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WATER MANAGEMENT IN METROPOLITAN AREAS OF LATIN AMERICA

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> The chief function of the city is to convert power into form, energy into culture, dead matter into the living symbols of art, biological reproduction into social creativity. The positive functions of the city cannot be performed without creating new institutional arrangements, capable of coping with the vast energies modern man now commands: arrangements just as bold as those that originally transformed the overgrown village and its stronghold into the nucleated highly organized city.
>
> **Lewis Mumford**

Every aspect of life in contemporary Latin American societies is touched by the growth of large urban complexes, some of which are already amongst the world's biggest agglomerations of human population and economic activities. Not surprisingly, the growth of such large urban agglomerations has had a severe repercussion on the water resource, as on the environment in general. One unfortunate indication of the extent of this impact has been the recent outbreak of cholera in many countries which was clearly related to deficient metropolitan water management. For three out of four Latin Americans alive today, the urban environment will be their living environment. In many respects, the people living in the large metropolitan areas of Latin America are the most privileged of the region, but, at the same time, these privileges are very unequally distributed and have been obtained in a very precarious manner. The development and management of the water resource infrastructure needed to support the multiple demands of populations of the metropolitan regions is far from secure.

Urbanization and the Water Resource

Two important changes in the spatial distribution and in the structure of human activity have had serious repercussions for the management both of flow regimes and of the quality of water in the countries of Latin America. The first has been the concentration of population in the major metropolitan centres accompanied by the increasing use of water-borne waste disposal systems and the second, the interference in the hydrologic cycle resulting from the expansion of urban areas, the intensification of agricultural land use in the vicinity of the metropolitan regions and the related increase in the artificial regulation of stream flow.

Equally significant, from the viewpoint of water management, have been the changes that have occurred in economic structure. Particularly important has been the growth of manufacturing since the 1950's. Despite the so called *lost decade* of the 1980's, manufacturing only decreased it contribution to the regional gross domestic product by 0. 9% in 1990 compared to 1970. Moreover, in the last twenty years the structure of manufacturing has changed and the manufacture of intermediate and capital goods has become of equal significance to that of food and other non-durable goods. It is the intermediate and capital goods industries that require large amounts of process water and produce the largest and most complex waste loads.

Every large metropolitan area in Latin America has a specific relationship to the water resource depending on its site. There are, however, common patterns in the nature of the relationship with increasing demands for domestic and industrial water supply, increases in the waste loads discharged to the water bodies of the metropolitan regions, occupation of flood plains and increased demands for water-based recreation. These demands are reflected in the necessity to tap ever more distant sources of water supply, in the drawing down of groundwater aquifers, often in the development of considerable shortfalls in the provision of public water supplies. A corollary of the expansion of the demand for water supply is the increase in the discharge of wastes, in terms of both the volume and concentration of contaminants, with the obvious consequence of the increasing pollution of water bodies (ECLAC, 1990). Even where discharge of waste loads is to the sea, considerable local, and not so local, pollution of water bodies has been the result in most cities of 100,000 and over population with the most dramatic cases in the larger cities, as in São Paulo, Rio de Janeiro and Buenos Aires. If the universal provision of water supply and sewerage services to the urban population is achieved then waste discharges through centralized waterborne sewage systems can be expected at least to triple from their current levels (see Annex). At the same time, as economic growth resumes in the region and industry expands again and higher levels of consumption are reached by the mass of the population, it can be expected that the concentration and range of contamination from industrial sources will increase more than proportionally.

Water supply and waste discharge are not, however, the only ways through which the growth of metropolitan regions has had an impact on the water resources of Latin America. Large concentrations of population and industry generate demands to drain wet lands and to protect built up areas from flooding caused through encroachments on to flood plains. The rate of run-off increases due to the growth in paved areas and to other changes in hydrologic regimes. Examples include the growth of Mexico City in the bed of Lake

Texcoco, the filling of the margins of Guanabara Bay in Rio de Janeiro, the expansion of Guayaquil over the estaurine marshes of the Guayas, the canalization of almost all streams in every urban area and the steady expansion of land covered with buildings, parking lots and roadways (the headquarters of this Commission are built on the flood plain of the Rio Mapocho). From 1950 to 2000, according to estimates made by ECLAC, the urbanized area of Latin America and the Caribbean will have increased from 3,120 to 27,500 square kilometers, over 0. 1% of the total surface area of the region (ECLAC,1979).

An important component of the challenge presented by the growth of large metropolitan regions is the increasing frequency of multiple and successive use of the related water courses. One often forgotten aspect is the large demand generated for water-related recreation, particularly by the poor. Recreation requires high water quality and, therefore, the protection of water bodies from contamination. At the same time, recreational use of the water resource may threaten the more fragile elements of aquatic ecosystems. The control and regulation of river flow also expands with industrial and urban growth, due to the increased demand for hydroelectric power. This means the regulation of flow regimes through the construction of dams, reservoirs and levees, the canalization of streams and other protective works, all of which results in changes in the spatial or temporal patterns of flow. The impact of hydroelectricity works on patterns of streamflow is increasing in the region. On the Parana River and its tributaries a chain of dams and reservoirs, accounting for almost all the storage capacity created after 1976, has been built culminating in Itaipu on a scale large even by global standards. In Chile, the flow regimes of most of the rivers between Santiago and Puerto Montt are or will be affected by the construction of dams for hydroelectric power generation. In Latin America as a whole more than ninety percent of reservoir capacity has been constructed since 1950.

