URBAN ENVIRONMENTAL MAPS

for

Delhi

Bombay

Ahmedabad

Vadodara

NATIONAL INSTITUTE OF URBAN AFFAIRS
NEW DELHI

February, 1994

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PREFACE

The urban environment has become the concern of not only biologists and engineers but planners, economists and entrepreneurs as well. The ability of municipalities to confront the urban environmental infrastructure improvement that are necessary in cities in India requires that political decisions be made, policies devised, training carried out and information disseminated. One could argue that the first of many steps that needs to be taken to deal with urban environmental improvements is to develop the information base on which research and environmental infrastructure development programs could be built.

The National Institute of Urban Affairs is a premier research and training institution for urban studies. The institute's mandate is to gather, analyse and disseminate studies on various facets of urban development. Environmental condition of our major cities has been deteriorating rapidly. However, the responsibilities of managing the urban environment is not clearly defined among the central, state and the local governments. The information base on the environmental condition is fragmanted.

This set of urban environmental maps is a pilot exercise taken up by NIUA as a source book of priority urban environmental problems that need to be addressed in major cities of India. It is hoped that these maps will be used by the public officials, non-governmental organisations and community groups to aquaint themselves about the urban environmental problems in their own cities. Hopefully, this awareness will lead to wide-spread actions on the part of all the residents of these cities to improve and manage their environment.

We gratefully acknowledge the financial support of the U.S. Agency for International Development for this study.

February, 1994

Dr. Dinesh Mehta
Director, NIUA

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Xeroxing Assistance	-	H.P. Pandey
	-	Gusai Ram

CONTENTS

ACRONYMS

1.	AMC	Ahmedabad Municipal Corporation
2.	AUDA	Ahmedabad Urban Development Authority
3.	BMC	Baroda Municipal Corporation
4.	BOD	Biological Oxygen Demand
5.	CPCB	Central Pollution Control Board, New Delhi
6.	DDA	Delhi Development Authority
7.	DO	Dissolved Oxygen
8.	DUAC	Delhi Urban Arts Commission
9.	DWS & SDU	Delhi Water Supply & Sewage Disposal Undertaking
10.	L&DO	Land and Development Office
11.	lpcd	litres per capita per day
12.	MCD	Municipal Corporation of Delhi
13.	mgd	million gallons per day
14.	mld	million litres per day
15.	NDMC	New Delhi Municipal Committee
16.	TCPO	Town & Country Planning Organisation
17.	VUDA	Vadodara Urban Development Authority

LIST OF MAPS BY SUBJECTS

Subjects	Map Numbers			
	Delhi	Bombay	Ahmedabad	Vadodara
1. General	1.1 - 1.4	2.1 - 2.3	3.1 - 3.2	4.1 - 4.2
2. Demography	1.5 - 1.6	2.4 - 2.5	3.3	4.3
3. Slums	1.7 - 1.8	2.6 - 2.7	3.4 - 3.5	4.4 - 4.5
4. Water Supply	1.9 - 1.13	2.8 - 2.9	3.6 - 3.7	4.6 - 4.9
5. Sewerage	1.14 - 1.17	2.10 - 2.12	3.8	410 - 411
6. Solid Waste	1.18	2.13 - 2.14	3.9	4.12
7. Transport	1.19 - 1.23	-	-	-
8. Green Spaces	1.24	-	-	-
9. Air Pollution	1.25 - 1.27	2.15	3.10	413 - 414
10. Noise Pollution	1.28 - 1.29	2.16	-	-
11. Miscellaneous	-	2.17	-	4.15

LIST OF TEXT

LIST OF MAPS

LIST OF TABLES

DELHI

LIST OF FIGURES

Delhi

Bombay

Ahmedabad

Vadodara

INTRODUCTION

The City and its Environment

There has been an increasing concern over the global environment and sustainability of the conventional development strategies. In recent years, many international documents and meetings have highlighted these, notably the Brundtland Report on Our Common Future and UNCED's Earth Summit. Within the context of sustainable development, as defined in the Brundtland Report, it is to be recognised that cities, in both developed and developing world, are inherently unsustainable. Cities draw upon a vast hinterland across the national boundaries, for resources and require a large environment to disperse their wastes. Concerns about sustainable urban development have been well documented in the UNDP's report on Urban Environment in Developing Countries and discussed in The World Urban Forum meeting in Curitiba in May 1992.

The Agenda 21, as the plan of action for a cleaner global environment in the Twenty First Century, outlines specific actions for human settlement development. Its chapter 28, popularly known as the Local Agenda 21, lists specific initiatives by local authorities in support of the environmental goals. As a level of governance that is closest to the people, the local governments can play a vital role in educating, mobilising and responding to the people in promoting sustainable development.

This report presents the status of urban environment in four metropolitan cities of India. It is a step towards initiating local actions for a cleaner environment and identifying a local agenda. The UNCED meeting had proposed that by 1996, most local authorities in each country should have undertaken a consultative process with their population and achieved a consensus on a Local Agenda 21 for the community.

Urban environmental management is essentially concerned with creating a healthy and pleasant physical environment. This implies that it is largely concerned with much of what the city governments are supposed to be doing: providing and maintaining infrastructure, safeguarding public health, planning and ensuring physical development in the interest of safety and public health. The environmentalists refer to these as the "Brown Agenda".

This Brown Agenda is well within the domain of the local authorities. The 74th Constitutional Amendment Act, provides constitutional status to the municipalities and looks at these urban governments as the third-tier of the Government in India to provide a range of physical facilities and perform roles that the local residents mandate from them. The process of democratic decentralisation that is envisaged in the constitutional amendment, will also imply that the inequities that exists today in resource distribution (e.g.water), will be eliminated through public demand. The urban poor, who have been by-passed in the conventional city planning and development approaches, will become the focus of resource allocations and distributions.

As the local communities and city governments begin the consultative process to identify the Brown Agenda, there is a need to move towards the Green Agenda of planning and managing the use of natural resources in a sustainable manner. The notion of regional self-reliance which means that most, though not all, resources needed by a city will be generated within its immediate region, is likely to become the primary consideration in the organisation and management of future cities.

Moving from the conventional urban management practices to evolving a 'Brown Agenda' and a 'Green Agenda' for a city will be a daunting task. The process of consultations necessary to evolve a local agenda will involve the city governments, community groups, NGOs and other interest groups. As a first stage of facilitating such a consultative process, information on environmental status of a city and its neighbourhoods, needs to be compiled. This report is an attempt towards such facilitation. It is based on informations that are available with the city governments and other agencies functioning in these cities. The emphasis on visual presentations, in the form of maps, is to highlight the spatial distributions of the environmental characteristics of the cities. This will, in our opinion, help the community groups, representing various sections and sectors of the city, to articulate their concerns effectively, and help evolve a common agenda for local actions to improve city's environment.

Purpose of the document

The main purpose of the present document, which contains maps of four cities, viz. Delhi, Bombay, Ahmedabad and Vadodara, has been prepared to provide information on urban environmental problems to city planners, administrators, potential investors etc. The maps show the existing environmental problems in different parts of the selected cities and also show the type of environmental infrastructure available as well as proposed.

Methodology

The present document is based on information collected from primary as well as secondary sources. The major sources of information were the municipal bodies of the selected cities. Published and unpublished information was also obtained from other sources as well for preparing the maps and text.

Delhi has been dealt with in much greater details as an example of what is possible if information is available. If information for other cities can be obtained in as much details then, given sufficient time, it would be possible to prepare detailed maps for other cities also.

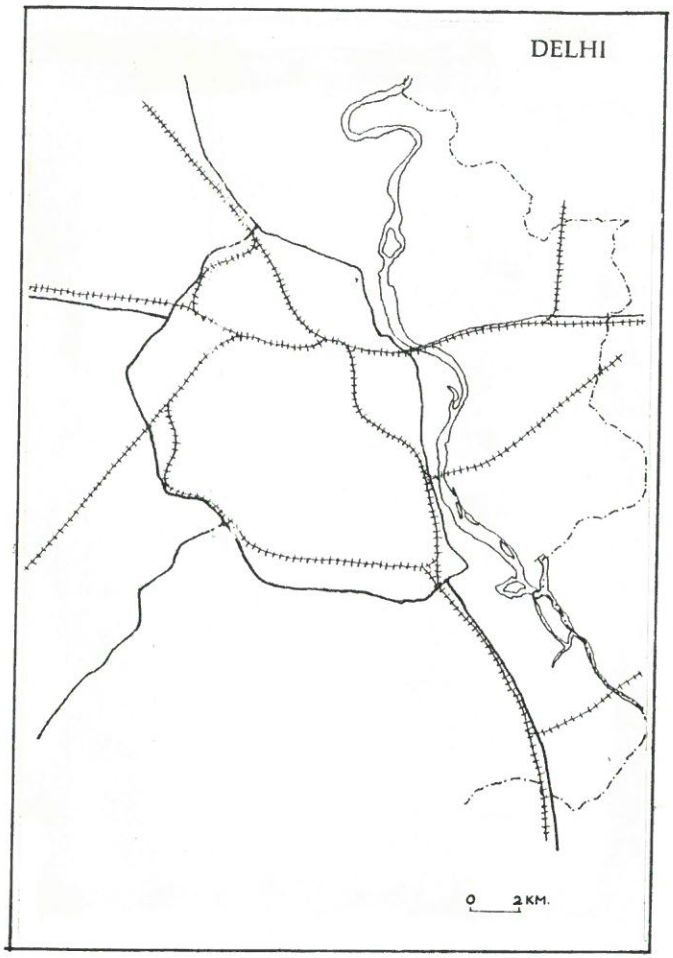
Limitations

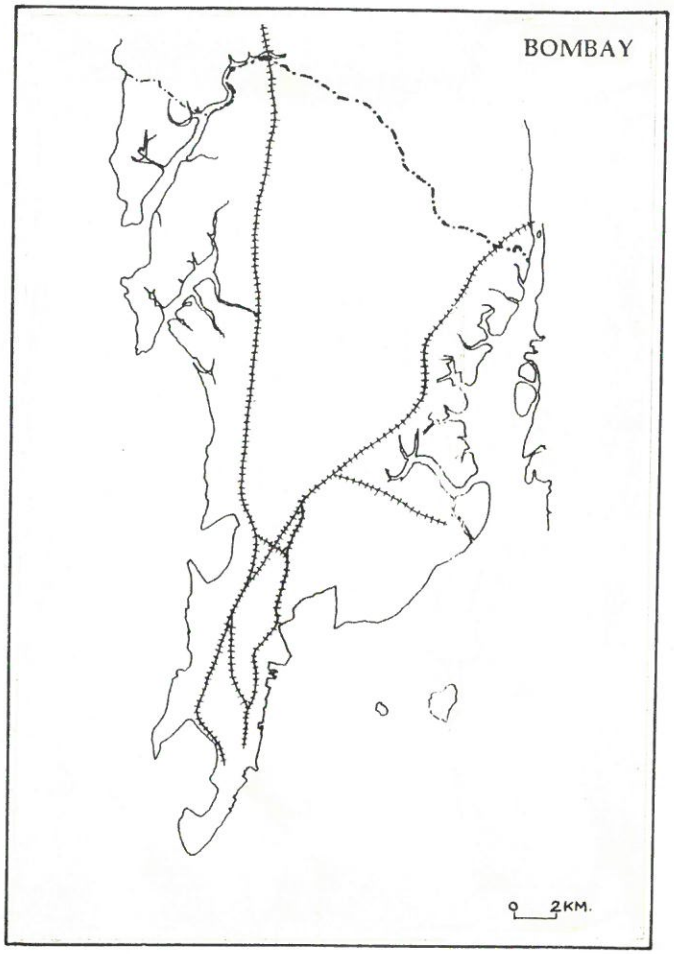
The major limitation in preparing this document was the lack of information available, the lack of uniformity in information obtained from different cities, the variation in the periods to which the data belonged and the outdated information base with respect to some items (e.g. land-use). Therefore, the present set of maps should, by no means, be considered comprehensive.

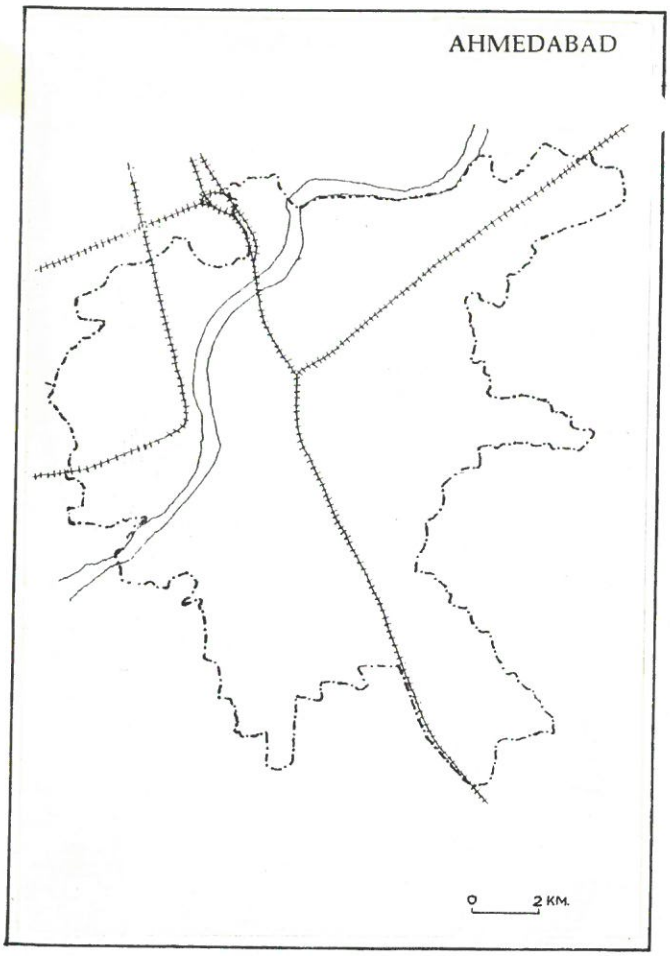
INDIA

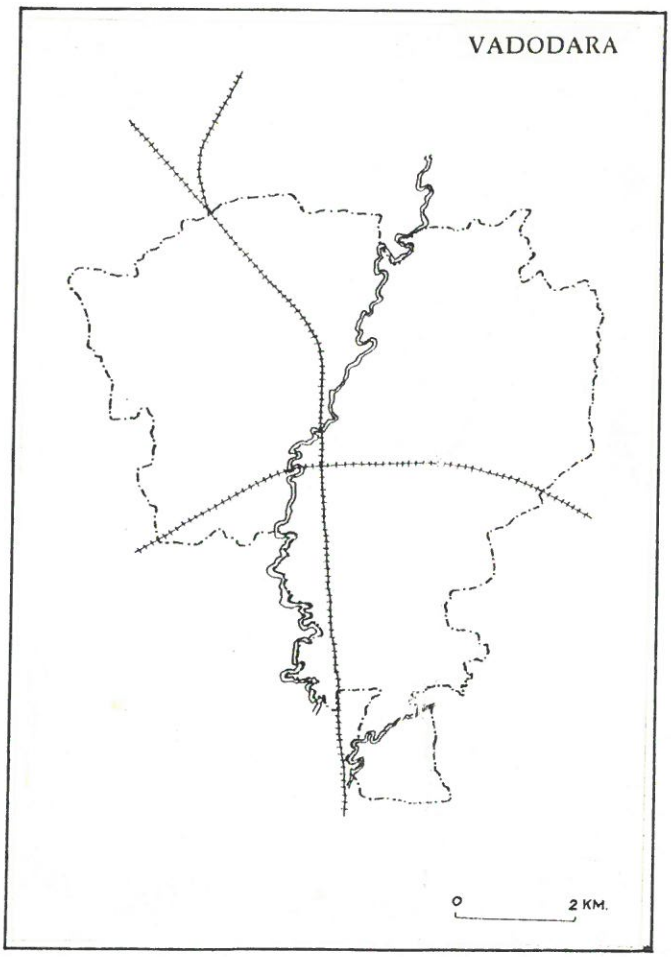
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

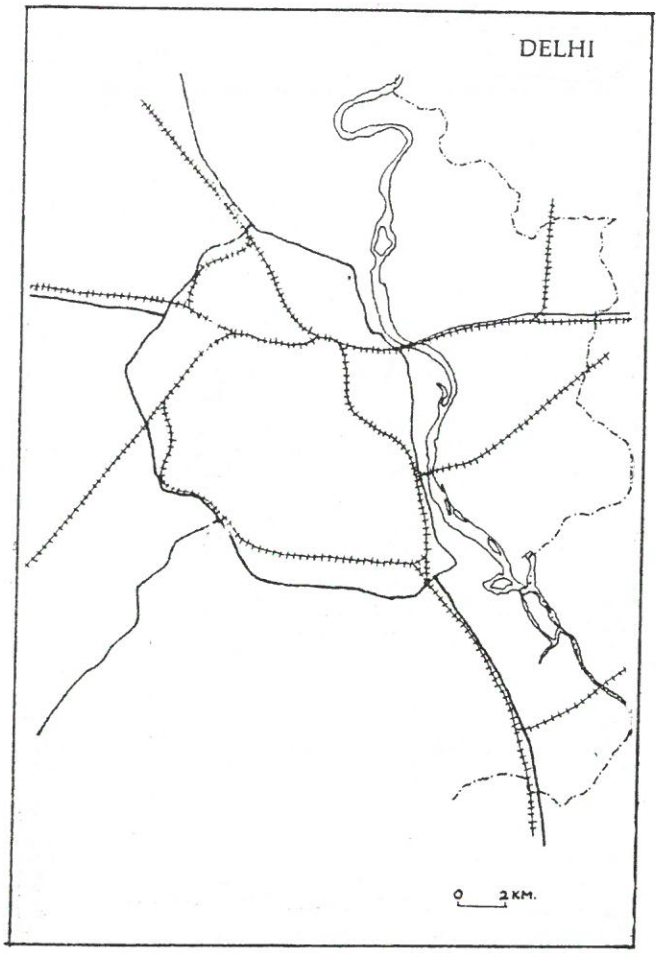


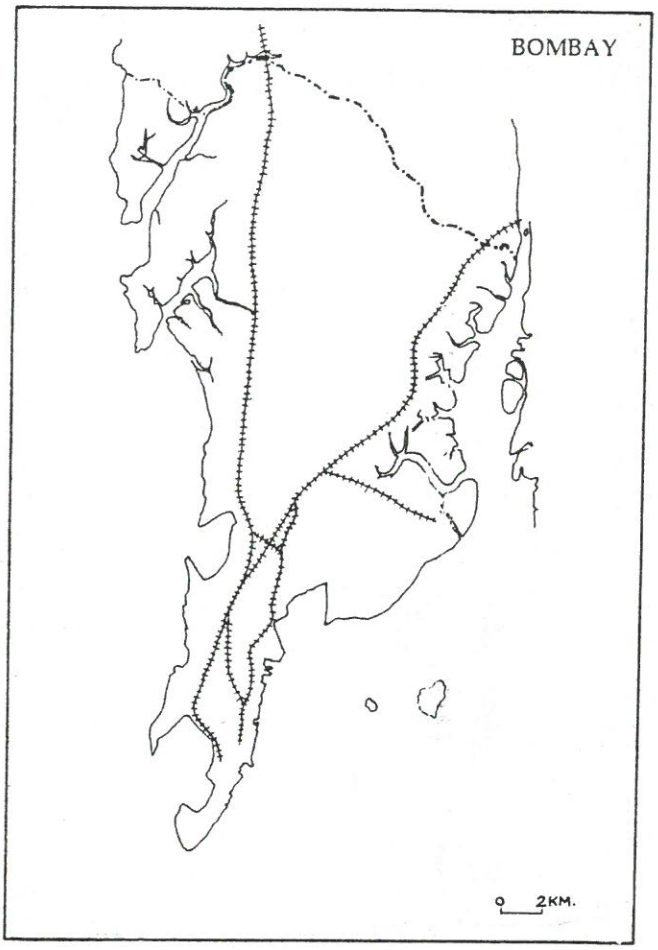


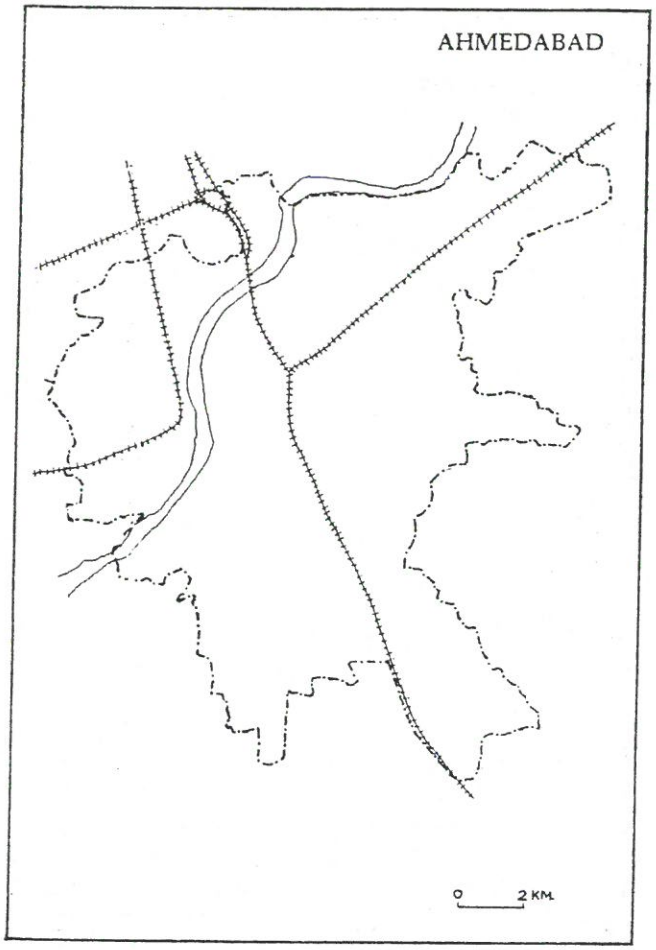


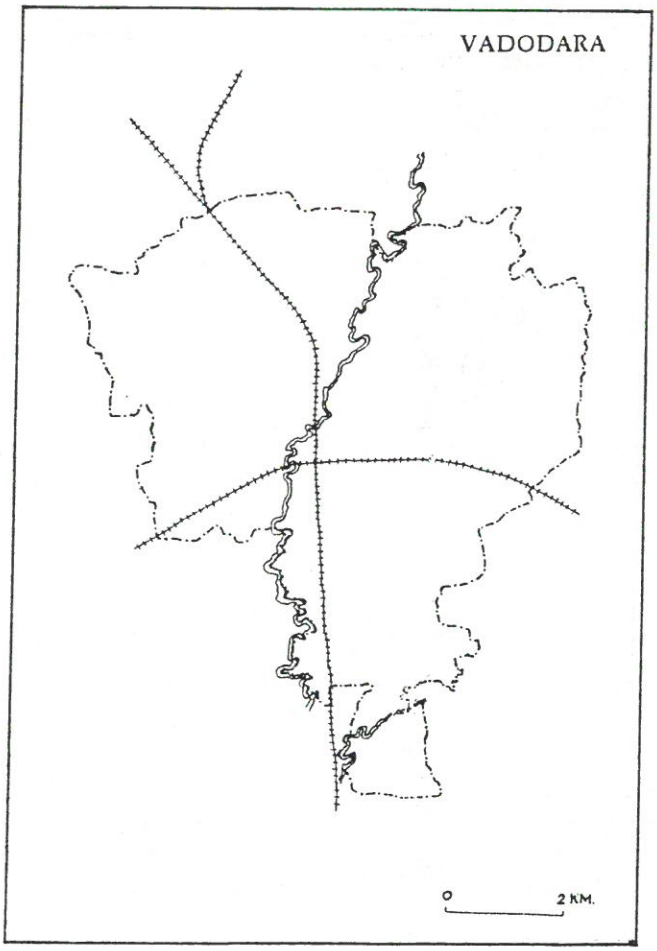


Selected Cities in India









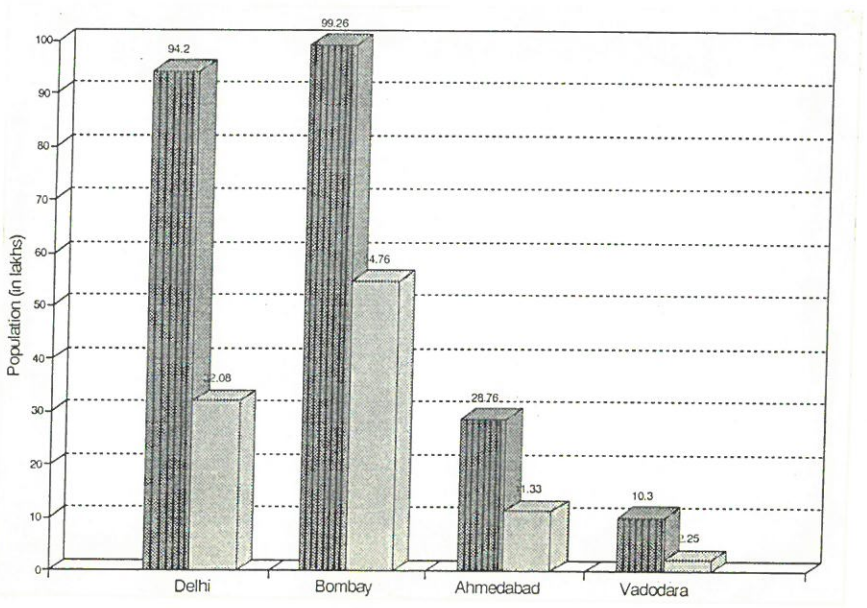
Selected Cities in India

Comparison across the selected cities

1. Demography

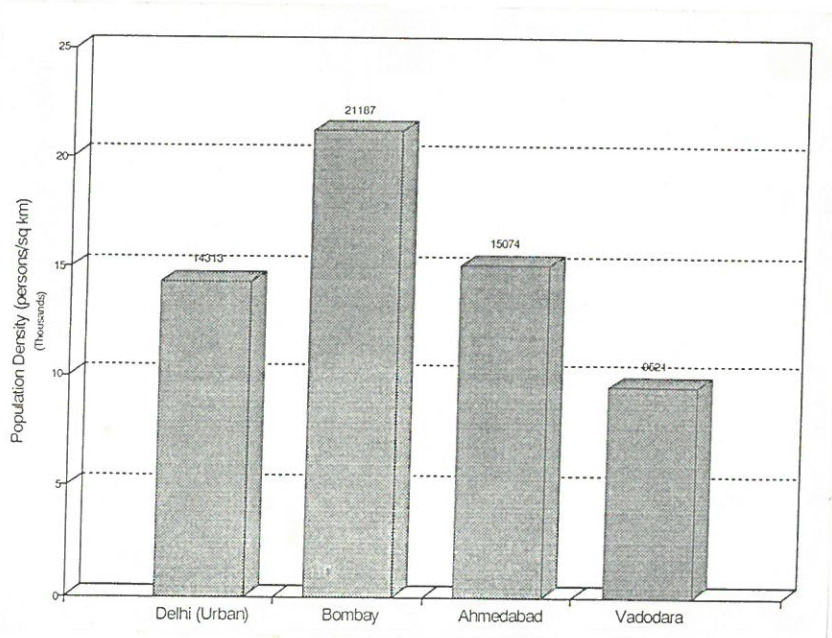
Total Population (in lakhs)

1991



Average Population Density (Persons/sq.km.)

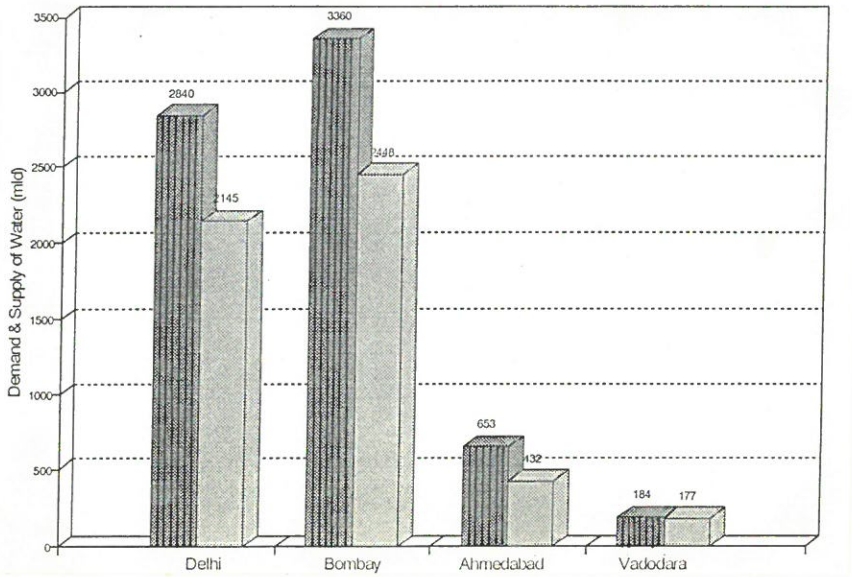
1991



2. Water Supply

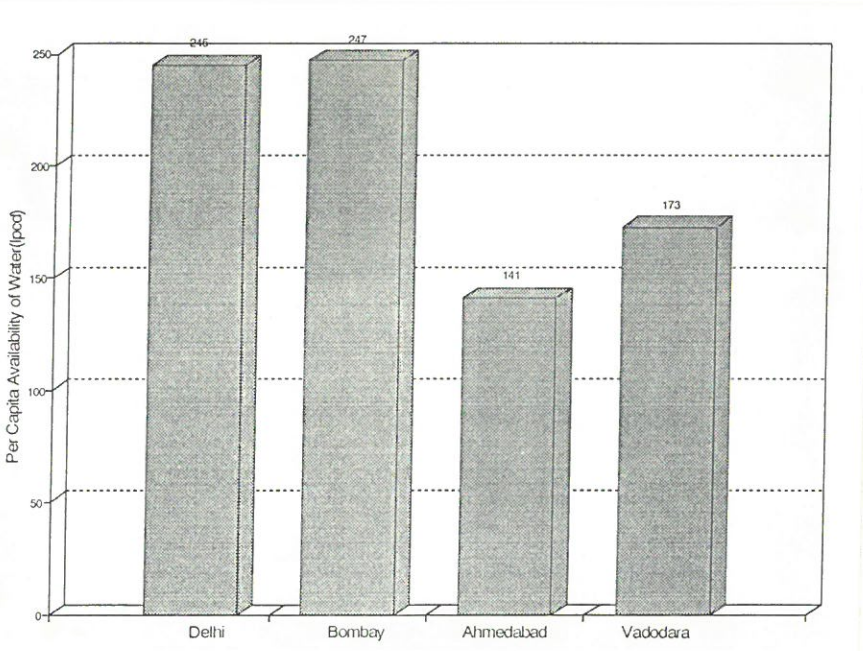
Demand and Supply of Water (mld)

1993



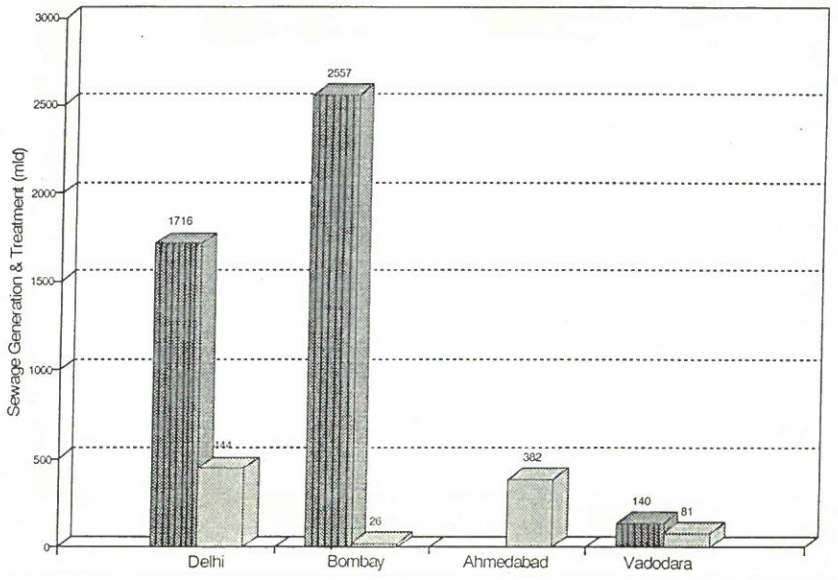
Per Capita Availability (lpcd)

1993



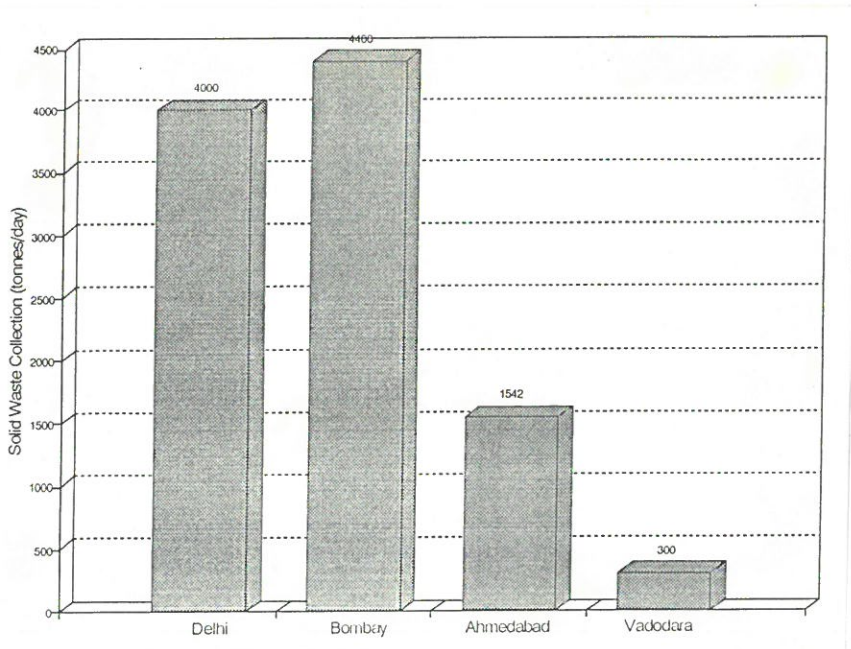
3. Sewerage

Sewage Generation and Treatment (mld)
1993



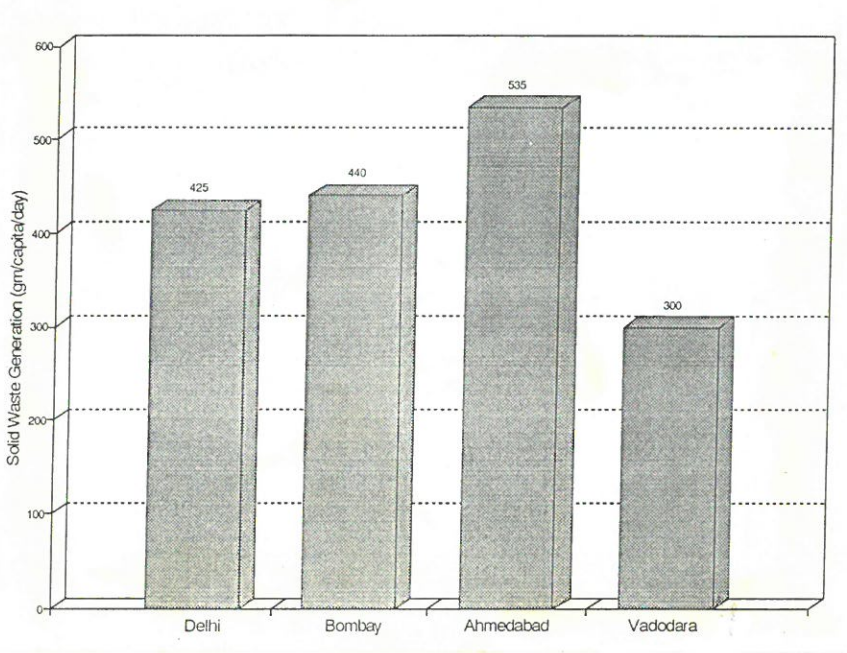
4. Solid Waste

Solid Waste Collection (tonnes/day)
1993



Per Capita Collection of Solid Waste (gpcd)

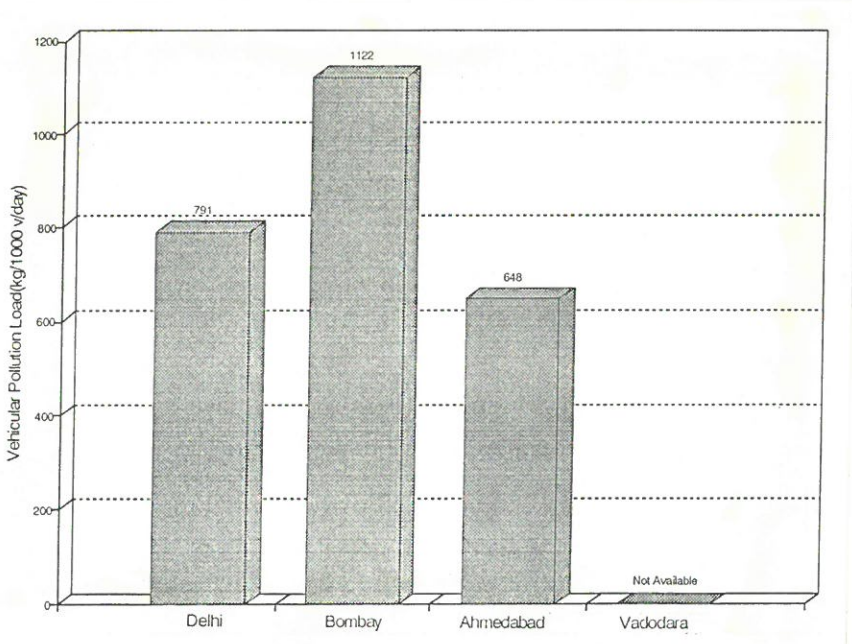
1993



5. Air Pollution

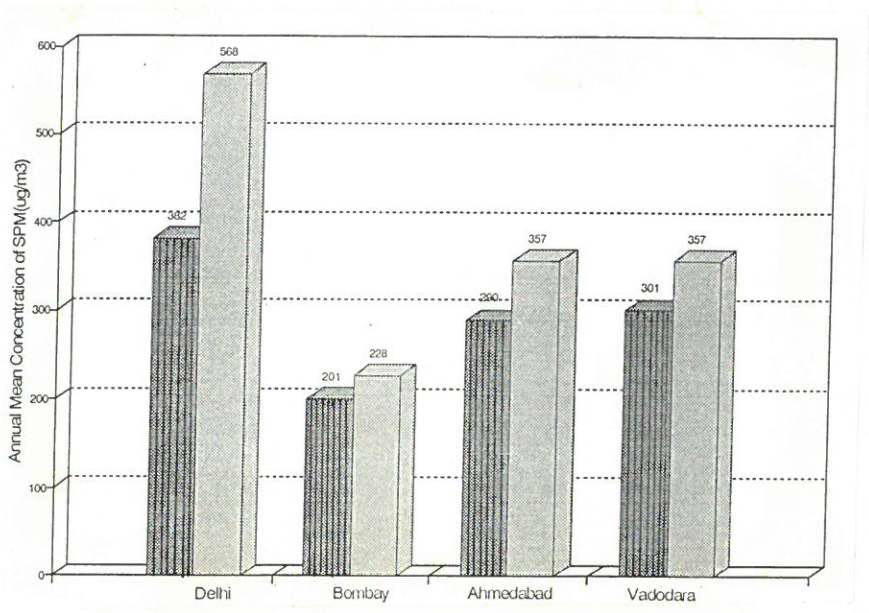
Vehicular Pollution Load per 1000 vehicles (tonnes/day)

