certain pollutants such as hydrocarbons, carbon monoxide and nitrogen oxides from vehicle exhaust pipes, either converting them to carbon dioxide by oxidation or reducing them to nitrogen or oxygen.

Environmental Criteria. The descriptive factors considered in establishing environmental standards for various pollutants. These factors are used to determine the maximum permissible limits for concentration levels, and to limit the number of annual exceedances.

Environmental Health Criteria. Critical summaries of existing knowledge regarding the immediate and long-term effects on human health and human well being, that can be expected from the presence of different substances in the air, water, soil, food, consumer products, and work environment; or by other factors such as noise, ionizing and non-ionizing radiation, radiant heat, and luminosity. These effects are expressed in quantitative terms.

Airshed. A specified physical space containing the layer of the atmosphere that is closest to its internal surface, and limited by uniform meteorological trends of small and medium scale.

Binational Airshed. A physical space containing regions from both the United States and Mexico.

Distillation. Separation of a mixture, using the different boiling points of its components.

Environmental Deterioration. The alteration suffered by one or more elements in an ecosystem, caused by the presence of an element that is foreign to the characteristics and the dynamics of the ecosystem.

Dysphonia. Difficulty in hearing.

Dyspnea. Difficulty in breathing.

Dispersion. Phenomenon that determines the magnitude of the resulting concentration and the area of impact, in which pollutants will disperse and dilute according to the meteorological and geographical conditions of the place in which they were released or generated.

Dose. Amount of substance administered to an organism that may produce an effect.

Ecosystem. Unit of functional structure and basic organization for the interaction of organisms with each other and with the environment, in a specified space.

Synergetic Effect. Combined result of two substances that act on a living organism, which is greater than the effect produced by the sum of the individual effects when applied separately.

Systematic Effect. The result of the interaction between a pollutant and an organism, having generalized nature, and occurring at a place distant from the point of entry of the substance. A systemic effect requires absorption and distribution of the substance throughout the body.

Thermal Efficiency. The ability of combustion equipment to utilize fuel energy, expressed in terms of heat.

Emission. Release of pollutants originating from chimneys and other escape ducts from industrial, commercial and residential areas, as well as motor vehicles, locomotives or exhaust from airplanes and ships.

Energy. The ability of a system to generate work.

Epidemiology. The study of the distribution of diseases or other health conditions and events in human populations related to age, gender, occupation, ethnicity, and economic status, with the purpose of identifying and combating health problems and promoting good health.

Measuring Equipment. Set of devices or instruments needed to measure the concentration of a specific pollutant present in a gas flux.

Erosion. The destruction and elimination of certain physical, chemical and biological characteristics present in the soil. The factors that increase ground erosion are: climate, precipitation (rain, snow, etc.), wind velocity, topography, degree and length of the slope, physical and chemical characteristics of the original soil, ground cover, its nature and the amount of ground cover, natural phenomena such as earthquakes and human factors, for example uncontrolled felling, subsequent burns, excessive grazing, the removal of important organic layers, etc.

Monitoring Station. Set of technical elements designed to measure simultaneously the concentration of pollutants in the air, with the purpose of evaluating air quality in a specific area.

Atmospheric Stability. Meteorological condition directly influenced by wind velocity and by its upward and downward movement, showing convective and advective air movements.

Service Stations. Establishments where gasoline, lubricants and other motor vehicle fuels are sold to the public.

Standards. Technical specifications, usually prepared in a format that is available to the public, developed with the consensus of receiving approval from all the affected parties. They are based on solid scientific data, technology and experience, with the object of promoting the optimal benefits to the community. These specifications must be approved by an appointed group of individuals at the national, regional or international level.

Stomas. Structures in the leaves of plants used for the exchange of gases and liquid substances.

Urban Structure. Roadways, access routes, different uses given to the terrain with the purpose of making cities more functional.

Exposure. The process through which a substance with toxic properties enters or is absorbed by an organism through any route.