The Metropolitan Population

Since 1950 Latin America and the Caribbean has experienced an expansion of population without equal in its history from 159 millions to 325 millions in 1980 and an estimated 450 millions in 1990. The annual rate of increase peaked at 2. 8 percent in the early sixties. It has since declined to around 2 percent and is expected to halve over the next 25 years (CELADE, 1990). The increase in population has been accompanied by a significant concentration of the population in urban areas. While in 1950 only 25 percent of the population was urban by 1980 over 50 percent lived in urban areas and by 1990 over 70 percent (United Nations 1991) .

Over this period, the urban population has increased at a rate 3 times that of the rural population. In 14 countries, the average rate of expansion of the urban population has been over 4% per year. Only in Argentina, Chile and Uruguay, the most urbanized countries, has the rate of increase in the urban population averaged below 3%.

The increase in the urban population has been heavily concentrated in the larger cities. In 1950 only in 4 countries, Argentina, Chile, Cuba and Uruguay did more than 20 percent of the population live in cities with more 100,000 inhabitants and only 7 cities had populations of over 1,000,000. By 1980, more than 20 percent of the people of Latin America lived in cities with more than 1, 000, 000 inhabitants, 25 cities, and it is estimated that by 2000 more than half the population will live in the 46 largest metropolitan areas.

At first, the expansion of the urban population occurred through migration. More recently, however, the expansion of the urban population has been largely through natural increase. The massive emigration led to a marked social differentiation within the cities. In 1986, ECLAC estimated that approximately 30 percent of the urban population lived in poor households and of these poor households approximately one-third were indigent (ECLAC 1992).

It is not surprising that the rapidity of the expansion in the urban population has strained the possibilities for urban management in all its aspects, not least water resource management. Rates of population growth has reached over 10 percent a year in some cities for some periods (Gallopin 1991). Moreover, the largest metropolitan regions in Latin America are now amongst the largest in the world and their is little historical experience of managing such large agglomerations of human activity.

Water Supply

In few metropolitan areas of Latin America does the whole of the population receive its drinking water in its home from public centralized water supply systems, but the majority do. By the end of the 1980's, only twenty percent of the urban population of the region was dependent on public taps, wells or tank trucks for their drinking water. This means, however, that more than 60,000,000 people living in cities are without a reliable source of safe drinking water. The majority of these people live in poor households in urban neighbourhoods with little formal incorporation into the organized urban system. There are, however, considerable differences among metropolitan areas, even ones which might otherwise be considered similar. For example, in Santiago the whole population has access to an efficient safe public water supply and to sewerage services while in Buenos Aires less than 60 percent of the population is served by public water supply and less than 40 percent by sewerage (Brunstein 1988).

In addition to the deficiencies in service provision, in many urban areas there is a lack of continuity in the supply of water within the public system. Demand beyond the production capacity of the system, lack of maintenance, high water losses, (in the typical system unaccounted for water amounts to between 40 to 60 percent of production (Yepes 1990)), lead to many systems functioning only intermittently. It is common that water supply and sanitation companies operate largely as construction companies, emphasizing expansion and new works. Preventive maintenance is uncommon and even repairs are often only carried out when emergencies arise. In general, it can be said that water supply and sanitation institutions function inefficiently in most metropolitan areas.

The failure to provide efficient public supplies leads the population to adopt alternative solutions. For example, in Buenos Aires it is estimated that more than 700,000 households obtain their water supply from individual wells, others have organized their own systems through cooperatives or private companies, while yet others have resorted to illegal connections to the lines of the public systems. The difficulty with such solutions is the lack of guarantee of the quality of the water obtained. At least, the population of Buenos Aires has access to an aquifer. In Lima, for many there exists no such alternative and the poor must rely on private water carriers and pay up to 17 times the price charged by the water utility per cubic metre (World Bank 1988).

Sanitation

The environmental health consequences of deficient water supply are compounded by the greater failure to provide adequate sewage disposal. This problem has two aspects the provision of household connections to a sewage system or to a properly functioning septic tank and the adequate and safe disposal domestic and industrial once they are collected in a waterborne sewage system.

The PanAmerican Health Organization (PAHO) estimated in 1988 that 49 percent of the urban population of Latin America and the Caribbean lived in dwellings with sewer connections, 32 percent in houses with septic tanks or latrines and 19 percent in housing lacking sanitation services all together. In general, the larger cities have a larger proportion of dwellings with sewage connections, but the situation is very varied ranging from zero in Port au Prince to over 90 percent in Santiago (see Annex).