1987-88



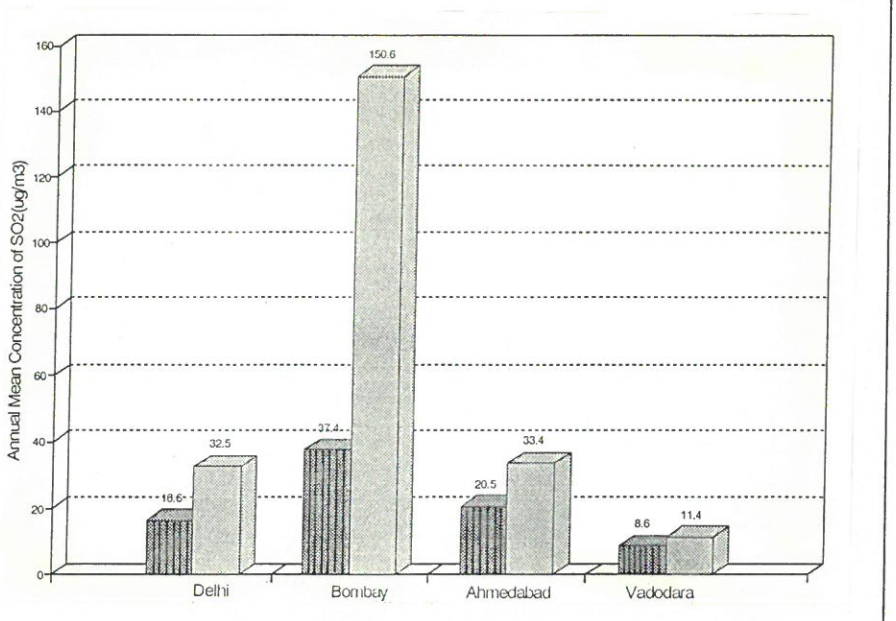
SPM

1990



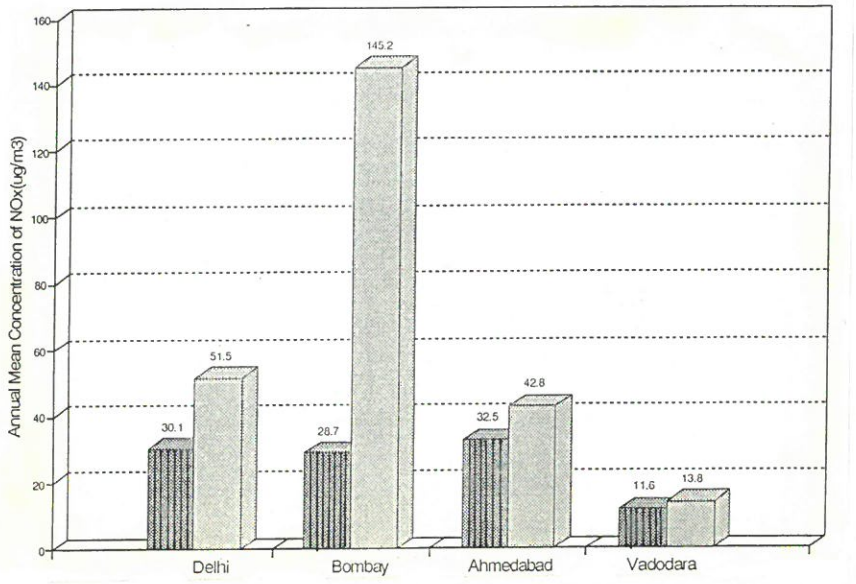
SO2

1990



NOx

1990



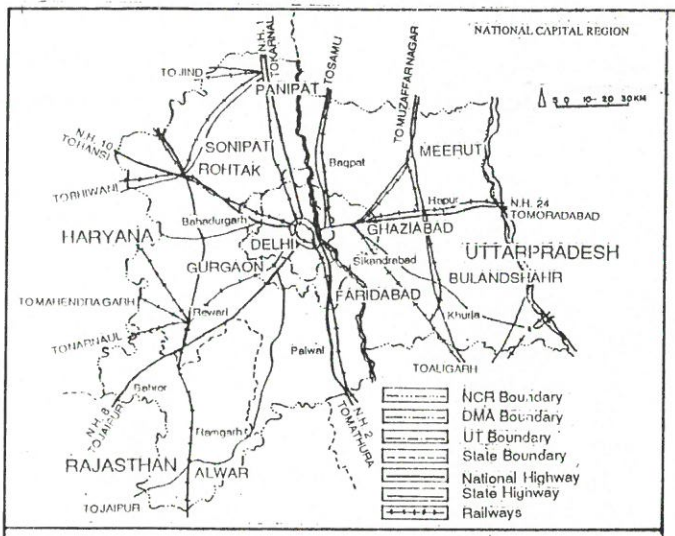
Avg of Annual Mean

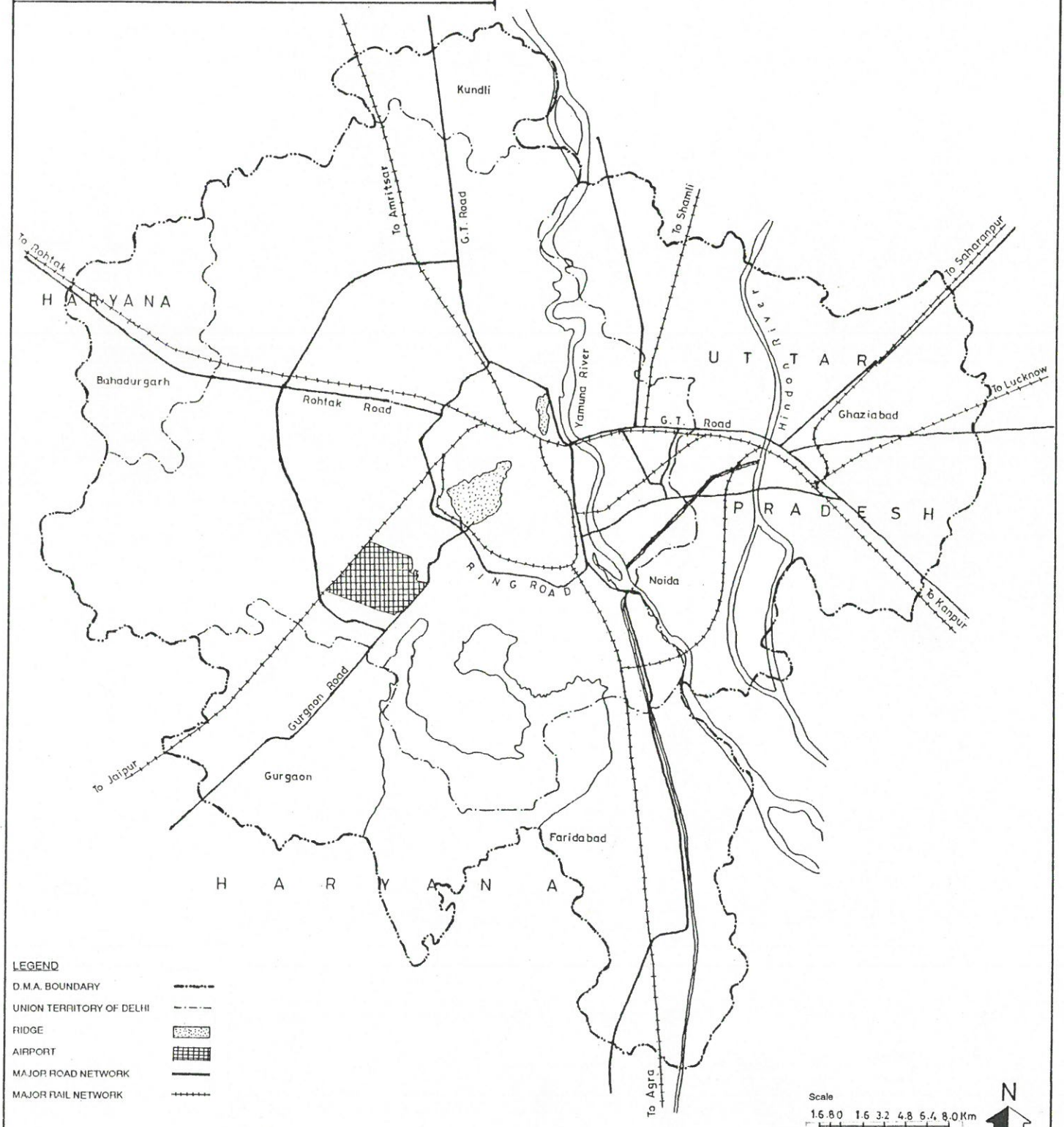
Max Annual Mean

DELHI

DELHI

Delhi Metropolitan Area





LEGEND

- D.M.A. BOUNDARY
- UNION TERRITORY OF DELHI
- RIDGE
- AIRPORT
- MAJOR ROAD NETWORK
- MAJOR RAIL NETWORK

Scale 1.6 0 1.6 3.2 4.8 6.4 8.0 Km

N

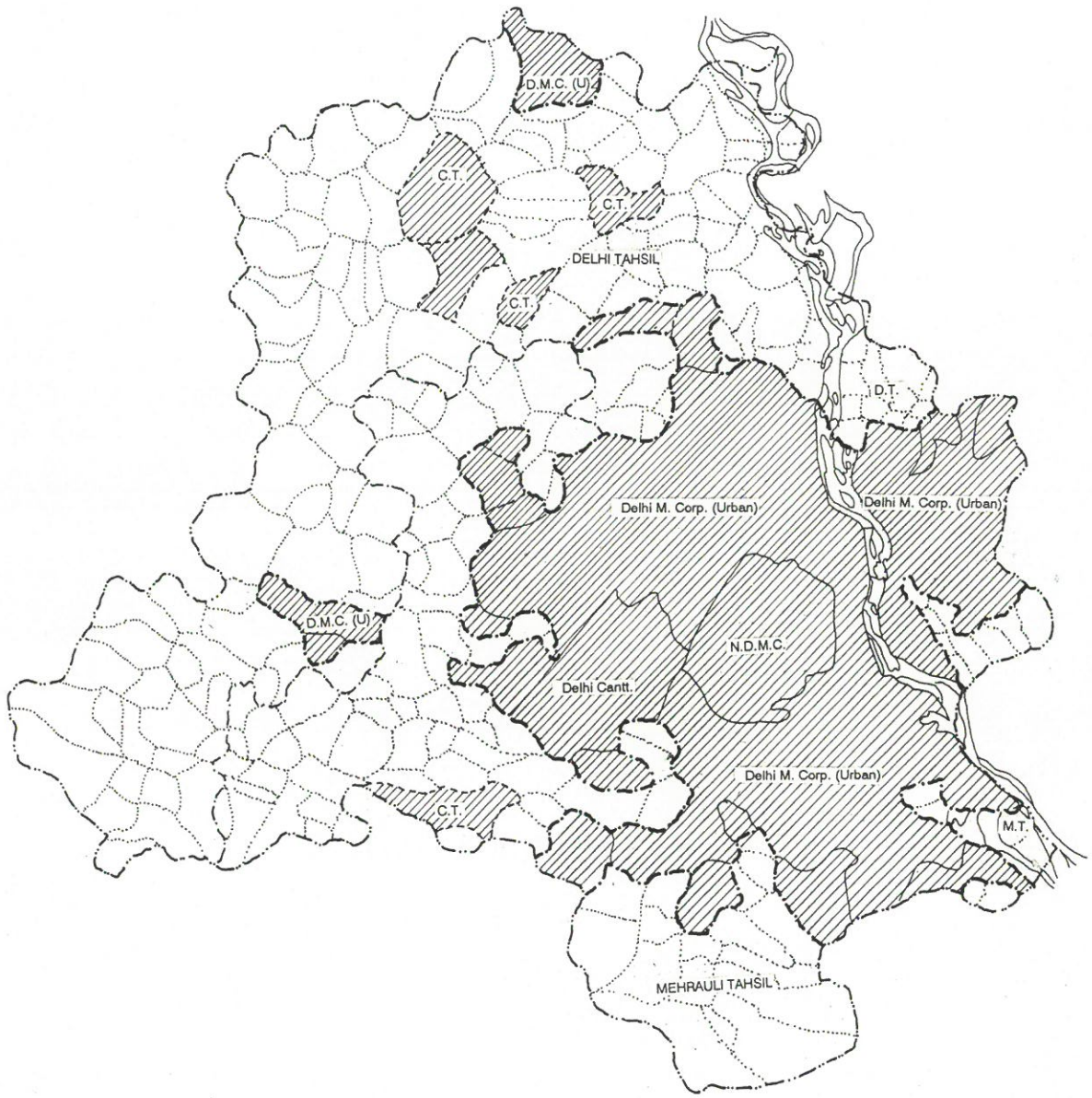
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: MPD (1981-2001).

DELHI

Union Territory



LEGEND

BOUNDARIES:

- UNION TERRITORY
- URBAN AGGLOMERATION
- MUNICIPAL AREA
- TEHSIL
- CENSUS TOWNS
- VILLAGE
- URBAN AREA

D.T.	DELHI TEHSIL
M.T.	MEHRAULI TEHSIL
D.M.C.(U)	DELHI MUNICIPAL CORPORATION (URBAN)
N.D.M.C.	NEW DELHI MUNICIPAL COMMITTEE
C.T.	CENSUS TOWN

Scale

2 0 2 4 6 kms

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Census of India (1981).

DELHI

LEGEND

- UNION TERRITORY OF DELHI
- MAJOR ROADS
- OTHER ROADS
- RIVER
- RAILWAYS

Scale 0 1 2 3 4 5 Km.

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

DELHI

Elevation of Selected Points (m)
(above mean sea level)

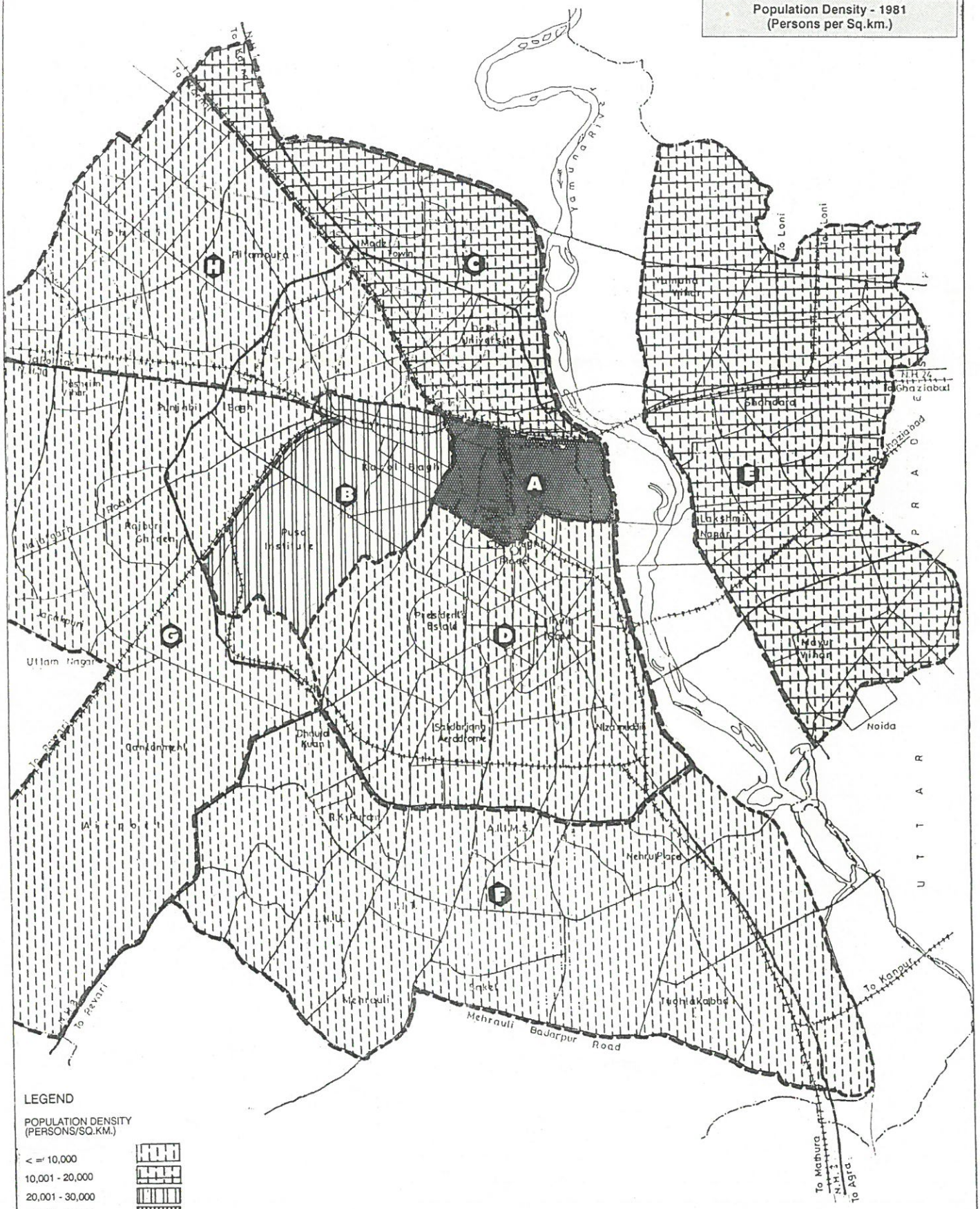
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Based on Delhi Guide Map published by Survey of India.

DELHI

Population Density - 1981
(Persons per Sq.km.)



LEGEND

POPULATION DENSITY (PERSONS/SQ.KM.)

- < =/ 10,000
- 10,001 - 20,000
- 20,001 - 30,000
- 30,001 - 40,000
- 40,000 - 50,000
- 50,000 - 60,000
- > = 60,001

PLANNING DIVISION (A)

PLANNING DIVISION BOUNDARY

Scale 0 1 2 3 4 5 Km.

N

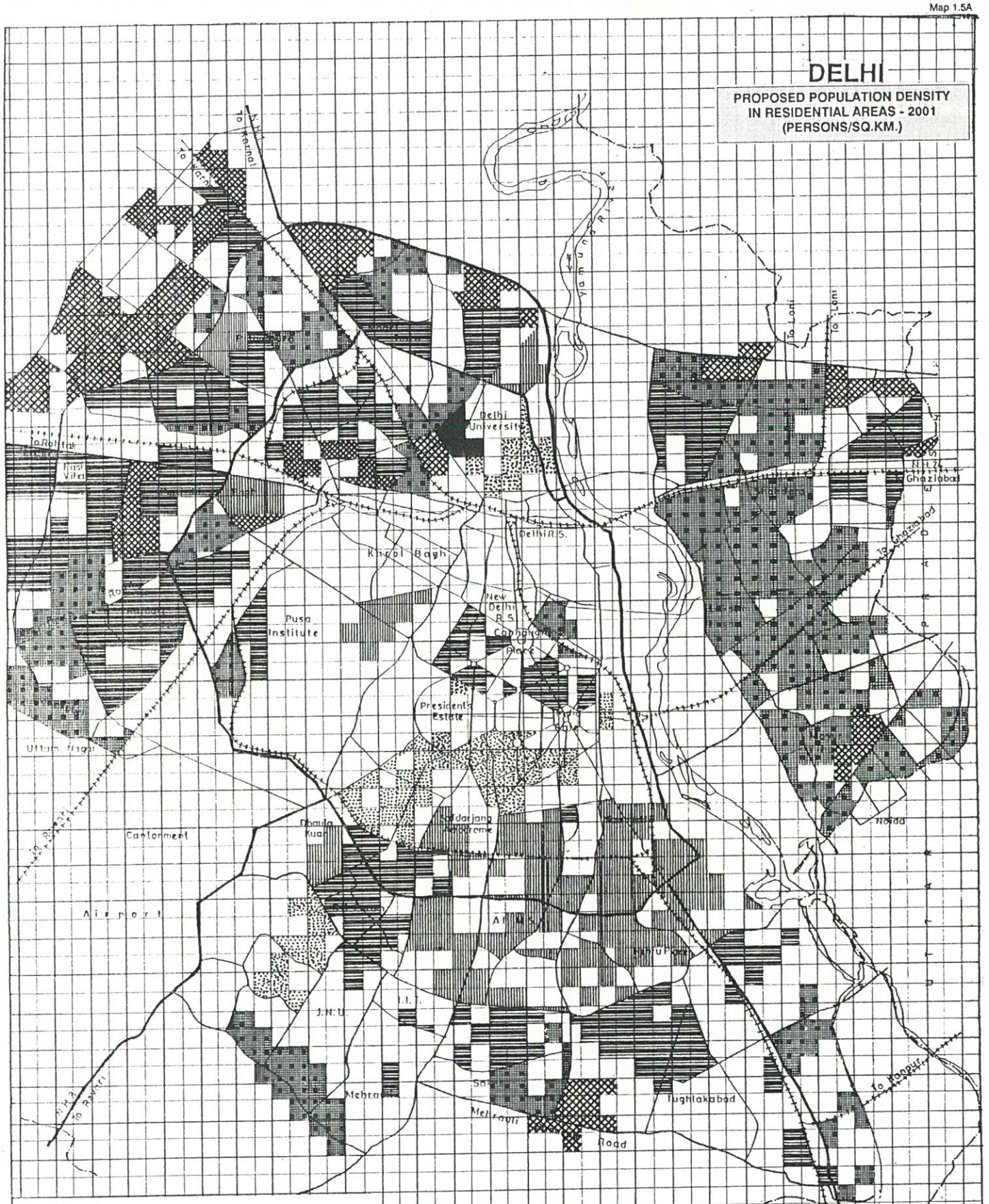
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: MPD (1981-2001).

DELHI

PROPOSED POPULATION DENSITY IN RESIDENTIAL AREAS - 2001 (PERSONS/SQ.KM.)



LEGEND

POPULATION DENSITY (PERSONS/SQ.KM.)	AVERAGE POPULATION REPRESENTED BY ONE SQUARE
= 20,000	5,000
20,001 - 30,000	6,250
30,001 - 40,000	8,750
40,001 - 50,000	11,250
50,001 - 60,000	13,750
> = 60,001	15,000

Scale 0 1 2 3 4 5 Km. N

Urban Environmental Maps

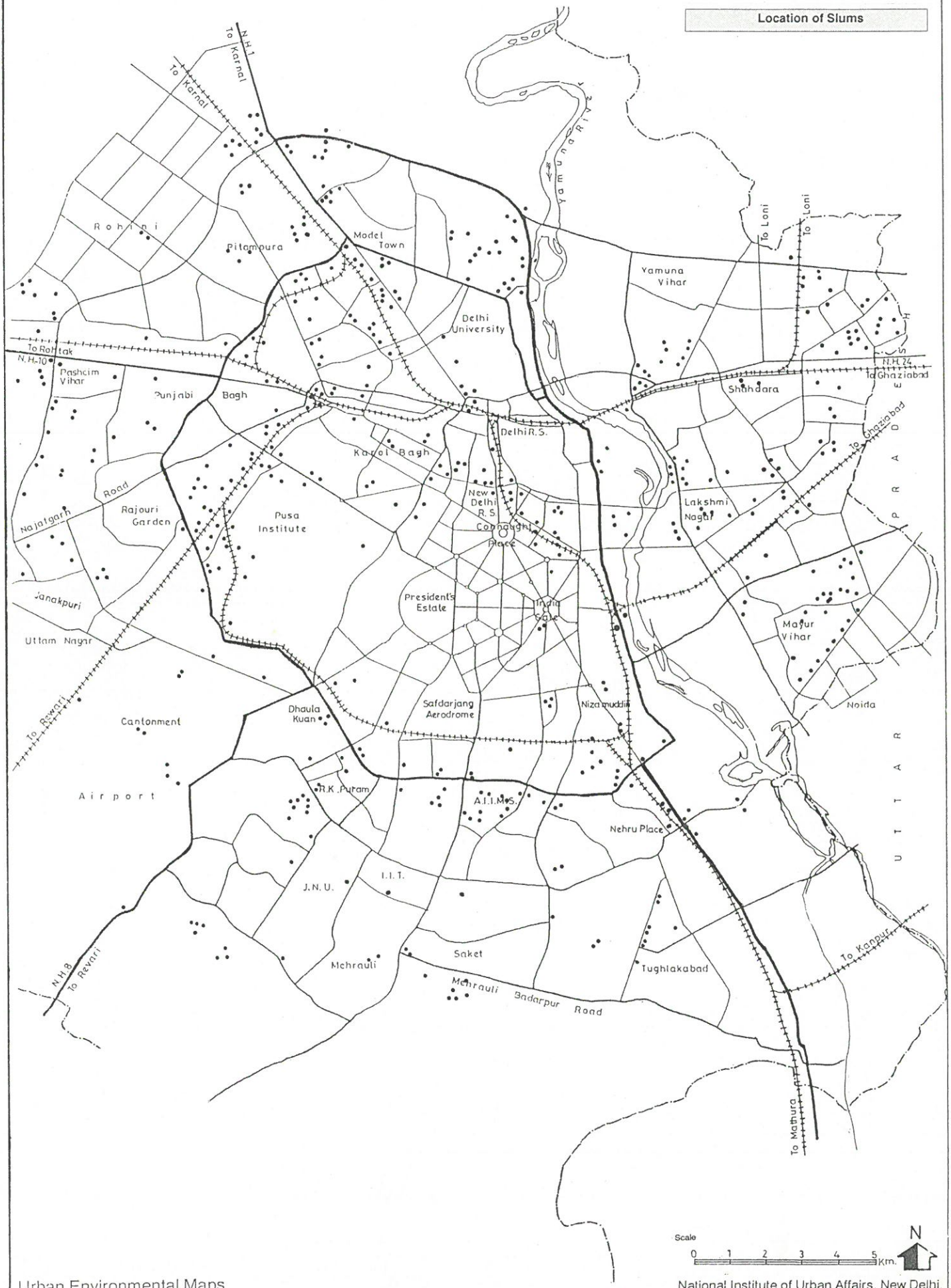
Grid Size - 0.5 km. X 0.5 km. (0.25 Sq.Km.)

National Institute of Urban Affairs, New Delhi.

Source: MPD (1981-2001).

DELHI

Location of Slums



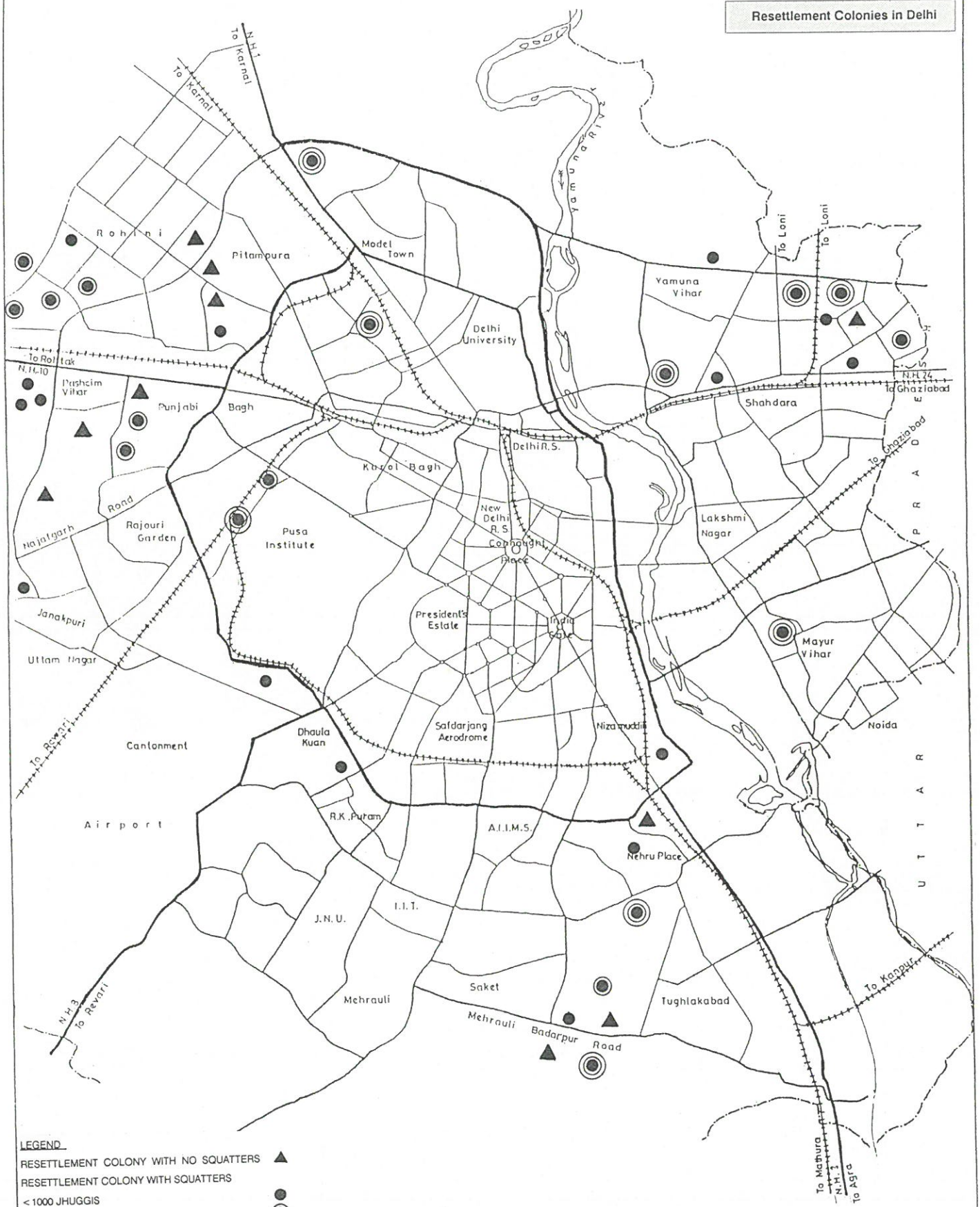
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: NIUA (nd.)

DELHI

Resettlement Colonies in Delhi



LEGEND

RESETTLEMENT COLONY WITH NO SQUATTERS ▲

RESETTLEMENT COLONY WITH SQUATTERS

< 1000 JHUGGIS ●

1001-5000 JHUGGIS ◉

5001-15000 JHUGGIS ◉

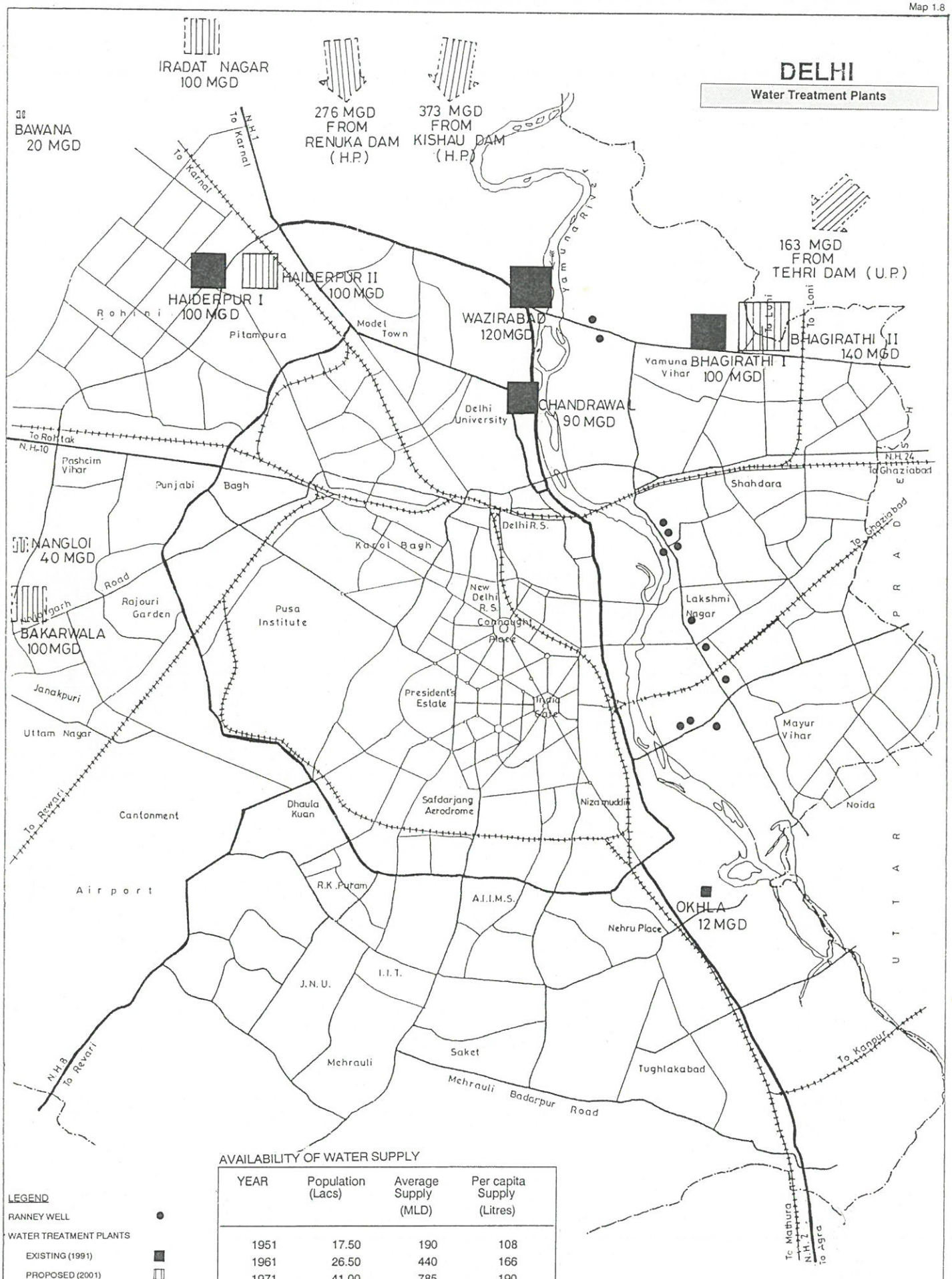
Scale 0 1 2 3 4 5 Km.

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Ali, Sabir (1990).



LEGEND

RANNEY WELL

WATER TREATMENT PLANTS

EXISTING (1991)

PROPOSED (2001)

AVAILABILITY OF WATER SUPPLY

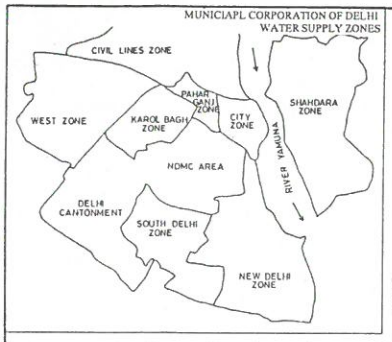
YEAR	Population (Lacs)	Average Supply (MLD)	Per capita Supply (Litres)
1951	17.50	190	108
1961	26.50	440	166
1971	41.00	785	190
1981	62.00	1150	185
1991	88.00	2160	245

Note: The Schemes of bringing water from Renuka, Kishau and Tehri dams are dependent on the completion of these dams

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: DWS & SDU (1993).

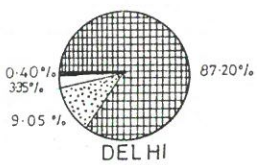


DELHI

Consumption of Water for Different Uses - 1991-92

ROHINI
CIVIL LINES ZONE
PAHARGANG ZONE
KAROL BAGH ZONE
WEST ZONE
CITY ZONE
SHAHDARA ZONE
SOUTH DELHI ZONE
NEW DELHI ZONE
Pitampura
Delhi University
Yamuna Vihar
To Loni
To Loni
To Rohtak
N.H.-10
Pashcim Vihar
Punjabi Bagh
N.H. 24
To Ghaziabad
Shahdara
To Ghaziabad
U T T A R P R A D E S H
Najafgarh
Rajouri Garden
Pusa Institute
New Delhi R.S.
Connaught Place
Lakshmi Nagar
Janakpuri
President's Estate
India Gate
Uttam Nagar
Mayur Vihar
To Rewari
Cantonment
Dhaula Kuan
Safdarjang Aerodrome
Nizamuddin
Noida
Airport
R.K. Puram
A.I.I.M.S.
Nehru Place
J.N.U.
Mehrauli
Saket
Tughlakabad
N.H.8
To Rewari
Mehrauli Badarpur Road
To Kanpur
To Mathura
N.H.2
To Agra

LEGEND
DOMESTIC
COMMERCIAL
PUBLIC
INDUSTRIAL



Scale
0 1 2 3 4 5 Km.
N

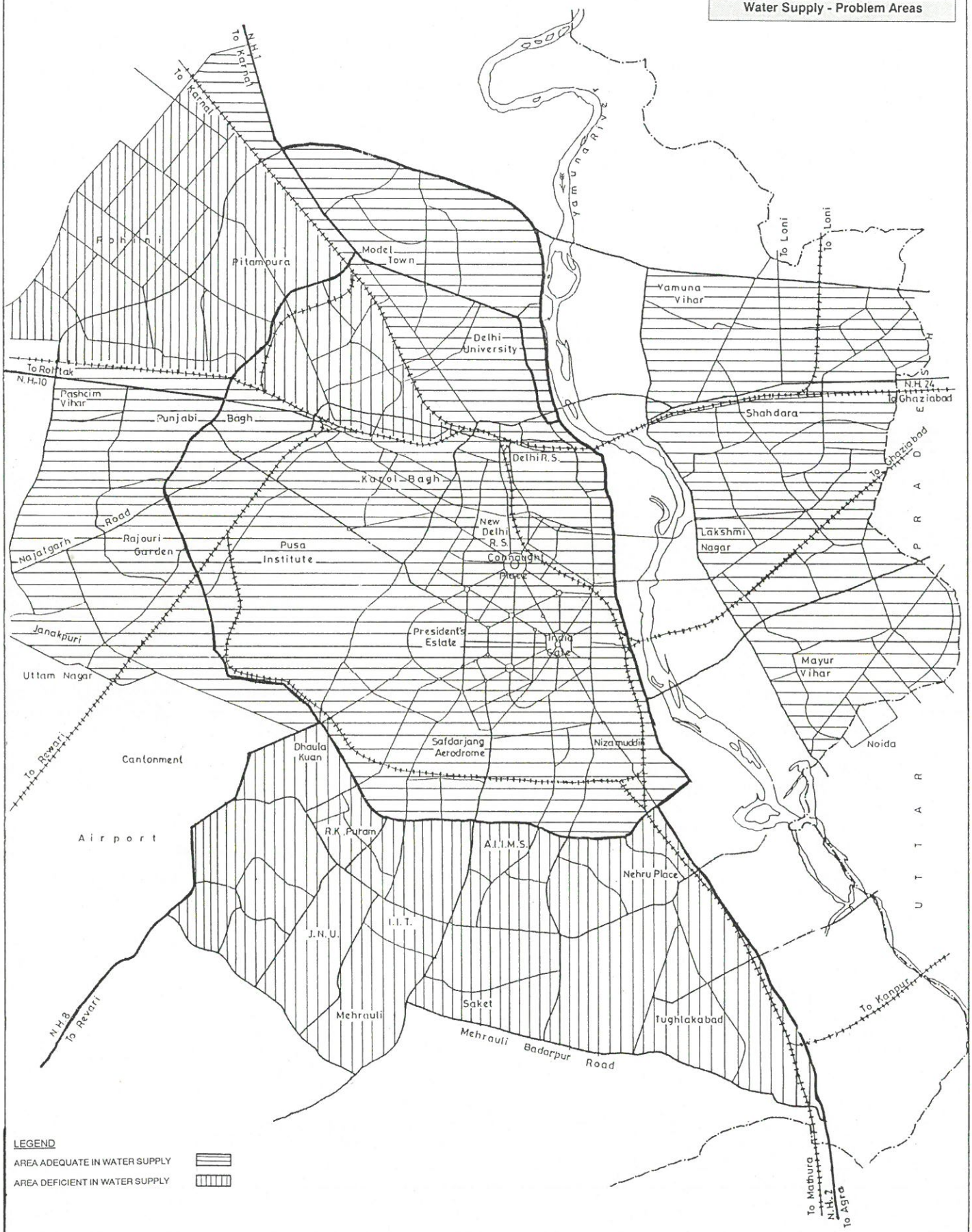
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: DWS & SDU (1993).

DELHI

Water Supply - Problem Areas



LEGEND

AREA ADEQUATE IN WATER SUPPLY

AREA DEFICIENT IN WATER SUPPLY

Scale 0 1 2 3 4 5 Km.

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: DUAC (1986) and DWS & SDU (1993).

DELHI

Prominent Water Supply Problem Areas
(Low pressure & contaminated water)

(SUMMER 1993)

Urban Environmental Maps

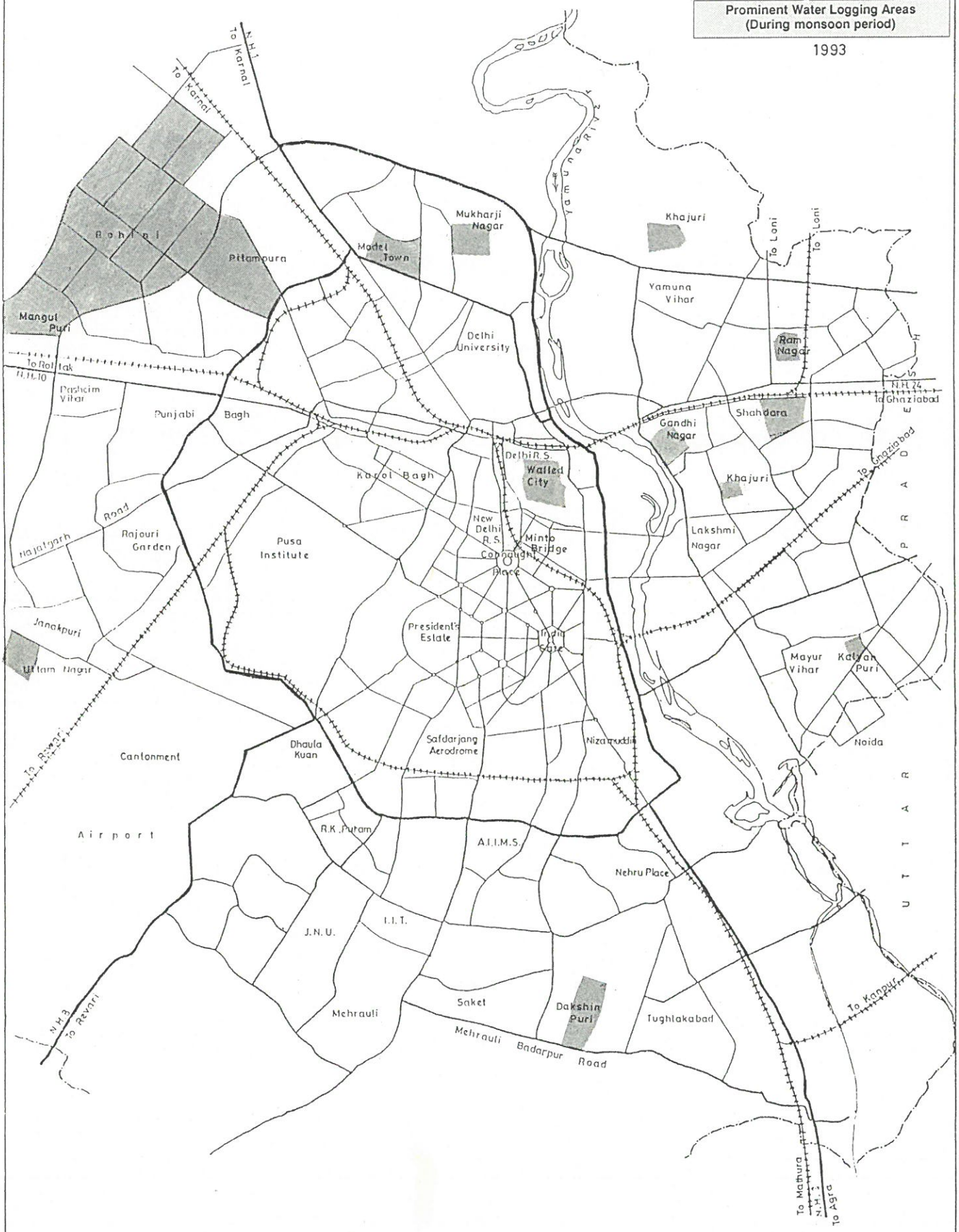
National Institute of Urban Affairs, New Delhi.

Source: Based on Newspaper Clippings.

