ESD

Second Annual World Bank Conference on Environmentally Sustainable Development

Draft

# The Human Face of The Urban Environment

September 19–21, 1994

## Management of Water Resources for Mexico City

ISMAEL HERRERA
*NATIONAL ACADEMY OF SCIENCES, AND NATIONAL ACADEMY OF ENGINEERING, MEXICO*

**THIS PAPER HAS BEEN PREPARED FOR THE ENVIRONMENTALLY SUSTAINABLE DEVELOPMENT CONFERENCE. VIEWS EXPRESSED ARE THOSE OF THE AUTHOR AND DO NOT NECESSARILY REFLECT THOSE OF THE WORLD BANK.**

# MANAGEMENT OF WATER RESOURCES FOR MEXICO CITY

Presented by: **ISMAEL HERRERA**
National Academy of Sciences (AIC) and
National Academy of Engineering (ANIAC), of Mexico
Apartado Postal 22-582
14000 Mexico, D.F., MEXICO

## INTRODUCTION

A variety of special conditions provoke interest on what has happened with Mexico City, specially during the second half of this century. The fact, in itself, that this city is the capital of an important country, with a population of more than 90 millions, is a distinction that attracts attention; but furthermore, it is the focus of economical, industrial, cultural and political activity of the country.

Historical and political reasons -in practice, Mexico is a very centralized country, in spite of the descentralization efforts made by the government in recent years, where most of the decisions of some importance are taken at its capital city- produce a strong tendency toward concentration of governmental services and industrial development, in Mexico City; thus, of population -for a any person living in the Country of Mexico, it is clear that living in Mexico City offers greater opportunities of improving.

The Metropolitan Area of Mexico City (*Area Metropolitana de la Ciudad de México*: AMCM or simply, Mexico City) includes the urban part of the Federal District and 17 municipalities of the State of Mexico. The Federal district in turn, is divided into 16 political delegations. The total area of the AMCM is approximately 3,773 $km^2$: 1,504 belonging to the Federal District and 2,269 to the State of Mexico. According to the last census (1990), 17% of the total population of the country -around 15 million people- and forty five percent of its industrial activity is at the AMCM. In addition, governmental offices, international business, cultural activities, the most important universities and research institutions, are densely concentrated in Mexico City: 38% of the Gross National Product is generated there. Very few capitals, of countries of some importance, are so dominant in the national economy.

If Mexico City was a city state, it would be the fourth largest economy of the western hemisphere -only behind, USA, Canada and Brazil. The challenge of problems associated with water supply of such a large city is greater because Mexico City is very high -the altitude of the Valley of Mexico, where it is located, is around 7,300 feet, and the lowest pass into this valley around 8,000. More to the point, a very important source of water supply -the Mexico City aquifer- and possible solution of these problems, cannot be exploited irrestictively because extensive land subsidence damage severily the city's civil works.

Due to importance of these problems and the lessons -most probably, useful for other parts of the world- that can be derived from them, the Academia de la Investigación Científica (National Academy of Sciences of Mexico), the Academia Nacional de Ingeniería (Mexico) and the National Academy of Sciences (USA), through the National Research Council, have undertaken a study -referred as the AIC/ANIAC/NRC, in what follows- whose results will soon be published. This study has been coordinated by a binational committee composed of fourteen members: seven for each country. In the first meeting of this committee, it was decided to address four subtopics: sources and disposal of water, quality issues, demand management and, the legal framework and institutional aspects.

In the first one, the question of where and how raw water can be obtained for the supply of Mexico City, is included; also, how it is eliminated -and in what conditions- after it has been used. For Mexico City, an important related point is the ever present risk of flooding. Flooding was recurrent in this area, since pre-Cortesian times and was only recently averted by means of a monumental construction: *el Sistema de Drenaje Profundo* (the deep drainage system), whose operation is considerably complex.

Quality issues lead to many related health and medical questions. Also, the procedures used for controlling quality had to be adressed.

An alternative to increasing supply, for granting satisfactory provision of water, is reducing demand. But this is an option that must handled with expertise, because the goal is to reduce demand without restricting development and progress. The general methodology for achieving it is *demand management*. This topic, however, is not new to the utilities in Mexico City; several projects with this orientation have been established in the past, although their implementation has been slow and not thorough.

The last subtopic to be covered is especially relevant for the water supply of Mexico City: laws and regulations of very different character apply, and a network of institutions, quite complex, are responsible for developing and administering, water and sewage services in the Metropolitan Area of Mexico City. Some of the institutions entrusted with such responsabilities are: the Federal Government through the National Water Comision (Comision Nacional del Agua: CNA), which in turn entrusts the Gerencia de Aguas del Valle de México (GAVM), the governments of the Federal District and the State of Mexico, and the local municipal governments, in addition to the Secretaria de Salud and the Secretaria de Desarrollo Social (SEDESOL), which are responsible for health and enviromental concerns, respectively.