Treatment of sewage prior to discharge is one aspect of water use and management which varies little across the region. It is estimated that less than 10 percent of sewage systems treat sewage adequately and that these systems account for less than 2 percent of total waste flows (ECLAC 1990). No single large metropolitan region treats more than a small proportion of its wastes and the majority treat none.

In few cities is there even any rational disposal of sewage. In most major urban areas sewage flows to the nearest water course. In consequence, most urban water courses are little more than open sewers and, as in São Paulo, it is common that streams flowing through the city are anaerobic due to the high sewage loads. In Santiago, according to 1990 data, the average annual flow of sewage to the Mapocho River is 9.6 m^3 a second while the average flow of the river, measured above the city, is only 6.6 m^3 a second. It is expected that the discharge will double over the next twenty years (Gomez 1991). Santiago is, however, fortunate, since the water supply and sanitation company is building collectors and treatment plants, the only metropolitan area currently with such a programme.

In cities without extensive sewerage systems, such as in Buenos Aires and Cordoba, Argentina, the widespread use of septic tanks and latrines leads to serious pollution of the groundwater. It is known, in the case of Buenos Aires, that the most superficial aquifers are seriously contaminated particularly from latrines used for in the absence of sewers (Brunstein 1988). Groundwater is a major source of water for water supply systems. At least, two major conurbations obtain the major share of the drinking water from wells, Mexico City and Lima and, in many others, groundwater is an important secondary source (Foster 1987) .

Drainage

Storm drainage systems are restricted to the central areas of the older large cities In most urban areas, when it rains it floods and urban flooding is a very common and costly phenomenon in the region. As much of Latin America lies in tropical and sub-tropical zones characterized by heavy rainfall, the amount of storm water runoff can be very significant, commonly over 1m^3 per minute for each square kilometre and in some cities more than 4m^3. A proportion of the storm water enters the sanitary sewage systems which can result in hydraulic overloading. This can be particularly serious when sewer overloading leads to flooding.

Urban flooding is a growing problem. In Buenos Aires serious flooding has become increasingly common in the last decade. The cause is the increased paved area and the failure to improve the capacity of the storm drains. The system was constructed to serve only the Capital Federal which forms the centre of the conurbation, but having less than one-third of the total population and having an even smaller proportion of the urbanized area. For example, the Arroyo Medrano was converted into a storm sewer in the late 1930's with an extension built in 1946. Until 1985, the capacity of the sewer was sufficient to prevent flooding. Following a major flood in January, 1985 there have been seven floods in the years to 1990 (Federovisky 1990). In part, the flooding arose from lack of maintenance, but is also due to the urbanization of the upper part of the watershed.

Frequent floods are one consequence of the absence of storm drainage. The damages caused can be significant, particularly if the floods are accompanied by landslides. It has been estimated that, at least, one-fifth of floods in Latin America were associated with landslides in recent years, although not all these were in urban areas (ECLAC 1990).

Water Quality

In Latin America and the Caribbean, the main cause of water pollution is the direct discharge of domestic and industrial wastes to surface water sources which leads not only to the contamination of these water bodies, but also to that of adjacent groundwater aquifers. The geographical distribution of water pollution is dominated by the flows originating from the large metropolitan areas. It is not surprising, in consequence to find that the water quality of water bodies in the vicinity of the large metropolitan area is seriously compromised.

A direct and sensitive measure of the overall state of pollution of water bodies by domestic sewage and other sources of gross biological contamination can be obtained by counting indicator organisms such as faecal coliforms. There are many individual reports of very high levels of coliforms in the water bodies which receive discharges from the large metropolitan centres, the Bogota River, the Mapocho River, the Tiete, any stream in Buenos Aires, Guanabara Bay, the Pacific Ocean off Valparaiso—Viña del Mar, but such information is not available for the majority of the region's water bodies. Recent data on 24 regionally representative Central and South American rivers suggests that the situation may be worse, on average, than in other parts of the world.

Twice the proportion of the rivers monitored in Central and South America as compared with rivers monitored in other parts of the world have faecal coliform counts of more than 100,000 per 100 ml (WHO 1987).

The process of industrialization, even if somewhat detained in many countries over the last ten years, has contributed to the increased occurrence of water pollution. In many countries, practically all but the most toxic industrial effluents are discharged without adequate treatment. For example, in Argentina the retention of industrial waste loads is reported to be 10% or less (Argentina 1984). Unfortunately, there is no information from which to determine the overall impact of industrial waste flows on water quality. It has been estimated that industrial effluents constitute 90% of water pollution in Mexico, while in Colombia industry is estimated to account for half of both water and air pollution (ECLAC 1990).

A water quality problem particular to point-source water pollution of urban origin is the use of polluted water for irrigation. This frequently occurs where large urban areas are located in areas of irrigated agriculture and where untreated wastes are returned to water courses which are subsequently used for irrigation. The use of untreated waste water for irrigation may give rise to serious sanitary problems. It has been one contributor to the 1991 cholera epidemic. Both pathogens and heavy metals, apart from having direct effects harmful to crops and soils, can subsequently enter the human food chain.