DELHI

Prominent Water Logging Areas (During monsoon period)

1993



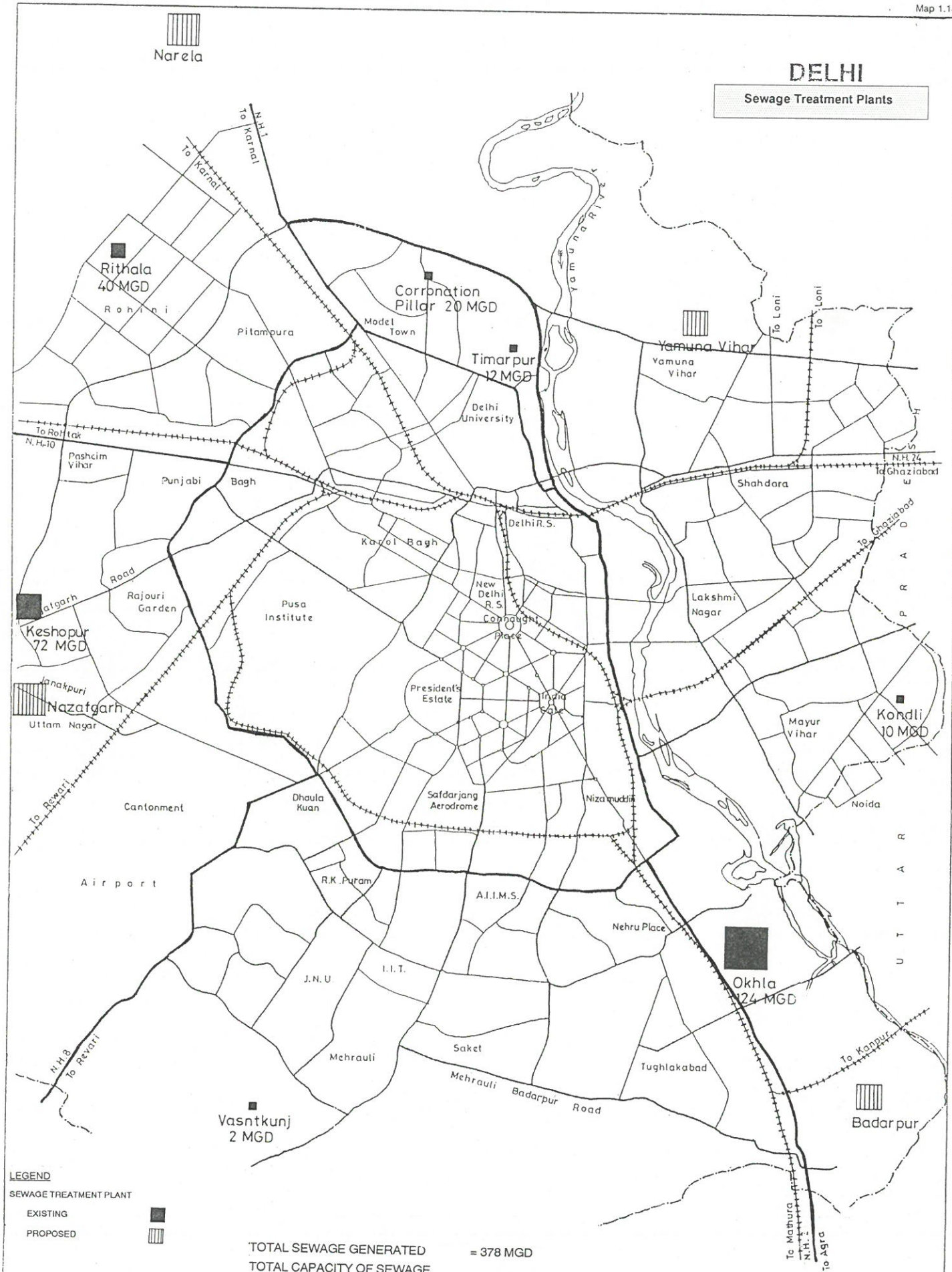
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Based on Newspaper Clippings.

DELHI

Sewage Treatment Plants



LEGEND

SEWAGE TREATMENT PLANT

EXISTING

PROPOSED

TOTAL SEWAGE GENERATED = 378 MGD

TOTAL CAPACITY OF SEWAGE TREATMENT PLANTS = 280 MGD

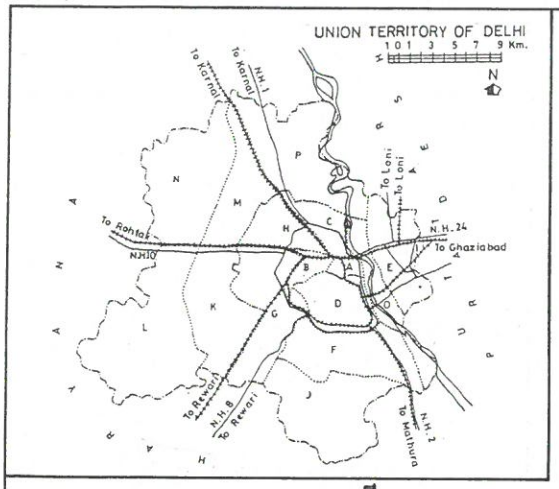
Scale 0 1 2 3 4 5 Km.

N

Urban Environmental Maps

Source: DWS & SDU (1993).

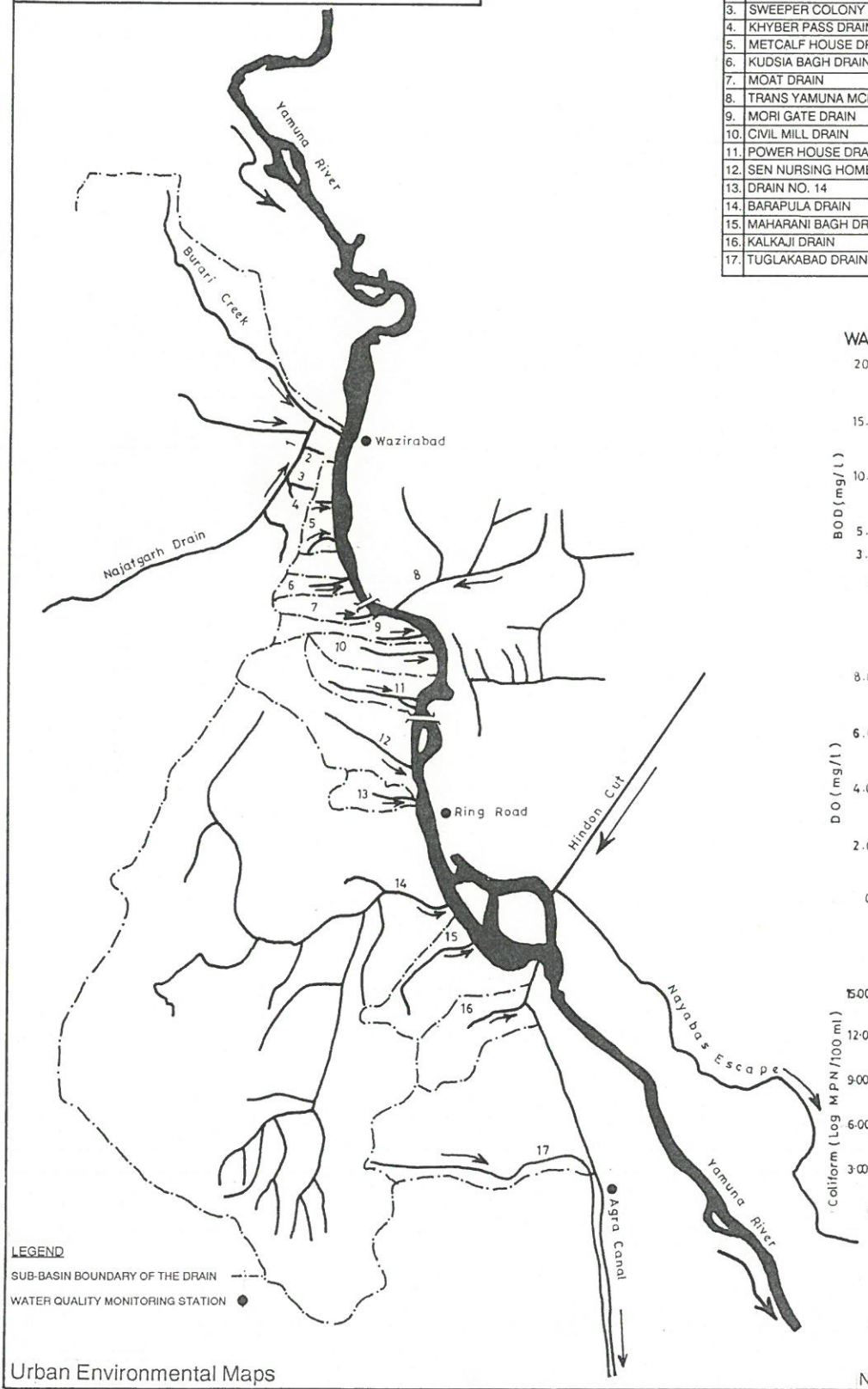
National Institute of Urban Affairs, New Delhi.



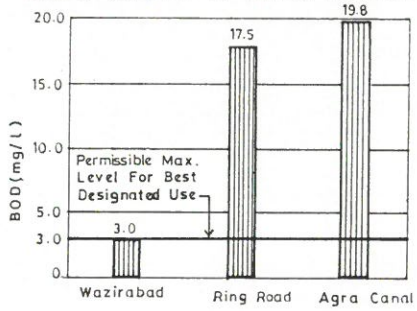
DELHI

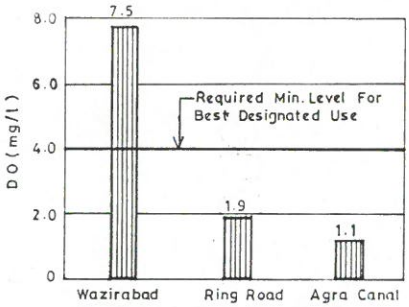
Discharge in River Yamuna from Drains and Water Quality of River Yamuna

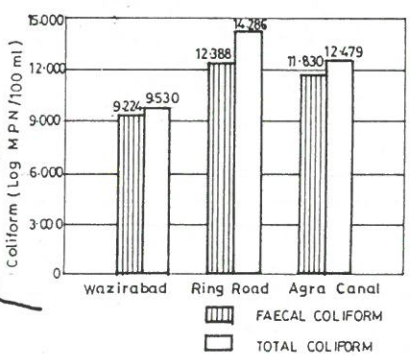
	DRAINS	FLOW(MLD)		TOTAL BOD Kg/Day	BOD mg/l	DO mg/l
		DOMESTIC	INDUST			
1.	NAJAFGARH DRAIN	287.50	18.10	105512	367	Nil
2.	MAGAZINE ROAD DRAIN	1.00		288	288	1.6
3.	SWEEPER COLONY DRAIN	1.00		325	325	6.0
4.	KHYBER PASS DRAIN	1.25		413	330	1.1
5.	METCALF HOUSE DRAIN	2.00		858	429	0.6
6.	KUDSIA BAGH DRAIN	7.50		1748	233	3.9
7.	MOAT DRAIN	3.75		1169	312	3.3
8.	TRANS YAMUNA MCD DRAIN	50.00	4.30	9238	185	1.0
9.	MORI GATE DRAIN	4.00		1165	291	2.2
10.	CIVIL MILL DRAIN	13.00		3952	304	Nil
11.	POWER HOUSE DRAIN	8.00		2416	302	0.8
12.	SEN NURSING HOME DRAIN	14.00		4625	330	2.4
13.	DRAIN NO. 14	3.00		1025	342	5.1
14.	BARAPULA DRAIN	125.00		41400	331	Nil
15.	MAHARANI BAGH DRAIN	11.00		3885	353	Nil
16.	KALKAJI DRAIN	9.00	0.40	3200	246	1.2
17.	TUGLAKABAD DRAIN	26.00		8600	331	0.7



WATER QUALITY OF RIVER YAMUNA







Scale
10 0 5 0 1 2 3 4 5 Km

N

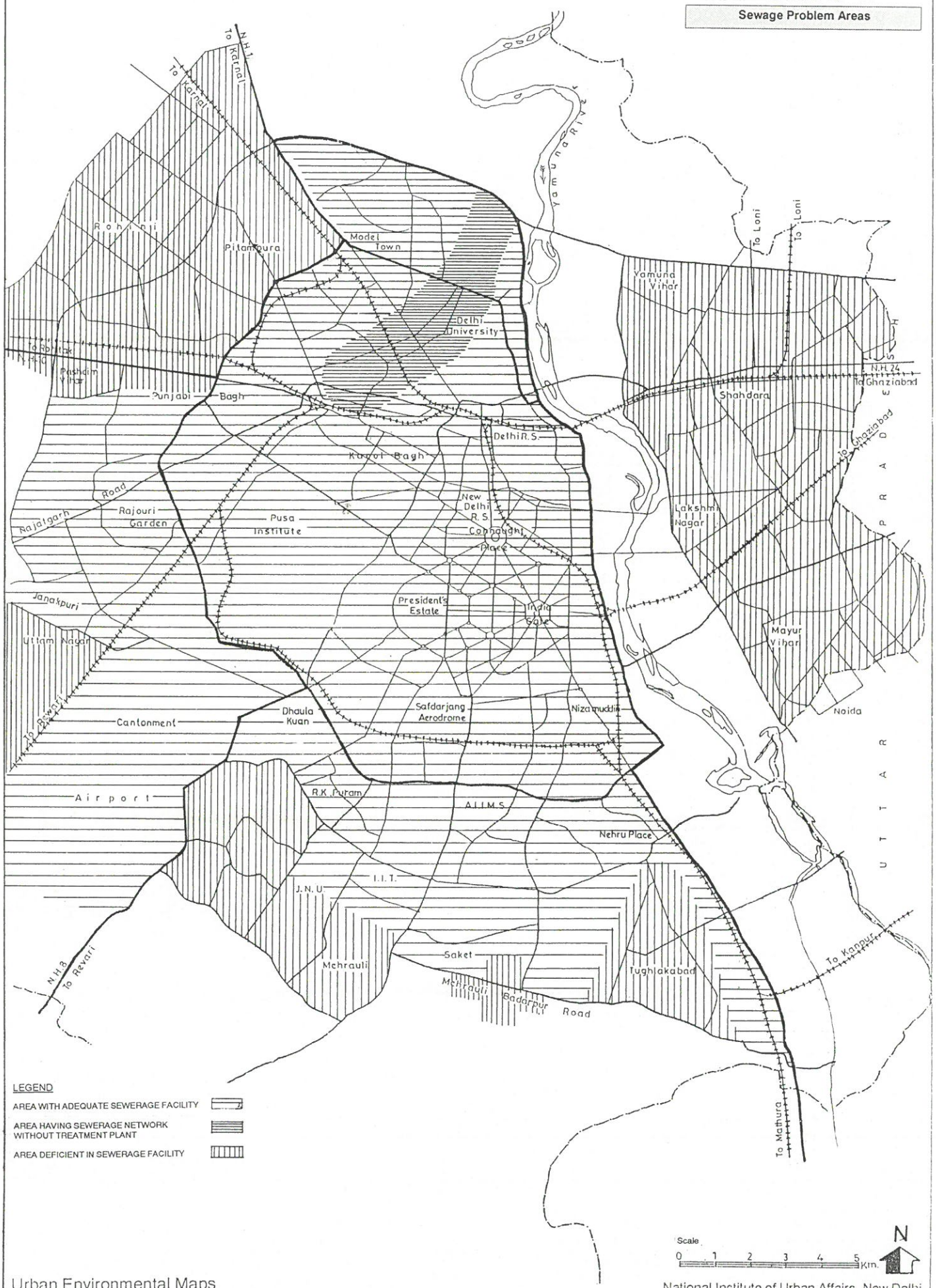
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CPCB (1980 & 1990).

DELHI

Sewage Problem Areas



Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: DUAC (1986).

DELHI

Wastewater Discharge from Industrial Areas

LEGEND

BOUNDARY
- STATE
- DRAINAGE BASIN
- SURVEYED ZONE

RIVER

DRAIN

ROADS

RAILWAY LINES

INDUSTRIAL AREA

Where

a = No. Of Total Units

b = No. Of Polluting Units

c = Effluent Flow In KLD

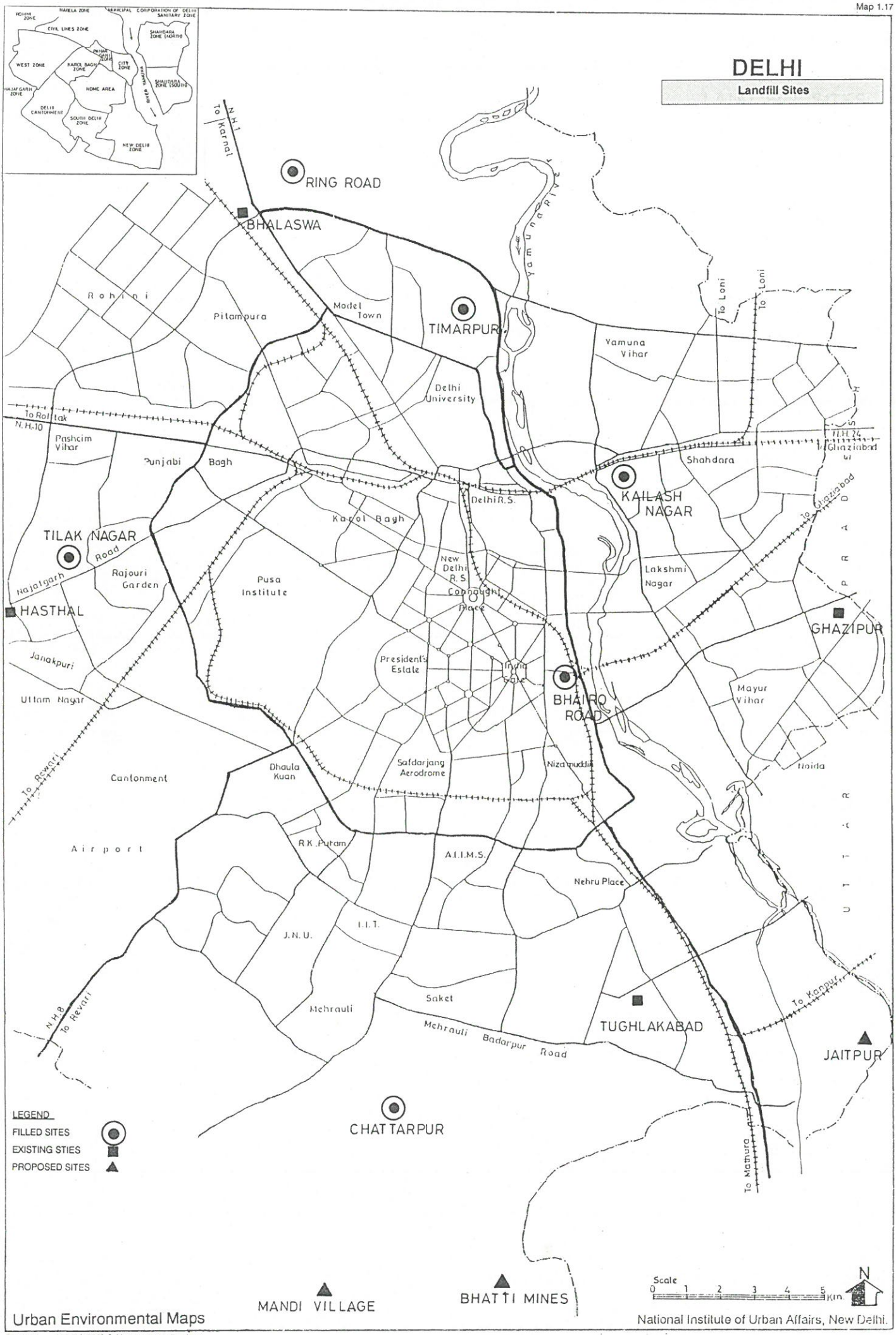
d = Total BOD Load kg/day

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CPCB (1979).



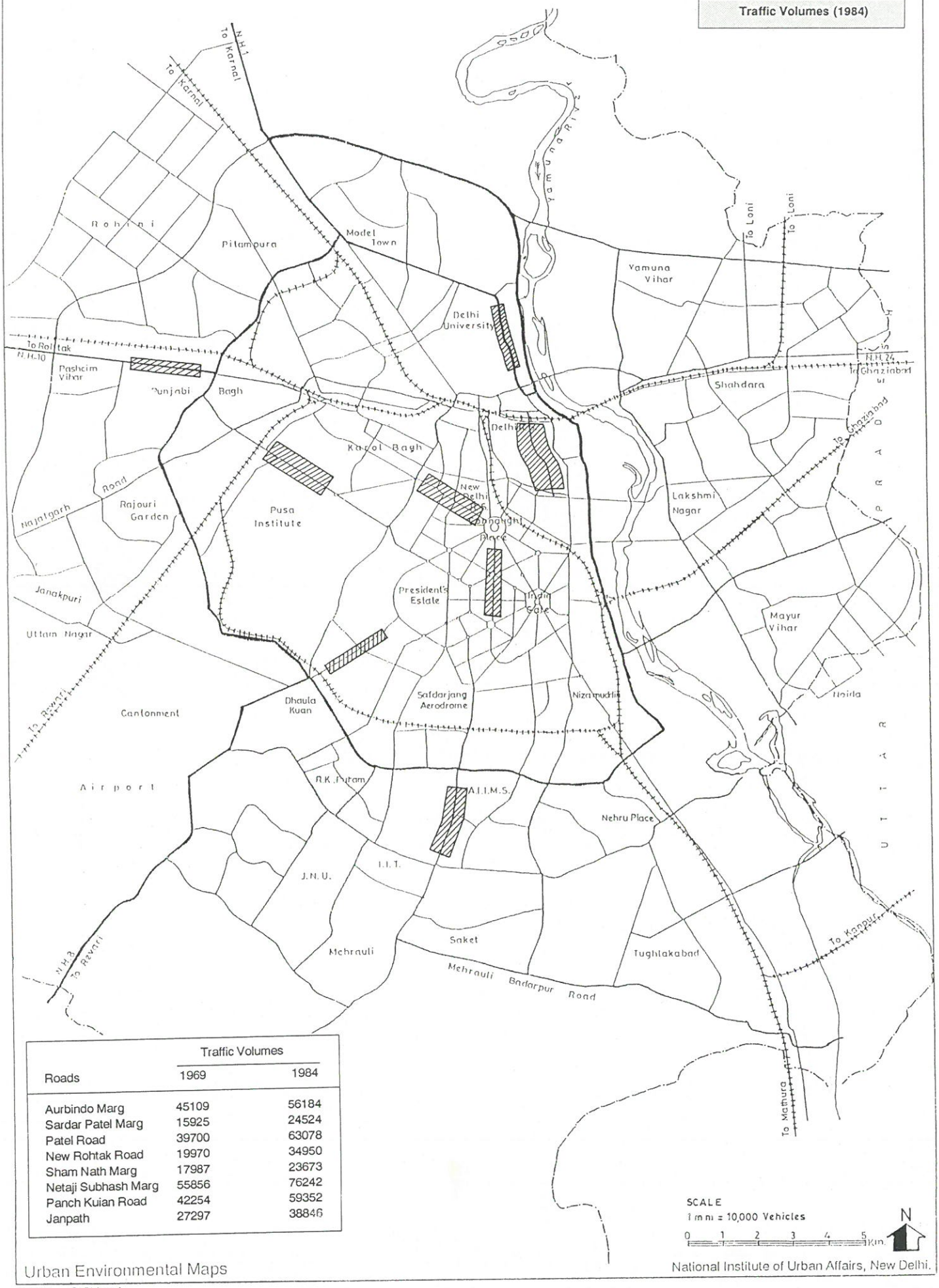
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: MPD (1993) & Newspaper clippings.

DELHI

Traffic Volumes (1984)



Roads	Traffic Volumes 1969	1984
Aurbindo Marg	45109	56184
Sardar Patel Marg	15925	24524
Patel Road	39700	63078
New Rohtak Road	19970	34950
Sham Nath Marg	17987	23673
Netaji Subhash Marg	55856	76242
Panch Kuian Road	42254	59352
Janpath	27297	38846

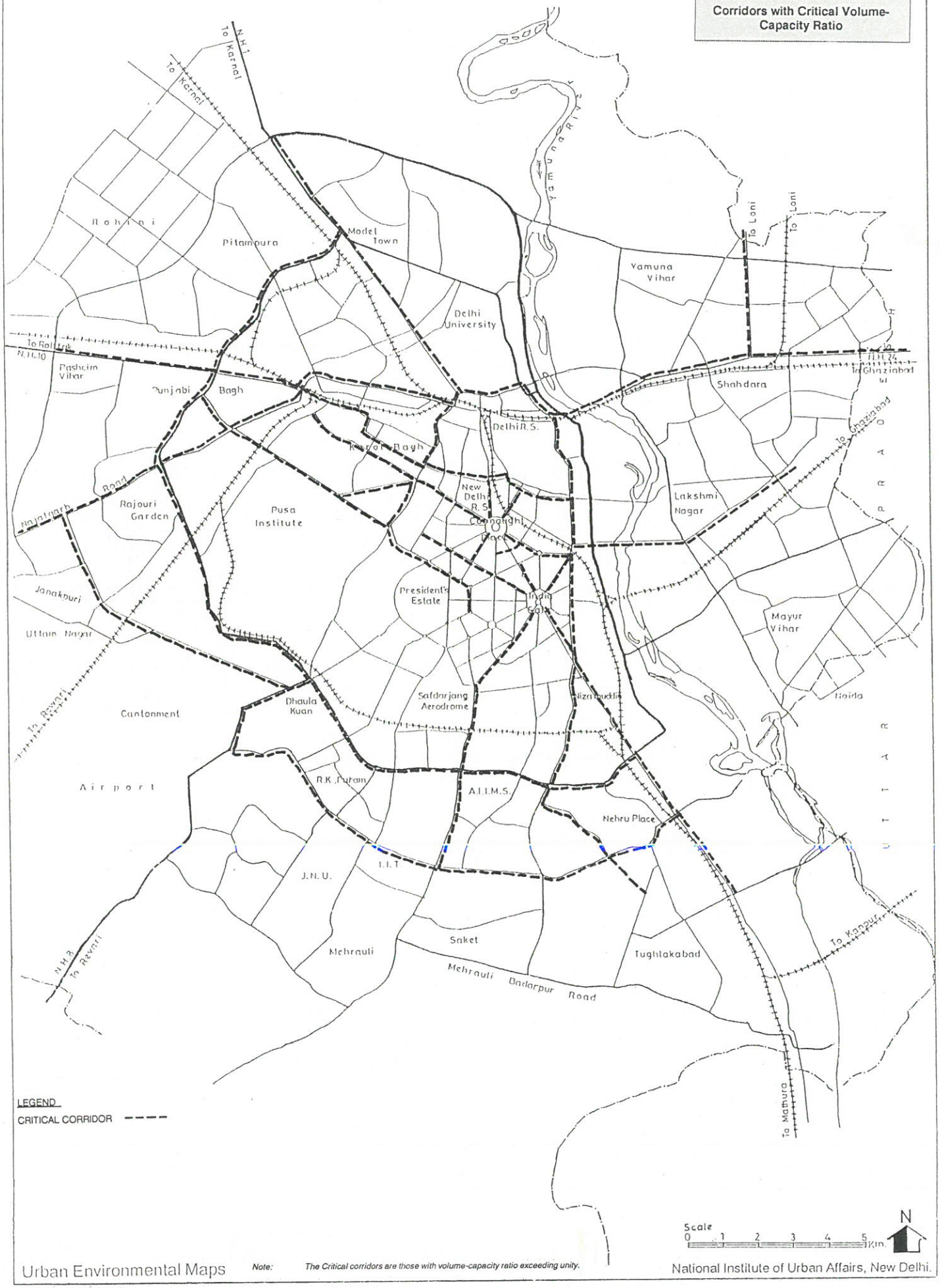
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CRRI (1984).

DELHI

Corridors with Critical Volume-Capacity Ratio



LEGEND

CRITICAL CORRIDOR ----

Urban Environmental Maps

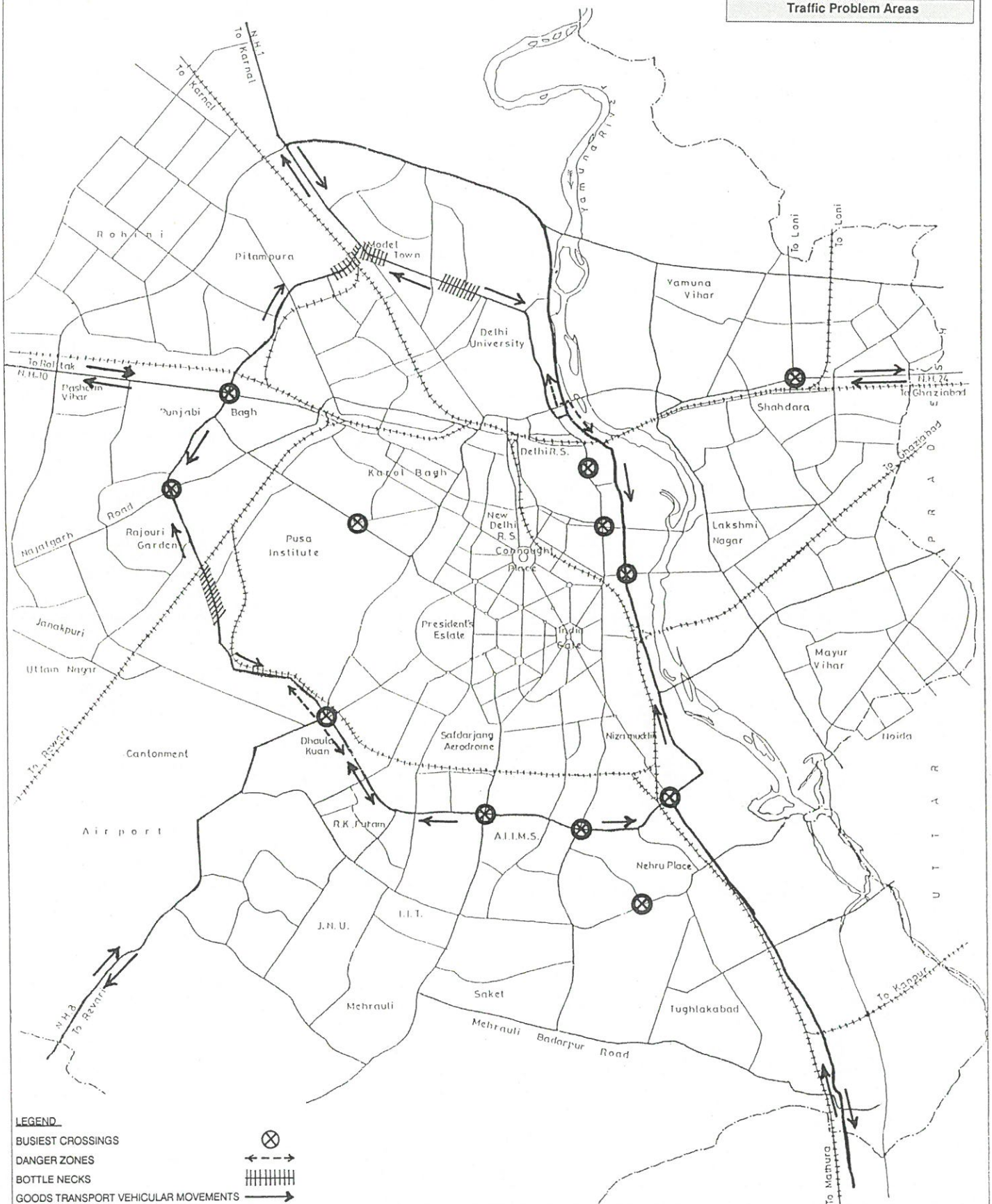
Note: *The Critical corridors are those with volume-capacity ratio exceeding unity.*

National Institute of Urban Affairs, New Delhi.

Source: DUAC (1986)

DELHI

Traffic Problem Areas



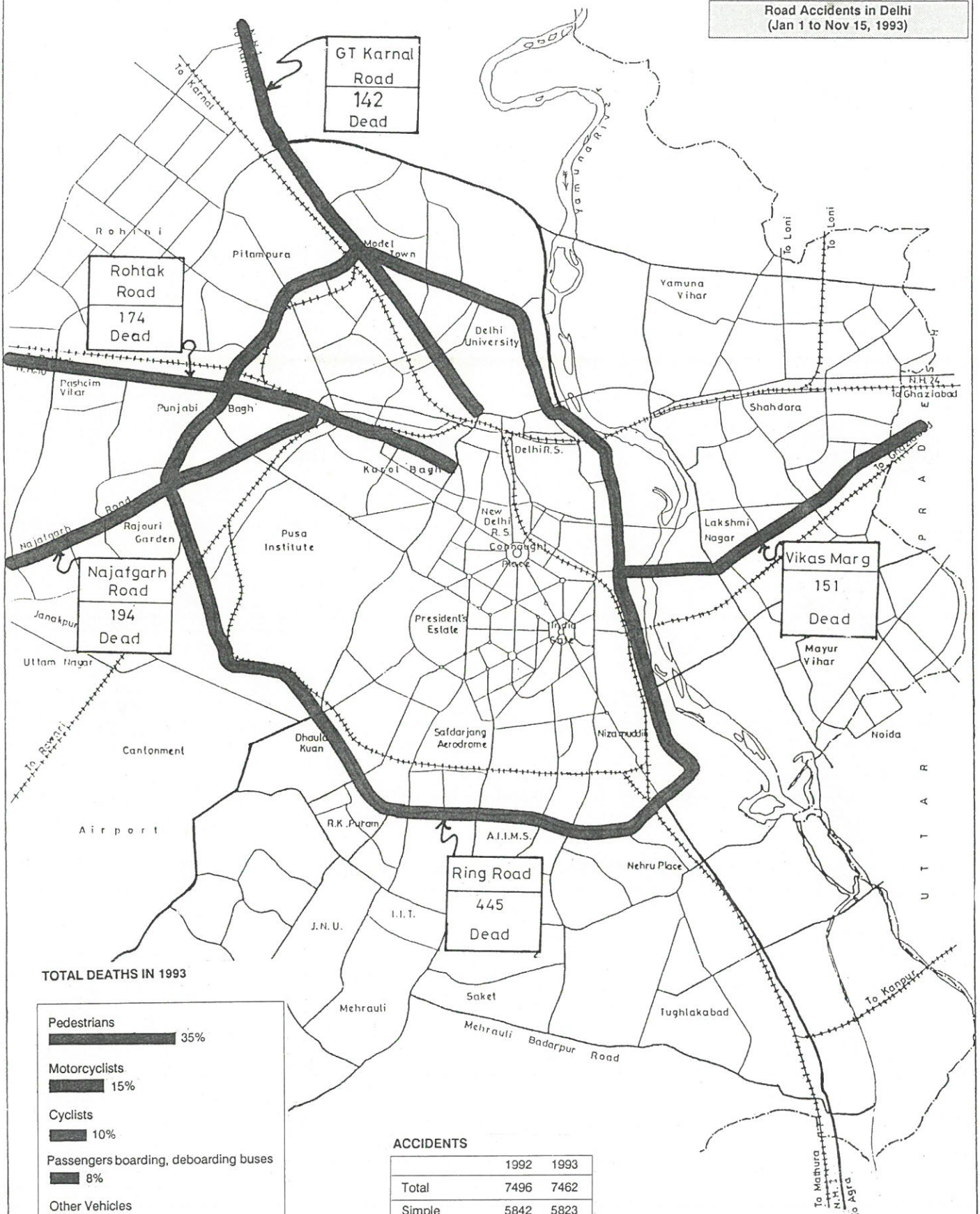
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CPCB (1988) & Indian Express, May 23, 1993.

DELHI

Road Accidents in Delhi
(Jan 1 to Nov 15, 1993)



TOTAL DEATHS IN 1993

Pedestrians	35%
Motorcyclists	15%
Cyclists	10%
Passengers boarding, deboarding buses	8%
Other Vehicles	8%
Hit and Run	22%

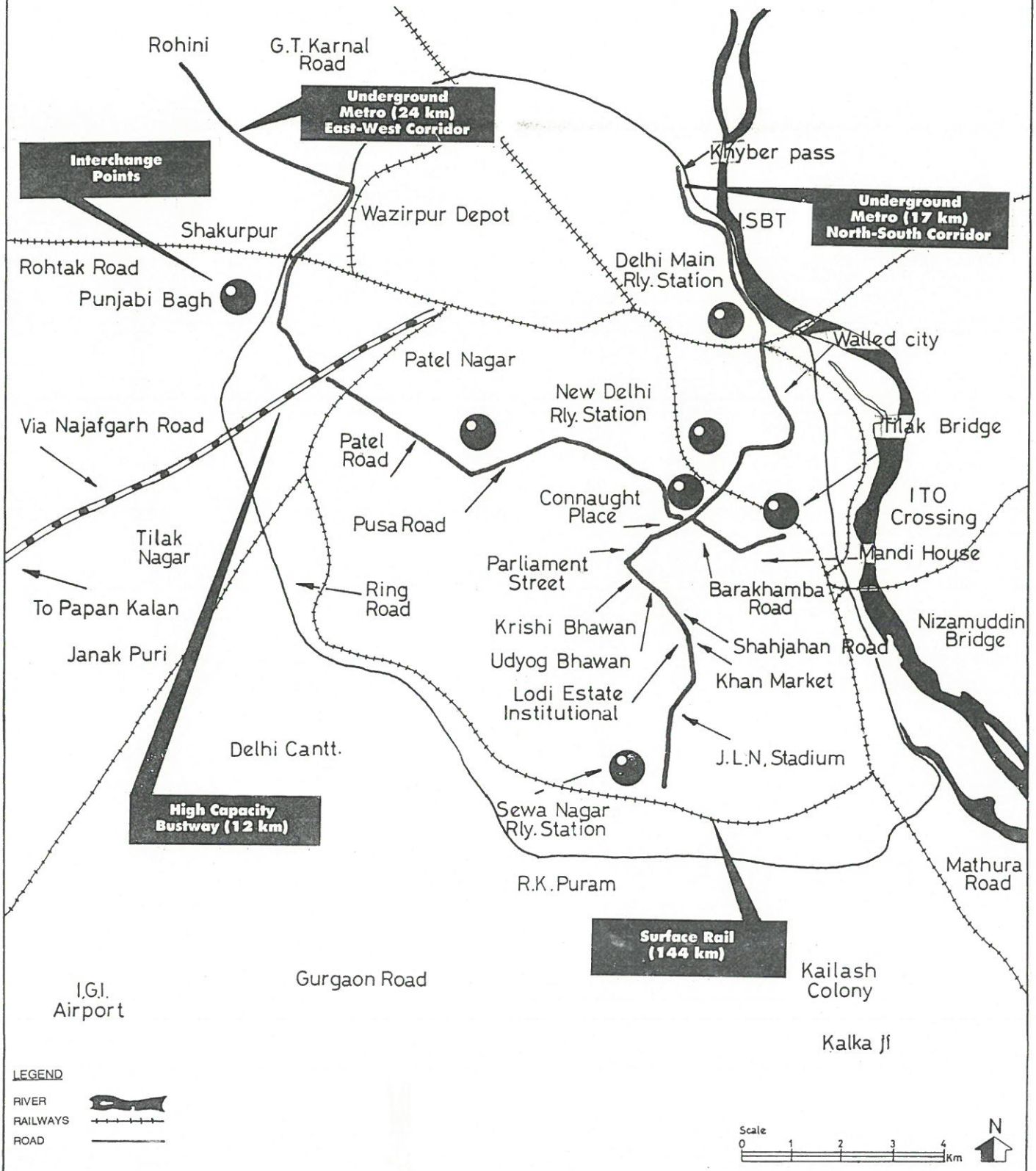
ACCIDENTS

	1992	1993
Total	7496	7462
Simple	5842	5823
Fatal	1654	1639
Deaths	1680	1730

Source: The Hindustan Times, Nov. 30, 1993.

DELHI

Proposed Mass Rapid Transit System



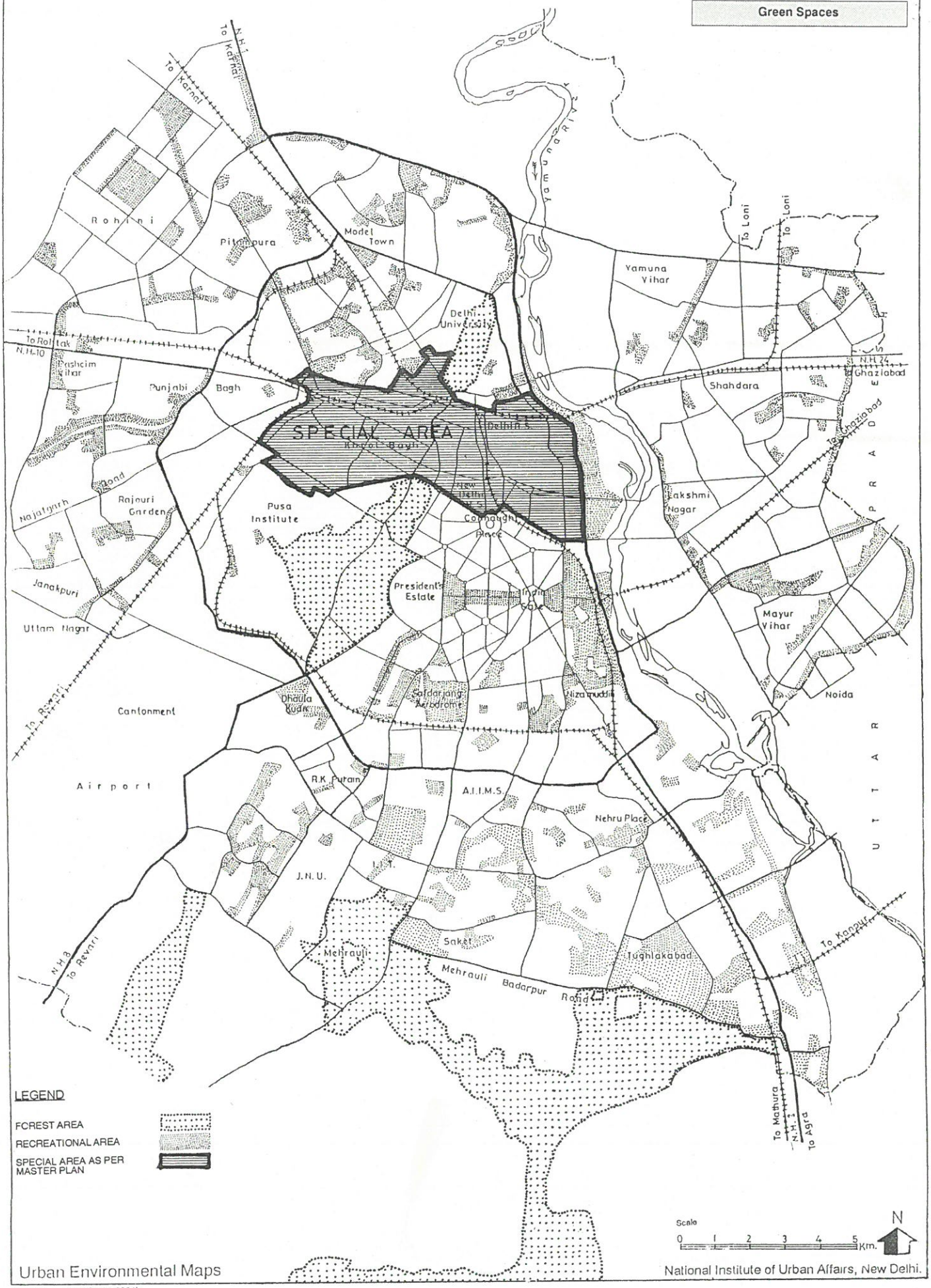
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Indian Roads Congress Journal.