Emissions Factor. The relation between the amount of contamination that is produced and the amount of raw material processed or the amount of energy consumed. For example: an emissions factor for a factory that uses boilers to produce iron could be the number of kilograms of particles emitted per ton of raw material processed.

Physiography. The branch of geology that studies the formation and evolution of the earth's relief, as well as the processes and results that determine its transformation.

Photochemicals. Pollutants that are produced by the reaction of two or more compounds in the presence of sunlight.

Photoreactivity. Trait of certain air pollutants that experience or undergo changes in their composition when reacting with each other or with other air constituents in the presence of sunlight.

Breathable Fraction. Particles less than 10 micrometers in diameter that can enter the pulmonary system without obstacle all the way to the alveoli.

Freon. Gas used for refrigeration which, when released in the atmosphere, reacts with ozone in the stratosphere, reducing the volume of the ozone protective layer.

Major Stationary Source. Any stationary source producing emissions greater than 91 metric tons (100 English tons), per year, for which there is a specific air pollution control in effect; or, any other stationary source that is designated by the Parties for purposes of the La Paz Agreement.

Fixed Source. In air pollution terms, it is defined as a fixed point of large quantities of pollutant emissions, generally of industrial nature.

Mobile Source. Any machine, apparatus, or device that emits pollutants into the atmosphere, water and soil, not having a fixed location. All vehicles, such as cars, ships, and airplanes are considered mobile sources.

Natural Gas. Gas mixture used as fuel. It is obtained from certain underground geologic formations. Natural gas is the mixture of hydrocarbons of low molecular weight, such as propane, methane, butane, and others.

Environmental Management. Administration procedures carried out through the setting of goals, planning, resource allocation, application of judicial mechanisms, etc., on human activities that influence the environment.

Temperature Gradient. Profile in the difference of magnitude for values that are higher or lower than a given temperature with respect to a reference temperature or a distance that is described vertically.

Binational Air Quality Workgroup. Workgroup formed as a result of the La Paz Agreement, charged with analyzing and solving air quality problems in the border region between Mexico and the United States.

Hydrocarbons. Organic compounds containing carbon and hydrogen in varied amounts. They are found especially in fossil fuels. Some of these compounds are hazardous air pollutants because of their carcinogenic nature; some others are important due to the role they play in ozone formation at the urban air level.

Aliphatic Hydrocarbons. Open chain hydrocarbons such as fats.

Aromatic Hydrocarbons. Compounds derived from benzene, which is a ring of 6 carbons with three double links.

Polycyclic Aromatic Hydrocarbons. A group of organic compounds having two or more benzenic rings. One of the better known compounds of this kind is benzo[μ]pyrene, do to its presence in urban air. These compounds are formed during the combustion process of fuels such as diesel. They may cause skin and pulmonary cancer.

Hydrolysis. Phenomenon consisting of the release of water through the breakdown of molecules.

Environmental Impact. Any change caused by a proposed project on human health and safety, plants, animals, soil, air, water, climate, the actual ground use, and resources for the traditional use of Indian populations, or physical structures, places or objects of historical, archeological, paleontological, or architectural relevance, or the integration of these factors. It also includes impacts on the cultural heritage or socioeconomic conditions resulting from those factors. "Impact" includes direct, indirect, or cumulative impacts.

Economic Incentives. Financial support instruments applied in environmental policy with the purpose of changing the predominant behaviors of production and consumption for the benefit of the environment.

Incineration. Process of vigorous and controlled oxidation through which solid, liquid and gaseous wastes are burned and turned into inert compounds such as ashes, carbon dioxide and water.

Incinerator. Device especially designed for the combustion of solid, liquid, or gaseous waste, through the proper manipulation of temperature, retention time, turbulence, and combustion air.

Air Quality Metropolitan Index (IMECA). An non-dimensional unit that allows us to compare the magnitudes of the different pollutants using a homogeneous scale ranging from 0 to 500, where 100 corresponds to the value of the Official Mexican Standard established for each pollutant.