A classic example of this problem is provided by Santiago, Chile. The index of faecal contamination in the River Mapocho fluctuates between 100,000 and 1,000,000 coliforms per 100 ml of water. This exceeds by various orders of magnitude the norms for irrigation water which is particularly important as vegetables which are customarily eaten raw are the main products grown. The principle effects of this gross pollution of irrigation water are felt in human health and the relationship has been clearly shown and known in Santiago for fifty years (Chile 1977). Only, however, with the cholera outbreak last year were effective measures taken to prevent the growing of fresh vegetables in the affected lands. Santiago has always had a high incidence of gastroenteritic diseases, despite the high and now universal provision of reliable and safe drinking water. In 1989, 7,500 cases of paratyphoid and typhoid fever, 8,700 cases of hepatitis and 750,000 cases of severe infant diarrhoea were reported in the Metropolitan Region (Gomez 1991). The incidence of these diseases has fallen sharply with the measures introduced to control cholera.

Metropolitan Water Management

Water management in Latin America is still predominantly use or purpose directed. The predominance of this approach is beginning to be shared with innovations tending towards a more integrated and resource-focussed management. The extent to which a more integrated approach is being taken is intimately related to the impact of the development of large scale urbanization on the use of the water resource.

In general, there are no examples of institutions formed to specifically undertake water management within metropolitan areas. In Colombia and in Brazil, there are institutions which have some direct responsibility for metropolitan water management, but in neither country is this the principal objective of the institution. In the majority of the countries of the region, there is not even the semblance of such an institution.

In metropolitan regions, management by water use normally means that the only effective water management institution, despite its inefficiencies, is the water supply and sanitation company. In Ecuador the services are managed separately, but generally one entity has responsibility for both services. The sanitation company, rarely private, may be municipal as in Colombia and much of Mexico, regional as in Chile, state or provincial as in Argentina and parts of Brazil or national, as is generally the case in Central America. Whatever their affiliation, the water supply and sanitation companies are too often financially weak and inefficient institutions. There are significant exceptions to this general situation, for example, the five companies included in the World Bank study of management and operational practices of well-run companies in the region, COPASA, Minas Gerais, ACUAVALLE, Colombia, E.P.M., Medellin, Colombia, EMOS, Santiago, Chile and C.A.D., Monterey, Mexico (Yepes 1990). The cause of the inefficiency of water supply and sanitation companies is the failure to charge tariffs which reflect the real cost of providing water and sanitation and the consequent loss of autonomy and, therefore, dependence on central government financing. In many countries, water supply and sanitation companies are not permitted to charge a commercial tariff for political reasons.

If water supply and sanitation companies are often inefficient, responsibility for other aspects of metropolitan water management is at best diffuse and at worst non-existent. Storm drainage is usually left to the municipalities, flood control may be their responsibility or left unassigned until disaster occurs, water quality control will often be the responsibility of the Ministry of Health, irrigation will belong to agriculture or perhaps to the private sector. The list of possible institutions which may be involved in water management in any one metropolitan area is very long and very varied. Recently, when in Santiago, Chile a meeting was organized to consider the integrated management of the Mapocho River almost 60 institutions were represented. More importantly, in most metropolitan regions no means exist to coordinate either policies or actions related to water management.

One exception to this is the case of the three major cities in Colombia, Bogota, Cali and Medellin. In Colombia, the Regional Corporations play an important role in water management and provide a vehicle for the consideration of metropolitan water resource management issues.

The Regional Autonomous Corporation (CAR) for the Bogota River was created in 1961 to promote regional development. In 1968, it was delegated authority for the management of water in the region under its jurisdiction which includes the entire watershed of the Bogota River and its tributaries from its source to its outlet in the Magdalena River. The CAR is managed by a Board of Directors of six members chaired by the Head of the National Planning Department (*Departamento Nacional de Planeación*). The members include the Mayor of Bogota and Governors of Boyacá and Cundinamarca. CAR has its own income, the main source of which is the national property tax on real estate within its area of jurisdiction.

The water management responsibilities of the CAR do not extend to water use. The main water user in the Bogota valley, is the City of Bogota for domestic and industrial water supply, for the transport and dilution of wastes (there is no sewage treatment) and for the generation of electricity. Secondary users are the smaller cities in the valley and agriculture for irrigation. The intensity of use is such that careful coordination is necessary, although not always achieved in practice. The main means of coordination are through the fact that the Mayor of Bogota is also the President of the municipal sanitation and electric power utilities, through the National Planning Department, and through a formal water committee of representatives of the CAR and the municipal utilities. The latter is only responsible, however, for the coordination of flow management through the various control systems which have been constructed on the river and its tributaries.

The systems in the Cali and Cauca valley and for Medellin are similar, although details vary. None of the three systems is free from shortcomings and improvements could be made in their effectiveness. In addition, none of the corporations have metropolitan water management as their central responsibility. Nevertheless, the experience of these corporations is indicative for the development of systems for the management of water resources within metropolitan regions in Latin America.