DELHI

Green Spaces



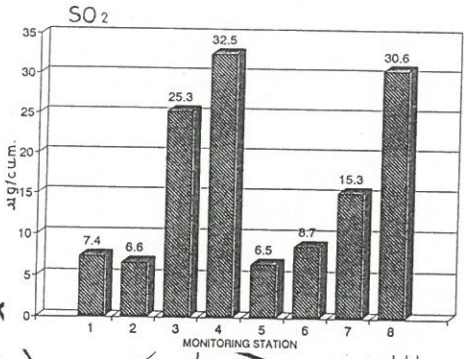
Urban Environmental Maps

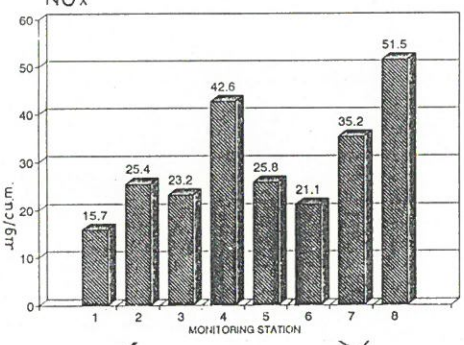
National Institute of Urban Affairs, New Delhi.

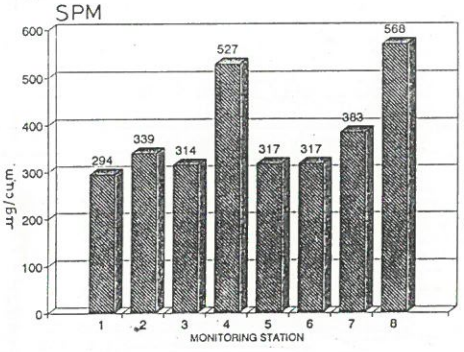
Source: MPD (1981-2001).

DELHI

Ambient Air Quality - 1990
(Annual Mean Values)







LEGEND

- RESIDENTIAL AREA
- INDUSTRIAL AREA
- COMMERCIAL AREA

MONITORING STATIONS

1. NIZAMUDDIN
2. ASHOK VIHAR
3. SHAHDRA
4. NAJAFGARH ROAD
5. JANAKPURI
6. SIRI FORT
7. NETAJI NAGAR
8. TOWN HALL

Scale 0 1 2 3 4 5 Km.

N

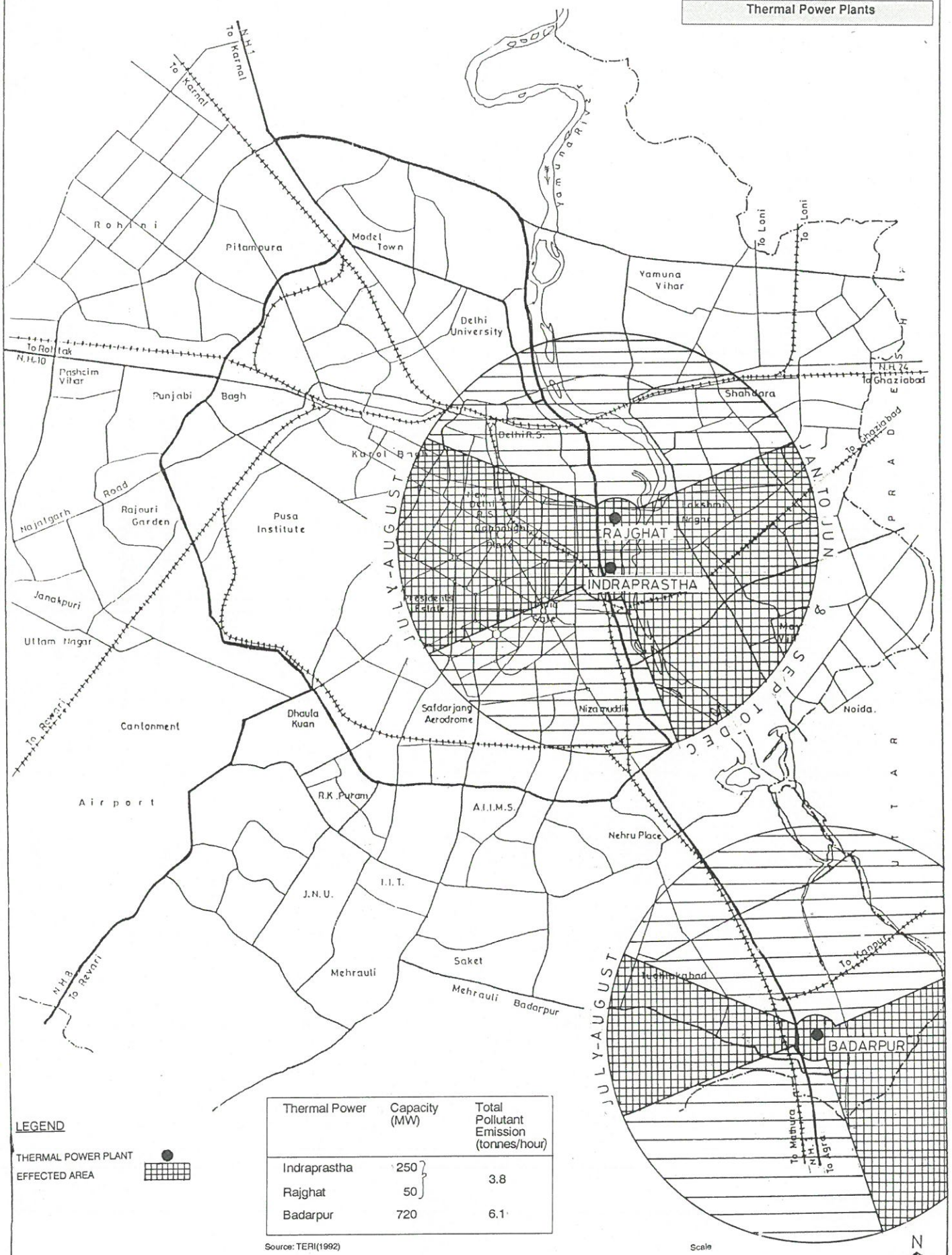
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CPCB (1990 & 1991).

DELHI

Thermal Power Plants



Thermal Power	Capacity (MW)	Total Pollutant Emission (tonnes/hour)
Indraprastha	250	3.8
Rajghat	50	
Badarpur	720	6.1

Source: TERI(1992)

LEGEND

THERMAL POWER PLANT

EFFECTED AREA

Scale 0 1 2 3 4 5 Km.

N

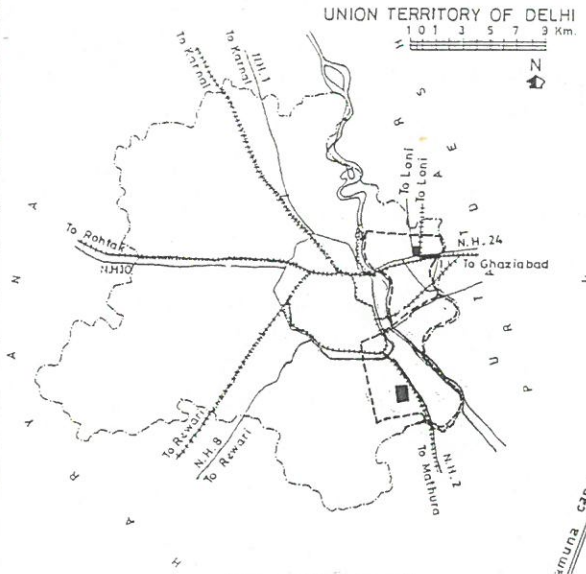
Urban Environmental Maps

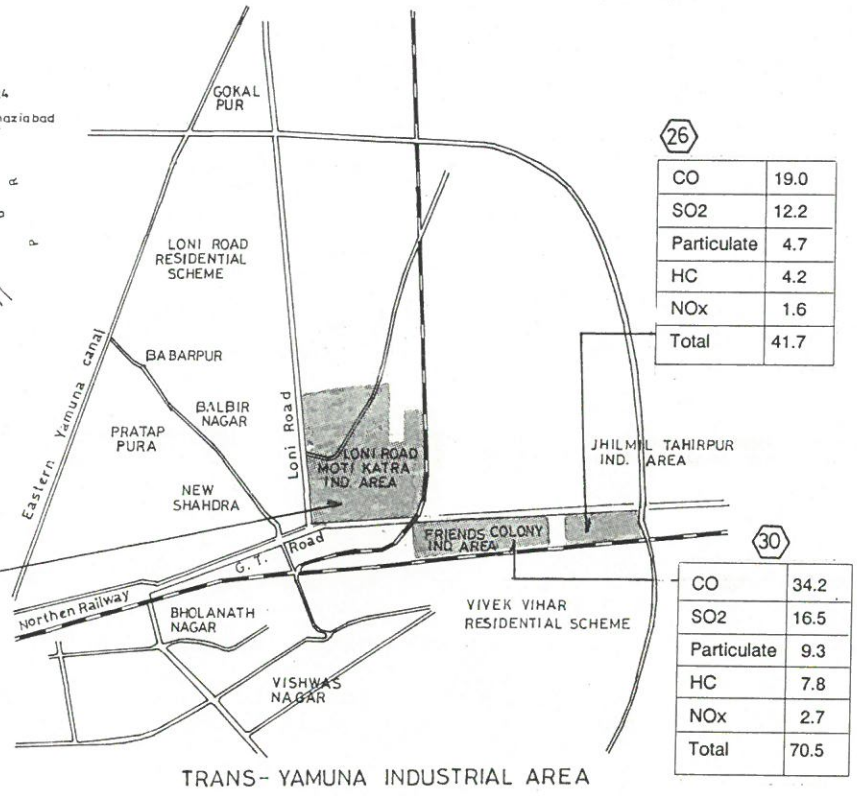
National Institute of Urban Affairs, New Delhi.

Source: Based on TERI (1992).

DELHI

Industrial Emissions (tonnes/month)





CO	25.5
SO2	51.9
Particulate	7.4
HC	5.8
NOx	5.5
Total	96.1

(11)

(26)

CO	19.0
SO2	12.2
Particulate	4.7
HC	4.2
NOx	1.6
Total	41.7

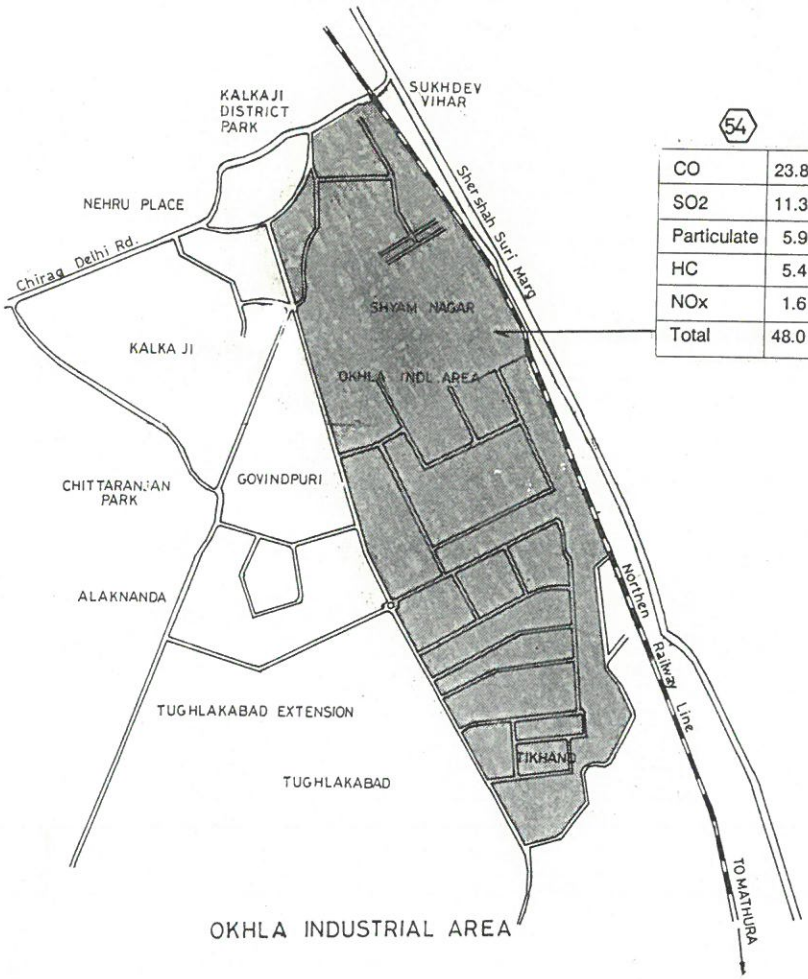
(30)

CO	34.2
SO2	16.5
Particulate	9.3
HC	7.8
NOx	2.7
Total	70.5

TRANS- YAMUNA INDUSTRIAL AREA

TOTAL EMMISSIONS FROM THE INDUSTRIAL AREAS

Total number of industries = 121	
	Tonnes/Month
CO	102.5
SO2	91.9
Particulate	27.3
HC	23.2
NOx	11.4
Total	256.3



(54)

CO	23.8
SO2	11.3
Particulate	5.9
HC	5.4
NOx	1.6
Total	48.0

OKHLA INDUSTRIAL AREA

LEGEND

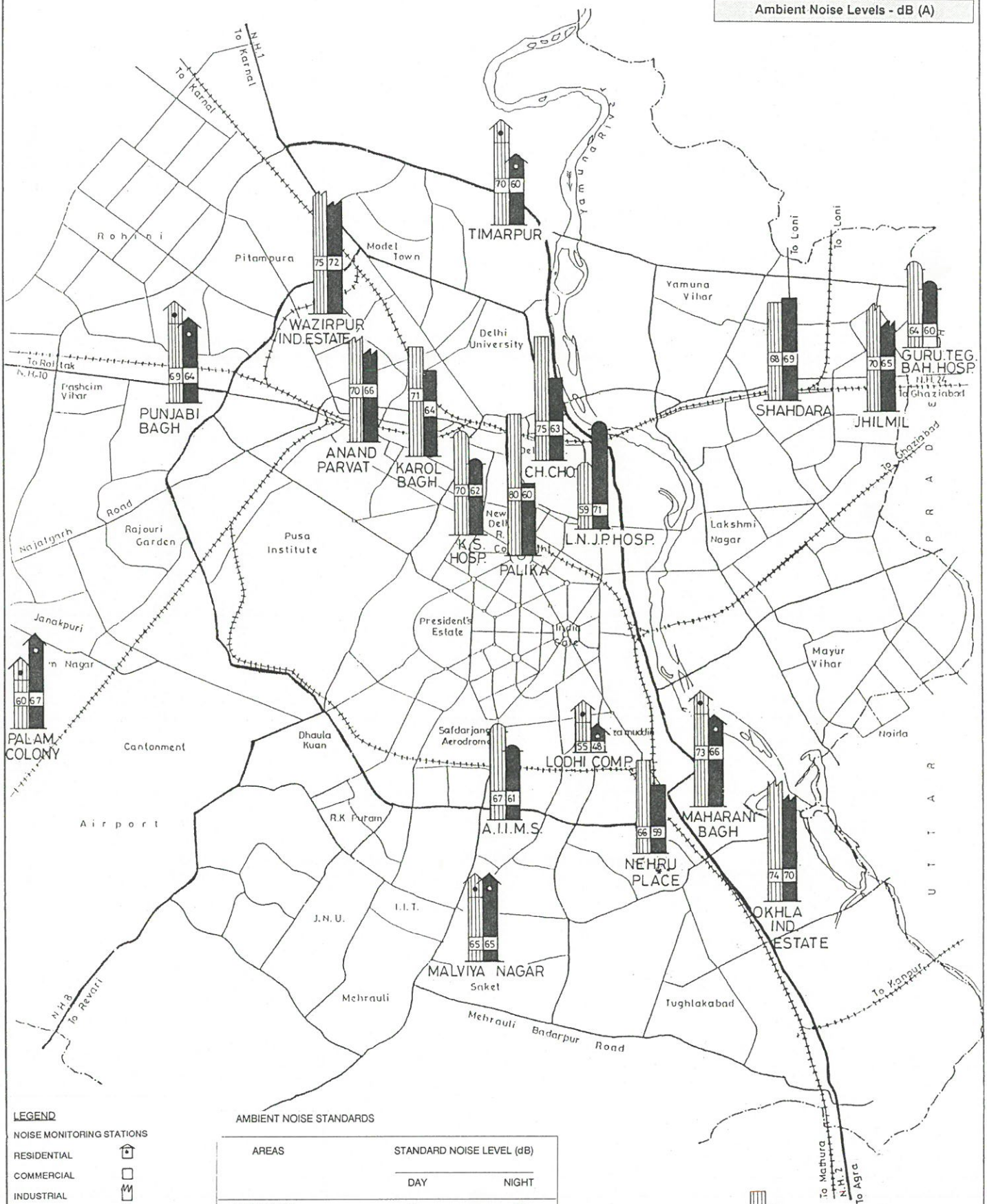
INDUSTRIAL AREA

NO. OF INDUSTRIES IN THE INDUSTRIAL AREA (11)

Source: CPCB (1986).

DELHI

Ambient Noise Levels - dB (A)



LEGEND

NOISE MONITORING STATIONS

RESIDENTIAL

COMMERCIAL

INDUSTRIAL

SILENCE

AMBIENT NOISE STANDARDS

AREAS	STANDARD NOISE LEVEL (dB)	
	DAY	NIGHT
RESIDENTIAL	55	45
COMMERCIAL	65	55
INDUSTRIAL	75	70
SILENCE	50	40

Source: Central Pollution Control Board (1989)

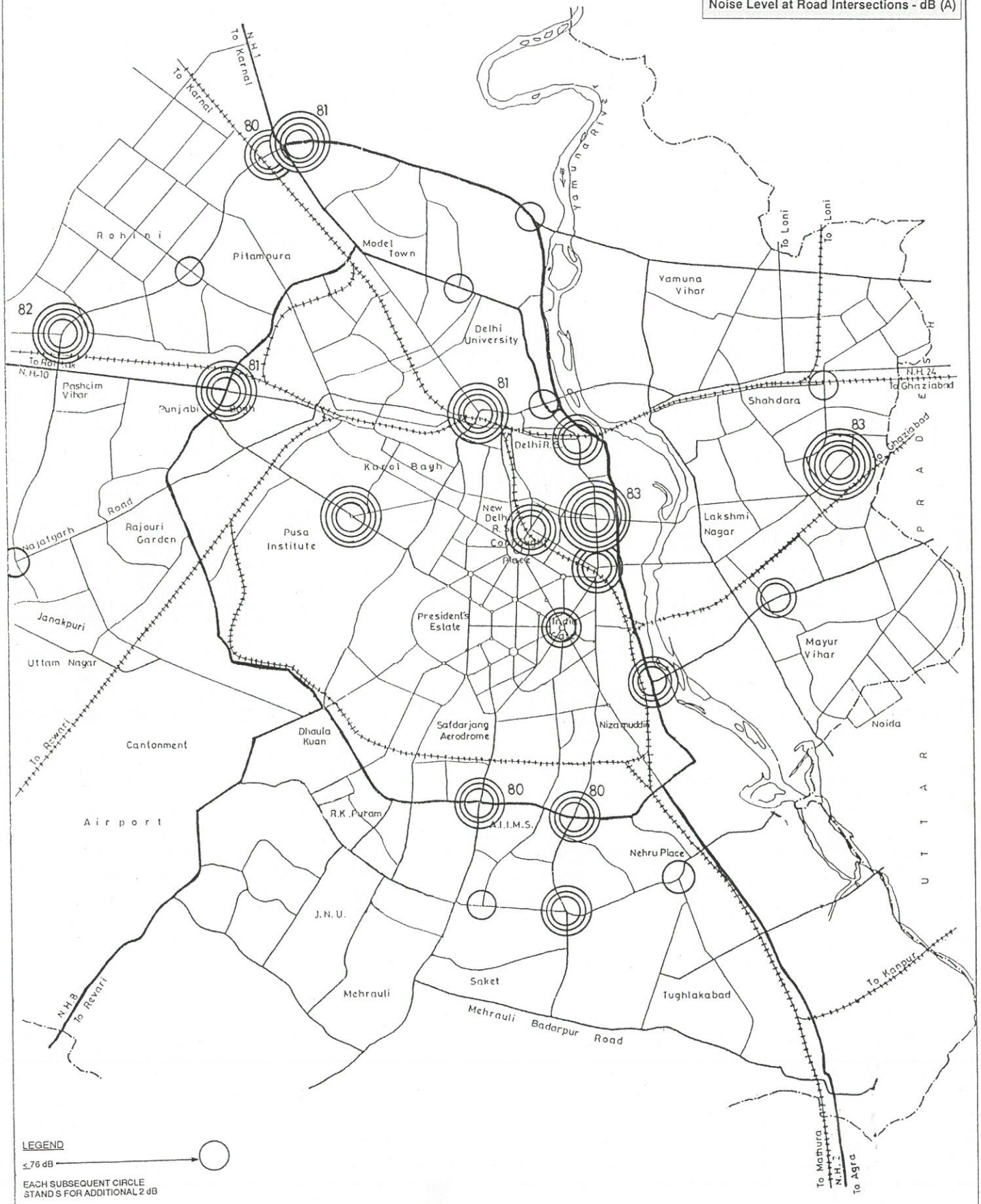
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CPCB (1991).

DELHI

Noise Level at Road Intersections - dB (A)



LEGEND

≤76 dB

EACH SUBSEQUENT CIRCLE STANDS FOR ADDITIONAL 2 dB

Scale 0 1 2 3 4 5 Km.

N

DELHI

1.1 The City

Delhi is a very ancient and historic city of India, its origin is lost in antiquity. There is a reference in Mahabharata regarding a city called Indraprastha which was built along the bank of river Yamuna in the area lying between the present Kotla Feroze Shah and Humayun's Tomb. But there is no direct evidence identifying this city with that of Delhi.

At the end of 12th century, Delhi passed into the hands of Muslim conquerors. Famous Qutub Minar was constructed by Qutub-ud-Din in 1200 AD. Then it was ruled by Khiljis and Tughlaqs. In 1526 AD, Babur, the founder of Mughal Empire, invaded India. Later on, Humayun built a fort called Din-I-Panah, now known as Purana Qila. Shahjahan built his capital at Delhi and constructed the Red Fort and the Jama Masjid. Delhi continued to be ruled by Mughals till 1857.

The city of Delhi went into the hands of the British in 1803 AD. In 1911, the capital of British Empire was shifted from Calcutta to Delhi. Sir Edward Lutyen designed the present New Delhi in 1930s.

The province of Delhi acquired the status of a State after the adoption of the Constitution of India. A Legislative Assembly was set up in 1952 which continued till 1956 when the Central Administration in Delhi was reintroduced. In 1966, a Metropolitan Council was set up which continued up to 1993. Again a Legislative Assembly has been formed in December 1993.

The only Tehsil of Delhi was bifurcated into two, Delhi and Mehrauli Tehsils during the decade 1961-71 and since then there has been no change. Now, Delhi comprises of one district having two Tehsils viz., Delhi and Mehrauli comprising 144 and 87 villages respectively. The urban Delhi covers Delhi Municipal Corporation (urban), New Delhi Municipal Committee, Delhi Cantonment and 27 Census Towns (as per 1981 census).

1.2 Demography

Delhi has witnessed a phenomenal population growth during past few decades. From a population of 405,819 in 1901, its population has grown to 9,420,644 in 1991. There was a sudden increase in the population in 1947, as a result of partition. The 1941-51 decade recorded a growth of 90%. Since 1951, the population of Delhi has been increasing at a rate of 52-53% every decade. During 1981-91, its population grew by 3,200,238. Taking this figure, on an average, everyday 877 persons were added to Delhi's population during 1981-91 decade. If this growth rate continues during 1991-2001, then Delhi would have 14,130,966 persons by the year 2001.

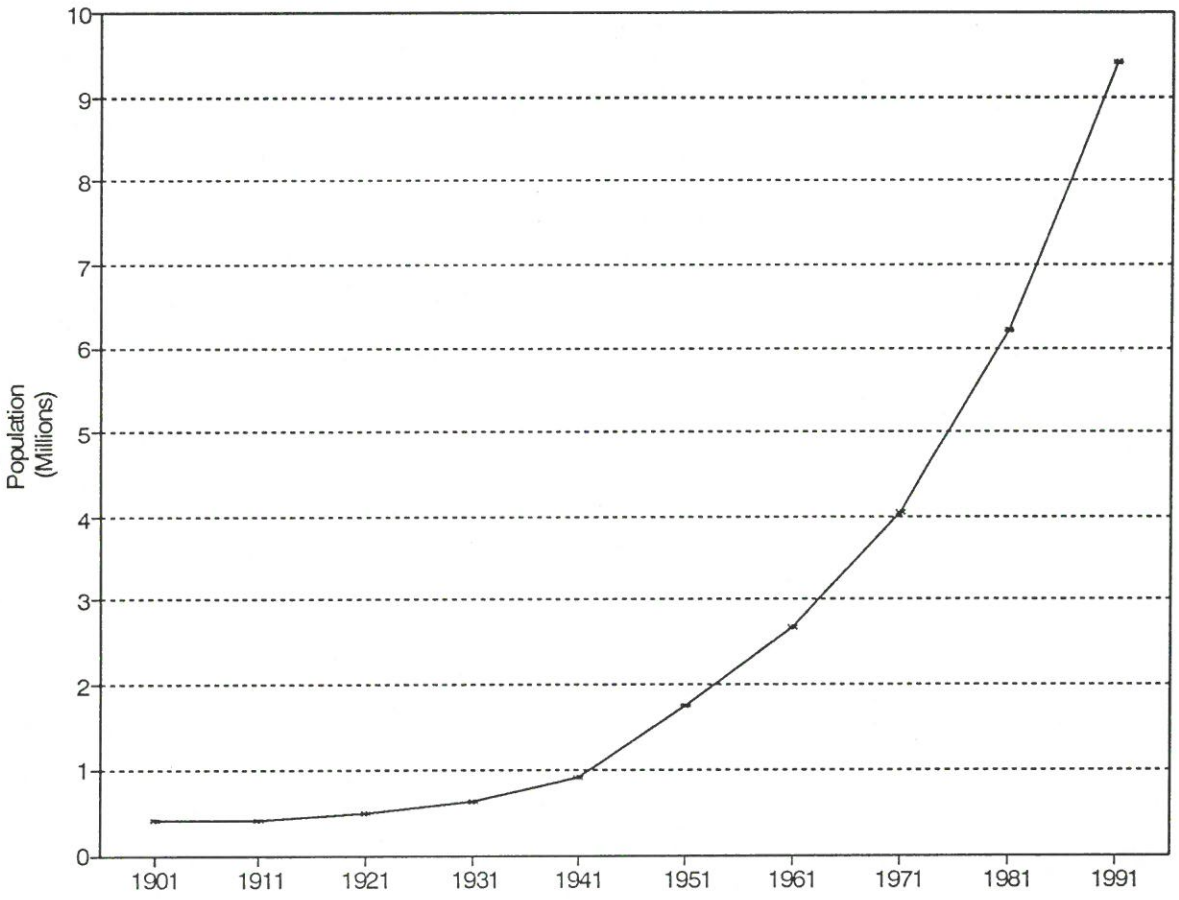


Figure 1.1: Population Growth in Delhi

Table 1.1: Decadal Variation in Population of Delhi Union Territory

Year	Population	Decadal Variation	Percentage Decadal Growth
1901	405819	-	-
1911	413851	+8032	+1.98
1921	488452	+74601	+18.03
1931	636246	+147794	+30.26
1941	917939	+281693	+44.27
1951	1744072	+826133	+90.00
1961	2658612	+914540	+52.44
1971	4065698	+1407086	+52.93
1981	6220406	+2154708	+53.00
1991	9420644	+3200238	+51.45

Source: Census of India (1991).

Urban population constitutes a major portion of total population of the Union Territory of Delhi. In 1981, the urban population was 92.73% of total population, which reduced to 89.93% in 1991. In absolute numbers, the urban population was 8,471,625 in 1991 compared to 5,768,200 in 1981. The population density for urban Delhi was 14,313 persons in 1991. (Table 1.2)

Table 1.2: Urban and Rural Population in Delhi Union Territory

	Year	Area (Sq.km)	Population	Population Density (Persons/sq.km)
Urban Delhi	1981	591.9	5768200	9745
	1991	591.9	8471625	14313
Rural Delhi	1981	891.1	452206	507
	1991	891.1	949019	1065
Delhi Union Territory	1981	1483.0	6220406	4194
	1991	1483.0	9420644	6352

Source: Census of India (1991), Paper 2 of 1992. Final Population Tables.

Upto 1971, only Delhi Municipal Corporation (Urban), NDMC and Delhi Cantonment Board constituted urban Delhi. In 1981, 27 new census towns were added which increased the area to 591.85 sq.km. in 1981 from an area of 446.26 sq.km. in 1971.

The population of DMC (urban) has doubled between 1971 and 1991. As against this in the NDMC area the population in 1981 and 1991 was less that in 1971. The population of the Cantonment Board is less than that of NDMC. Both NDMC and Cantonment Board have about 43 sq. km of area, but the population of Cantonment is only one-third of NDMC's population

(1991). The population density has increased considerably in DMC (urban) over the last two decades, recording a density of 19,899 persons per sq.km. in 1991 as compared to 9119 persons per sq.km. in 1971.

Table 1.3: Growth of Population in Urban Delhi

Urban Local Body	Area (sq.km)	1971		1981		1991	
		Population	Population Density (Persons/ sq.km)	Population	Population Density (Persons/ sq.km)	Population	Population Density (Persons/ sq.km)
Delhi Municipal Corporation (Urban)	360.55	3287883	9119	4884234	13547	7174755*	19899
New Delhi Municipal Committee	42.74	301801	7061	273036	6388	294149*	6882
Delhi Cantonment Board	42.97	57339	1334	85166	1982	94326*	2195

* Provisional Population

Source: Census of India (1981), Series-28, Delhi and
Census of India (1991), Series-31, Delhi.

The Delhi Development Authority has divided the entire Union Territory into 15 divisions. Out of these, 8 divisions form the urban area. In 1981, division 'A'(walled city area) had the maximum population density of 53685 persons per sq.km. while division 'F' (south Delhi area) with 6876 persons per sq.km. had the lowest density (Table 1.4).

Table 1.4: Population Density in Urban Delhi - 1981

Planning Division	Area (Sq.km)	Population (1981)	Population Density (Persons/sq.km)
A	11.59	622207	53685
B	23.04	567804	24644
C	39.59	530547	13401
D	68.55	496058	7236
E	87.97	1028794	11695
F	119.58	822200	6876
G	118.65	868277	7318
H	56.77	517687	9119
Total	525.74	5453574	10373

Source: Master Plan of Delhi (1981-2001)

To control the growth of population, the National Capital Region was formed in 1986 with the idea of diverting the population and economic activities to satellite towns. The National Capital Region spread over 30,242 sq.km covers parts of the States of Haryana, U.P. and Rajasthan and the Union Territory of Delhi.

For the purpose of planning, the Delhi Metropolitan Area (DMA) was formed, comprising of Delhi U.T., Ghaziabad-Loni Complex and NOIDA in U.P., Faridabad-Ballabhgarh Complex, Gurgaon, Bahadurgarh and Kundli in Haryana. The DMA which is spread over an area of 3182 sq.km. is expected to contain the population of Delhi U.T. to 112 lakhs by the year 2001.

Table 1.5: Population Assignment for 2001

(in lakhs)

Area	Population Assigned - 2001		
	Urban	Rural	Total
National Capital Region	234	91	325
Delhi Metropolitan Area	147	3	150
Delhi Union Territory	110	2	112

Source: Interim Development Plan-2001, National Capital Region Planning Board.

1.3 Housing and Slums

Urban Delhi in 1981 accommodated about 11.5 lakh households in different types of housing - resettlement, squatter, plotted, multifamily, unauthorised, villages, traditional and others. As per the Master Plan for Delhi (1981-2001) another 13 lakh households would be add to the existing ones by the year 2001.

In 1961, there was a shortage of 1,40,000 dwelling units in Delhi. This shortage increased to around 3 lakhs in 1981. During the period 1981-2001, an additional 16.5 lakh dwelling units would be required.

Table 1.6: Housing Requirements in Delhi (1981-2001)

(in lakhs)

Period	New Housing Required	Average per year
1981-1986	3.23	0.65
1986-1991	3.74	0.76
1991-1996	4.34	0.87
1996-2001	4.83	0.97

Source: Master Plan of Delhi (1981-2001)

To fulfil the housing demand by the year 2001, about 222 housing units are to be constructed every day. The Master Plan of Delhi envisaged construction of about 7.4 lakh dwelling units during 1961-81, but only 5.43 lakh dwelling units became available. Going by these figures, it seems that that problem of housing will only increase with every passing year and will push a major percentage population to already congested areas. This, in turn, will affect the already strained services and lead to poor living conditions.

There has been a continuous growth in slum population in all metropolitan cities in the country. Delhi occupies the third position with respect to slum population with 32 lakh persons residing in slum areas. Calcutta has 43.8 lakh persons in slums (Table 1.7). In 1981, 31.4% of Delhi's population was residing in slums which increased to 32.8% in 1990.

Table 1.7: Slum Population in Four Metropolitan Cities

City	Slum Population (in lakhs)	
	1981	1990
Calcutta	32.8	43.8
Greater Bombay	28.3	41.2
Delhi	18.0	32.0
Madras	13.6	21.0

Source: The Times of India, Aug 1,1992

Table 1.8: Estimated Slum Population in Delhi (1990)

Year	Urban Population (in lakhs)	Estimated Slum Population (in lakh)	Slum Population as % of urban Population
1981	57.29	18.00	31.40%
1990	97.67	32.08	32.84%

Source: TCPO (1985), A Compendium on Indian Slums

1.4 Water Supply

The main source of water for Delhi is river Yamuna. About 87% of total supply is met by the river and only 13% from ground sources although Delhi's underground strata is not suitable for being tapped on account of unacceptable quality of water. Out of 504 million cu.m./year of ground water resource, the consumption in Union Territory of Delhi is 363 million cu.m./year; thus leaving a balance of 141 million cu.m./year. Out of total supply of 2145 mld, only 282 mld is withdrawn from tubewells and ranney wells. A major share of Yamuna's water is diverted by the States of U.P. and Haryana into their canals at Tajewala. At Wazirabad in Delhi, the river has a flow of only 48.2 cu.m./sec. Between Wazirabad and Okhla, 9.28

cu.m./sec of water is withdrawn and 11.11 cu.m./sec. of wastewater is discharged into the river during its 25 km run through the city.

Table 1.9: Yamuna Flow, Withdrawl and Discharge (March-May)

S.No.	Location	Distance from previous point(km)	River flow (cu.m/sec)	Withdrawl (cu.m/sec)	Discharge (cu.m/sec)	Resultant flow (cu.m/sec)
1.	Tajewala	*200	92.59	44.39	nil	48.2
2.	Wazirabad	250	48.2	8.96	nil	39.24
3.	Najafgarh drain	-	39.24	nil	3.36	42.6
4.	Trans Yamuna drain	-	42.6	nil	0.58	43.18
5.	Sen Nursing Home		43.18	nil	0.31	43.49
6.	Barapula drain	-	43.49	nil	1.45	44.94
7.	Maharani Bagh		44.94	nil	0.26	45.2
8.	Okhla	25	45.2	0.32	5.15	50.03
9.	Hindon Cut	-	50.35	nil	0.1	50.45
10.	Agra Canal	-	69.37	12.68	nil	57.77

* From Yamunotri Glacier to Tajewala

Source : NEERI

Over the years there has been augmentation of water supply in Delhi. Prior to the Master Plan for Delhi (MPD)-62, the total supply of filtered water to the city was 273 mld. During the period 1961-81 about 877 mld of filtered water supply was added. The MPD-62 adopted the norm of 273 litres per capita per day, which was revised in 1981 to 363 litres per capita per day. In 1981, the supply-demand gap was 1104 mld. Rapid growth of population has neutralized all the efforts to augment city's water supply.

Table 1.10: Demand and Supply of Water in Delhi (mld)

1981			1993			2001		
Demand	Supply	Gap	Demand	Supply	Gap	Demand	Supply	Gap
2131	1150	981	2840	2145	695	5121	4189	932

Source : MPD (1981-2001) and DWS & SDU (1993).

Table 1.11: Total and Per Capita Water Supply

Year	Population (in million)	Average Supply (in mld)	Per Capita availability (liters per day)
1971	4.1	785	190
1981	6.2	1150	185
1990	8.8	2160	245
1995*	10.5	2860	272
2001*	12.8	3520	275

* Projected figures

Source: DWS & SDU (1993)

The revised norm of 363 litres per capita per day (80 gallons per capita per day) has been worked out after considering domestic, industrial, commercial, fire protection, garden based and floating population based demands. The minimum domestic water supply should be 135 lpcd (30 gpcd).

At present there are 5 water treatment plants in Delhi supplying 1917 mld of drinking water to citizens of Delhi. By 1997, three more water treatment plants will supply an additional 727 mld and another three treatment plants with additional capacity of 1544 mld would be ready by 2001. Thus, the citizens of Delhi, it is expected, would get 4188 mld of water by 2001 against a demand of 5121 mld.

Table 1.12: Existing Water Treatment Plants

	Treatment Plant	Area (in ha)	Capacity (mld)
1.	Wazirabad	29.54	545
2.	Chandrawal	36.77	409
3.	Haiderpur	25.46	454
4.	Bhagirathi	26.59	454
5.	Okhla	14.96	55
	Total	133.32	1917

Source : DWS & SDU (1993)

Among the long term proposals - 1090 mld from Tehri Dam (U.P.), 1695 mld from Kishau Dam (H.P.) and 1254 mld from Renuka Dam (H.P.) will be made available on the completion of these dams.

Table 1.13: Proposed Water Treatment Plants

	Water Treatment Plants	Capacity (1997) (mld)	Capacity (2001) (mld)
1.	Haiderpur II	454	-
2.	Nangloi	182	-
3.	Bawana	91	-
4.	Bhagirathi II	-	636
5.	Iradat Nagar	-	454
6.	Bakarwala	-	454
		727	1544
	Total Capacity by 2001		4188

Source: DWS & SDU (1993).

Consumption of water for different uses

Out of total water supplied (439083 million litres) in 1991-92, 87.6% was used for domestic, 8.8% for commercial, 3.2% for public and 0.4% for industrial uses.

Table 1.14: Zonewise Consumption of Water for Different Uses (1991-92)

	Zone	Use				
		Domestic (%)	Commercial (%)	Public (%)	Industrial (%)	Total Consumption (in million litres)
1.	Civil Lines	80.0	14.4	4.9	0.7	37199 (100%)
2.	West	95.0	4.2	0.8	-	54962 (100%)
3.	Karol Bagh	86.8	8.3	4.9	-	34204 (100%)
4.	Paharganj	90.0	8.8	0.9	0.3	33503 (100%)
5.	City	72.1	12.5	13.1	2.3	39363 (100%)
6.	South Delhi	91.5	8.0	0.5	-	48000 (100%)
7.	New Delhi	92.8	6.2	0.9	0.1	67853 (100%)
8.	Shahdara	96.5	2.7	0.8	-	57435 (100%)
9.	Rohini	92.3	2.3	4.4	1.0	49582 (100%)
	Delhi	87.2	9.0	3.3	0.4	439083 (100%)

Source: DWS & SDU (1993).

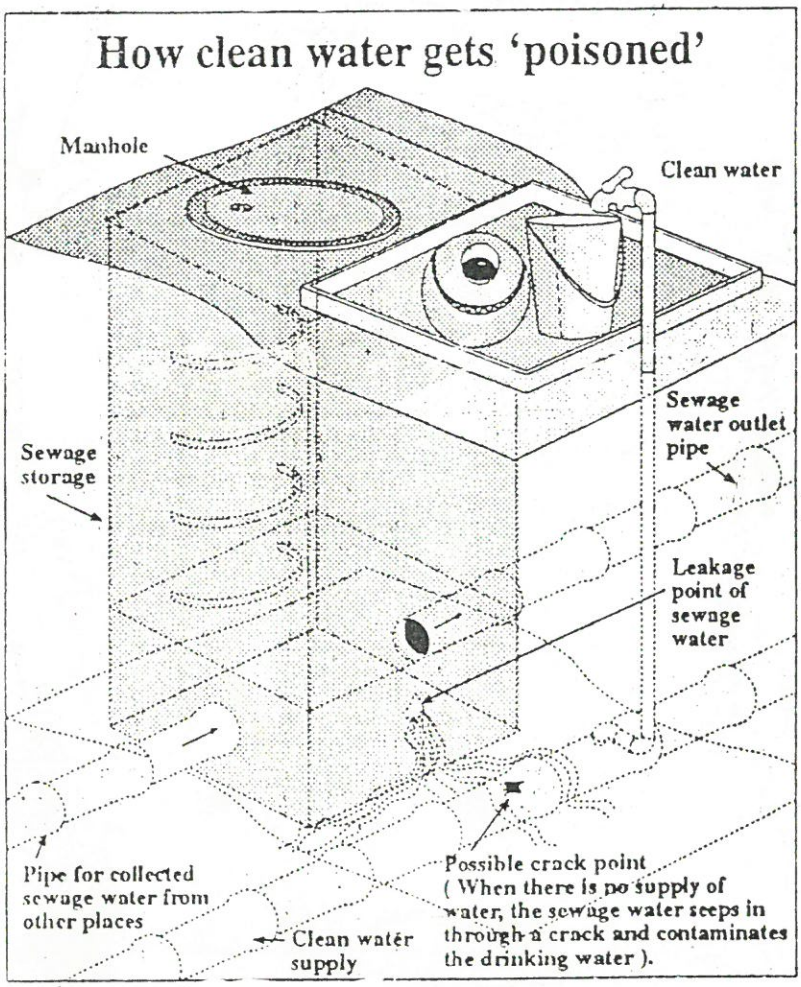


Figure 1.2: Contamination of drinking water.