Industry. A set of material operations performed to obtain one or more products starting with the transformation of natural resources.

Traffic Engineering. Planning activities for urban roadways, traffic lights and traffic signals, among others, geared toward attaining the optimal performance of the road service structure of a city.

Emissions Inventory. A listing, by source, of the amount of pollutants released to the air in a community; it is used to establish standards or emissions levels.

Desegregated Inventory. A system of database and mathematical calculations used for identifying and quantifying atmospheric emissions generated by the different sectors and polluting sources, such as industry, commerce, vehicles, ground and vegetation, among others.

Thermal Inversion. Atmospheric condition in which a layer of cold air is trapped underneath a layer of hot air, in such way that it hinders the natural convection movement of air. This event causes the pollutants that are present within the trapped layer to be diffused horizontally instead of vertically, and their concentration rises to a very high level when they encounter a reduced dilution capacity and the continuous emissions input.

Kilocalories. Unit of measure that represents the amount of heat required to rise the temperature of one liter of water by one degree Celsius or centigrade.

Consultative Mechanisms for the Modification or Installation of New Industries Located in the Border Region. The United Mexican States and the United States of America have established mechanisms to inform each other in a timely manner about any new facilities or changes in existing facilities located within the border region.

Urban Physical Environment. A set of natural physical elements (land and climate) and the entire set of works and structures performed by the society that male-up the geographic space of an urban environment, considering the quantitative and qualitative aspects of such elements.

Metabolism. Energy attainment and cell structure formation through the degradation of food.

Heavy Metals. All metals with elemental density greater than 4.5 kilograms per liter and which are deficiently metabolized and eliminated by the body, causing diverse toxic impacts.

Methane. Gaseous, flammable and colorless hydrocarbon. This gas is found in its natural state in deep caverns and mines. It is also emitted by the anaerobic decomposition processes of organic matter, and in swamps.

Meteorology. The study of the physical and energy phenomena produced in the atmosphere.

Metropolis. The main city in a country, state, or region. It comes from the Greek words “mater” which means mother, and “polis” which means city; thus, mother city. It is also generally used to refer to a large city.

Monitoring. Periodical or continuous supervision or proofing, to determine the degree of compliance with the established requirements for pollution levels in several biotic environments.

Microenvironmental Monitoring. Monitoring of the pollution levels in a limited area of the environment that reflects the environmental conditions that are particular to that area.

Carbon Monoxide (CO). Poisonous, colorless, and odorless gas, produced by the incomplete oxidation of fossil fuels.

Morbidity. Any deviation, subjective or objective, from a physiological or psychological state of well being. In this sense, the illness, disease and condition of morbidity are defined in similar manner, and, according to the World Health Organization, it can be measured in three terms: sick people, disease, and duration.

Mutagenic. An agent capable of causing changes in the genetic structure of an organism.

Fog. A cloud that is in contact with the ground. At a regional level, fog is formed by different processes. During the winter, by irradiation (i.e., the cooling of layers near the earth’s surface and their resulting condensation.) During the summer, due to the displacement of cloud nuclei from the Gulf of Mexico.

Maximum Permissible Level. The maximum concentration of a pollutant that must not be exceeded; (for example, standards that allow the exceedance of the maximum level only once a year).

Ambient Air Quality Levels. Critical environmental levels of air pollutants (for example, Normas Oficiales Mexicanas de Calidad del Aire and The National Ambient Air Quality Standards).

NOM-ECOL-086-94. The Official Mexican Standard that establishes environmental specifications for fossil, liquid and gaseous fuels used in fixed as well as mobile sources.

Environmental Quality Standard. Numerical data adopted to be used as the frame of reference for comparing environmental measurements with the purpose of interpreting them.

Environmental Health Standards. Technical specifications or other available documents to the public, formulated by a recognized authority at the national, regional or international level, with the cooperation of the affected parties, and based on a review of scientific and technological results, as well as experience, with the object of safeguarding human health or the environment, while considering other social objectives. These standards are enforceable by law and are made to be complied with.