Conclusions

Water management in Latin America is far from optimum despite the progress that has been made in the application of scientific management techniques. This is especially the case in the urban regions where the use of the water resource is most intensive and conflictive. In these regions the intensive use of water bodies for the transport and dilution of wastes has been difficult to accommodate in the existing management systems as has the increasing urbanization of many river basins.

A recent study by ECLAC shows that many issues inherent to water system operation are being poorly handled and even ignored in the running of systems (Lee 1990). This is the case almost without exception with respect to the maintenance of infrastructure, but other aspects of system operation and management are seriously disregarded as well. These circumstances apply equally forcefully to the management of urban water resource systems as to the management of water resources in general.

It is also observable that any differences in management performance seem to be due not to organizational structure, although having an institutional structure in which issues related to metropolitan water management can be publicly discussed helps, but to the degree of dynamism of management in any specific case. There is some evidence, however, that the establishment of a clear distinction between responsibility for the management of the resource and responsibility for the management of the resource's use can be beneficial. Private sector or user responsibility for use management can be a valuable tool towards achieving this distinction.

In the case of metropolitan water management, this would translate itself into the establishment of some mechanism for the discussion of policy and for coordinating actions. The particular nature of the mechanism would naturally have to depend on individual circumstances. No one solution can fit all cities and it is not proposed that a new bureaucracy should be created. There must be a place, however, for the discussion of the issues inherent in metropolitan water management if better management is to be achieved. It is necessary, therefore, that, whatever its nature the mechanism created should be a means for public participation as well as for coordination between the public institutions responsible for water related policies and programmes and the public and private institutions responsible for water use.

Of itself, a institutional innovation will not solve the problems of metropolitan regions and their water resources. One of the major restraints on the achievements of improvements in water supply and sanitation has been the weak financial situation of publicly owned water supply and sanitation companies. This can be seen to be an even more serious constraint for the control of water quality. The failure to provide public leadership in water quality severely hampers the introduction of an effective policy to control the private sector.

The financial restraint must be removed and there is only one solution, the self-financing of water supply and sewerage services. Tariffs for water supply and sanitation must be established and collected which give water supply and sanitation companies sufficient revenues to finance system expansion, system maintenance and the construction and operation of sewage treatment plants. Unless this is done, the water resources of the metropolitan regions of Latin America have no other future than continual degradation.

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Annex 1

Characteristics of direct water use in the major cities of Latin America and the Caribbean
(latest available data)

Country	City	Population, 1990 (thousands) a/	Water supply		Sewerage		Recipient water body
			% served	l/c/d	% served	Outflow	
Argentina b/	Cordoba	1136	69	354	19	2	River Primero
	Buenos Aires	11509	66	523	55	25	River Plate and tributaries
	Rosario	1084	64	453	29	3	River Parana
Bolivia	La Paz c/	1234	75	173	50	1	River de La Paz
Brazil d/	Belem	1029	83	279	30	n/a	Marajo Bay
	Belo Horizonte	3598	83	279	30	n/a	River Das Velhas and others
	Brasilia	2362	83	279	30	n/a	Paranua Sta Maria
	Campinas	1659	83	279	30	n/a	River Capivari
	Curitiba	2031	83	279	30	n/a	River Belem
	Fortaleza	2088	83	279	30	n/a	Atlantic Ocean
	Goiania	1679	83	279	30	n/a	River Meia Ponte
	Manaus	1215	83	279	30	n/a	River Amazon
	Porto Alegre	3124	83	279	30	n/a	Estuary of Guaiba
	Recife	2492	83	279	30	n/a	Atlantic Ocean
	Rio de Janeiro e/	10714	83	279	30	20	Guanabara Bay and Atlantic Ocean
	Salvador	2401	83	279	30	n/a	Atlantic Ocean
	Santos	1199	83	279	30	n/a	Atlantic Ocean
	São Paulo	17395	83	279	30	28	River Tiete and Lake Billings
Chile	Santiago f/	4734	98	400	92	10	River Mapocho
Colombia	Baranquilla g/	1019	50	332	48	n/a	River Magdalena
	Bogota h/	4851	96	200	84	11	River Bogota
	Cali h/	1555	96	155	76	5	River Cauca
	Medellin h/	1585	96	155	76	n/a	River Medellin
Costa Rica	San Jose i/	1016	100	468	69	n/a	River Virilla and River Grande de Tarcoles
Cuba	Havana j/	2099	83	456	39	n/a	Gulf of Mexico
Dominican Republic	Santo Domingo k/	2203	27	250	39	n/a	River Ozama
Ecuador	Guayaquil l/	1674	58	187	48	n/a	Rivers Guayas and Salado
	Quito m/	1241	62	187	62	n/a	River Guaillabamba
Haiti	Port-au-Prince n/	1031	15	60	0	n/a	Bois de Chene
Mexico o/	Guadalajara	3161	92	288	82	7	River Santiago
	Mexico City	20192	97	245	82	41	River Tula and Lerma/Panuco
	Monterrey	2970	92	265	82	6	River Santa Catarina
	Naucalpan	1192	83	270	68	n/a	n/a
	Puebla	1267	83	270	68	n/a	River Atoyac
Nicaragua	Managua p/	1012	86	n/a	59	3	Lake Managua
Peru	Lima q/	6247	60	250	85	12	Pacific Ocean
Uruguay	Montevideo r/	1197	99	181	76	n/a	Atlantic Ocean
Venezuela s/	Caracas	4096	78	205	68	n/a	River Guaire and RiverTuy
	Maracaibo	1146	78	205	68	n/a	Lake Maracaibo