Source: The Hindustan Times, July 4, 1993.

At present there are 48 underground reservoirs having total capacity of 402.39 million litres and 54 overhead tanks having a total capacity of 82.13 million litres. There are also 123 boosting stations spread all over the Union Territory.

Table 1.15: No. of Water Connections and Length of Water Mains

Year	No. of Water Connections	Length of Water Mains (km)
1985-86	5,11,288	3742
1988-89	7,50,351	6627
1991-92	9,46,374	-

Source : DWS & SDU (1993).

About 74% of total connections were metered, while the rest 26% were unmetered connections in 1991-92.

Water Supply - A Realisitic Picture

Despite there being a supply of 245 lpcd, the supply situation becomes grim every summer. Except the NDMC area of 42.74 sq.km. the rest of the city has problems in getting drinking water. There is a problem of low pressure in the entire city. In most of the localities, the water does not reach beyond the first floor. This has led to installation of booster pumps in a large proportion of the houses. Due to erratic municipal supply many residents have also dug their own borewells to ensure continuous supply of water.

About 15 to 20% of total supply is lost in leakages, taps being left open and use in horticulture. The timings of supply are erratic. People get up as early as 3 a.m. to fill water. Entire East Delhi, North-West and West Delhi all have the same story to tell. In posh localities, the residents routinely requisition water tankers. Those who cannot do so, have to wait for municipal supply.

Besides the quantity, quality of potable water is another serious concern, as it directly affects the health of citizens. At many places, the sewage water gets mixed up with water supply thus contaminating it. Every year there are several cases of cholera, gastro-enteritis and other diseases.

In the walled city area, the pipes are very old and they develop cracks and get corroded. This also increases the possibility of water contamination. The Corporation has recently set aside about Rs.6 crores for replacing pipes in the Walled City and Sadar Paharganj areas.

1.5 Sewerage

The sewerage system started soon after New Delhi was built and a sewage farm was established near Kilokri village where pumped sewage was used for irrigation. Later, the sewage farm was abandoned and a sewage treatment plant of 82 mld capacity was constructed in 1938 at Okhla. By 1956, the capacity of this plant was increased to 164 mld. Later on, sewage treatment plants at Coronation Pillar with a capacity of 91 mld and at Keshopur with a capacity of 54 mld were commissioned in 1957 and 1960 respectively. At present, the total capacity of the sewage treatment plants is 1272 mld, while the total quantity of sewage generated in the city is 1716 mld. Thus the remaining 444 mld of sewage goes into drains untreated.

Table 1.16: Existing Sewage Treatment Plants

	Sewage Treatment Plant	Capacity (mld)	Type of Treatment	Treated Effluent Disposed
1.	Okhla	563	Secondary	Partly on land for irrigation
2.	Keshopur	327	Secondary	- do -
3.	Coronation Pillar	91	Primary/ Secondary	- do -
4.	Rithala	182	Secondary	Supplementary drain
5.	Kondli	45	Secondary	In drain
6.	Vasant Kunj	10	-	In drain
7.	Timarpur	54	-	River Yamuna
	Total	1272		

Source : DWS & SDU (1993).

By 1995, with the increased capacity of existing sewage treatment plants and commissioning of new sewage treatment plants, the total capacity would be increased to 2088 mld. As per the Master Plan of Delhi (1981-2001), sewage treatment facility was available for 536 mld against the required 1804 mld in 1981. In 2001, the total required capacity of STPs would be 4098 mld. There are 17 drains carrying sullage/waste water with outfall in Yamuna river (Table 1.17). Out of these 17 drains, 5 drains cater to city's 95% population. These drains were actually meant for carrying rain water but sullage/sewage is also being discharged into them due to lack of sewerage system in many areas. These drains together have a flow of 589.8 mld including 22.8 mld of industrial wastewater. Two major drains Najafgarh and Barapula together have a flow of 412.5 mld (70% of total flow). The Najafgarh drain carries sullage/sewage discharge from 4 rural and 38 urban villages. All these drains have high BOD and low DO values.

The river water quality also deteriorates in Delhi. From a BOD value of 3.0 mg/l at Wazirabad (North Delhi), it goes as high as 19.8 mg/l at Agra Canal (South Delhi). The DO value also goes down from 7.5 mg/l to 1.1 mg/l between these two points. Such a deteriorated water quality has rendered the river without aquatic life.

Out of city's 44 resettlement colonies, sewer lines have been provided only in 19 colonies. Even among these 19 colonies, sewer lines with outfall into the river existed in only 10 colonies. Laying of sewer lines in the remaining colonies is being done by MCD on priority basis.

Among the 108 urban villages under MCD jurisdiction, sewerage facilities exist only in 69 villages. It is proposed to cover the remaining villages during the Eighth Five Year Plan. The most affected area in terms of drainage is Shahdara, which alone has 251 unauthorised colonies.

Even areas like Mukherjee Nagar, Pitampura and Rohini in the North West which have proper sewerage system, become heavily waterlogged during rainy season. This happens because of uncollected solid waste which enters the sewerage system and clogs the lines, thus resulting in waterlogging. In some localities, even backflow of sewage occurs because of clogged sewer lines, which further worsens the situation.

Table 1.17: Drains in Delhi

S.No.	Drain	Flow (mld)		BOD (mg/l)	DO (mg/l)
		Domestic	Industrial		
1.	Najafgarh Drain	287.50	18.10	367	Nil
2.	Magazine Road Drain	1.00		288	1.6
3.	Sweeper Colony Drain	1.00		325	6.0
4.	Khyber Pass Drain	1.25		330	1.1
5.	Metcalf House Drain	2.00		429	0.6
6.	Kudsia Bagh Drain	7.50		233	3.9
7.	Moat Drain	3.75		312	3.3
8.	Trans Yamuna MCD Drain	50.00	4.30	185	1.0
9.	Mori Gate Drain	4.00		291	2.2
10.	Civil Mill Drain	13.00		304	Nil
11.	Power House Drain	8.00		302	0.8
12.	Sen Nursing Home Drain	14.00		330	2.4
13.	Drain No.14	3.00		342	5.1
14.	Barapula Drain	125.00		331	Nil
15.	Maharani Bagh Drain	11.00		353	Nil
16.	Kalkaji Drain	9.00	0.40	246	0.7
17.	Tuglakabad Drain	26.00		331	0.7
	Total	567.00	22.80		

Total flow (domestic + industrial) = 589.80 mld

Source : CPCB

There are 600 unauthorized/non-regularised colonies and about 800 jhuggi clusters, which, as per the official policy will not be provided sewerage facilities. Even the areas qualifying under the official policy as regularised are still to be covered in this regard. For instance, out of 553 unauthorized/regularised colonies, sewerage facility has been made available only in 250 and the work in some more is going on. All these colonies are to be covered by the end of the Eight Five Year Plan up to 1997 and an amount of Rs.50 crore has already been earmarked for this purpose.

1.6 Solid Waste

The amount of solid waste generated in Delhi is 4000 tonnes/day, giving an average of 400 grams per capita per day. The solid waste collected from various parts of the city is dumped in the land-fill sites at Ghazipur, Bhalaswa, Tughlakabad, Hasthal and Mandawli. Out of these, Ghazipur landfill site is the largest one - spread over an area of 99 acres. It has been in use since 1984 and has a future life of about a decade. However, the life of Hasthal and Mandawli sites is almost over. Another site at Tughlakabad will be filled in another year.

Ghazipur land-fill site serves the entire East Delhi. Waste from Idgah Slaughter house is also dumped here. North Delhi, central areas, and parts of Rohini are covered by Bhalaswa site. Garbage from the rest of Rohini area and Narela goes to Mandawli, while Hasthal gets waste from Najafgarh and West Delhi areas. Tughlakabad site covers South Delhi and New Delhi areas.

Table 1.18: Existing Land-Fill Sites

	Land-fill site	Capacity (Tonnes/day)	Area (acres)	In use since	Future life (Years)
1.	Ghazipur	1200	99	1984	10
2.	Bhalaswa	1400	-	1992	-
3.	Tughlakabad	1200	7	1992	1
4.	Hasthal	200	64	1986	Almost over
5.	Mandawli	-	15	1991	Almost over

Source:
(i) The Times of India, July 27, 1992
(ii) The Indian Express, August 4, 1992
(iii) The Times of India, April 3, 1993
(iv) MCD (1993)

With the life of Hasthal and Mandawli sites almost over, MCD was not only in imminent danger of having only one solid waste disposal site, but was also likely to incur more expenditure. Transporting waste from all parts of the city to Ghazipur would have been a costly affair for the MCD. After getting two new sites of Bhalaswa and Tughlakabad, the problem of paucity of waste disposal sites is no longer there.

The Master Plan-2001 had ear-marked seven sites for disposal of solid waste, out of these five sites -- Rohini (58.5 acres), Timarpur (40 acres), Jahangirpuri (12 acres), Near Sarai Kale Khan (20 acres) and Gopalpur village (20 acres) are not available for disposal. Procuring landfill sites is a problem since the owners of the land of proposed sites rarely want to hand it over for dumping. Again officials of DDA and MCD have identified new sanitary landfill sites.

Table 1.19: New Sanitary Land-fill Sites

Land-fill site	Area (acres)	Future Life (Years)
Near Jaitpur Village	42	13
Near Mandi Village	282	72
Bhatti Mines	-	100

Source: The Times of India, July 27, 1992.

The important point, however, is whether these sites would be made available to MCD by DDA. Though the MCD seems to be collecting solid waste from all parts of the city under its jurisdiction, there are areas which are not cleaned on a regular basis. In a clean up drive last year (1992) for two weeks, MCD cleared 36,000 tonnes of garbage.

Compost Plant

A compost plant, with financial aid from WHO through Union Ministry of Agriculture, was set up in 1981 at a cost of Rs 94.5 lakhs. It was using 90-100 tonnes of garbage every day. The compost manufactured at the plant was being supplied to the horticulture department, nurseries and kitchen gardens. When the plant started, the MCD spent Rs. 6 lakhs every year to run it, after a decade the cost increased to nearly Rs.35 lakhs per year. In the beginning losses had been estimated at around Rs. 15 lakhs per year but they mounted over the years. Therefore it was closed in early 1992.

Hospital Waste

Delhi has 43 general and 27 special hospitals beside a number of clinics, polyclinics, dispensaries and private nursing homes. The hospital waste requires very safe disposal either by incineration or deep burial as it is likely to spread dangerous diseases.

Some of the city hospitals do have incinerators, but they are either not properly utilised by the staff or remain out of order for extended periods. The Health Ministry's guidelines suggest that the landfill sites used for dumping solid waste should be fenced off and scavenging strictly prohibited. Usually, the waste is dumped in the open near the hospitals thus inviting scavengers, flies and stray dogs. Hospital waste contains disposable needles and syringes which are sold by scavengers to people who recycle them and these are again sold as new in the market. The waste is thoroughly overturned by ragpickers -- often with bare hands and feet -- to get something which could be sold. During rainy season, the waste starts stinking.

Safdarjung hospital has an incinerator but the concerned staff, perhaps not aware of the dangers of hospital waste, throw it in the open garbage dump ouside the hospital. It is important to note that these hospitals on the one hand cure patients, and on the other, become a source of several diseases because of such open dumping.

Behavioural Aspects

Despite not being able to collect the garbage generated from the various parts of the city and looking after its safe disposal by the authorities, there has also been very little cooperation by the citizens of Delhi. In MCD area, there are 1,624 open dustbins and 333 covered ones. The residents frequently toss their trash on streets and pavements to avoid going all the way to the dustbin. So, the MCD has to hire sweepers to cart the trash to dustbins. In congested areas, the residents show resistance when a dustbin is put near their home. As there is no choice because of the high population density and less open space, such residential areas are left without dustbins and with garbage.

1.7 Transport

There has been a phenomenal increase in the number of motor vehicles in Delhi. As of today, there are more than 20 lakh motor vehicles in Delhi. The most popular mode of personal transport, two wheelers, alone accounts for about 14 lakh vehicles. Cars and Jeeps are other personal vehicles numbering about 4.5 lakhs. Among the public transport vehicles, there are about 20,000 buses, 70,000 autorickshaws and 10,500 taxis. There are about 1.10 lakh goods transport vehicles like trucks and vans.

The transportation network is predominantly road-based, the ring railway's role in meeting the demand is insignificant. Major portion of travel needs of the commuters are met by the DTC, which alone carries about 55 lakh passengers daily.

Table 1.20: Registered Motor Vehicles in Delhi

	Type of Vehicles	1971	1985	1988	1993 (Approx)
1.	Cars and Jeeps	61521	174890	279708	450000
2.	Motor Cycles and Scooters	109112	637267	978698	1400000
3.	Auto Rickshaws	10812	31354	51700	70000
4.	Taxis	4105	8654	9094	10500
5.	Buses	3266	13815	16319	20000
6.	Goods Vehicles etc.	15262	58925	80412	110000
	Total	204078	924905	1415931	2060500

Source : Delhi Statistical HandBook (1989), Bureau of Economics and Statistics, Delhi.

Needless to say that due to insufficient services of the public transport, the number of private vehicles is increasing rapidly. This has increased the congestion on roads.

Table 1.21: Delhi Transport Corporation (DTC)

	Description	1970-71	1985-86	1988-89
1.	Total Buses in the fleet	1288	4033	4248
2.	Buses on Road (Daily Average)	870	3452	3744
3.	Passengers (in lakh) Daily Average	7.36	31.82	42.79
4.	Kilometers Operated Daily Average (in lakh)	1.45	7.53	8.27

Source : Delhi Statistical Handbook (1989), Bureau of Economics and Statistics, Delhi.

The roads carry a traffic volume of 6000 Passenger Car Units (PCUs) per hour and this goes up to as much as 12,000 PCUs per hour during peak hours in certain areas. The ITO bridge, constructed in 1964-65, was designed to carry 40,000-45,000 PCUs, but it now carries about 1,00,000 PCUs. It has been estimated that if vehicles continue to grow at the present rate in Delhi, buses and personal vehicles together will exceed the capacity of road network and cause breakdown of the system, endless delays and loss of energy in the coming years.

Table 1.22: Roads in Delhi

(in km.)

Agency	1970-71	1985-86	1988-89
Local Bodies			
MCD	6874	15418	17812
NDMC	796	1244	1272
Delhi Cantt. Board	124	143	-
Public Works Department			
National Highways	219	372	-
Other Roads	218	873	-
Total	8231	18050	19084

Source: Delhi Statistical Hand Book (1989), Bureau of Economics and Statistics, Delhi.

Of all the UTs and States in India, Delhi has the top place with 1284.0 km of road length per 100 sq.km. of area followed by Chandigarh with 1260.5 km per 100 sq.km.

To provide a better public transport service, more number of private buses were started in 1993 in a phased manner. This includes Redline and Whiteline buses in addition to the existing fleet of about 4200 DTC buses.

Table 1.23: Public Transport in Delhi (Jan, 1993)

	Public Transport	Nos.
1.	DTC (1000 obsolete buses to be phased out from a total of 4,200)	3,200
2.	Redline Service (1,500 private buses under STA and DTC operation to merge with 3,000 Redline buses)	4,500
3.	Whiteline Express	200
4.	A.C. Blueline Express	No. not Specified
5.	Motorcycle Taxi Service	500
6.	Autorickshaw (existing)	68,000 (Approx.)
7.	Taxis (existing)	10,600 (Approx.)

Source: The Hindustan Times, Jan 25, 1993.

The idea behind introduction of new buses was to provide the commuters with better service, reduce waiting time and an option to shift to public transport from private transport. Immediately after the introduction of these new buses, the average waiting time was reduced from 30 minutes to 12 minutes.

The increasing number of pedestrians, vehicles and encroachments on roads as well as heterogenity of traffic, together are causing congestion on most of the roads. Delhi is a city with about 48 categories of road users -- including camels, elephants, stray cattle, bullock-carts, rickshaws, hand-carts in addition to other slow and fast moving vehicles.

Table 1.24: Man/Animal Driven Vehicles in Delhi

Vehicle (in MCD area)	1981-82	1984-85	1988-89
Rickshaw	3300	1373	4179
Tonga	1791	1354	1089
Rehra	484	346	353
Hand Carts	6233	6517	4993
Bullock Carts	695	775	714
Cycle Rickshaw Trolley	5893	6305	5676

Source: Delhi Statistical Handbook (1989), Bureau of Economics and Statistics, Delhi.

Impact of Increase in Motor Vehicles

Besides generating air and noise pollution, there has been an increase in road accidents in Delhi due to increase in automobiles. In Delhi, 1651 fatal accidents occured in 1991 against 1,460 and 1,559 in 1989 and 1990 respectively. About 20 lakh vehicles plying on 20,000 km long roads in Delhi claim 4% of the total fatalities that occur in the country. The capital's 50 km long freeway, Ring Road, has several accident prone zones and bottlenecks. Every year after monsoon, a number of roads are affected.

Table 1.25: Road Accidents in Major Cities (1991)

City	Population (lakhs)	Motor Vehicles (lakhs)	Total Accidents	Persons Killed	Rate of* Accident	Rate of* Fatalities
Delhi	93.7	19.92	8065	1778	86.07	18.87
Bombay	105.0	6.28	25477	365	242.63	3.47
Calcutta	107.0	4.72	10017	441	93.61	4.12
Madras	38.9	6.25	5242	428	134.75	11.00

* Per one lakh population

Source: The Hindustan Times, Sep 21, 1992

To meet the complex and ever growing transportation requirements of the Capital, an integrated Mass Rapid Transit System (MRTS) is suggested by the experts. According to a study conducted by the Rail India Technical and Economic Service (RITES), the proposed multimodal MRTS scheme comprises of components of existing rail corridors, a metro corridor and a corridor for a high capacity bus system.

The proposed 144 km surface rail corridor would comprise of the existing underutilized Ring Railway and seven spurs connecting the regional towns of Ghaziabad, Faridabad, Gurgaon, Ballabhgarh, Sonepat and Loni. The underground metro rail system would cover 41 km and consist of two corridors - the East-West (24 km) and the North-South Corridor (17 km). The high capacity bus system for the MRTS would cover a distance of 12 km (from Patel Nagar to Papankala).

1.8 Green Spaces

Due to rampant encroachment on the ridge, the big green lung of Delhi, hundreds of acres of vegetation has disappeared. On the survival of the ridge depends the survival of 9 million Delhi residents. Its forests help purify the air, reduce temperature and noise and block duststorms coming from the Thar. The ridge is divided into three zones in the Capital -- Northern Ridge (87 hectares), Central Ridge (864 hectares) South Central Ridge (626 hectare) and Southern Ridge (6200 hectares).

The Ridge has been extensively damaged by encroachers. The slow and steady damage began in 1962, when the Home Ministry set up a wireless station on an 18.8 acre plot. Soon Rabindra Rangshala came up on another 36 acres. Over the years, four schools, a polo pavilion, a Hanuman temple, ISRO's Earth Station, the Hindu Rao Hospital, slum colonies and petrol pumps have occupied a large chunk of the Ridge land. Quarrying and construction have mostly destroyed the vegetation in southern zone which includes Mehrauli. Another reason for the present state of the Ridge is the multiplicity of governmental organisations dealing with it -- CPWD, DDA, MCD, NDMC, L&DO and the Urban Development Ministry. The ridge was declared as reserved forest by the architect of New Delhi, Sir Edwin Lutyens. Delhi's first Master Plan (1961-81) also granted it status of a forest.

In the recent years, there have been efforts by the government and NGOs to make the city green. 'Greenline' an NGO, has since it inception in 1991, planted almost 30,000 trees on 100 km road stretches, 20 roundabouts and in several schools, colonies and slums. The Ministry of Environment and Forests has launched a country-wide scheme for setting up 'Smriti Vans' in which individuals will plant trees in memory of their near and dear ones.

1.9 Air Pollution

Thermal Power Stations

There are two thermal power stations right in the centre of the city - Rajghat Thermal Power Station (RTPS) and Indraprastha Thermal Power Station (ITPS). The third one is at the southern end of the Union Territory -- Badarpur Thermal Power Station (BTPS). The RTPS and ITPS together produce 300 MW of power and emit 3.8 tonnes of pollutants every hour. These two thermal power stations have often made headlines for the plumes of smoke that they release into the atmosphere. The Delhi Pollution Control Committee (DPCC) has been trying to force the Delhi Electrical Supply Undertaking (DESU), which operates these power plants, to control the emissions. In October 1992, the RTPS was asked to reduce the emission of suspended particulate matter from a level of 2000 mg/cu.m. to 150 mg/cu.m. Both these power stations together release 2722 tonnes of pollutants every month into the air.

Table 1.26: Emissions from Thermal Power Stations in Delhi

Thermal Power Station	Capacity (MW)	Coal Consumption (tonnes/ month)	Pollutant Emissions (tonnes/month)					Total Pollutant Emissions (tonnes/hour)
			TSP*	SO2	CO	HC**	NOx	
Indraprastha and Rajghat	300	108943	62	1218	160	80	1202	3.8
Badarpur	720	262279	102	1993	262	141	1915	6.1

* TSP-Total Suspended Particulates
** HC- Hydro-Carbons

Source: TERI (1992)

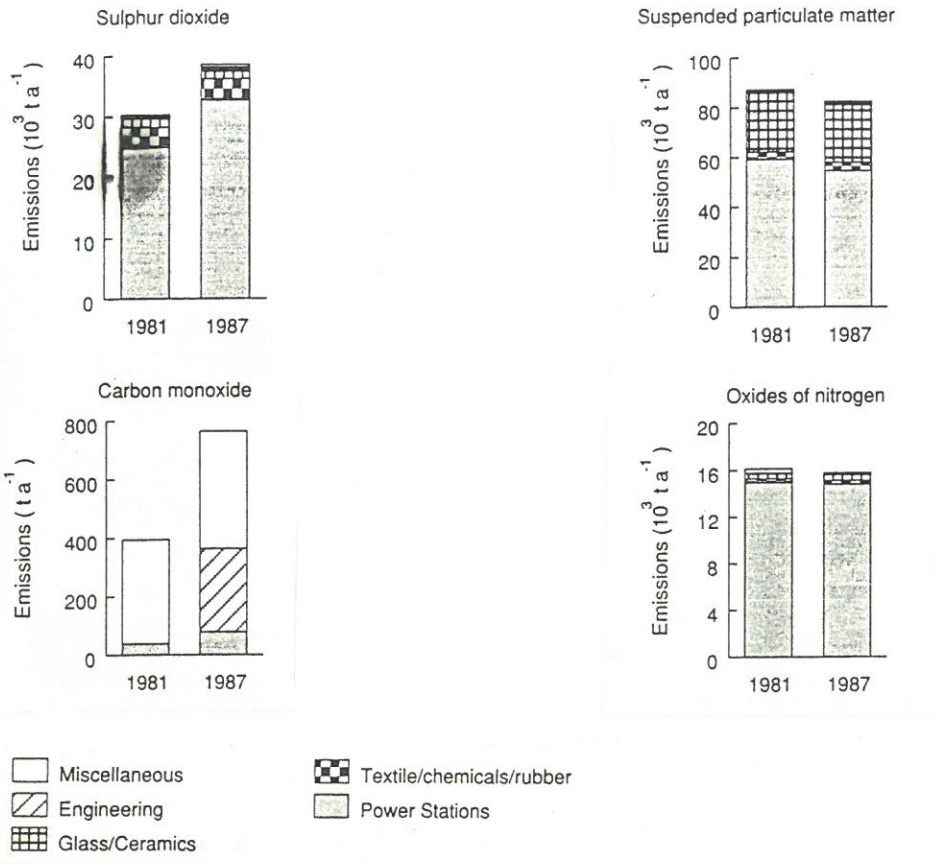


Figure 1.3: Estimated industrial pollutant emissions by source.

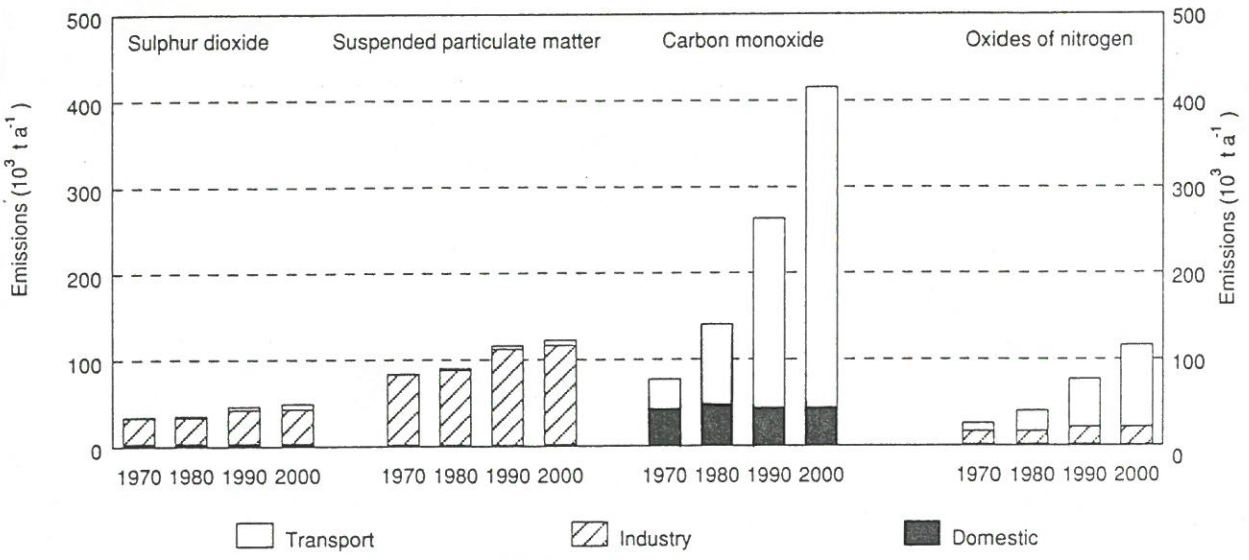


Figure 1.4: Estimated and projected anthropogemic emissions by source.

Source: NEERI (1991).

The Bharat Heavy Electricals Limited (BHEL) is carrying out necessary rectifications in RTPS at the cost of Rs.3 crores. Renovation-cum-modernisation of ITPS is being done by DESU at the cost of Rs.18 crores.

Another major problem related with these power plants is disposal of fly-ash. About 25,000 tonnes of fly-ash is produced by the thermal power stations in Delhi. Now DESU is giving the fly-ash free of cost to anyone who wants to produce bricks out of it. DESU has also made land available to DDA for allotment to enterpreneurs who want to set-up flash brick making units. Since this land is 15 kms. away, it is not economical for enterpreneurs to transport fly-ash for such use.

Vehicular Pollution

Though in quantitative terms, the pollutants released from vehicles are less than those released by thermal power stations, an alarming fact about vehicle exhaust is that the pollutants remain closer to the ground and as such, tend to be more lethal than those of the thermal power stations in Delhi. The pollutants released by different vehicles are estimated to be about 900 tonnes/day. In 1992, 91 out of 3842 DTC buses were found emitting smoke more than the prescribed limit (65 Hartridge Smoke Units).

A number of traffic policemen, street vendors, drivers and pedestrians are affected by the vehicle exhaust. To combat the pollution menace, some manufacturers have started selling pollution masks. The Delhi Traffic Police has provided these pollution masks to traffic policemen at congested intersections.

As a measure to reduce pollution menace, battery buses were introduced in 1984 with a fleet of just 10 buses. These buses run on 9 routes covering Connaught Place, ISBT, Red Fort, CGO Complex and parts of East Delhi. The battery buses are pollution-free and noiseless and their maintenance cost is also low. In 1992, only 40 such buses were on the road out of a fleet of 112 buses.

There are a number of petrol stations in the city checking the emission level of vehicles. Despite there being efforts to control and reduce the pollution menace, the fact remains that the number of vehicles in Delhi is still continuing to increase and as a result, the vehicular pollution is also increasing everyday.

Air Quality Situation

Sulphur Dioxide (SO_2)

Annual Emissions

The industrial sources, thermal power stations in particular, are responsible for majority of SO2 emissions in Delhi. It is estimated that the power stations in Delhi produce around 25,550 tonnes of SO2 per annum. Total anthropogenic SO2 emissions are estimated approximately at 45,000 tonnes per annum in 1990 with a projected increase to 49,000 tonnes per annum by 2000.

With the growth in the number of vehicles, SO2 emissions from transport sector have increased and will continue to increase. The number of diesel driven vehicles (the main vehicular source of SO2) have increased from 16,658 in 1971 to 75,709 in 1987. On an average week day in 1981, 17500 goods vehicles were entering or leaving Delhi. About 1650 goods vehicles were bypassing the city.

Ambient Concentrations

Though the annual mean concentration of SO2 at all the monitoring stations has been well below the standard limit in residential, commercial and industrial area, the concentration in winter months is generally higher than the rest of the months in the year. At Shahadra, the maximum SO2 concentration of 101.8 ug/cu.m was recorded in March , 1990. The annual maximum concentration at all the monitoring stations does not generally exceed 50 ug/cu.m.

Suspended Particulate Matter (SPM)

Annual Emissions

In 1990, total SPM emissions were around 115,700 tonnes per annum as per NEERI estimates. These emissions are estimated to increase to 122,600 tonnes per annum by 2000. Increasing SPM emissions are attributed to industries especially the ceramic (brick) industries which are the major sources of SPM after power stations. Domestic emissions have remained relatively stable due to rapid population growth which counters the reduction achieved by changes in fuel use in other sectors.

Anthropogenic emissions are not the only source of SPM in Delhi. Natural dust storms which blow in premonsoon period increases the concentration of particulate matter considerably in the atmosphere. This natural dust remains in circulation for longer periods. Road transport adds considerably to anthropogenic SPM in Delhi. A survey of over 50 road side sites in 1987 indicated that there is a strong correlation between motor vehicle densities and SPM concentrations. Besides direct motor vehicle emissions, resuspension of natural dust and settled particles is also likely to be an important factor. Spot SPM samples taken at Connaught Place were found to exceed those around the Indraprastha power plant which creates widely recognised smoke and fly-ash problem.

Table 1.27: Prescribed Ambient Air Quality Standard of CPCB (ug/cu.m)

Category	SPM	SO_2	NO_x	CO
Industrial Mixed Use	500	120	120	5000
Residential & Rural	200	80	80	2000
Sensitive	100	30	30	1000

Table 1.28: Annual Mean Concentration of SO_2, NOx and Particulate Matter (1987-90) in ug/cu.m.

Pollutant	Year	Monitoring Station							
		Nizamuddin (I)	Ashok vihar (I)	Shahadara (I)	Nazafgarh Road (I)	Janakpuri (R)	Sirifort (R)	Netaji Nagar (R)	Town Hall (C)
SO_2	1987	15.5	2.9	16.6	-	10.1	6.2	-	-
	1988	10.4	4.7	17.5	-	15.9	2.3	-	-
	1989	13.0	5.0	13.5	-	6.2	4.8	-	-
	1990	7.4	6.6	25.3	32.5	6.5	8.7	15.3	30.6
NO_X	1987	23.6	17.0	14.6	-	16.6	19.9	-	-
	1988	11.6	26.0	16.8	-	24.4	16.1	-	-
	1989	17.5	23.4	15.5	-	18.3	15.1	-	-
	1990	15.7	25.4	23.2	42.6	25.8	21.1	35.2	51.5
Particulate matter	1987	452	687	515	-	454	410	-	-
	1988	286	310	354	-	232	211	-	-
	1989	331	385	361	-	322	328	-	-
	1990	294	339	314	527	317	317	383	568

I - Industrial
R - Residential
C - Commercial

Source: CPCB (1990 & 1991)

Ambient Concentrations

The annual mean concentration of particulate matter is higher than the prescribed limits in all the residential areas. The industrial areas do not exceed the limits. The summer months (May-June) have concentrations as high as 1500 ug/cu.m. Natural dust storms which blow in the city during summer, causes higher concentrations of particulate matter. Undoubtedly, the particulate matter poses pollution menace for almost throughout the year.

Oxides of Nitrogen (NO_X)

Annual Emissions

Total emissions of NO_X were around 73,000 tonnes per annum in 1990. Industrial emissions accounted for around 15,000 tonnes per annum during 1980s. More than 90% of industrial NO_X emissions are from thermal power stations. With the increase in vehicles, transport NO_X emissions have increased significantly and will continue to increase in future. Diesel driven goods vehicles and buses are important sources of transport NO_X. It is estimated that by the year 2000, diesel driven vehicles will account for 96% of vehicular NO_X emissions.

Table 1.29: Vehicular Emissions in Delhi (1986-87)

Category		No. of registered vehicles	Pollution Load (tonnes/day)				
			PM	SO2	NO_x	CO	HC
A. Petrol Driven							
1.	Cars, Jeeps & Station Wagons	2,11,774	1.49	0.36	14.47	180.95	27.10
2.	Taxis	8,808	0.09	0.02	0.86	10.7	1.61
3.	Two Wheelers	7,70,110	3.02	0.30	1.05	256.76	151.00
4.	Three Wheelers (including goods)	45,151	0.31	0.03	0.11	33.10	15.57
	Total (A)	10,35,843	4.91	0.71	16.49	481.51	195.28
B. Diesel Driven							
1.	Buses						
(a)	Registered in Delhi	14,766	1.4	2.8	38.9	23.5	3.9
(b)	Entering & Leaving	1,500 (approx.)					
2.	Goods Vehicles	64,555	2.27	3.96	59.0	39.9	8.8
	Total (B)	80,821	3.67	6.76	97.9	63.4	12.7
	Grand Total (A+B)	11,16,664	8.58	7.47	114.39	544.91	207.98

Total vehicular pollution load = 883.33 tonnes/day

Source: CPCB (1988), Assessment of Vehicular Pollution in Metropolitan Cities - Part II Delhi.

Ambient Concentrations

The annual mean concentration of NOx is also well below the standards for residential, commercial and industrial areas. Annual mean values do not exceed 25 ug/cu.m., except in the case of Nazafgarh Road and Town Hall where it reached around 50 ug/cu.m. in 1990. Annual maximum values of 81.8 ug/cu.m., 107.5 ug/cu.m and 147.3 ug/cu.m were recorded at Netaji Nagar, Najafgarh Road and Town Hall respectively.

Carbon Monoxide (CO)

The major source of CO emissions is transport. In 1990, total CO emissions were estimated around 265,000 tonnes per annum. These emissions are projected to reach 400,000 tonnes per annum by the year 2000.

A study conducted by the Central Road Research Institute, New Delhi at 20 intersections and involving 120 policemen revealed that traffic policemen at Lothian Bridge and G.T. Road-Shahdara intersections were exposed to 20 times the permissible CO levels.

Lead

Lead is mixed with petrol to reduce knocking in motor vehicles. Its use with petrol makes the fumes toxic. When inhaled it causes colic pain, anaemia, insomnia, mental confusion, delirium and mania.

In Delhi, petrol comes from Mathura refinery, which supplies it with 0.58 gm/lit of lead. The petroleum industry has been asked to reduce it to 0.15 gm/lit.

1.10 Noise Pollution

Having achieved the dubious distinction of being one of the most polluted cities of the world, Delhi is now heading towards increasing noise pollution. The various sources of noise pollution in the city include automobiles, railways, aircraft, machines and sirens in industrial areas, public address systems, social and religious activities etc.

Noise level standards for India have been set by the Central Pollution Control Board. The highest permissible noise levels are for industrial areas, followed by those for commercial, residential and silence zones in that order. In general, the day time noise levels are than those prescribed for the night time.

According to a survey conducted by CPCB at 19 monitoring stations in Delhi, it was found that the noise levels in all residential areas, except Lodi Complex, were higher in the day time than the standards. In the industrial areas the day and night time noise levels were mostly within the prescribed limits. However, the noise levels in commercial areas were significantly higher than the standards both during the day and night time. The most disturbing trend was found in the silence zones where not only the day time noise levels were higher than the standard but even the night time noise levels exceeded the permissible limits.

Noise levels monitored at road intersections hover around 80 dB. Sounds emanating from engines, use of pressure horns, playing stereos at high volume etc. together create unbearable noise levels. Apart from persons travelling by various modes, the traffic policemen and street vendors are exposed to the menace of air and noise pollution for long periods of time.

The noise pollution results in ailments like pain in muscles recurring headaches, fatigue, high blood pressure and also peptic ulcer. Very high noise levels such as 125 dB(A) result in bursting of ear drums.

Table 1.30: Ambient Noise Levels in Delhi (1992)

S.No.	Location		Noise Level (dBA)							
			Day				Night			
			Leq	Min	Max	Std	Leq	Min	Max	Std
Residential						**55**				**45**
1.	Maharanibag	CSIR Complex	73	54	114	-	66	57	102	-
2.	Malviya Nagar	B.1/24	65	46	90	-	65	38	89	-
3.	Lodi Complex	B.I/27	55	45	69	-	48	39	91	-
4.	Palam Colony	Near Baghdora	60	48	78	-	67	33	82	-
5.	Punjabi Bagh	B.I/8/71	69	44	114	-	64	39	97	-
6.	Timarpur	Sect.4	70	45	90	-	60	43	86	-
Commercial						**65**				**55**
7.	Connaught Place	Palika Bazar	80	56	102	-	60	43	78	-
8.	Karol Bagh	Ajmal K. Market	71	50	112	-	64	53	103	-
9.	Nehru Place	CCI Building	66	54	79	-	59	41	92	-
10.	Chandni Chowk	Town Hall	75	63	91	-	63	50	75	-
11.	Shahdara	Subzi Mandi	68	58	85	-	69	48	102	-
Industrial						**75**				**70**
12.	Jilmil	Sahani Rubber Industry	70	58	84	-	65	44	101	-
13.	Okhla Ind.Est.	Phase-III,F/91	74	59	94	-	70	49	98	-
14.	Wazirpur Ind.Est.	Near A-93	75	64	94	-	72	67	83	-
15.	Anand Parvat	Near Mahajan Steel Co.	70	64	78	-	66	67	103	-
Silence Zone						**50**				**40**
16.	AIIMS	Near Casualty Campus	67	54	87	-	61	54	77	-
17.	Jai Prakash Narayan Hospital	Near Emergency Campus	59	44	73	-	71	49	98	-
18.	Kalavati Saran Hospital	Near Casualty Campus	70	52	83	-	62	47	103	-
19.	Guru Teg Bahadur Hospital	Emergency Campus	64	53	82	-	60	44	102	-

Std = Ambient Noise Standards - CPCB, 1989.

Source: CPCB (1991), Noise Level in Metropolitan Cities, Part I - Delhi.

Table 1.31: Noise Levels at Various Traffic Intersections in Delhi

dB(A)

S.No.	Locations	Leq.	Min.	Max.
1.	Crossing of Outer Ring Road and Kalkaji Road	76	66	82
2.	Crossing of Outer Ring Road with Shastri Marg	79	60	88
3.	Crossing of Outer Ring Road with Shivaji Marg at Mahavir Nagar	76	60	88
4.	Crossing of Outer Ring Road (NH 10) at Traffic Booth	82	70	88
5.	Crossing of Outer Ring Road at Pritampura	76	60	88
6.	Crossing of Outer Ring Road and Ambala Road	80	72	88
7.	Crossing of Outer Ring Road and NH 1 at Traffic Booth	81	66	82
8.	Crossing of Outer Ring Road and Wazirabad Road	74	70	80
9.	Crossing of Ring Road in front of ISBT	75	70	88
10.	ITO Crossing Near Science Academy	82	68	95
11.	Crossing of Ring Road and Hapur Road	79	70	82
12.	Crossing of Inner Ring Road and Rohtak Road at Traffic Booth	81	72	86
13.	Near the India Gate	77	66	80
14.	Minto Bridge Crossing Near Thomson Road	80	72	93
15.	Anand Vihar near Police Check Post	83	64	88
16.	Crossing of NH 24 and NOIDA Link Road	77	64	82
17.	Crossing of Nasar Marg and Khel Marg	76	62	80
18.	Crossing of Shankar Road and Pusa Road	81	73	93
19.	Dariyaganj to Red Fort Road at the Overbridge	83	66	90
20.	Near Lothian Bridge	79	68	89
21.	Kingsway Camp Crossing	74	69	87
22.	Azad Market Crossing	81	60	105
23.	AIIMS Crossing	80	65	94
24.	Mulchand Crossing of MG Road and Hospital Road	80	66	117
25.	Shahdra Crossing near Subji Mandi	69	58	84

Source: CPCB (1991), Noise Level in Metropolitan Cities, Part I - Delhi.

Summing Up

Not too long ago Delhi used to be a city with wide clean roads, old monuments, lot of green areas and good health facilities, public amenities and infrastructural facilities. However, with increase in population in the last few decades the quality of life in the city has deteriorated considerably. Delhi has now become synonymous with congestion, air pollution, noise pollution, water scarcity etc.

The infrastructural services in the city are in a sorry state. The water supply situation shows a widening gap between demand and supply. About one-fourth of the waste water generated goes into drains untreated. Pollutants in water have reached such levels that acquatic life has nearly ceased to exist. Uncollected solid waste and hazardous waste pose serious threat to the health of the citizens.

Delhi is now dotted by slums throughout its length and breadth. About a third of its population lives in slums. Housing shortages in the city continue to increase with demand outstripping supply.