Olefines. Hydrocarbons, also known as alkenes, with a double link between two carbon atoms and having a low molecular weight. They are characterized by having certain physical properties such as volatility and atmospheric reactivity.

Ecological Arrangement. Planning process aimed at evaluating and programming land use and natural resource management in the national territory and other zones over which the country has sovereignty and jurisdictional rights to preserve and restore the ecological balance and protect the environment.

Oxidant. A compound that accepts electrons and raises the valence of another compound when reacting with it.

Photochemical Oxidants. Pollutants that are formed by the action of sunlight on nitrogen oxides and reactive hydrocarbons in the air.

Ozone. Photochemical oxidant produced by the reaction between reactive hydrocarbons, nitrogen oxides and the intensity of solar radiation.

Parameter. The amount measured or pondered over an environmental indicator.

Vehicular Fleet. The number of motorized vehicles that circulate in a human settlement.

Particulates. A pollutant generated by the processes of combustion, heating, production, transport, and handling of pulverized materials. It consists of ashes, smoke, metals, etc. The main emissions source are industries where ovens, boilers, incinerators, etc. are used, as well as motor vehicles that run on diesel. Some natural sources include eroded areas, unpaved roads, volcanic emissions, etc. Particles in the air can be measured as TSP or PM10.

Breathable Fraction Particles (PM10). Standard used for measuring the concentration of solid and liquid particles suspended in the atmosphere, with a diameter equal to, or less than 10 micrometers, which dictates the behavior of particles in the lungs: PM10 penetrate the deepest parts of the lungs and, through clinical and epidemiological studies, have been found to cause health problems in the most sensitive groups of the population, such as children and people with respiratory illnesses.

Primary Particles. Those that are emitted directly to the air.

Secondary Particles. Those that are formed in the atmosphere through the transformation of gases such as (SOx, NOx, and VOCs) in solids or liquids.

Calorific Power. The ability of an energy producing substance to produce heat, expressed in calories per unit of weight or volume. For example, in metric units, it can be expressed as kilocalories per liter or in English units, as BTU/barrel.

Acid Precipitation. A type of harmful rain that occurs when certain pollutants such as sulfur dioxide and nitrogen oxides react with moisture in the atmosphere to form their respective acids dissolved in precipitated water in the form of rain. It can also be acid snow, acid dew, etc.

Total Suspended Particles (TSP). Any material that exist in the solid or liquid state in the atmosphere, with aerodynamic diameter greater than the individual molecules but smaller than 100 μm.

Electrostatic Precipitator. A device to control particles that works through processes of electrostatic charge and electrical attraction.

Vapor Pressure. A trait of chemical compounds that tend to become volatile, which in the vapor phase exercise pressure on their surroundings.

Medium-life Consumer Product. These include industrial items related with the manufacture of electronic products for home and business use.

Long-life Consumer Products. These include industrial items related with the manufacture of heavy-duty machinery and equipment.

Border XXI Program. Bilateral cooperation program assumed by the federal governments of Mexico and the United States to generate environmental alternatives that promote the transition to sustainable development for border communities in both countries.

Environmental Protection. A set of policies and measures applied to preserve and improve the environment, and to prevent and control its deterioration.

Radiation. Energy propagation through matter and space, in the form of fast particles or waves.

Ultraviolet Radiation. Electromagnetic radiation with wavelengths smaller than those of visible light, but greater than those of X-rays.

Infrared Radiation. Electromagnetic radiation with wavelengths greater than those of visible light.

Reactivity. The ability of an element or substance to chemically interact with other substances, releasing energy and other products.

Vapor Recovery. Device used in service stations to control evaporative emissions generated when gasoline and other fuels are loaded and unloaded.

Natural Resource. Natural element of ecosystems susceptible or not to being utilized to the benefit of man.

Catalytic Reduction. Chemical reaction between substances favored by the promoting action from a substance know as a catalyzer.