Source:

a/ United Nations, Department of International Economic and Social Affairs, World Urbanization Prospects 1990. Estimates and projections of urban and rural populations and of urban agglomerations, ST/ESA/SER.A/121, New York, 1991, pp.187-194.

b/ The World Bank, Infrastructure and Energy Operations Division, Country Department IV, Latin America and the Caribbean Regional Office, Staff appraisal report. Argentina. Water supply and sewerage sector project, Report 8425-AR, November 26, 1990, Annexes1-4. Water supply is estimated from per capita water production (in the province of Cordoba for Cordoba, in the province of Santa Fe for Rosario, average for OSN - for Buenos Aires). Drinking water supply (urban and rural concentrated populated connected to public water supply), sewerage (urban and rural concentrated population connected to public sewerage) and sewage outflows are estimated in the same way.

c/ According to The World Bank, Country Department III, Infrastructure and Energy Operations Division, Latin America and the Caribbean Region, Staff appraisal report. Bolivia.Major cities water and sewerage rehabilitation project, Report 8479-BO, November 6, 1990, pp.13 and 68, about 75% of the population of in the La Paz area has house connections and some 50% of the population is connected to the sewerage network. Water supply is calculated from the volume of water produced and the number of persons served (average for La Paz Municipal Water and Sewerage Services Company (SAMAPA)). The volume of sewage outflow is defined as volume of sewage billed (total for La Paz Municipal Water and Sewerage Services Company (SAMAPA)).

d/ Guillermo Yepes, Management and operational practices of municipal and regional water and sewerage companies in Latin America and the Caribbean, The World Bank, Policy Planning and Research Staff, Infrastructure and Urban Development Department, Report INU61, January 1990, Discussion Paper, pp.21-22. Average for regional companies. Drinking water supply by means of house connections, sewerage by means of house connections and net water production per capita. Note, however, that according to PanAmerican Health Organization, Health Conditions in the Americas. 1990 Edition. Volume I, Scientific Publication Nº 524, 1990, pp.232-233, drinking water supply and sewerage by means of house connections in all urban areas are 91% and 42%, respectively. Estimate of domestic sewage outflow for São Paulo from The World Bank, Projects Department, Latin America and the Caribbean Regional Office, Brazil. Staff appraisal report. São Paulo industrial pollution control project, Report 2158b-BR, February 15, 1980, p.77. Domestic sewage flows projection for 1985.

e/ According to PanAmerican Health Organization, Health Conditions in the Americas. 1990 Edition. Volume II, Scientific Publication Nº 524, 1990, p.78, 20 m^3 per second of sewage is discharged into Guanabara Bay

f/ According to the International Conference on Water and the Environment, Dublin, Ireland, January 26-31, 1992, Basic Report for Reference. Chile, p.12, in the Metropolitan Region, drinking water supply coverage was 98.4% and sewerage coverage - 92.0% (as of 31.12.90.). According to Denise Bore, Francisco Pizarro and Nora

Cabrera, Diagnóstico de la contaminación marina en Chile. Anexos, Corporaciòn de Fomento de la Producción, Instituto de Fomento Pesquero, AP86/37, February 1986, the sewage discharge is 400 litres per inhabitant per day (assumed to equal water supply). According to Raquel Alfaro F. (Managing Director of EMOS), "Tratamiento de aguas servidas del Gran Santiago", Revista AIDIS, Nº 8, April 1991, p.10, the present sewage discharge from Santiago is $10 m^3$/second.

g/ The World Bank, Projects Department, Latin America and the Caribbean Regional Office, Staff appraisal report. Colombia. Barranquilla water supply project, Report 5631-CO, November 8, 1985, pp.6-7 and 24. Drinking water supply by means of house connections, average per capita sale of drinking water and coverage by registered sewer connections.