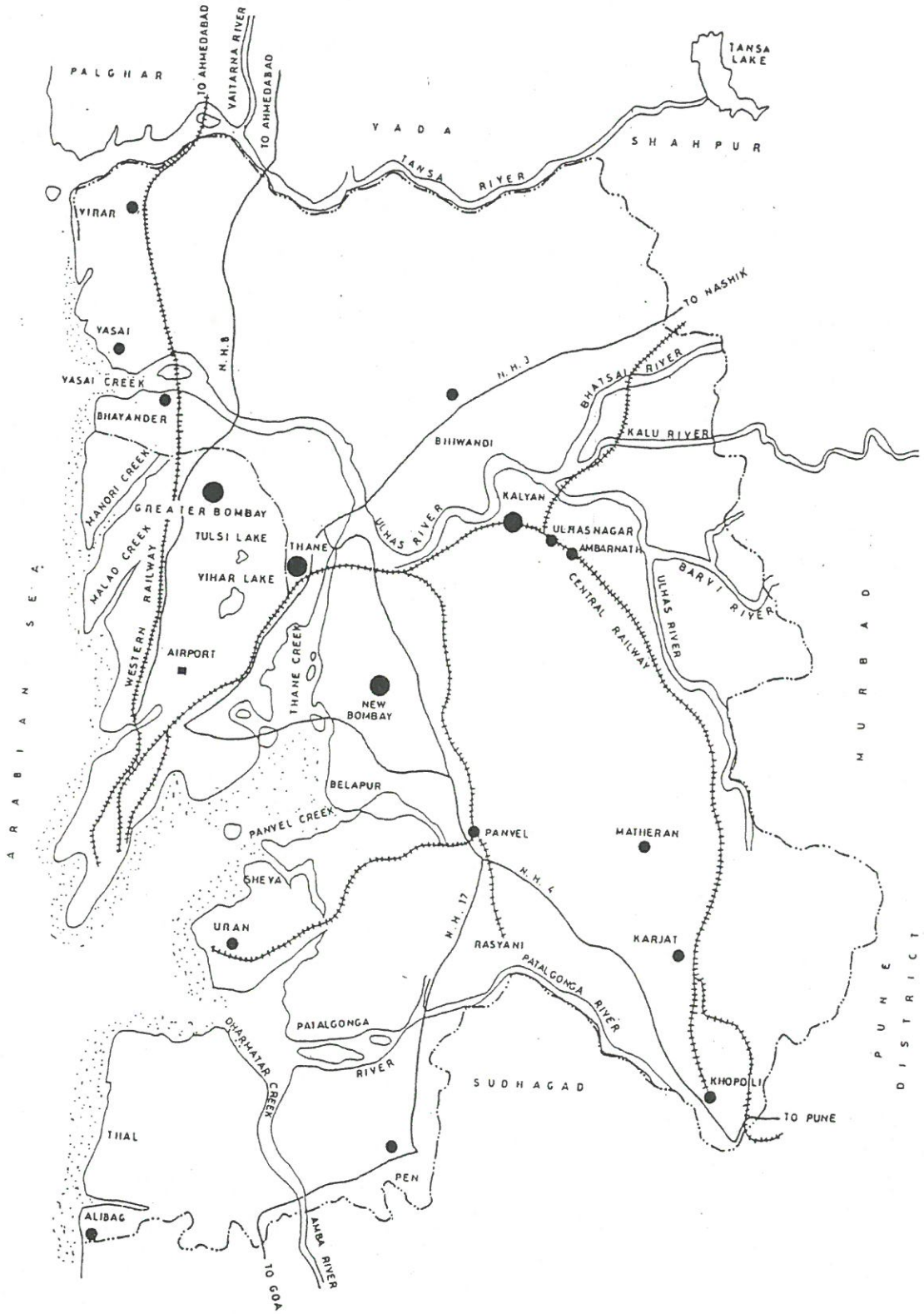
Vehicular traffic in the city has increased manifold in the last few decades. With increase in the traffic on roads, the number of road accidents have also gone up making it the highest amongst the four largest metropolitan cities. More motor vehicles on roads have also resulted in deterioration in air quality due to greater emissions. The air quality in Delhi is rated amongst the worst in the world. Noise levels have also increased over the years with decibel levels reaching one-and-a-half to two times the prescribed limits in certain areas.

Delhi no longer has the numerous green and open spaces it used to have. Increasing population and concomitant growth in demand for housing and infrastructure have greatly reduced the open spaces in the city. The slow destruction of the Ridge in Delhi is a clear example.

BOMBAY

BOMBAY

Bombay Metropolitan Region



LEGEND

- BOMBAY METROPOLITAN BOUNDARY
- NATIONAL HIGHWAY
- RAILWAYS
- GREATER BOMBAY BOUNDARY
- MUNICIPAL CORPORATION
- MUNICIPAL COUNCIL
- RIVERS

Scale

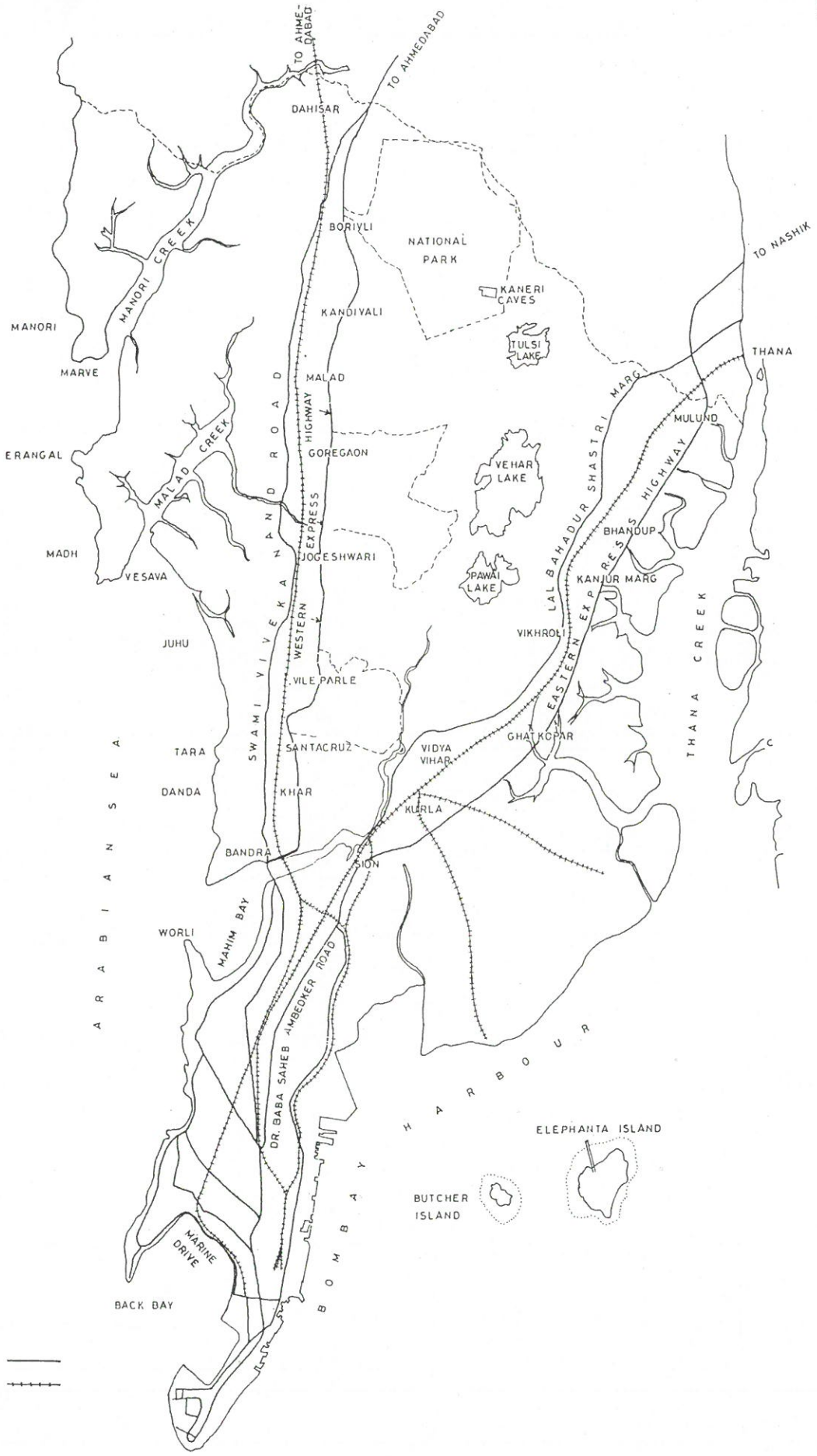
3.0 1.5 0 3 6 9 12 15 km

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

BOMBAY



LEGEND

ROADS

RAILWAYS

Scale

1 .5 0 1 2 3 4 5 Kms.

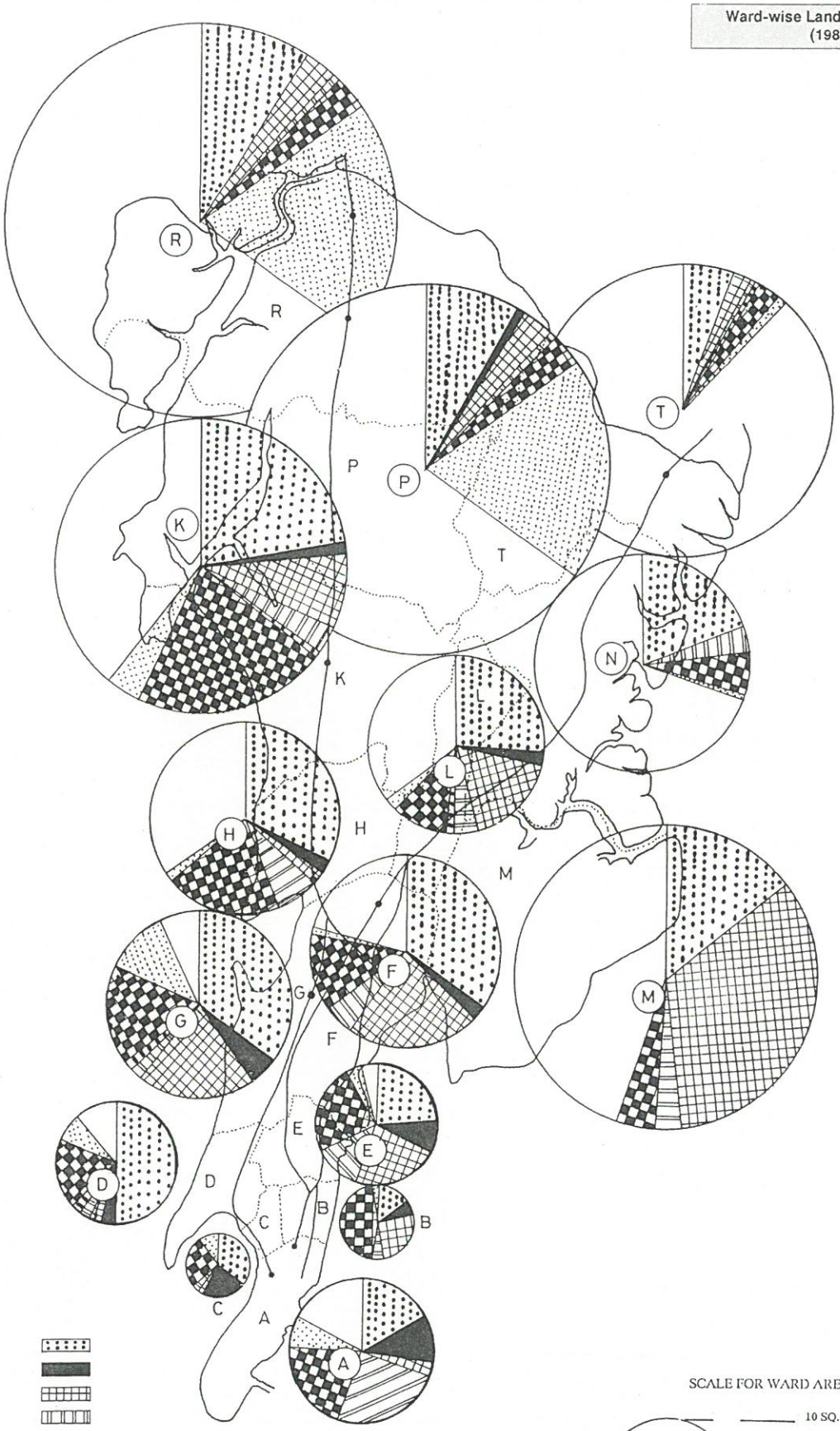
N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

BOMBAY

Ward-wise Land use Analysis (1981)



LEGEND

- RESIDENTIAL
- COMMERCIAL
- INDUSTRIAL
- PUBLIC & SEMI PUBLIC
- PUBLIC UTILITIES
- TRANSPORT & COMMUNICATION
- RECREATIONAL
- AGRICULTURE, VACANT, BARREN, MARSHY, HILLY OR WATER BODIES

SCALE FOR WARD AREA

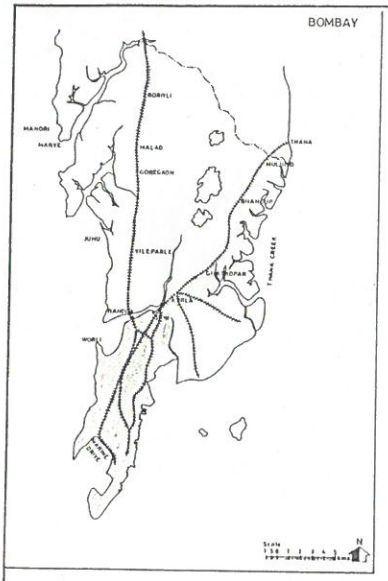
10 SQ. KM
5 SQ. KM
1 SQ. KM

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Report on the Draft Development Plan (Revised) 1981-2001 for Greater Bombay.



BOMBAY

Net Density of Population (1981) in Bombay City

LEGEND

PERSONS/HECTARE

- 0 TO 500
- 501 TO 1000
- 1001 TO 2500
- 2501 TO 5000
- 5001 TO 7500
- 7501 TO 10,000
- 10,000 & ABOVE

Scale

1·0 0·5 0 1 2 Km.

N

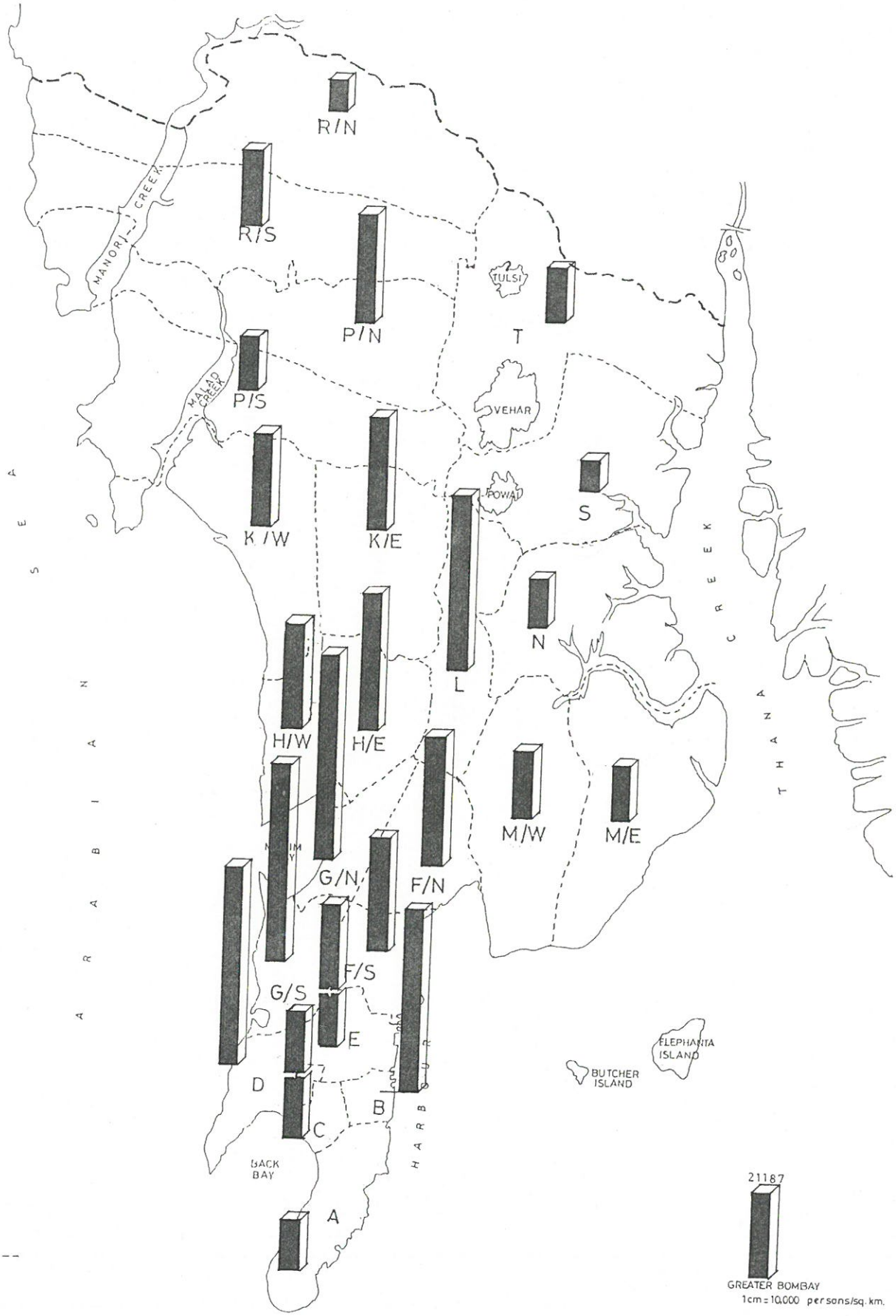
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Report on the Draft Development Plan (Revised) 1981-2001 for Greater Bombay.

BOMBAY

Wardwise Population Density - 1991



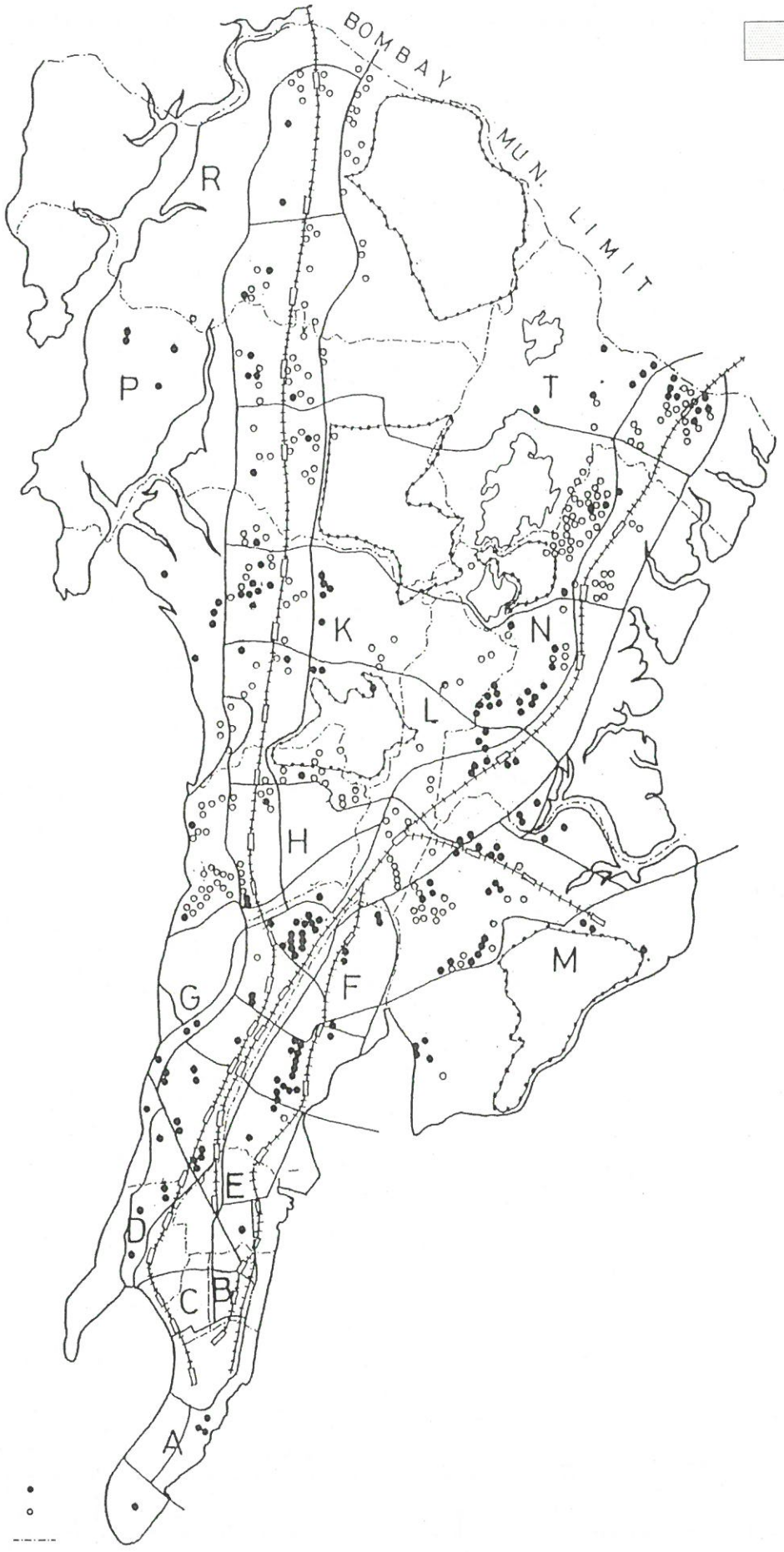
Urban Environmental Maps

Source. Based on data provided by MCGB (1993).

National Institute of Urban Affairs, New Delhi.

BOMBAY

Location of Slums



LEGEND

AMENITIES PROVIDED ●

AMENITIES NOT PROVIDED ○

WARD BOUNDARY -·-·-·-

Scale

1.0 0.5 0 1 2 3 4 5 Km

N

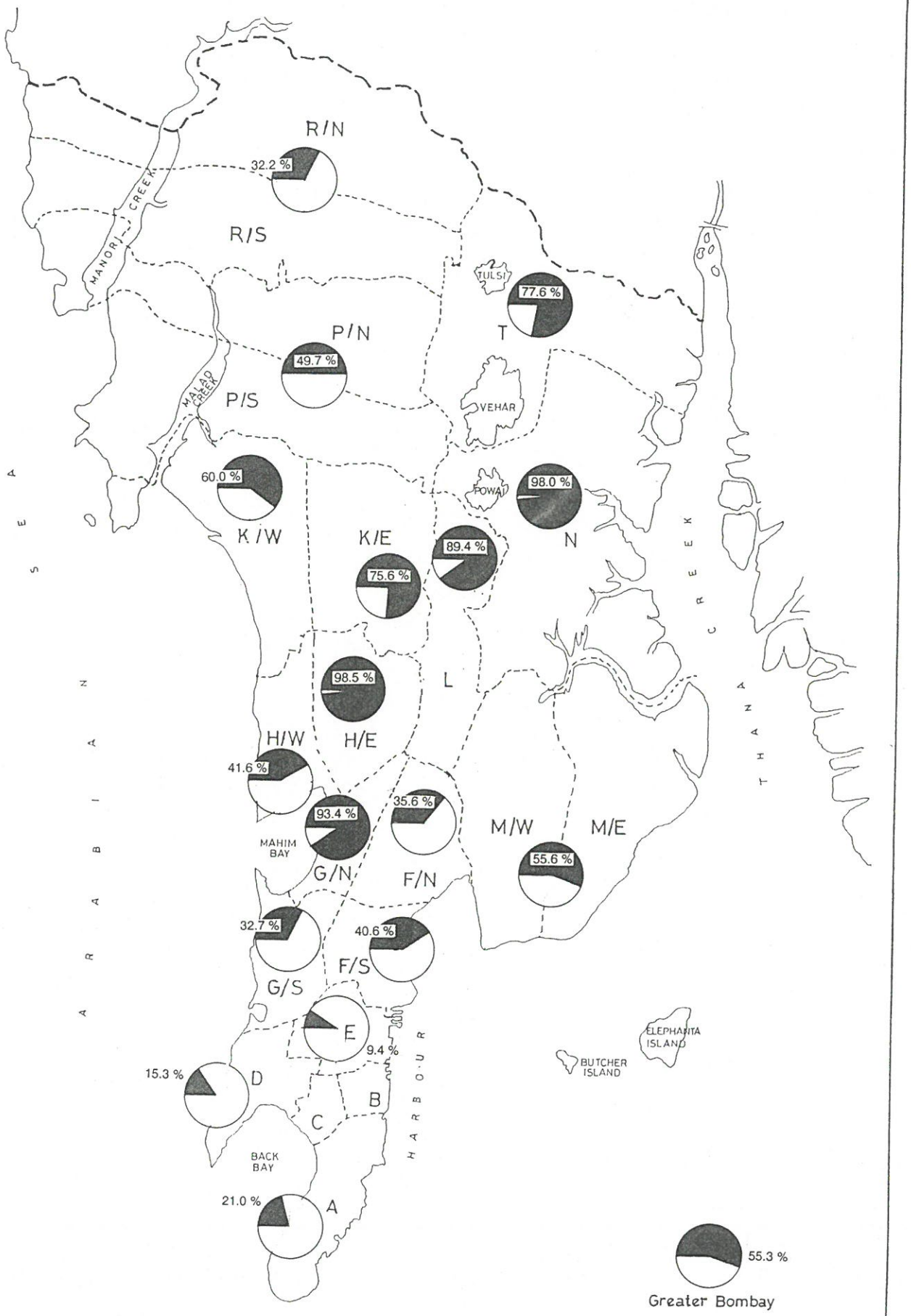
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Report on the Draft Development Plan (Revised) 1981-2001 for Greater Bombay.

BOMBAY

Wardwise Slum Population (1991)



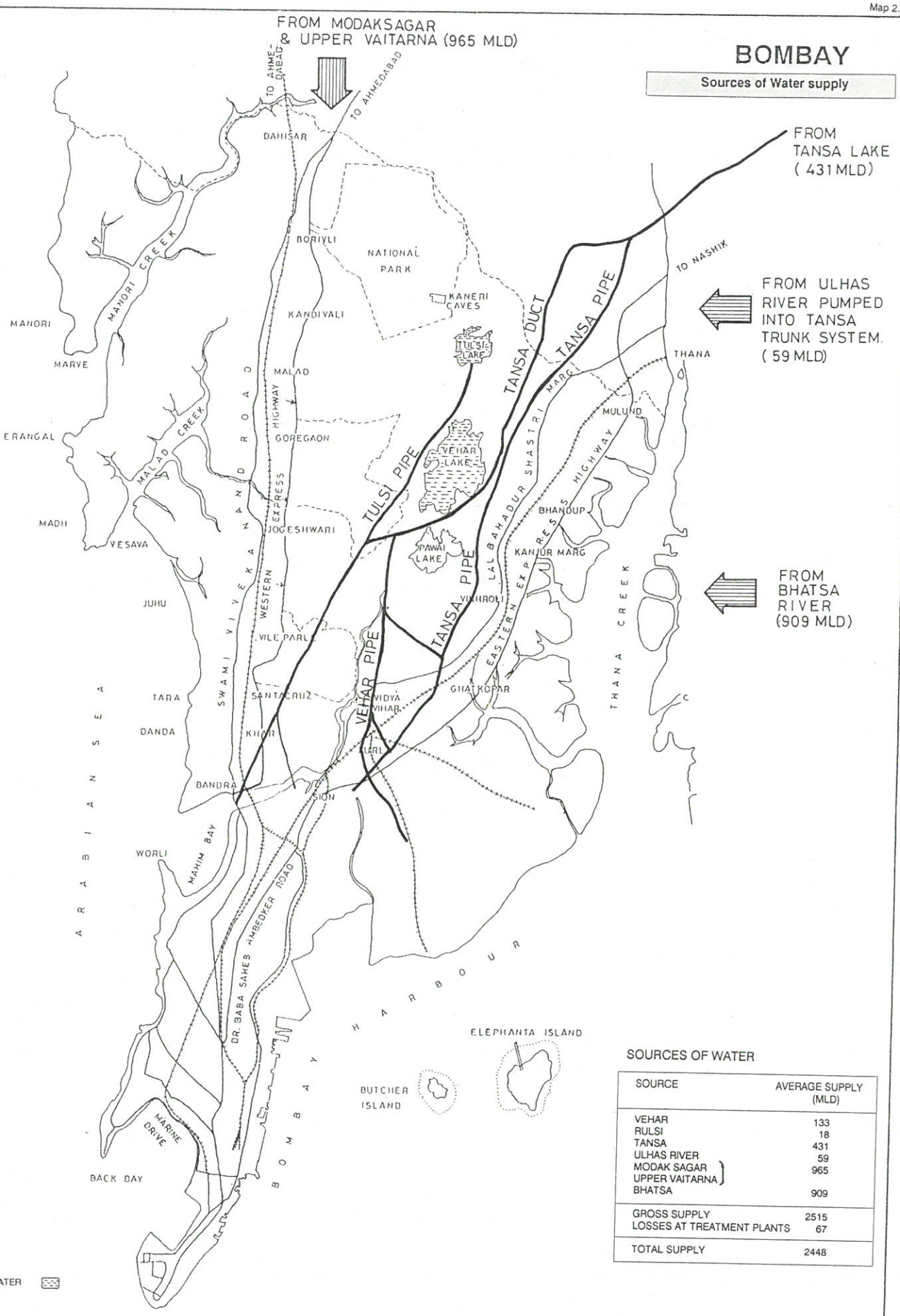
Urban Environmental Maps

Source: MCGB (1993).

National Institute of Urban Affairs, New Delhi.

BOMBAY

Sources of Water supply



SOURCES OF WATER

SOURCE	AVERAGE SUPPLY (MLD)
VEHAR	133
RULSI	18
TANSA	431
ULHAS RIVER	59
MODAK SAGAR, UPPER VAITARNA	965
BHATSA	909
GROSS SUPPLY	2515
LOSSES AT TREATMENT PLANTS	67
TOTAL SUPPLY	2448

LEGEND

SOURCES OF WATER

Scale 1 .5 0 1 2 3 4 5 Kms.

N

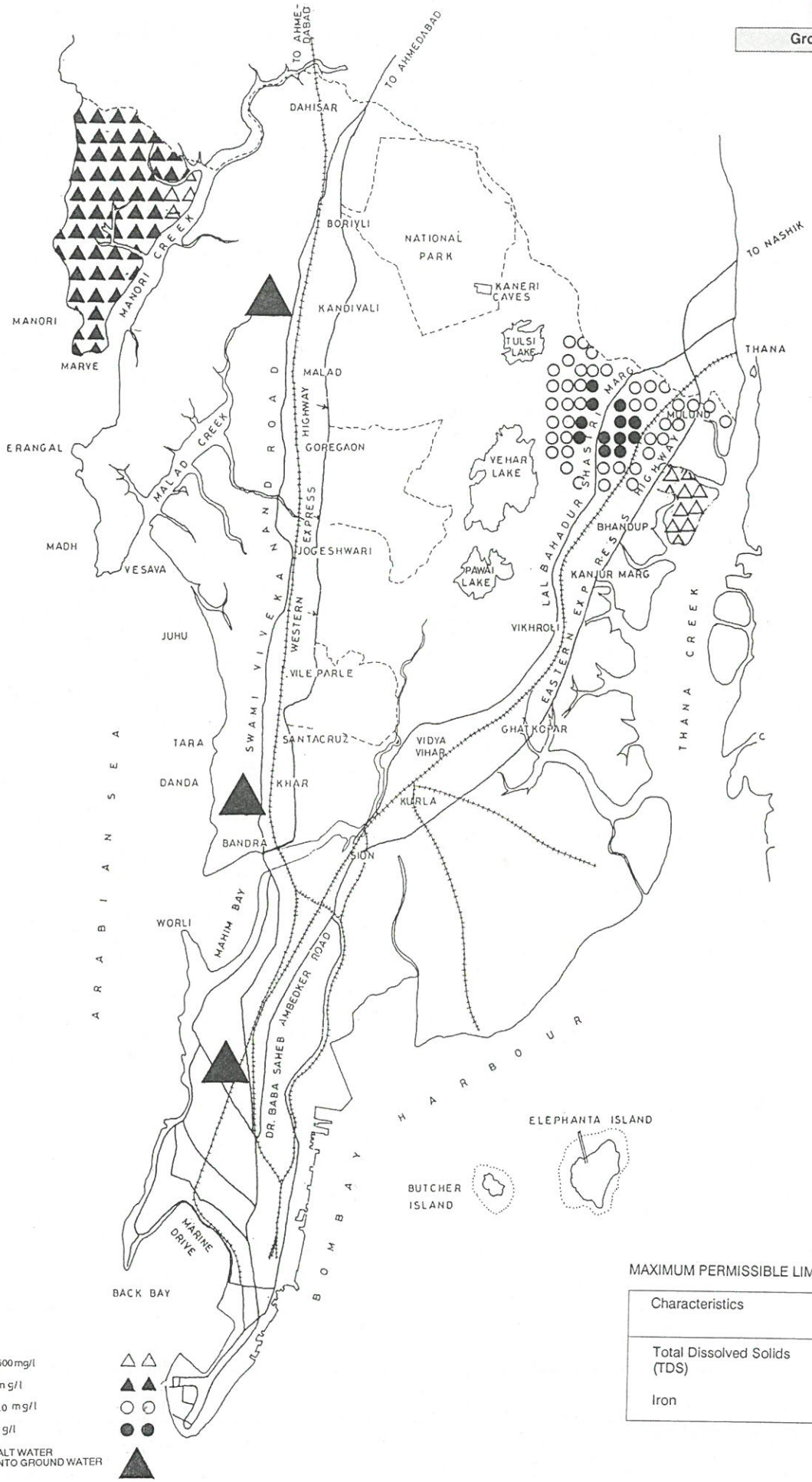
Urban Environmental Maps

Source: MCGB (1993).

National Institute of Urban Affairs, New Delhi.

BOMBAY

Ground Water Quality



LEGEND

TDS 1000-1500 mg/l

TDS 1500 mg/l

IRON 0.30-1.0 mg/l

IRON 1.0 mg/l

AREAS OF SALT WATER INTRUSION INTO GROUND WATER

MAXIMUM PERMISSIBLE LIMITS FOR POTABLE WATER

Characteristics	Max. Permissible Limit (mg/l)
Total Dissolved Solids (TDS)	500
Iron	0.30

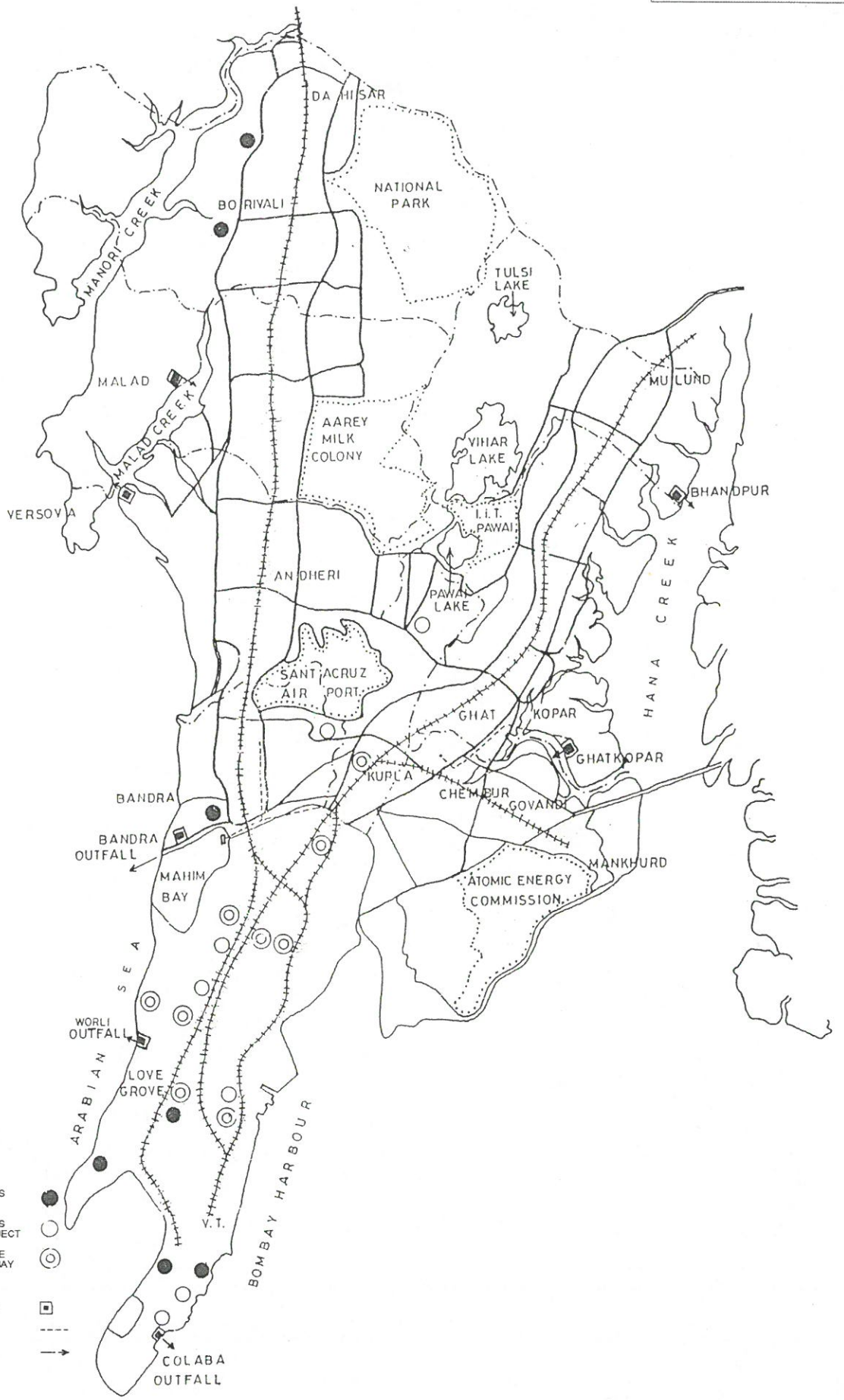
Scale

1·0 0·5 0 1 2 3 4 5 Km.

N

BOMBAY

Sewerage Pumping Stations



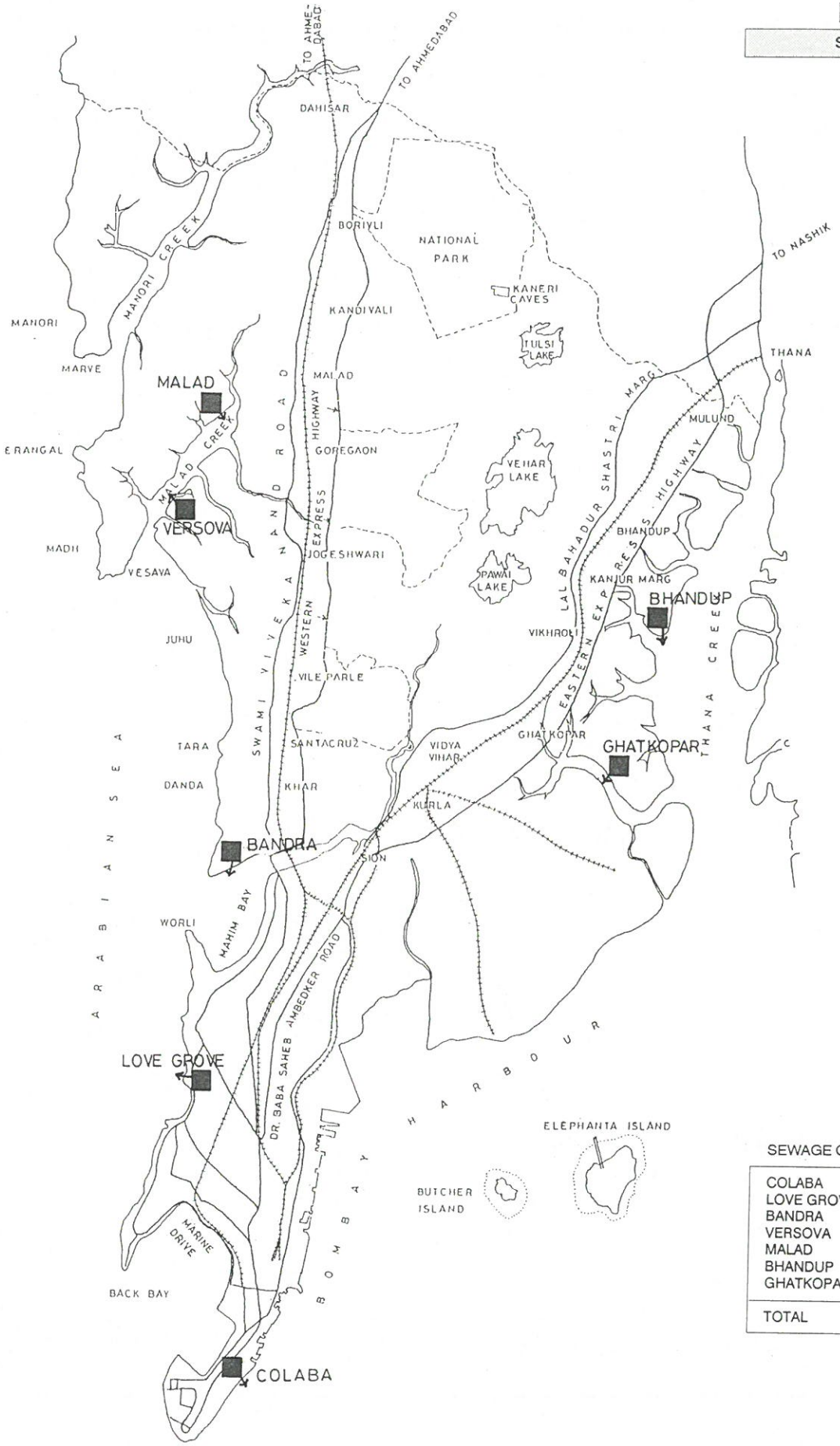
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Report on the Draft Development Plan (Revised) 1981-2001 for Greater Bombay.

BOMBAY

Sewage Outfalls



SEWAGE OUTFALLS

COLABA	41 MLD
LOVE GROVE	750 MLD
BANDRA	800 MLD
VERSOVA	130 MLD
MALAD	280 MLD
BHANDUP	176 MLD
GHATKOPAR	380 MLD
TOTAL	2557 MLD

Scale
1 .5 0 1 2 3 4 5 Kms.