Reforestation. The act of planting trees in barren areas where there used to be vegetation.

Environmental Regulation. Legal instruments that establish the conditions under which people must conduct themselves to comply with environmental legislation.

Environmental Health. The part of public health administration engaged in the ways of life, substances, forces and conditions surrounding people, which can have an influence on their health and well being.

Environmental Risk. The possibility (or probability) that a particular exposure, or series of exposures, may cause harm to the health of those individuals that are subjected to those exposures.

Public Health. The condition of total physical, mental and social well being of the population.

Synergism. An interaction of two or more chemicals that results in an effect greater than the sum of their separate effects.

Monitoring System. A set of stations or instruments for automated air quality surveillance.

Extratropical Systems. Meteorological systems generated in high latitudes and normally related with high temperatures and strong winds. The typical extratropical systems are cold fronts, polar air masses, jet streams, etc. Also, during the winter season it is typical to find anticyclonic systems, which affect a country after the occurrence of a cold air system; they are atmospheric systems whose nucleus is characterized by high pressure and mild winds that move clockwise in the northern hemisphere. This type of system causes poor pollutant dispersion in their zone of influence.

Immune System. The ability of organisms to respond in the presence of infectious agents. This system protects the body from microbial diseases.

Tropical Systems. Meteorological systems formed in the intertropical convergence zone (the zone where winds from the northern and southern hemisphere flow together), which are formed by different atmospheric conditions (winds, air masses, temperature, etc.) And manifest themselves in the form of tropical hurricanes, storms, depressions, disturbances, or waves. Normally, when these systems approach a country, they generate conditions that are favorable for the dispersion of pollutants.

Smog. A term derived form the combination of the English words “smoke” and “fog”, commonly used to refer to air pollution caused by the gases generated from vehicular exhaust and factories.

Sublimation. Direct transformation of a substance from the solid to the gaseous state.

Soil. A complex mixture of small particles of rocks, minerals, organisms, air, and water. A dynamic body that changes continuously in response to climatic conditions, vegetation, local topography, material of origin, age, use, and human abuse.

Sustainability. The condition of managing natural resources with the purpose of assuring sustainable and environmentally rational decisions; those which, when put into practice, allow for the continuation of the social and economic development process in benefit of current and future generations.

Toxicity. The inherent ability of a chemical agent to produce a harmful effect on living organisms.

Toxic. Chemical agent that, when entering the body, depending on its quantity rather than quality, is capable of causing alterations in biological systems.

North American Free Trade Agreement (NAFTA). Pact signed in 1993 between Mexico, the United States of America and Canada, with the purpose of reducing tariffs and non-tariff related barriers in trade between these three countries; it includes a Parallel Agreement regarding the Environment.

Threshold. The level of intensity of a stimulus below which no effect is perceived on the exposed medium.

Urbanization. Provision of basic services to a community that lacks them, or to an area in which a human settlement is to be built.

Ground Use. Term used in urban planning to refer to the specific purpose assigned for the use of a piece of land.

Viability. The set of roadways or geographic spaces used for circulation and displacement of vehicles and pedestrians.

Northern Border Zone. The area extending 100 kilometers to the north and 100 kilometers to the south of the border between Mexico and the United States.