h/According to Jaime Saldarriaga Sanín, Estudio de caso: el sistema de la cuenca del río Bogotá Resumen, LC/R.572, April 20, 1987, p.7, 96% population of Bogotá has drinking water supply and 84% sewerage. According to Jaime Saldarriaga Sanín, Gonzalo Cortés, César Rodríguez, El recurso hídrico en la cuenca del Río Bogotá, III Congreso Colombiano de Cuencas Hidrográficas, Cali, August 1985, p.4, the use of water in Bogota is some 200 litres a head. The estimate of sewage outflow is based on data from the same source (water demand of $13 m^3$/sec of which 15% is consumed and 85% returns to the river). According to Yomaira E. Giraldo Macías, La gestion financiera: la experiencia de las empresas publicas de Medellin, Innovación y Desarrollo en Empresas de Agua Potable, Oportunidades para Estrategias Exitosas Aprovechando las Experiencias en América Latina y el Caribe, San José, Costa Rica, December 4-7, 1989, p.1, the coverage in the three major Colombian cities is 96% in water supply and 76% for sewage. According to El sector de agua potable y saneamiento en Colombia, Document 06, Regional Seminar on Water Supply and Sanitation for Low-Income Groups in Rural and Periurban Areas, Recife, September 29 - October 5, 1988, per capita consumption is less than 155 litres a day. Information of sewage outflow of Cali is from Raul Arias Uribe, Corporación Autónoma Regional del Cauca (CVC), Manejo de aguas residuales en la cuenca del alto río Cauca, III Congreso Colombiano de Cuencas Hidrográficas, Cali, August 1985.

i/ Innovación y Desarrollo en Empresas de Agua Potable, Oportunidades para Estrategias Exitosas Aprovechando las Experiencias en América Latina y el Caribe, El proceso de mejoramiento operacional. La experiencia del Instituto Costarricense de Acueductos y Alcantarillados, San José, Costa Rica, December 4-7, 1989, pp.15-16. Metropolitan area: water supply (all forms), sewerage (house connections), water supply per head calculated by dividing the drinking water demand by the total number of persons served.

j/ According to the International Conference on Water and the Environment, Dublin, Ireland, January 26-31, 1992, Informe de la República de Cuba, pp.8-9, urban drinking water supply by means of house connections is 83.0% and sewerage - 39.1%. Both estimates are for all urban areas. According to Osvaldo Montero Ojeda, El programa Cubano para el abastecimiento de agua y saneamiento para poblaciones de bajos ingresos, Document 14, Regional Seminar on Water Supply and Sanitation for Low-Income Groups in Rural and Periurban Areas, Recife, September29 - October 5, 1988, p.3, in Cuba, 6 395 000 people in both urban and rural areas are served by drinking water supply systems.

k/ The World Bank, Latin American and the Caribbean Regional Office, Dominican Republic: the 1989-1991 public sector investment program, Report 7600-DO, Volume I, January 18, 1989, pp.62-65. Tap inside house and private toilet. Water supply estimated from the production of piped water divided by the population.

l/ The World Bank, Projects Department, Latin America and the Caribbean Regional Office, Staff appraisal report. Ecuador. Second Guayaquil and Guayas province water supply project, Report 6268b-EC, November 24, 1986, p.4. Public water supply and public sewerage (1985). Water supply is assumed to be equal to average water consumption in all urban areas (taken from CWS Unit, Division of Environmental Health, World Health Organization, The International Drinking Water Supply and Sanitation Decade. Review of mid-decade progress (as at December 1985), September 1987, p.92.)

m/ Situación de abastecimiento de agua y saneamiento en Quito, Ecuador, Document 15, Regional Seminar on Water Supply and Sanitation for Low-Income Groups in Rural and Periurban Areas, Recife, September29 - October 5, 1988, p.4. Drinking water supply by means of house connections. Information on coverage by sewerage is from PanAmerican Health Organization, Health Conditions in the Americas. 1990 Edition. Volume I, Scientific Publication Nº 524, 1990, pp.232-233, average for all urban areas in Ecuador (house connections). Water supply is assumed to be equal to average water consumption in all urban areas (taken from CWS Unit, Division of Environmental Health, World Health Organization, The International Drinking Water Supply and Sanitation Decade. Review of mid-decade progress (as at December 1985), September 1987, p.92.)

n/ The World Bank, Department III, Infrastructure and Energy Operations Division, Latin America and the Caribbean Region, Staff appraisal report. Haiti. Centrale Autonome Metropolitaine D'Eau Potable (CAMEP) Port-au-Prince water supply project, Report 7613-HA, April 7, 1989, pp.9 and 11. Drinking water supply by private house connections. Average per capita water consumption defined as average annual volume of water made available by CAMEP in relation to the total population. Information on sewerage from PanAmerican Health Organization, Health Conditions in the Americas. 1990 Edition. Volume I, Scientific Publication Nº 524, 1990, pp.232-233 (all urban areas).