N

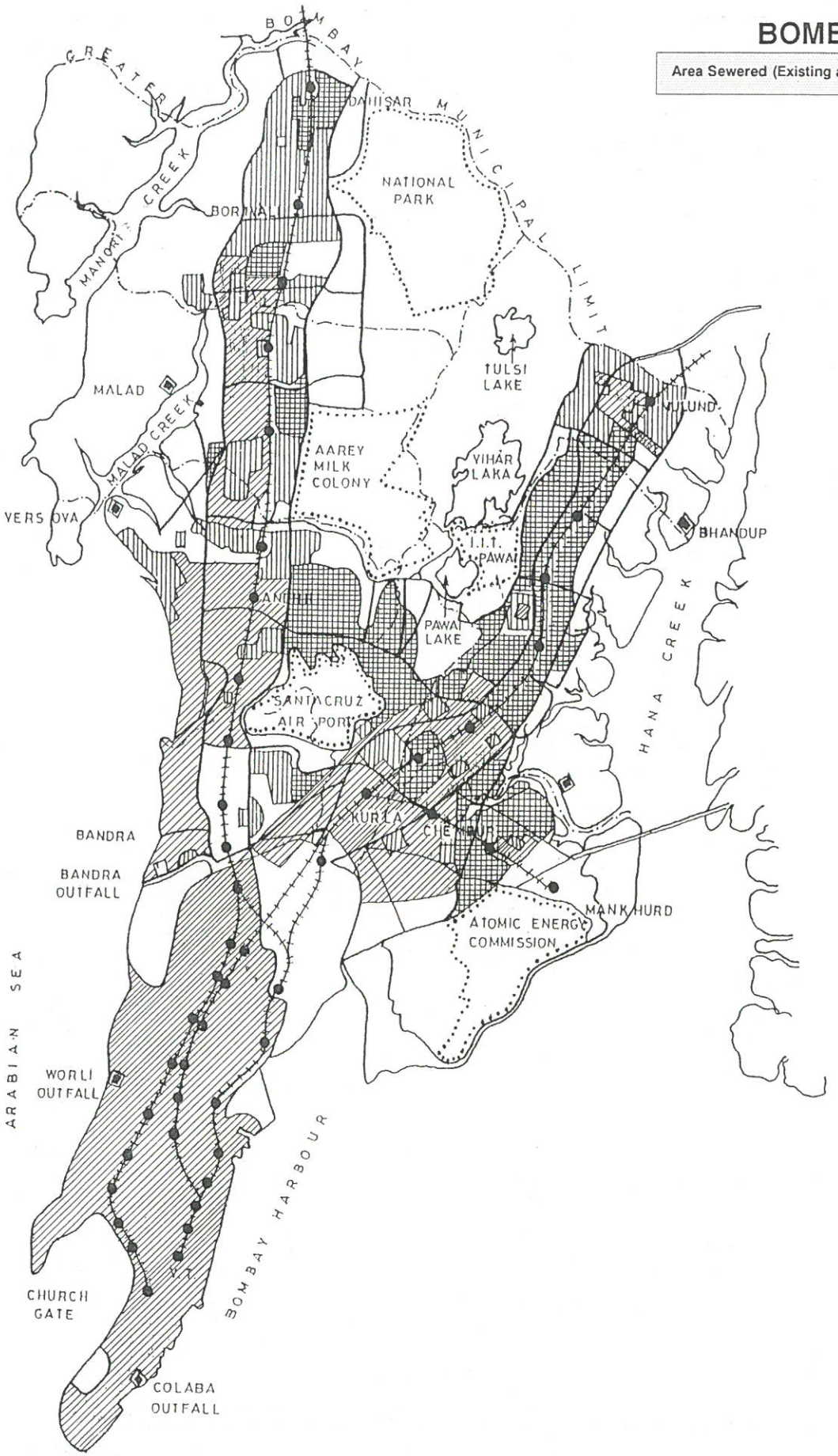
Urban Environmental Maps

Source: MCGB (1993)

National Institute of Urban Affairs, New Delhi.

BOMBAY

Area Sewered (Existing and Proposed)



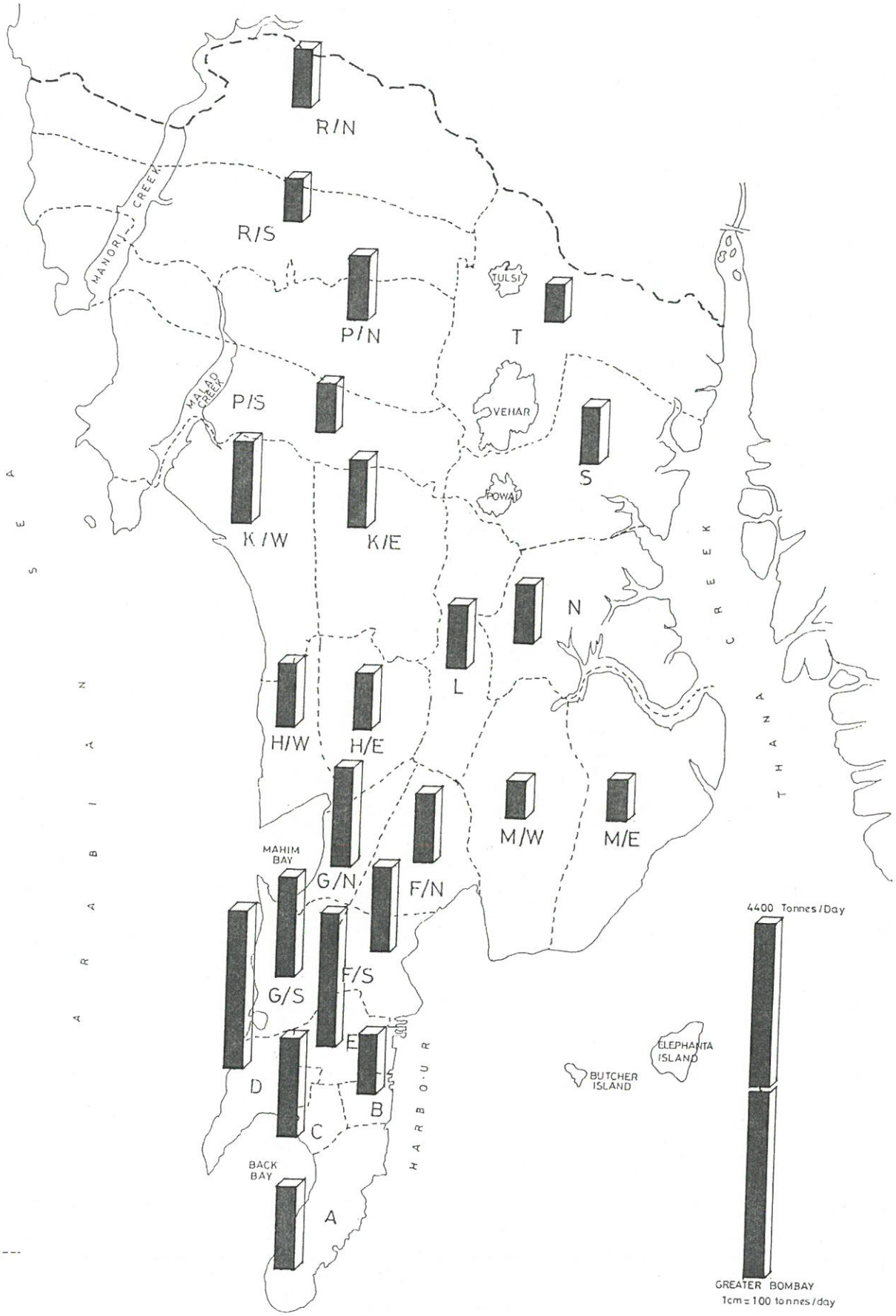
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Report on the Draft Development Plan (Revised) 1981-2001 for Greater Bombay.

BOMBAY

Wardwise Generation of Solid Waste



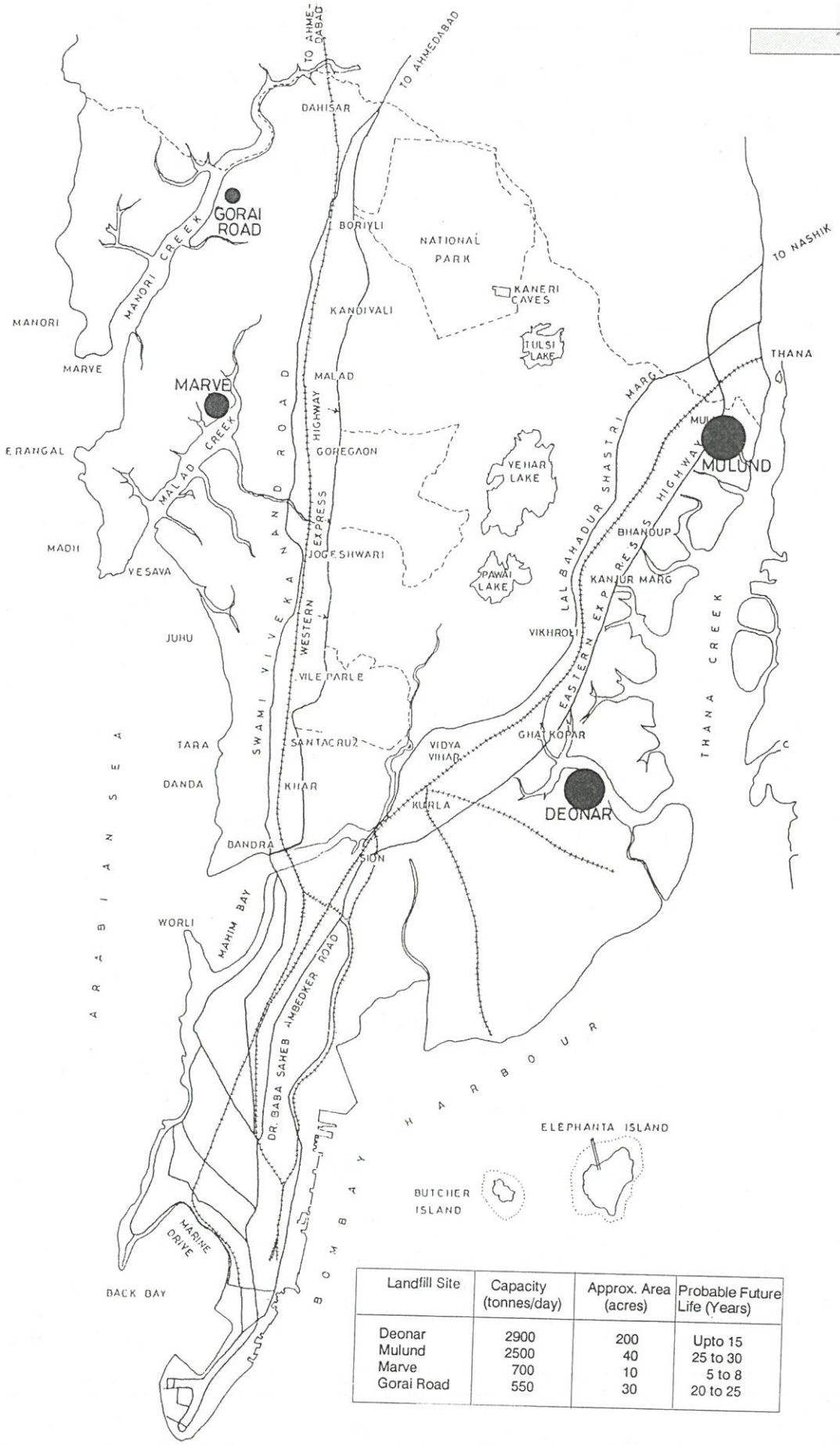
Urban Environmental Maps

Source: MCGB (1993).

National Institute of Urban Affairs, New Delhi.

BOMBAY

Landfill Site



Landfill Site	Capacity (tonnes/day)	Approx. Area (acres)	Probable Future Life (Years)
Deonar	2900	200	Upto 15
Mulund	2500	40	25 to 30
Marve	700	10	5 to 8
Gorai Road	550	30	20 to 25

Scale

1 5 0 1 2 3 4 5 Kms.

N

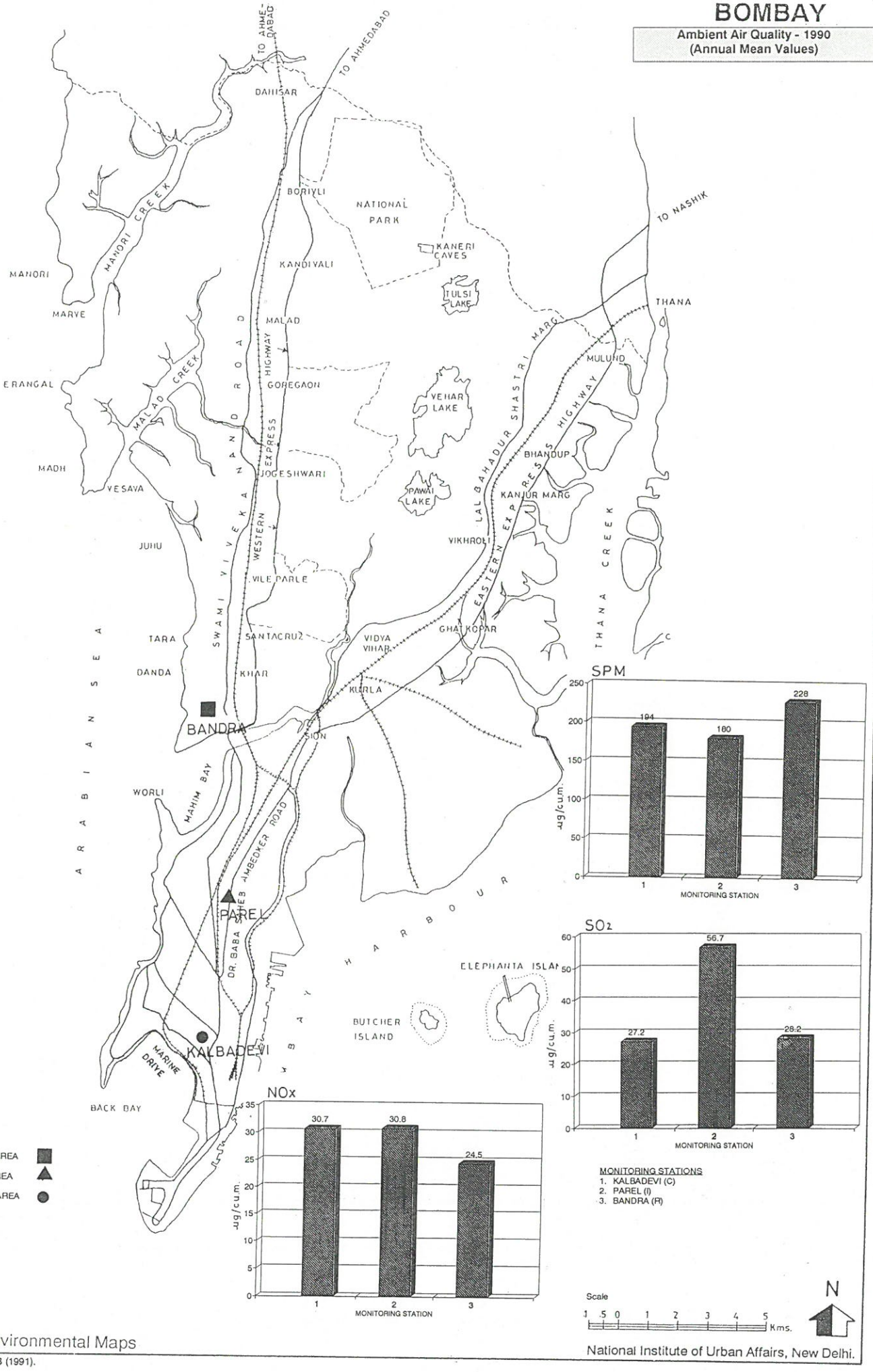
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: MCGB (1993).

BOMBAY

Ambient Air Quality - 1990
(Annual Mean Values)



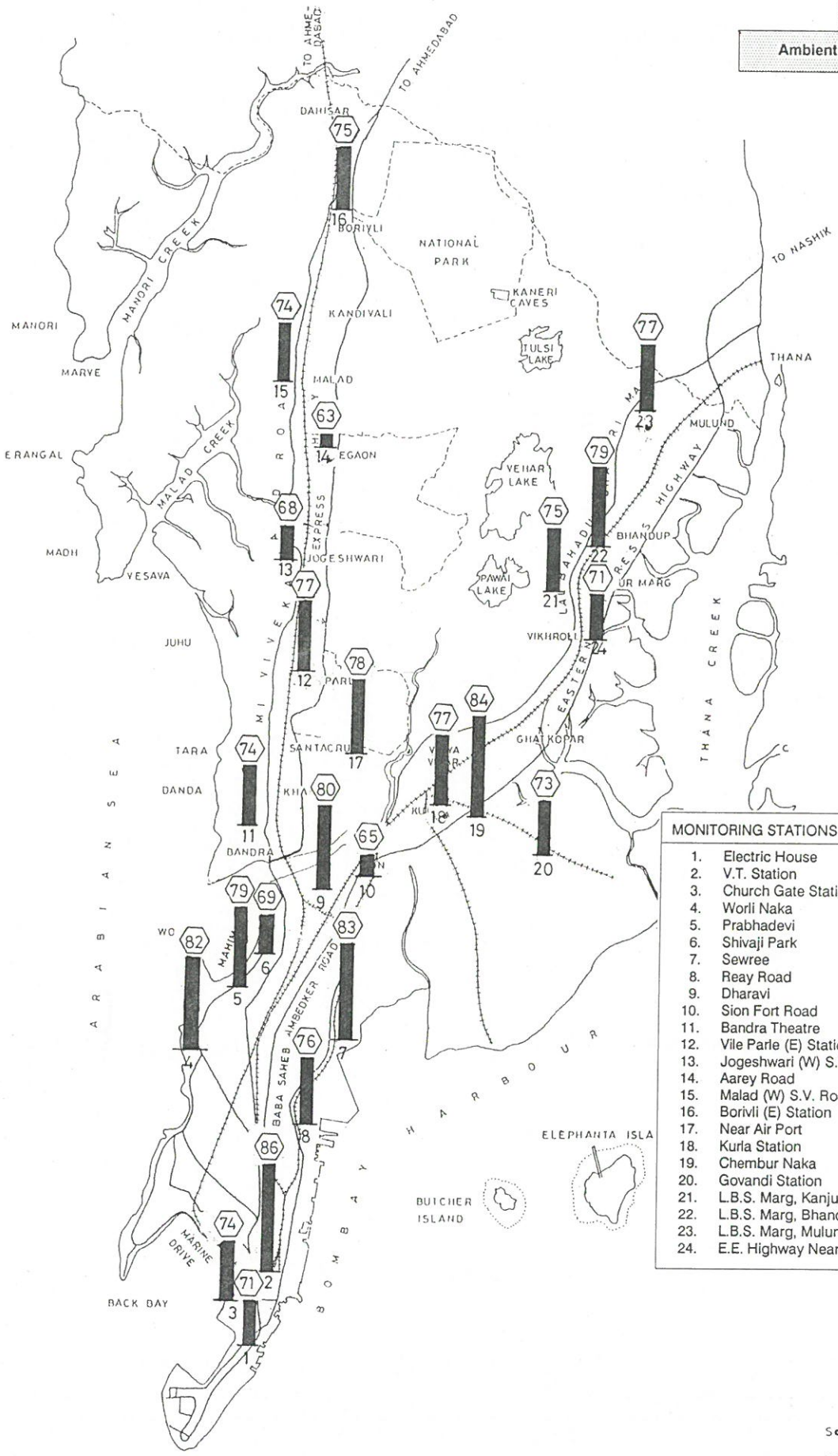
Urban Environmental Maps

Source: CPCB (1991).

National Institute of Urban Affairs, New Delhi.

BOMBAY

Ambient Noise Levels (dB)



MONITORING STATIONS		NOISE LEVEL (dB)
1.	Electric House	71
2.	V.T. Station	86
3.	Church Gate Station	74
4.	Worli Naka	82
5.	Prabhadevi	79
6.	Shivaji Park	69
7.	Sewree	83
8.	Reay Road	76
9.	Dharavi	80
10.	Sion Fort Road	65
11.	Bandra Theatre	74
12.	Vile Parle (E) Station	77
13.	Jogeshwari (W) S.V. Road	68
14.	Aarey Road	63
15.	Malad (W) S.V. Road	74
16.	Borivli (E) Station	75
17.	Near Air Port	78
18.	Kurla Station	77
19.	Chembur Naka	84
20.	Govandi Station	73
21.	L.B.S. Marg, Kanjur Marg (IV)	75
22.	L.B.S. Marg, Bhandup (W)	79
23.	L.B.S. Marg, Mulund (W)	77
24.	E.E. Highway Near Vikhroli	71

80 NOISE LEVEL

9 MONITORING STATION

Scale
0 cm = 60 dB
additional 1 cm = 10 dB

Scale
1 .5 0 1 2 3 4 5 Kms.

N

Urban Environmental Maps

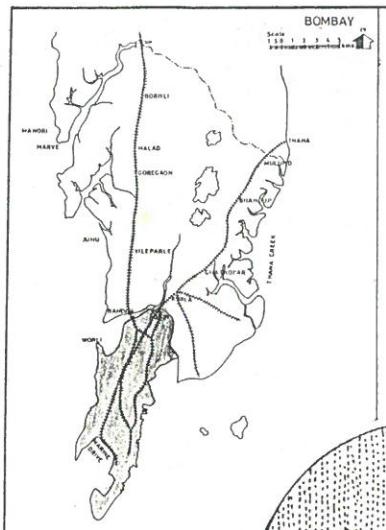
Note: The Noise Levels were recorded during day time in working day of Nov. and Dec. 1992

National Institute of Urban Affairs, New Delhi.

Source: MCGB (1993).

BOMBAY

Number of Building and their Future Life in Bombay City



LEGEND

- 0 LIFE
- 0 TO 5 YEARS
- 5 TO 15 YEARS
- 15 TO 25 YEARS
- ABOVE 25 YEARS

SCALE

Scale
1.0 0.5 0 1 2 Km

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Report on the Draft Development Plan (Revised) 1981-2001 for Greater Bombay.

BOMBAY

2.1 The City

Bombay, the capital of the state of Maharashtra and a major seaport and airport of India, is one of a group of seven islands. Many attribute the Marathi name of Bombay (i.e. Mumbai), to a derivation from *Mumba Ai* or *Maha Amba,* the patron goddess of the Kolis, the original inhabitants, whereas 'Bombay' is derived from the Portuguese word *Bombaim* meaning a good bay.

Captain Cooke took charge of the island of Bombay in 1664 from the Portuguese and decided to build a town for the trading class. In 1717, the Fort was built which had three gates, the Apollo Gate at the south, the Church Gate at the west and the Bazar Gate at the north with the port and the Castle at the centre.

In 1750, the Governor moved to Parel and made his permanent residence there. After the Great Fire broke out in 1803 within the Fort, the then Government decided to develop the city outside the Fort.

In 1862, the Rampart Removal Committee proposed a definite plan for the construction of roads, water supply and drainage and for buildings. During the period 1861-65, many institutes sprung up in the city. In 1896, plague took a heavy toll of human lives because of insanitary conditions in the city.

Today, the city of Bombay has become the financial capital of India. Increasing activities and congestion in South Bombay prompted City and Industrial Development Corporation (CIDCO) to develop New Bombay, which aims to reduce pressures on the existing city.

2.2 Demography

The city of Bombay had a population of 10,000 in 1661 which rose to 651,632 by 1872 when the first decennial census was held in India. The city's population, following the partition of the country, increased to 2,966,902 in 1951. This population increase was not only due to the influx of refugees into the city but also due to the merger of a large number of towns with Greater Bombay and the increase in trade due to a big spurt in industrial growth in a big way. Between 1951 and 1981, the decennial growth rate remained in the range of 35% to 45%. During the decade between 1981-91, however, the growth rate of the population within municipal bounds fell to 20 percent while that of Greater Bombay Urban Agglomeration grew by 52.5 per cent. In 1991, the population of Bombay Municipal Corporation area stood at 9.92 million while that of Greater Bombay Urban Agglomeration stood at 12.57 million.

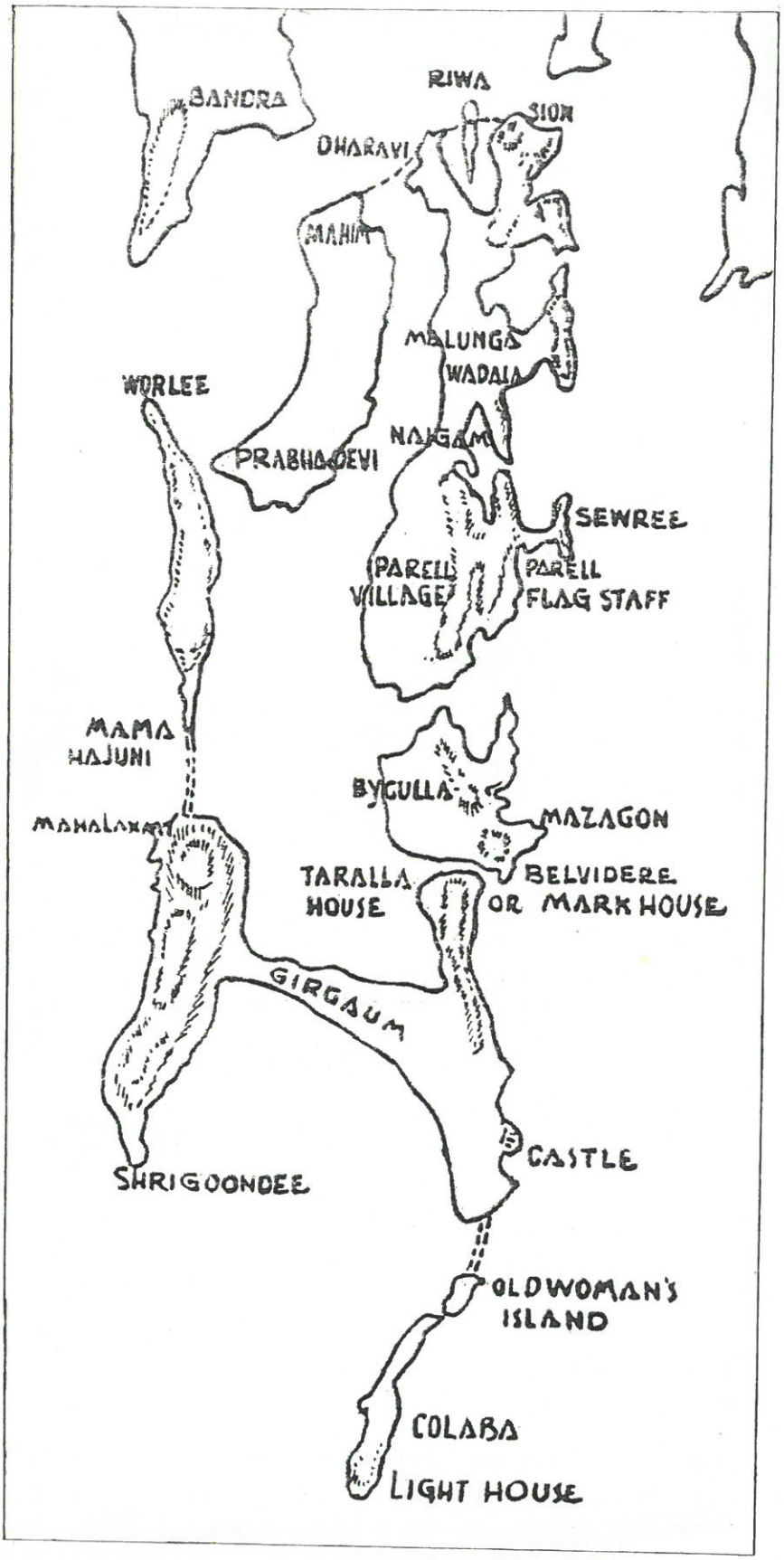


Figure 2.1: Map of Bombay showing islands as they existed in 1670.

Source: MCGB (1964), *Report on the Development Plan for Greater Bombay.*

Table 2.1: Population Growth in Area under Municipal Corporation of Greater Bombay

Year	Population	Decadal Variation	Decennial Growth Rate(%)
1901	812,912	-	-
1911	1,018,388	+ 205,476	+ 25.28
1921	1,244,934	+ 226,546	+ 22.24
1931	1,268,306	+ 23,372	+ 1.88
1941	1,686,127	+ 417,821	+ 32.94
1951	2,966,902	+ 1,280,775	+ 75.96
1961	4,152,056	+ 1,185,154	+ 39.95
1971	5,970,575	+ 1,818,519	+ 43.80
1981	8,243,405	+ 2,272,830	+ 38.07
1991	9,925,891	+ 1,682,486	+ 20.41

Source: Census of India (1991).

The Municipal Corporation of Greater Bombay (MCGB) is divided into three areas -- city, western suburbs and eastern suburbs. There are a total of 23 wards in MCGB - 9 wards in the city, 8 wards in the western suburbs and 6 wards in eastern suburbs. Out of a total population of almost ten million in MCGB, the city accommodates 31,59,907 persons (32%), the western suburbs 39,35,685 persons (40%) and the eastern suburbs 28,03,955 persons (28%). The average population density of MCGB is 21,187 persons per sq.km. The highest population density is in ward 'C' of the city - 1,10,575 persons per sq.km. Also ward 'C' is the smallest ward in the city with an area of only 1.78 sq.km. Wards 'R/N' and 'S' are very thinly populated. As per the figures provided by the MCGB, the residential area under the Corporation cover 74.64 sq.km. (16% of total area of the Corporation) This gives a net density of population of 1,32,630 persons per sq.km. (1991).

Table 2.2: Wardwise Population (Provisional) of Greater Bombay - 1991

S.No.	Ward	Population (1991)	Area (sq.km.)	Population Density (Persons/sq.km.)
	City			
1.	A	1,93,158	14.00	13,797
2.	B	1,16,529	2.47	47,178
3.	C	1,96,823	1.78	1,10,575
4.	D	3,43,422	6.63	51,798
5.	E	4,63,515	7.40	62,637
6.	F/S	4,17,448	14.00	29,818
7.	F/N	4,30,406	12.98	33,159
8.	G/S	5,17,668	10.00	51,767
9.	G/N	4,80,938	9.07	53,025
	Total (City)	31,59,907	78.33	40,341 (Average)

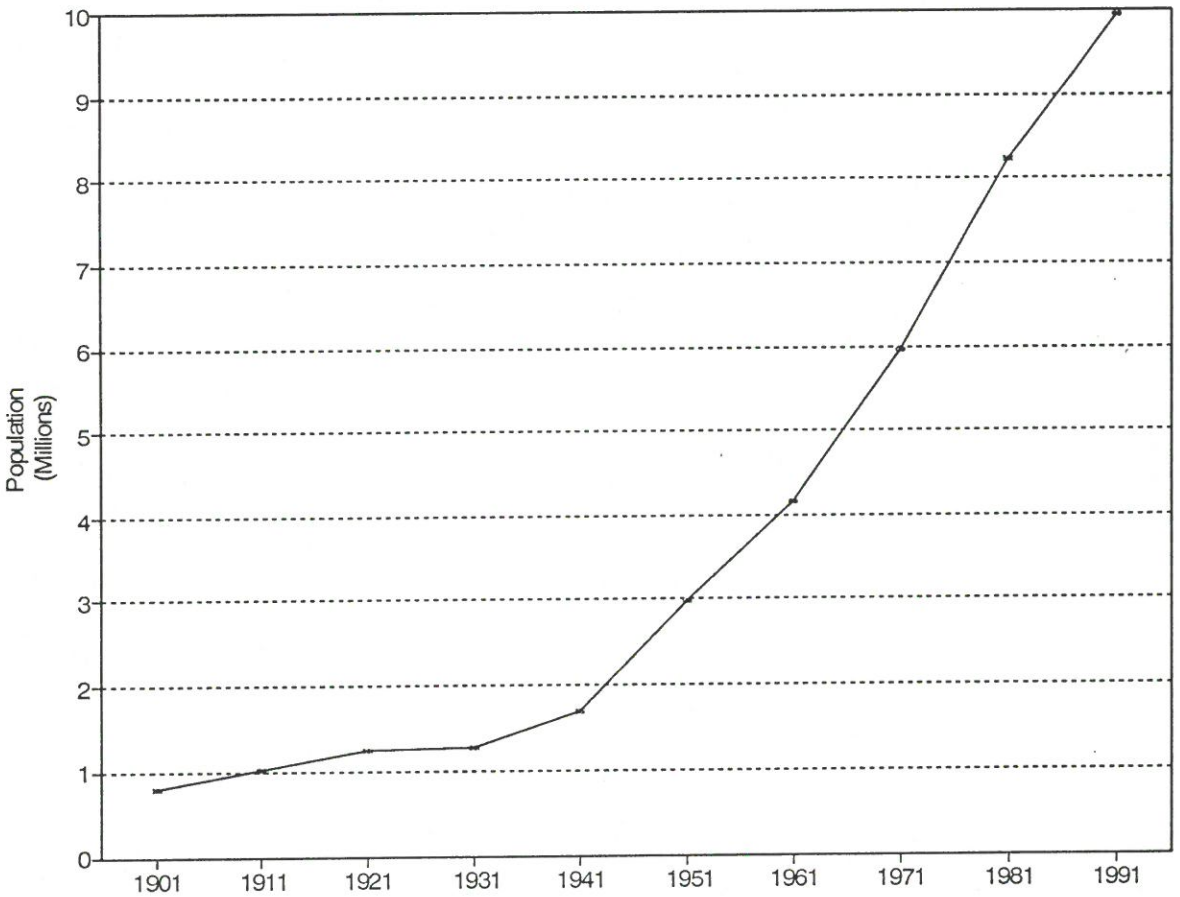


Figure 2.1: Population Growth in Bombay

S.No.	Ward	Population (1991)	Area (sq.km.)	Population Density (Persons/sq.km.)
	Western Suburbs			
10.	H/E	4,79,705	13.53	35,455
11.	H/W	3,22,141	11.55	27,891
12.	K/E	6,90,779	23.50	29,395
13.	K/W	5,47,121	22.00	24,869
14.	P/S	3,54,984	24.88	14,268
15.	P/N	5,61,938	19.30	29,116
16.	R/S	3,68,940	17.78	20,750
17.	R/N	6,10,077	68.61	8,892
	Total (Western Suburbs)	39,35,685	201.15	19,566 (Average)
	Eastern Suburbs			
18.	L	6,12,651	13.46	45,516
19.	M/W	3,52,384	19.50	18,071
20.	M/E	4,71,485	32.50	14,507
21.	N	5,10,708	39.00	13,095
22.	S	5,68,660	64.00	8,885
23.	T	2,88,067	19.31	14,918
	Total (Eastern Suburbs)	28,03,955	187.77	14,933 (Average)
	Grand Total (Greater Bombay)	98,99,547	467.25	21,187 (Average)

Source: Municipal Corporation of Greater Bombay (1993).

2.3 Slums

In Greater Bombay, more than half the population resides in 2641 slums spread all over the Corporation area. Nearly 5.5 million people in Greater Bombay live in slums and squatter hutments. The eastern suburbs have about 77% population living in slums. Wards 'G/N', 'H/E' and 'N' have more than 90% population residing in slums. Wards 'B' and 'C' do not have any slums (Table 2.3). The slum population of Bombay has grown from 28.3 lakhs in 1981 to 54.8 lakhs in 1991. Most of the slums are located on low-lying lands that get flooded during heavy monsoons every year and on land unfit for regular housing development. One of Bombay's largest slum houses 0.18 million people in a sq.km. of area.

Dharavi, the largest slum in Bombay and in Asia, is spread over 4.5 sq.km of prime land in Central Bombay. The initial settlers in this slum occupied private land, but slowly took over municipal and government owned land. At present 2.5 sq.km. of Dharavi land belongs to the Corporation and one sq.km. each belongs to private landowners and the government. In the early 1980s, Dharavi had an estimated 65,000 dwelling units of various types and a stable population of 3,00,000 with and a floating population of 100,000.

Table 2.3: Wardwise Number of Slums and Slum Population

	Ward	Number of Slums	Estimated Slum Population (1991)	Slum Population as % of Ward Population
	City			
1.	A	6	40,540	21.0%
2.	B	-	-	-
3.	C	-	-	
4.	D	15	52,620	15.3%
5.	E	1103	43,660	9.4%
6.	F/S	46	1,69,380	40.6%
7.	F/N	24	1,53,030	35.6%
8.	G/S	61	1,69,380	32.7%
9.	G/N	3	4,49,000	93.4%
Total (City)		1258	10,77,610	34.1%
	Western Suburbs			
10.	H/E	153	4,72,430	98.5%
11.	H/W	843	1,33,905	41.6%
12.	K/E	9	5,21,965	75.6%
13.	K/W	7	3,28,215	60.0%
14.	P/S	81	4,55,590	49.7%
15.	P/N	5		
16.	R/S	3	3,15,195	32.2%
17.	R/N	5		
Total (Western Suburbs)		1106	22,27,300	56.6%
	Eastern Suburbs			
18.	L	99	5,47,775	89.4%
19.	M/W	68	4,57,935	55.6%
20.	M/E	21		
21.	N	20	5,00,335	98.0%
22.	S	34	6,64,685	77.6%
23.	T	35		
Total (Eastern Suburbs)		277	21,70,730	77.4%
Total (Greater Bombay)		2641	54,75,640	55.3%

Source: MCGB (1993).

2.4 Water Supply

Water supply for Bombay city comes mainly from lakes. The water supply from various sources is approximately 2500 mld. As against this, the total demand for water is presently 3360 mld. The per capita supply averages 247 litres per day.

Table 2.4: Water Supply in Greater Bombay

(mld)

Sl.No.	Sources	Average Supply (April 1991 to March 1992)
1.	Vihar	133
2.	Tulsi	18
3.	Tansa	431
4.	Ulhas River	59
5.	Modak Sagar	
6.	Upper Vaitarna	965
7.	Bhatsa	909
		2515
	Less : Losses at treatment plants	67
	Total	2448

Source: MCGB (1993)

The water supplied to the city is treated, filtered and chlorinated. In order to maintain adequate pressure of water, service reservoirs have been built at suitable elevations. At present there are 22 service reservoirs in operation.

The ground water in the Corporation is not potable. At a few locations, salt water has intruded into ground water making it unfit for human consumption. The total dissolved solids (TDS) are in excessive concentration in the areas of Bhayander and Marve. The concentration of iron exceeds 0.30 mg/l in Thane.

Table 2.5: Water Supply and Demand in Bombay

(mld)

Year	Supply	Demand	Gap
1991	2448	3360	912
2001	3518	4092	574
2011	5148	4419	- 729

To meet the growing demand for water, the authorities are planning to tap water from Kalu river and Middle Vaitarna.

2.5 Solid Waste

The per capita per day refuse generation in Greater Bombay amounts to 400 to 500 gms. An average of 4000 tonnes of refuse and 2000 tonnes of debris is collected daily. Ten per cent of the total refuse generated is collected door to door. The remaining 90% is collected through the communal collection method. The city has four dumping grounds with a combined capacity

of 6050 tonnes per day. The total area covered by the dumping grounds is 280 acres. The total number of vehicles for waste collection is 1100. Of these, 800 are owned by the authority and 300 are hired from private contractors. The frequency of collection is twice a day. The total expenditure incurred on conservancy and transport for the year 1991-92 was Rs.135.09 crores.

Table 2.6: Wardwise Collection of Solid Waste (tonnes/day)

S.No.	Ward	Quantity of waste collected (tonnes/day)	Quantity generated per capita per day (gms.)
	City		
1.	A	220	1140
2.	B	160	1375
3.	C	260	1320
4.	D	410	1195
5.	E	350	755
6.	F/S	220	530
7.	F/N	180	420
8.	G/S	260	500
9.	G/N	260	540
Total (City)		2320	735
	Western Suburbs		
10.	H/E	150	315
11.	H/W	170	530
12.	K/E	180	260
13.	K/W	220	400
14.	P/S	130	370
15.	P/N	170	300
16.	R/S	120	325
17.	R/N	150	245
Total (Western Suburbs)		1290	330
	Eastern Suburbs		
18.	L	170	280
19.	M/W	100	285
20.	M/E	110	235
21.	N	160	315
22.	S	150	265
23.	T	100	350
Total (Eastern Suburbs)		790	280
Total (Greater Bombay)		4400	445

Source: MCGB (1993).

Out of the total solid waste collected per day, more than 50% is collected from the city area. The average per capita generation of solid waste is 445 gms/capita/day, while the maximum is in the city area. Wards A,B,C and D generate more than 1000 gms/capita/day of solid waste. The lowest per capita generation is in the Eastern Suburbs, amounting to 280 gms/capita/day.

The hospital waste collected from various hospitals, nursing homes and maternity homes is also dumped in the landfill sites.

Table 2.7: Landfill Sites in Bombay

S.No.	Land-fill Site	Capacity (Tonnes/day)	Approx. Area (acres)	Probable Future Life
1.	Deonar	2900	200	Upto 15 years.
2.	Mulund	2500	40	25 to 30 years.
3.	Marve	700	10	5 to 8 years.
4.	Gorai Road	550	30	20 to 25 years.

Source: MCGB (1993).

2.6 Sewerage and Drainage

Bombay city has had the same sewerage system for the last 70 years which has now become overloaded. In Greater Bombay, much of the area under the Municipal Corporation is covered by the waste water collection system. Nearly 90 per cent of the households in the city are served by the sewerage system. Most of the waste water is discharged untreated into the sea at present.

The first sewage outfall was built at Worli in 1880. In 1935, a modern sewage treatment plant was built at Dadar. By 1960, new outfalls came up at Khar, Versova and Ghatkopar. At present there are 7 sewage outfalls in the city discharging 2557 mld of sewage into the sea.

Table 2.8: Sewage Outfalls in Bombay

S.No.	Sewage Outfall	Capacity (mld)
1.	Colaba	41
2.	Love Grove	750
3.	Bandra	800
4.	Versova	130
5.	Malad	280
6.	Bhandup	176
7.	Ghatkopar	380
	Total	2557

Source: MCGB (1993).