The brief presentation I will make here, only intends to give an idea -just a taste- of the kind of information and results of this study; clearly, it is not a summary, because it would have been impractical to try to cover all the subjects of the study, in such a short time.

## POPULATION AND URBAN EVOLUTION

There is evidence of human presence in the Valley of Mexico, since 25,000 B.C., and human settlements since 5,000 B.C. In the time of the Spanish Conquest, there were between 200,000 and 300,000 inhabitants in Mexico-Tenochtitlan -this population was larger than any of the Spanish cities of that time. However, population declined drastically immediately after the Conquest, and it was not until about 400 years after, that population reached -and overtook- its pre-Cortesian level. The evolution of the population is summarized in Table 1.

| Table 1 | *Population of Mexico City (1742-1990)* |
|---|---|
| *Year* | *Population* |
| 1742 | 101,000 |
| 1803 | 138,000 |
| 1900 | 345,000 |
| 1910 | 400,000 |
| 1930 | 1,000,000 |
| 1950 | 2,952,199 |
| 1960 | 5,125,437 |
| 1970 | 8,882,882 |
| 1980 | 13,873,912 |
| 1990 | 14,987,000 |

By the turn of the century, in 1900, the population was only 345,000, but after the Mexican Revolution of 1910, the population of Mexico City became quite dynamic, growing at a rate of 6% per year, or more, until 1970 and 5% per year during the seventies; apparently, however, since that time the growth of population has slowed down -it was only less than 1% per year during the eighties.

Until 1940, the city grew towards the west and northwest, and the south, with a unique well defined center of the city. Later, the rapid urban growth due the fast industrialization process that took place, favored the birth of many subcenters. Regarding the manner in which new land is incorporated into the AMCM, it is possible to distinguish at least two mechanisms: a relatively well organized one, which takes place in a planned manner and produces residential areas for the middle and upper classes, and other one which takes place according to a disordered pattern and that could be called the "urbanistic model of the poor". This latter process is associated with illegal procedures for appropriating land, such as invasions by people that recently immigrated into the AMCM from other parts of the country. In this pattern, after some time the authorities intervene, firstly to regularize land possession and eventualy to supply urban services, including water supply, although the services may remain inappropriate for long periods of time.

## WATER SUPPLY

The Valley of Mexico is a closed basin -although it has been artificially opened- and it is important to distinguish between internal and external sources of raw water. The most important source supplying water for Mexico City, is an internal one: the aquifer that underlies it (see Table 2). Another important source is

Table 2 Water Supply Distributed by Sources
Federal District (DF) and State of Mexico (E. de M.)

| Source | Federal District $m^3$/sec | State of Mexico $m^3$/sec | Total $m^3$sec | % |
|---|---|---|---|---|
| Ground Water | 27.0 | 21.3 | 48.3 | 80.1 |
| Valley of Mexico | 22.7 | 20.3 | 43.0 | 71.3 |
| Lerma | 4.3 | 1.0 | 5.3 | 8.8 |
| Surface Water | 8.3 | 3.7 | 12.0 | 19.9 |
| Cutzamala System | 7.6 | 3.0 | 10.6 | 17.6 |
| Río Magdalena | 0.2 | | 0.2 | 0.3 |
| Presa Madin | | 0.5 | 0.5 | 0.8 |
| Springs and Ice | 0.5 | 0.2 | 0.7 | 1.2 |
| Total Supply of Water | 35.3 | 25.0 | 60.3 | 100 |

the Cutzamala System, which takes water from the Cutzamala-Lerma-Santiago Basin, approximately 100 km west of the Valley of Mexico and around 1,000m below it. Another important external source is the Lerma Valley, which yields groundwater. Internal surface water -Río Magdalena, Presa Madin, springs and ice (from Popocatepetl and Iztlacihuátl)- represents only a small fraction of the total supply: 2.3%.

On the basis of the total households available, it is estimated that, in the Federal District (DF), 97% of the population has access to water by means of a distribution system, while the supply for the other 3%, is by means of tank-trucks or self supply. In the case of the State of Mexico (E. de M.), this proportion is 90.5% to 9.5%. The consumption in the DF is 364 l/p.d. (liters per person per day) and in the E. de M. 230 l/p.d.; it varies considerably with income and the kind of household. For comparison: in USA it varies from 250 to 1,120, with an average of 660. Due to the rapid growth of the city, the government of the DF (DDF) establish 150 l/p.d., as its basic quota to supply the new urban population.