o/ According to Dirección General de Construcción y Operación Hidráulica, Secretaría General de Obras, "Programa de uso eficiente del agua en la ciudad de México", in Comisión Nacional del Agua, Ingeniería Hidráulica en México, May - August 1991, p.23, 97% of population has access to drinking water supply by means of house connections. According to Alfonso Camarena Larriva, Apreciación de la situación al final de decenio internacional de abastecimiento de agua y saneamiento en México y perspectivas para el futuro, p.7, coverage by drinking water supply in the metropolitan areas of Mexico City, Guadalajara and Monterrey averages 92.1% while in cities from 50000 to 1000000 inhabitants averages 83.2% (assumed for Naucalpan and Puebla). Coverage by sewerage is 82.4% and 68.2%, respectively. According to Secretaría de Agricultura y Recursos Hidráulicos, "Programa Nacional de Aprovechamiento del agua 1991-1994", Diario Oficial, December 5, 1991, p.23, total water supply to Mexico City (metropolitan area) is 63000 litres per second, in Guadalajara 11000 litres per second and Monterrey 9500 litres per second. According to the same source, total national water supply is estimated to be 170000 litres per second and the total effluent outflow is 110000 litres per second. Effluent outflows of Mexico City (metropolitan area), Guadalajara and Monterrey are estimated to the basis of their respective water supply (mentioned above) and the national ratio. According to Jorge C.Saavedra Shimidzu, "Análisis de histogramas de consumo de agua potable en México", Comisión Nacional del Agua, Ingeniería Hidráulica en México, January-April 1991, p.16, the supply in Monterrey is 265 litres per person a day. in Mexico city and Guadalajara estimated on the basis of above data (total water supply to the number of persons with service). Results were adjusted proportionally to supply in Monterrey. On other urban areas water supply is assumed to be equal to average water consumption in all urban areas (taken from CWS Unit, Division of Environmental Health, World Health Organization, The International Drinking Water Supply and Sanitation Decade. Review of mid-decade progress (as at December 1985), September 1987, p.92.)

p/ According to Instituto Nicaragüense de Recursos Naturales y del Ambiente (IRENA), "Tema I: Problemática de la calidad del agua del Lago de Managua," Managua, October 1982, in Instituto Nicaragüense de Recursos Naturales y del Ambiente, Información básica sobre el Lago de Managua (Xolotlan), OSL/Tall/1, Taller Internacional de Salvamento y Aprovechamiento Integral del Lago de Managua (Xolotlan), Managua, from November 29 to December 2, 1982,p.1, outflow of sewage, including industrial effluents, amounted to 1.75 m^3/sec in 1982 and was expected to reach 6.35 m^3/sec in 2000. On this basis the likely volume of sewage in 1990 would be about 3.11 m^3/sec. According to the International Conference on Water and the Environment, Dublin, Ireland, January 26-31, 1992, Presentación, pp.12-13, sewerage coverage in Managua is 59%. As for drinking water supply coverage, it was assumed to be equal to the average drinking water supply coverage in the cities of the Pacific coast of Nicaragua, 85.5%, (same source).

q/ According to James Brooke, Feeding on 19th century conditions, cholera spreads in Latin America, April 21, 1991, "40 percent of Lima's 7 million residents do not have access to potable, piped water". According to Alfonso Prialé Jaime, Revisión de los progresos del Decenio Internacional del Abastecimiento de Agua y del Saneamiento 1981-1990, Reunión del Grupo de Trabajo, Washington, D.C., May 10-12, 1989, coverage by sanitation services (sewers and latrines) in the Lima Metropolitan Area is 85.0%. Note that according to the same source, drinking water supply coverage is 95.8%. Volume of sewage outflow is from Marc J.Dourojeanni, Gran geografía del Perú. Naturaleza y hombre. Volume IV. Recursos naturales, desarrollo y conservación en el Perú, Manfer, Juan Mejía Baca, p.134. This figure is for Lima and Callao taken together. Water supply is assumed to be equal to average water consumption in all urban areas (taken from CWS Unit, Division of Environmental Health, World Health Organization, The International Drinking Water Supply and Sanitation Decade. Review of mid-decade progress (as at December 1985), September 1987, p.92.)

r/ Administración de las Obras Sanitarias del Estado, Situación actual y resumen de gestión. Abril 1985 - Diciembre 1989. Versión corregida, p.5. Coverage by drinking water supply in Montevideo (department). Administración de las Obras Sanitarias del Estado, Plan para el período

1990-1995. (Draft, February 1990), p.8, "dotación". According to A.-Raszap, Situación del sector en Uruguay, Document 25, Regional Seminar on Water Supply and Sanitation for Low-Income Groups in Rural and Periurban Areas, Recife, September 29 - October 5, 1988, p.2, 76% of the population of Montevideo has sewerage.

s/ PanAmerican Health Organization, Health Conditions in the Americas. 1990 Edition. Volume I, Scientific Publication Nº 524, 1990, pp.232-233, drinking water supply by means of house connections and sewerage by means of house connections, all urban areas. Water supply is defined as water billed to the number of persons served (average for the whole country). Data from República de Venezuela, Presidencia de la República, Oficina Central de Estadástica e Informática, Anuario estadástico de Venezuela. 1990, pp.633 and 637.

Note:

Levels of drinking water supply and sewerage coverage are expressed in percent and correspond to service through house connections (where data on house connections is not available, other data were used). Drinking water supply in litres per head a day, sewerage outflow is in cubic metres per second. Data in the table may be not directly comparable.

l/c/d – litres per capita per day.

n/a – not available.