Actions	Directly Responsible Parties	Other participants
1. INDUSTRY, COMMERCE AND SERVICES		
1. Regulate emissions in potentially polluting companies through the issuance of environmental licenses, permits, and authorizations	Municipal, State and Federal government with their respective legal authority	Industrial, Commercial and Service Sector
2. Implement a vapor recovery program at storage terminals and gas stations	State Government and Pemex	Intermunicipal Air Quality Monitoring Council (Consejo Intermunicipal de Vigilancia de Calidad del Aire), service station owners
3. Develop the Municipal Emissions Registry	Tijuana and Rosarito Municipal Governments	State Government, Commercial and Service, Chambers and Associations
4. Evaluate the development of a Pollutant Emissions and Transfer Registry (RETC) in Tijuana-Rosarito	State Government	Tijuana and Rosarito Municipal Governments, SEMARNAP, Non-Government Organizations and Academic Institutions
5. Strengthen inspection and oversight of industrial and service establishments	Tijuana and Rosarito Municipal Governments, State and Federal Government	
6. Prompt a program for the reduction of Volatile Organic Compounds (VOCs)	State Government, SEMARNAP	Industrial Sector
2. URBAN AND TRANSPORTATION MANAGEMENT		
1. Start the Vehicle Emissions Program in the Municipality of Tijuana	Tijuana and Rosarito Municipal Governments	State Government, SCT, Chambers of Commerce, Transportation Sector
2. Strengthen vehicular inspection in the importation of used vehicles	Tijuana and Rosarito Municipal Governments	State Government, SEMARNAP, SHCP, SECOFI, Customs Authorities
3. Integrate vehicular inspection with vehicle maintenance programs	Tijuana and Rosarito Municipal Governments	State Government, Transportation Sector
4. Study different alternatives for mass transportation and for the renewal of the vehicular fleet	Tijuana and Rosarito Municipal Governments	State Government, Transportation Sector, Industrial Sector

Actions	Directly Responsible Parties	Other participants
5. Implementation of a campaign to warn visibly polluting vehicles	Tijuana and Rosarito Municipal Governments	State Government and NGOs
6. Develop and integrated study of roadways and transportation	Tijuana Municipal Government	Municipal Planing Institute of Tijuana, State Government and Transportation Sector
7. Induce new growth, soil use, and public transportation design patterns	Tijuana and Rosarito Municipal Governments	State Government, SEMARNAP and SHCP
3. ECOLOGICAL RECOVERY		
1. Prompt a change in the type of fuel used at the Federal Electric Power Commission (CFE)	Secretariat of Energy (SE) and Federal Electric Power Commission (CFE)	State Government and SEMARNAP
2. Convene with PEMEX the supply of oxygenated, low RVP gasoline	PEMEX	Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP
3. Develop a Municipal Program and Regulation on reforestation, and follow-up of the paving programs	Tijuana and Rosarito Municipal Governments, Municipal Reforestation Committee of Tijuana	State Government, SEMARNAP, NGOs, Academic and Research Institutions and general public
4. Develop a program of financial incentives for individuals, institutions, and organizations that develop pollution prevention and control programs	SHCP and SEMARNAP	Tijuana and Rosarito Municipal Governments, and State Government
4. RESEARCH AND INTERNATIONAL AGREEMENTS		
1. Local operation of the Air Quality Monitoring Network	Tijuana Municipal Government	State Government, SEMARNAP, EPA and CARB
2. Review periodically the emissions inventory	State Government and SEMARNAP	Tijuana and Rosarito Municipal Governments, Academic and Research Institutions
3. Consolidate an epidemiological monitoring program associated to air pollution	Tijuana and Rosarito Municipal Governments State Government	SEMARNAP, SSA, ISESALUD, Academic and Research Institutions

Actions	Directly Responsible Parties	Other participants
4. Reach agreements with institutions of higher education to conduct air pollution related studies	Tijuana and Rosarito Municipal Governments	State Government and SEMARNAP
5. Reach agreements with international institutions to conduct air pollution related studies	Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP	Academic and Research Institutions
6. Reinforce the actions of the Border XXI Program	SEMARNAP	State Government, Municipal Governments, EPA, CARB and San Diego County
5. PUBLIC INVOLVEMENT		
1. Promote the involvement of the Binational Alliance for Quality of the San Diego-Tijuana-Rosarito Airshed	Tijuana and Rosarito Municipal Governments, State Government and SEMARNAP	NGOs
2. Develop an environmental awareness and education program for the Tijuana-Rosarito region	Tijuana and Rosarito Municipal Governments	State Government, Academic and Research Institutions, NGOs and Private Parties

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