THE MEXICO CITY AQUIFER

It is a very thick one and has been explored recently to great depths: 3,000 to 4,000. The AIC/ANIAC/NRC study contains its detailed description, as it is known at present. An important feature, is a thick cover of very compressible clay which produces subsidence of the ground when it is exploited and causes much damage to constructions and civil works, in general, of the city.

Water is being extracted at a rate of 43 $m^3$/sec (Table 2). On the other hand, the figure of 16 $m^3$/sec is generally accepted for the recharge of the aquifer, although more optimistic computations of around 26 $m^3$/sec have also been presented. Anyway, although the aquifer is being overexploited, it could continue supplying water at the present rate for many years -a century or more- if it were not for the associated land subsidence which is extremely costly and inconvenient.

Another important fact is that not all of the area of the aquifer is covered by the clay layers: only around 20% of it. This opens some management opportunities for the exploitation of the aquifer, with respect to the associated land subsidence, and these are already being used, to some extent, by the utilities.

QUALITY

All the water from Cutzamala System is purified at the treatment plant of Los Berros. Its installed capacity is 10.0 $m^3$/sec, although at present it treats 10.6 $m^3$/sec; in the original project its capacity was 24 $m^3$/sec. The treatment consists of precloration, coagulation/floculation, gravity sedimentation and rapid filtration with sand.

There are several treatment plants which were originally projected for treating the groundwater coming from wells located in the Valley of Mexico. In these plants, at present, only chlorine desinfection is performed.

The quality of the water coming from the aquifer of Mexico City, in general, is quite good. The thick layers of clay that cover the aquifer have very low permeability and constitute a very effective protection against pollutants. However, as has been mentioned, only 20% of the area is overlayed by such strata and the rest is exposed. The aquifer is especially vulnerable in the recharge areas and the risks are increased because many of the irregular settlements, with inadequate services, have been established there.

DEMAND MANAGEMENT

The main problems in this respect are: 1) insufficiency of water planning policies; 2) weak finances as a consequences of traditional practices for water pricing and enforcing payments; and 3) inequity in the access to water -in sufficient quantity and quality-, specially for sectors of low income.

Water costs as well as water consumption are out of control; thus, it is not clear to what extent increased water supply is necessary to cop with increasing population and economic activity. Because of water scarcity and, stricter water quality and environmental norms, water costs have escalated leaving water utilities with a yearly deficit estimated in one million U.S. dollars. This restricts drastically the ability of the system to expand and provide essential services to areas that lack them.

Water authorities, until recently, focused their attention in constructing new and impressive water works; however, little attention had been given to demand management. The traditional concept of water administration must be replaced by a broader one which gives attention not only to water supply, but also to demand management. The concept of *water conservation* must be replaced by *efficient use of water*, in which users must play an active role. In addition to other actions, many of them of educational character, effective metering of consumption and enforcement of bills are very important. Also, restructuring of prices; a fundamental key to demand management is establishing realistic pricing.

LEGAL AND INSTITUTIONAL FRAMEWORK

An outstanding fact is that the institutional framework for water management in Mexico City, in particular for the Federal District, is undergoing a very extensive change as a result of the

Presidential Decree of July 14, 1992. This important document creates a new *Comisión de Aguas del Distrito Federal* (Water Comision for the Federal District: CADF). The main goal is to increasing the efficiency of water supply and disposal of waste water. The *Dirección General de Construcción y Operación Hidráulica* (DGCOH) -the entity mainly resposible for these functions at the DDF- will continue to operate, but potabilization and water supply, drainage and treatment of residual waters will be privatized.

# ISMAEL HERRERA

Ismael Herrera is a mathematician devoted to applications of mathematics: civil engineering, geophysics and groundwater. He received his PhD from the Division of Applied Mathematics at Brown University (USA), after having carried out undergraduate studies in Chemistry, Physics and Mathematics, at the National University of Mexico (UNAM). His scientific work includes both methodological contributions, as well as specific applications.

He has been Director of the Institute of Geophysics at UNAM on different periods, and was organizer and founder of the National Council for Science and Technology (CONACYT). The distinctions he has received for his achievements include the most important prizes offered in Mexico. He is former President of both the National Academy of Sciences and the National Academy of Engineering of Mexico. His international activity includes editorial responsibilities and advisory positions for many societies and universities. In particular, he is editor of the journal Numerical Methods for Partial Differential Equations (John Wiley) and has participated in the Advisory Council (civil Engineering and Operations Research), at Princeton University.