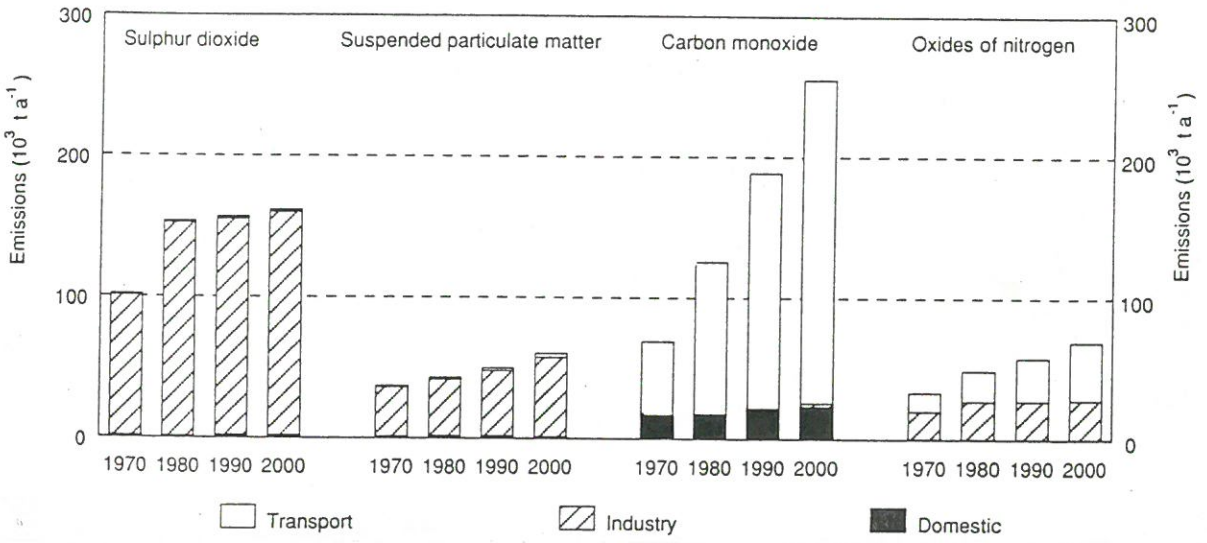


Figure 2.3: Estimated and projected anthropogemic pollutant emissions in Bombay by source.

Source: NEERI (1991).

Industrial wastes from the city and its suburbs are often discharged into public sewers for which discharge standards are applied. Industrial wastes contribute only about 10% of the total sewage flow of Bombay.

Although Bombay has separate sewer system for storm drainage and sewage, the two are linked at places. Discharging of storm drainage in the coastal waters has led to considerable pollution of coastal surface water, which has been found to have BOD ranging from 5.0 to 22.3 mg/l at different sites.

2.7 Air Pollution

Annual Emissions

It is now an established fact that the major sources of air pollution in Bombay are the large number of automobiles. Nearly 60% of the total pollution load in the city can be attributed to them. Figure 2.3 shows that industrial sources account for almost all SO_2 emissions in Bombay. During 1970-80, there was a significant increase in SO_2 emissions. Between 1980 and 1990, the total emissions have not increased considerably. In 1990, the estimated total SO_2 emissions were around 157,000 tonnes per annum. This is largely due to the introduction of natural gas as a fuel source.

Suspended particulate matter (SPM) has been continuously increasing over the years. Like SO_2, the dominant source of SPM is industries. Domestic emissions have remained relatively constant despite the increase in population. This is because of the shift from traditional fuels to liquified petroleum gas. With the increase in the number of vehicles, SPM emissions from the transport sector have also increased.

The Oxides of nitrogen have also been increasing, though industrial NO_X emissions have remained almost constant from 1970 to 1990. It is only due to the transport sector that NO_X emissions are rapidly increasing.

Table 2.9: Industrial Emissions Inventory for Bombay (1973)

	Industry	Annual emission (tonnes/annum)		
		SO_2	SPM	NO_X
1.	Chemical	48,180 (45%)	2,920 (19%)	7,045 (29%)
2.	Textile	27,010 (24%)	1,351 (9%)	4,453 (18%)
3.	Power Plants	22,630 (21%)	10,366 (67%)	10,950 (46%)
4.	Others	10,950 (10%)	803 (5%)	1,643 (7%)
	Total	108,770 (100%)	15,440 (100%)	24,091 (100%)

Source: NEERI (1991), *Air Pollution Aspects of Three Indian Megacities,* Volume II: Bombay.

The increase in CO emissions is mainly because of the increase in the number of vehicles. Estimated CO emissions have increased from 69,000 tonnes per annum in 1970 to 188,000 tonnes per annum in 1990. There has been an increase in domestic CO emissions also. As per CPCB estimates for 1986-87, total emissions from vehicles were 583.96 tonnes/day (i.e., 213,145 tonnes/annum). CO emissions accounted for almost 70% of total emissions.

Table 2.10: Vehicular Pollution Load in Greater Bombay (1986-87)

	Vehicle	No. of Registered Vehicles	Vehicular Pollution Load (Tonnes/day)				
			PM	SO_2	NO_X	CO	HC
A.	**Petrol Driven**						
1.	Two Wheelers	1,86,952	0.720	0.072	0.250	61.83	36.40
2.	Three Wheelers	24,577	0.200	0.200	0.020	25.85	10.00
3.	Four Wheelers	2,56,707	2.395	0.580	23.220	290.32	43.55
	Total (A)	4,68,236	3.315	0.672	23.490	373.40	89.95
B.	**Diesel Driven**						
1.	Buses	6,714	0.484	0.969	13.566	8.200	1.356
2.	Matadors etc.	11,072	0.298	0.258	0.657	0.730	0.185
3.	Trucks	34,616	1.218	2.436	34.104	20.620	3.410
	Total (B)	52,402	2.000	3.663	48.327	29.550	4.951
	Total (A+B)	5,20,638	5.315	4.335	71.867	407.55	94.90

Total Vehicular Pollution Load = 583.96 tonnes/day

Source: CPCB (1990), *Assessment of Vehicular Pollution in Metropolitan Cities, Part III - Bombay.*

Ambient Concentration

CPCB is monitoring air quality at three stations in Bombay - Kalbadevi, Parel and Bandra. Though the annual mean values at the three stations are well within the limits prescribed by the CPCB, the annual maximum values exceed the standards. (Table 2.11)

Table 2.11: Annual Mean and Maximum Concentrations of SO_2, NO_X and Particulate Matter (in ug/cu.m.) 1990

Pollutant	Monitoring Station					
	Kalbadevi (Commercial)		Parel (Industrial)		Bandra (Residential)	
	Mean	Max.	Mean	Max.	Mean	Max.
SO_2	27.2	141.3	56.7	150.6	28.2	87.5
NO_X	30.7	145.2	30.8	77.5	24.5	65.2
Particulate Matter	194	457	180	504	228	474

Source: CPCB (1991), *Ambient Air Quality Statistics of India.*

2.8 Noise Pollution

The city of Bombay is characterised by congestion, with industrial, commercial and residential activities competing for limited space. This has resulted in high noise levels in the city. Monitoring of noise levels at 27 stations by MPCB and CPCB indicates that the ambient noise levels exceed the standard limits at most places in Bombay during the day time. (Table 2.12). While in industrial areas, the night time noise levels are lower, in other areas, even night time noise levels are much higher than the prescribed standards. The most important source of noise pollution is identified as vehicular traffic.

Table 2.12: Sound Level at Selected Places in Bombay

S.No.	Name of the Place	Sound Level in dB(A)		
		1989	1991	1992
1.	Electric House	69	72	71
2.	V.T. Station	80	85	87
3.	Churchgate Station	74	77	74
4.	Worli Station	79	80	82
5.	Prabhadevi	78	78	79
6.	Shivaji Park	67	67	69
7.	Sewree	82	82	83
8.	Ray Road	76	77	76
9.	Dharavi	78	80	80
10.	Sion Fort Road	67	67	65
11.	Near Bandra Theatre	73	80	74
12.	Jogeshwari (W) S.V.Road	68	70	68
13.	Malad (W) S.V.Road	74	80	74
14.	Borivali (E) Near Station	70	72	75
15.	Aarey Road	60	62	63
16.	Vile Parle (E) Near Station	62	69	77
17.	Near Airport	68	81	72
18.	Kurla Station (W)	67	78	77
19.	Chembur Naka	78	82	84
20.	Govandi Station (E)	69	71	73
21.	L.B.S.Marg, Kanjur Marg (W)	73	73	75
22.	L.B.S. Marg, Bhandup (W)	75	78	79
23.	L.B.S. Marg, Mulund (W)	70	76	77
24.	Eastern Express Highway Near Vikhroli	64	71	71

Note: The Sound Levels were recorded during day time in working days of November and December.

Source: MCGB (1993).

2.9 Health

The Municipal Corporation of Greater Bombay has 24 Municipal Hospitals, 36 Municipal Maternity Homes, 152 Municipal Dispensaries, 38 Dental Clinics and 533 other Charitable Trusts' Hospital. There are total 806 registered private nursing homes - 256 in 'city', 373 in the Western Suburbs and 177 in the Eastern Suburbs.

Table 2.13: Wardwise Health Facilities in Greater Bombay (1990-91)

	Ward	Municipal Hospitals	Municipal Maternity Homes	Municipal Dispensaries	Dental Clinics	Other Hospitals	Total
1.	A	1	-	5	4	1	11
2.	B	-	1	3	2	4	10
3.	C	-	1	5	2	8	16
4.	D	1	-	6	2	6	15
5.	E	3	2	12	4	15	36
6.	F/S	4	2	9	2	4	21
7.	F/N	1	1	7	4	3	16
8.	G/S	-	1	13	-	-	14
9.	G/N	-	2	10	2	65	79
10.	H/E	1	1	6	-	-	8
11.	H/W	1	-	7	1	3	12
12.	K/E	-	10	-	-	-	10
13.	K/W	1	2	6	3	66	78
14.	L	1	1	8	2	15	27
15.	M/E	1	2	5	-	6	14
16.	M/W	1	1	6	1	35	44
17.	N	2	-	6	2	65	74
18.	P/S	-	1	3	-	29	33
19.	P/N	2	1	9	1	56	69
20.	R/S	1	1	5	1	2	10
21.	R/N	1	1	5	1	83	91
22.	S	-	2	8	2	25	37
23.	T	2	3	8	2	42	57
Total		24	36	152	38	533	783

Source: Know Your Ward (1990-91), Municipal Corporation of Greater Bombay.

Health problems related to pollution are on the rise in the city. Air pollution in particular, causes respiratory problems. In a study conducted in Chembur in 1978 and again in 1990, it was found that the number of people affected by dry cough and breathlessness had gone up during this period. Cases of hypertension as well as those of bronchitis, T.B. and cardiac problems had also gone up.

Table 2.14: Incidence of Diseases in Chembur Area (% of sample population)

Health Problem	1978	1990
Cough	3.0	16.0
Dyspepsia	5.9	13.0
Bronchitis	4.5	7.6
Cardiac disorder	4.3	6.7
Chest disorder	0.1	4.4
Hypertension	3.6	7.3

Source: Based on sample survey conducted in Chembur in 1978 and 1990 (sample size - 1,122 in 1978 and 751 in 1990)

Summing Up

Bombay is the financial capital of India. The city area of Bombay is very crowded and has high densities. However, the suburbs have relatively lower densities. The city area has very little open space.

Nearly half the city's population resides in slums. Bombay has the largest slum in Asia. Slums line many of the roads and railway lines in the city. The housing problem in Bombay is acute. Most of the buildings are in a dilapidated state and need to be urgently repaired.

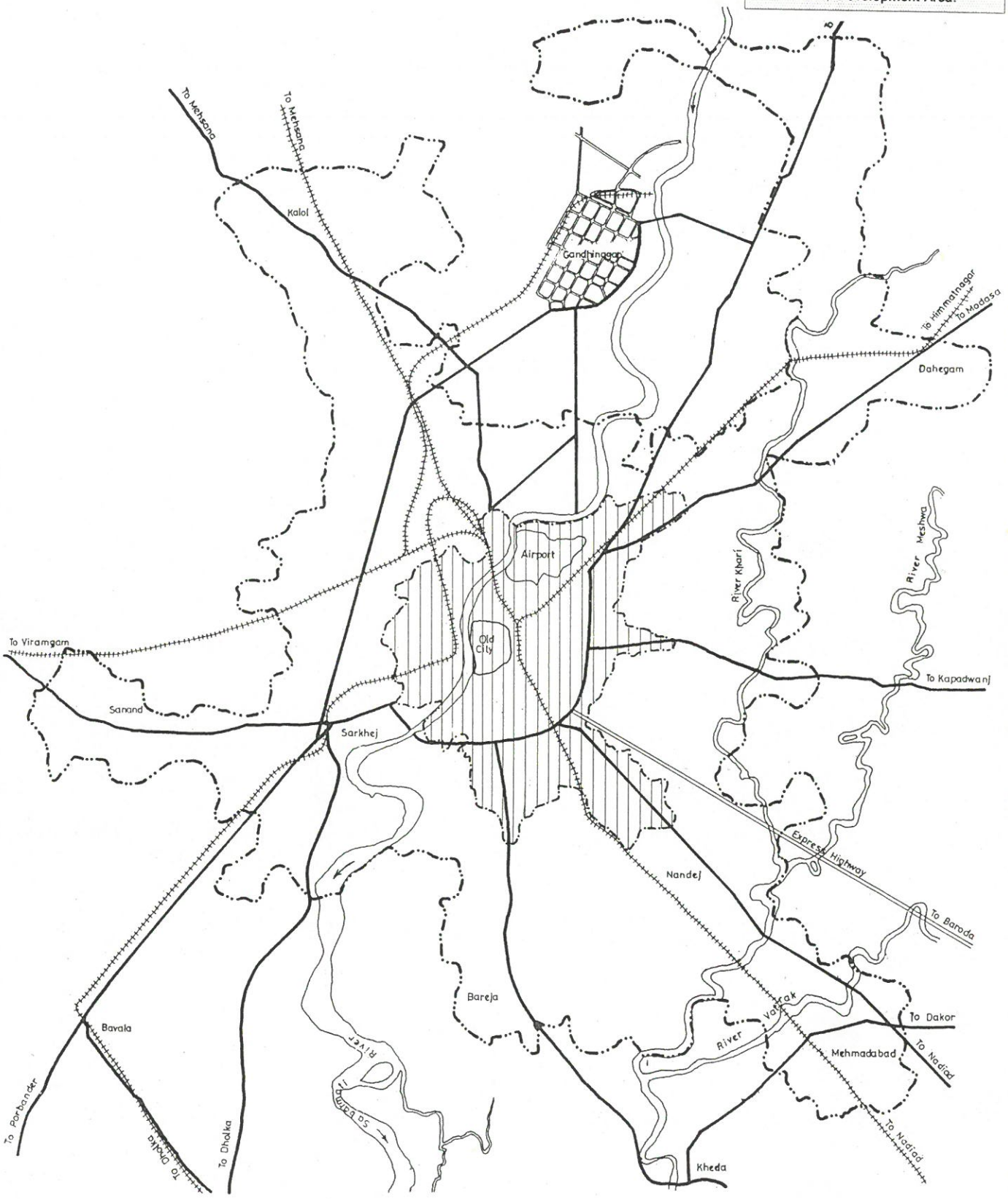
The water supply in the city is also coming under pressure and the gap between demand and supply is increasing. The waste water in the city is discharged untreated into the ocean. Solid waste collection in the city is satisfactory. However, some of the waste from the city's hospitals is also dumped in the landfill sites alongwith other wastes.

The vehicle population in the city has also increased considerably over the years and has resulted in increased emissions. However industrial air pollution has reduced in the last few years due to switching over to cleaner fuels by certain major industries. Noise pollution in the city has increased and has crossed the prescribed limits in many areas. The average noise level recorded in the city exceeds the comfort level of human ears. Health problems related to pollution are also on the increase in the city, particularly in the industrial areas.

AHMEDABAD

AHMEDABAD

Urban Development Area.



LEGEND

AUDA BOUNDARY

AMC BOUNDARY

MAJOR ROADS

RAILWAY

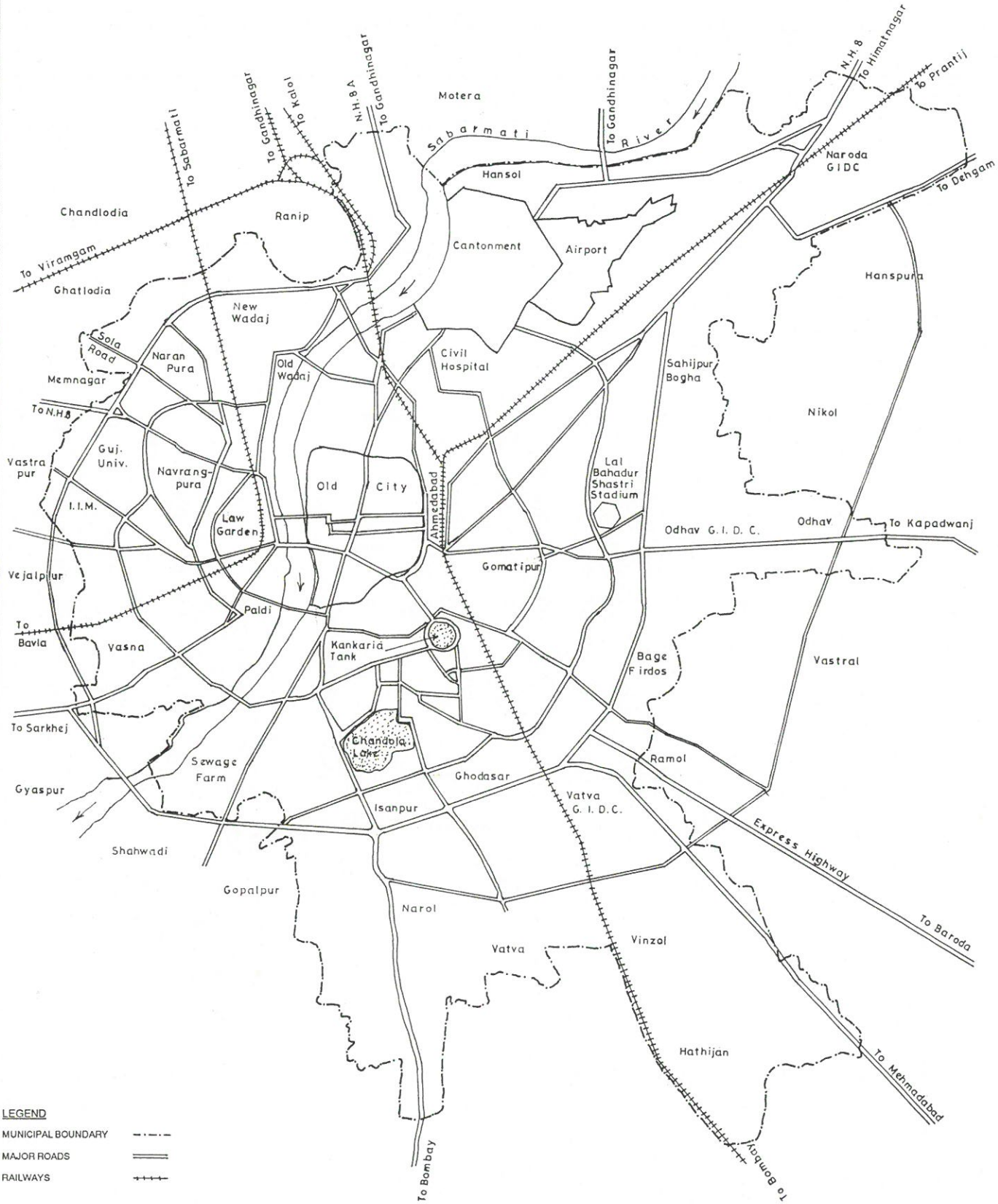
N

Scale 0 1 0 2 4 6 8 Km.

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

AHMEDABAD



LEGEND

MUNICIPAL BOUNDARY

MAJOR ROADS

RAILWAYS

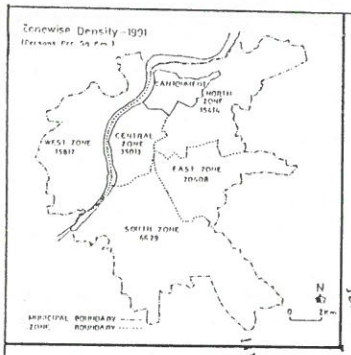
Scale

0 2 5 10 20 Km

N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.



AHMEDABAD

Wardwise Population - 1991

398,410

Motera
Sabarmati River
To Gandhinagar
N.H.8
To Himatnagar
To Prantij
Naroda GIDC
To Dehgam
Hansol
Chandlodia
Ranip
Cantonment
Airport
Hanspura
To Viramgam
Ghatlodia
To Sabarmati
To Kalol
To Gandhinagar
Sola Road
Memnagar
To N.H.8
Naran Pura
New Wadaj
Old Wadaj
Civil Hospital
Sardarpur Barrage
Nikol
Vastrapur
Guj. Univ.
Navrangpura
Old City
Ahmedabad
Lal Bahadur Shastri Stadium
I.I.M.
Law Garden
Odhav G.I.D.C.
Odhav
To Kapadwanj
Vejalpur
Gomati
To Bavla
Vasna
Paldi
Kankaria Tank
Bage Firdos
Vastral
To Sarkhej
Chandola Lake
Sewage Farm
Ramol
Gyaspur
Ghodasar
Isanpur
Vatva G.I.D.C.
Shahwadi
Express Highway
To Baroda
Gopalpur
Narol
Vatva
Vinzol
Hathijan
To Mehmadabad
To Bombay
To Bombay

28,76,710

CITY
1 Cm= 20 000 Persons

LEGEND

WARD BOUNDARY ----

WARD NUMBER 19

Scale
0 .2 .5 1.0 2.0 Km

N

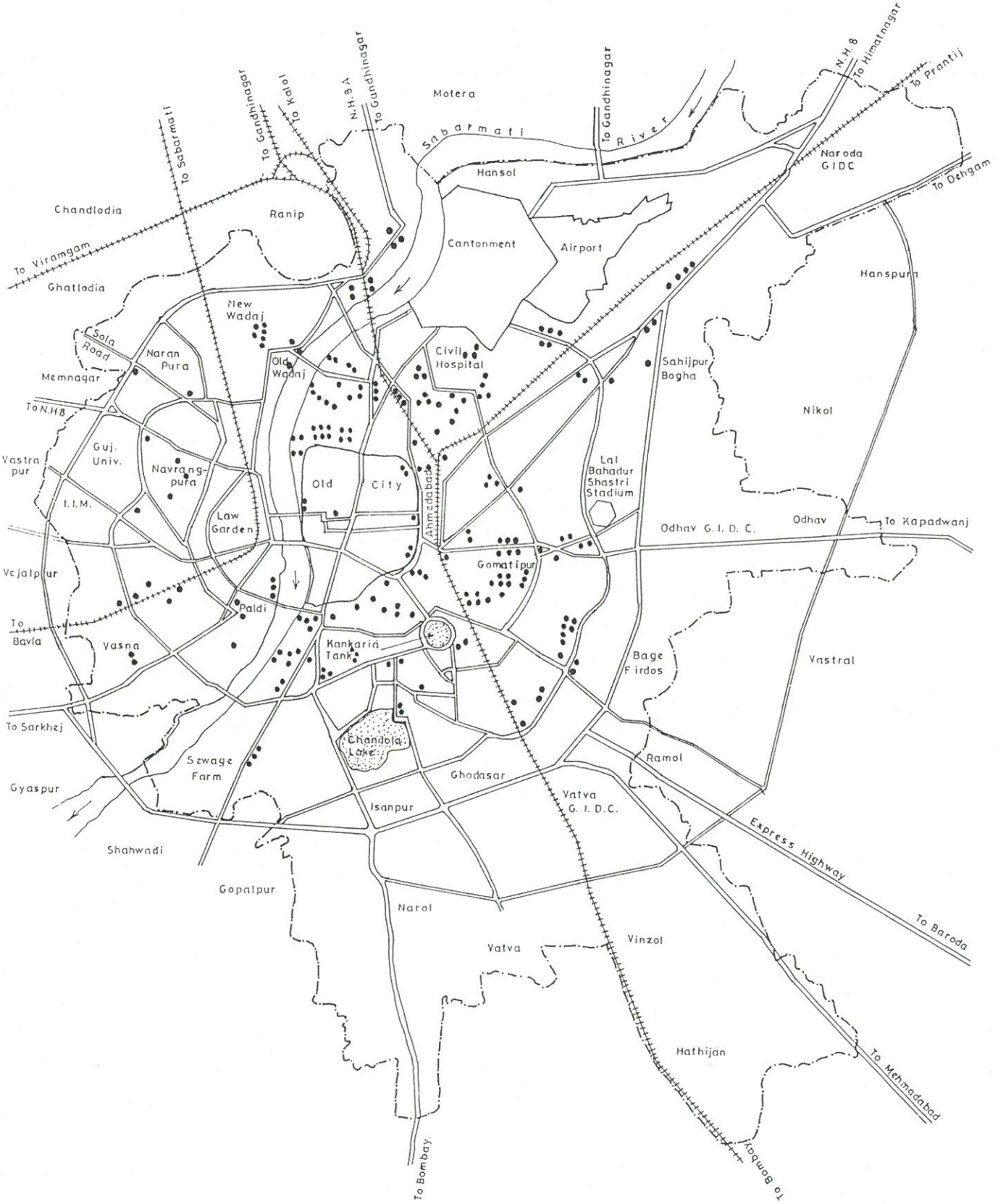
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Statistical Outline of Ahmedabad City (1991-92).

AHMEDABAD

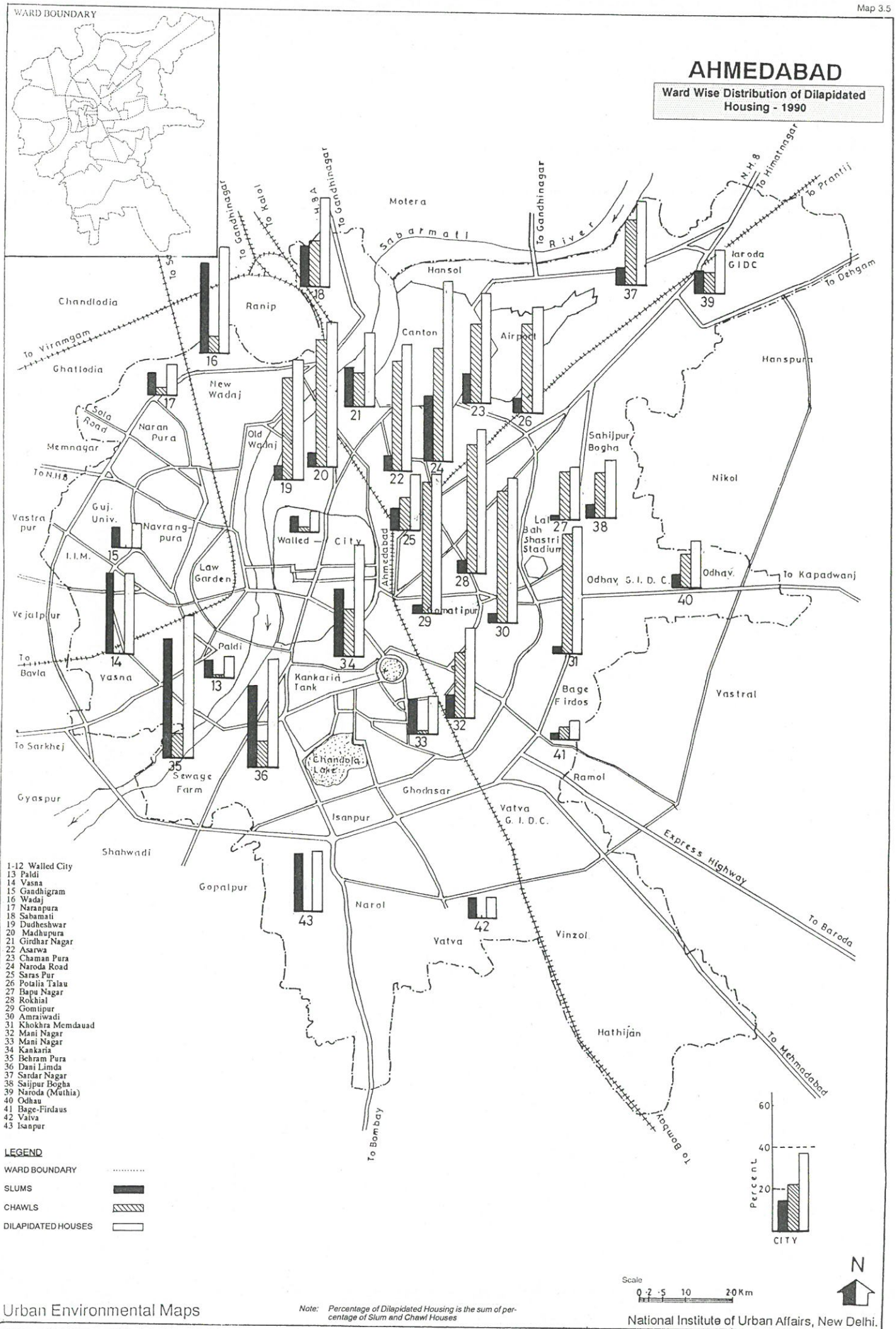
Location of Slums



Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Patel (1977).



Urban Environmental Maps

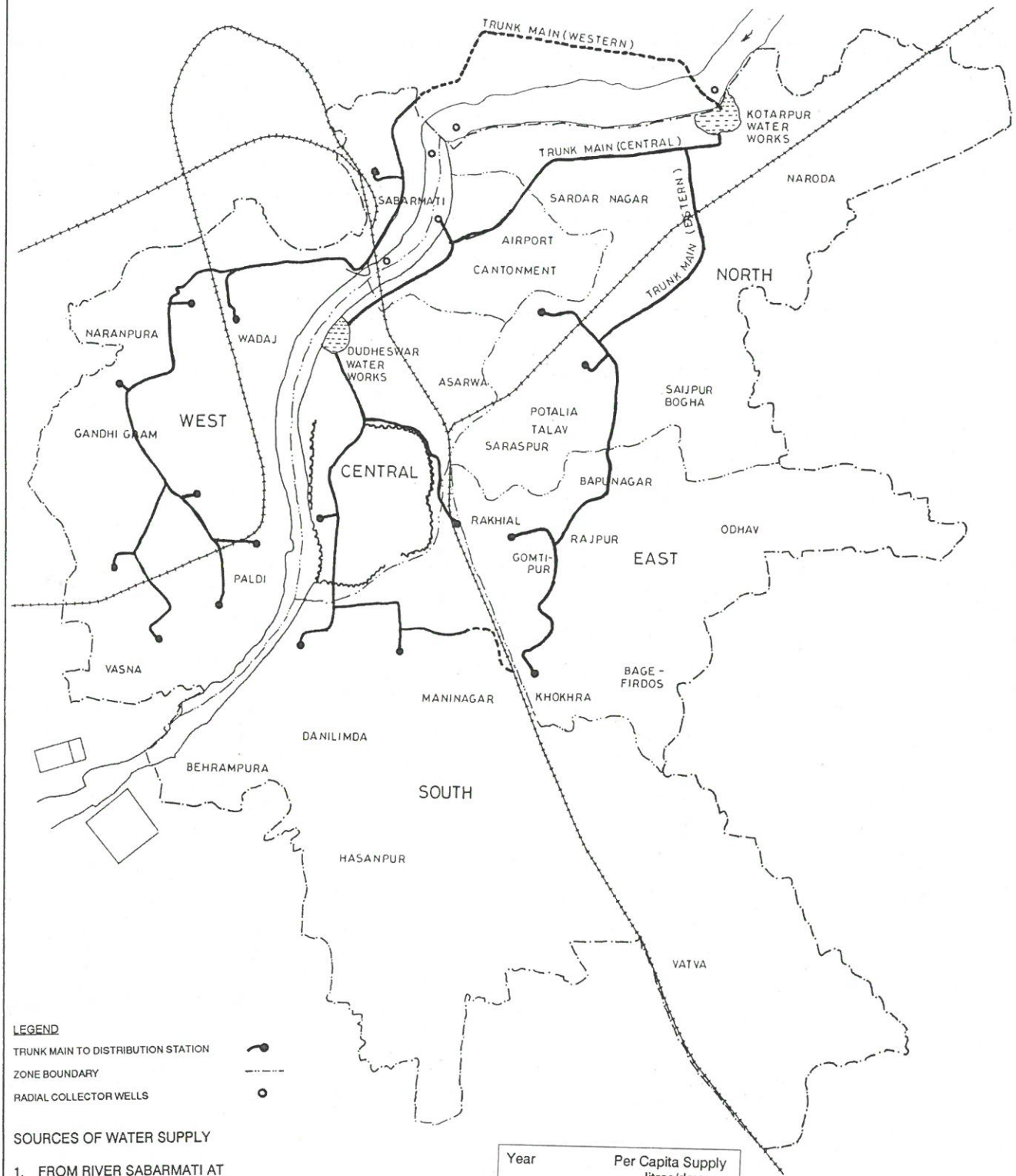
Note: Percentage of Dilapidated Housing is the sum of percentage of Slum and Chawl Houses

National Institute of Urban Affairs, New Delhi.

Source: List of Slums and Chawls in Ahmedabad (1992).

AHMEDABAD

Sources of Water Supply and Distribution Network



LEGEND

TRUNK MAIN TO DISTRIBUTION STATION

ZONE BOUNDARY

RADIAL COLLECTOR WELLS

SOURCES OF WATER SUPPLY

1. FROM RIVER SABARMATI AT DUDHESHWAR WATER WORKS	68	MLD (15 MGD)
2. FROM RADIAL COLLECTOR WELLS - 5 Nos. CONSTRUCTED IN THE BED OF RIVER SABARMATI	114	MLD (25 MGD)
3. FROM 250 Nos. OF TUBEWELLS SCATTERED ALL OVER THE CITY THROUGH ZONAL TUBEWELL STATIONS - 48 Nos.	250	MLD (55 MGD)
TOTAL	432	MLD (95 MGD)

Year	Per Capita Supply litres/day
1951	82
1961	182
1971	209
1981	167
1991	141

Scale

0 2 5 10 20 Km

N

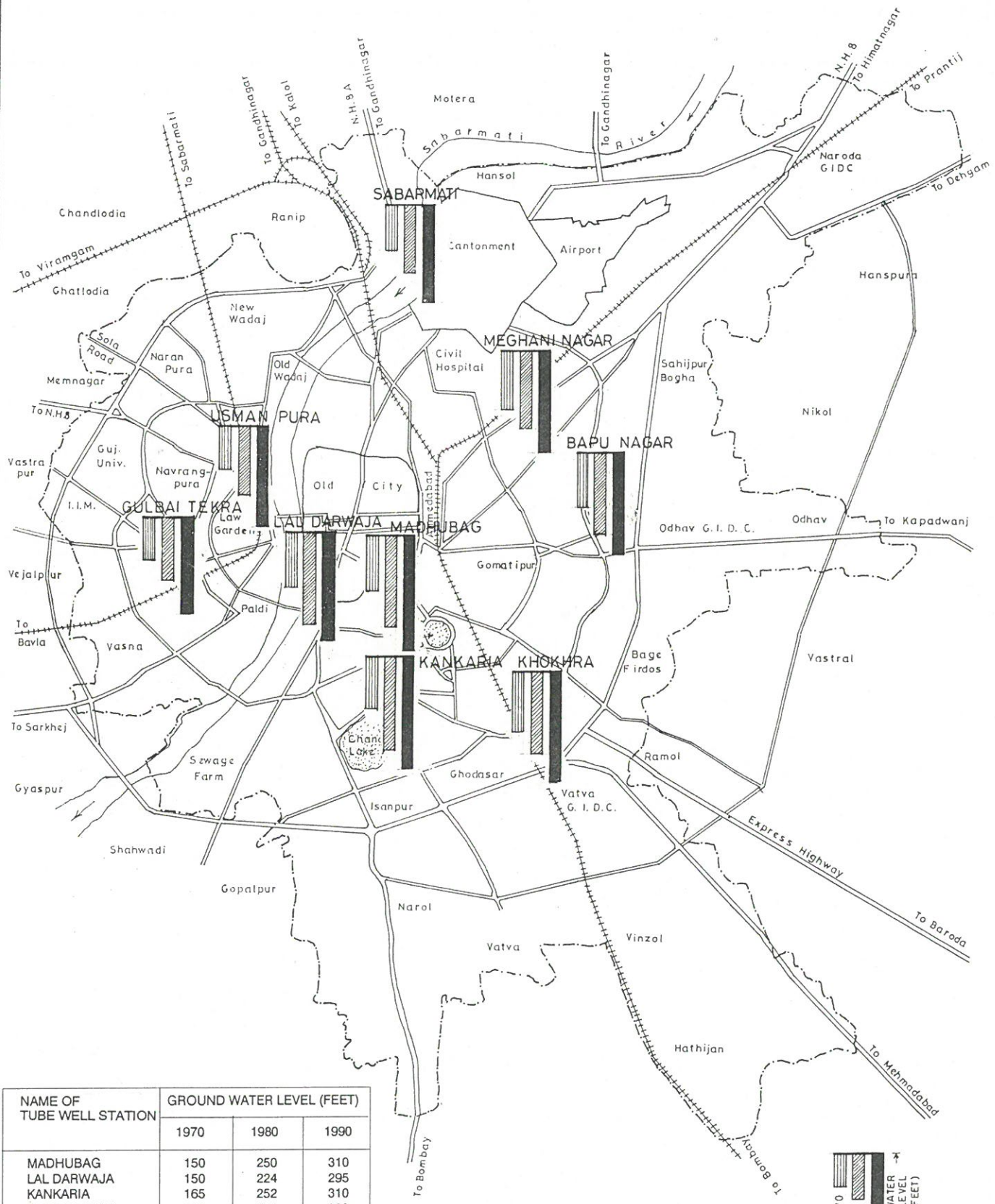
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi

Source: AMC (1993).

AHMEDABAD

Ground Water Level

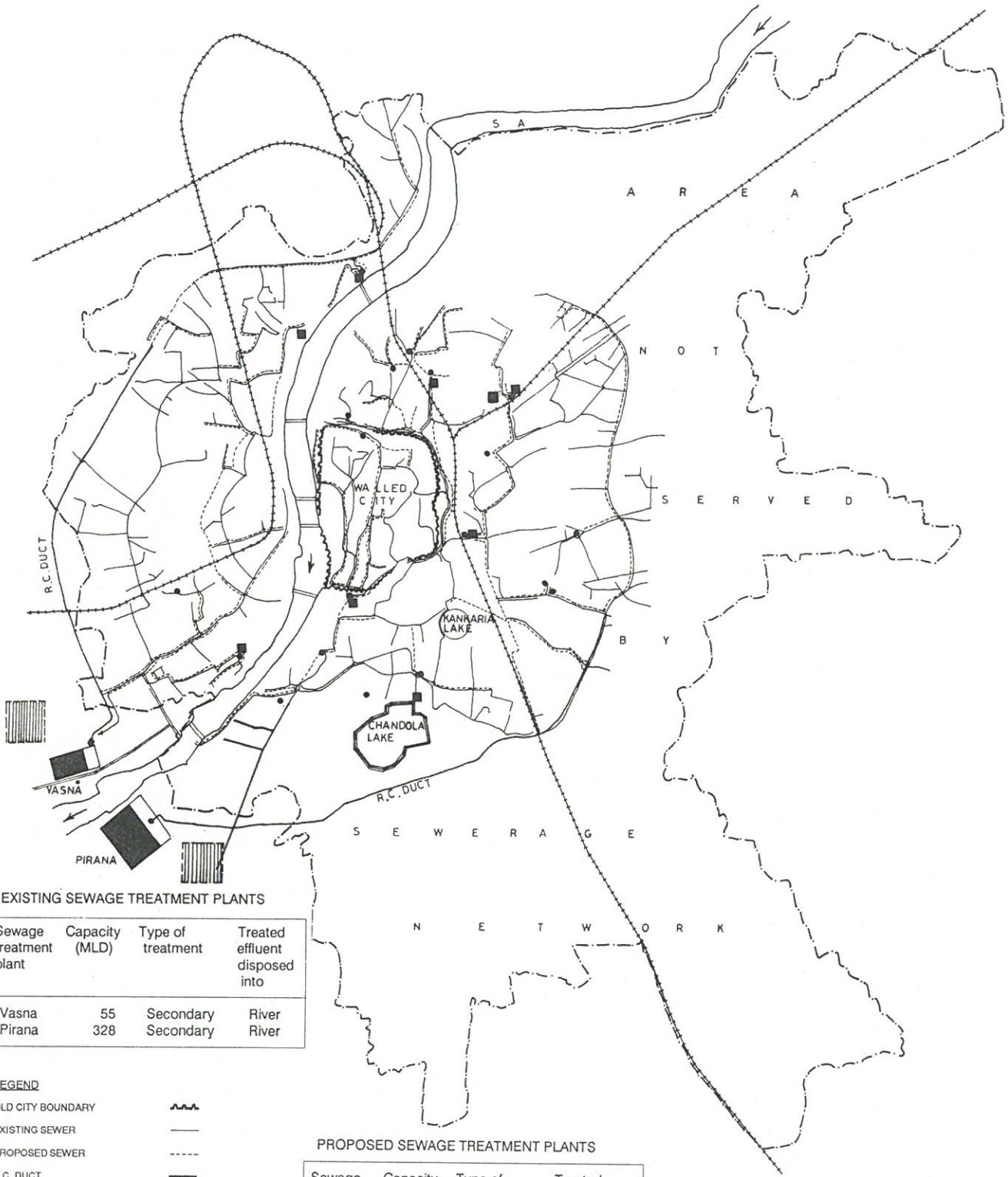


NAME OF TUBE WELL STATION	GROUND WATER LEVEL (FEET)		
	1970	1980	1990
MADHUBAG	150	250	310
LAL DARWAJA	150	224	295
KANKARIA	165	252	310
GULBAI TEKRA	115	170	260
USMAN PURA	120	192	275
SABARMATI	120	185	260
MEGHANI NAGAR	160	210	275
BAPU NAGAR	150	225	280
KHOKHRA	160	224	300

Source: Bhandari, N. et. al. (nd.).

AHMEDABAD

Sewerage Network



EXISTING SEWAGE TREATMENT PLANTS

Sewage treatment plant	Capacity (MLD)	Type of treatment	Treated effluent disposed into
Vasna	55	Secondary	River
Pirana	328	Secondary	River

LEGEND

- OLD CITY BOUNDARY
- EXISTING SEWER
- PROPOSED SEWER
- R.C. DUCT
- EXISTING PUMPING STATIONS
- PROPOSED PUMPING STATIONS
- SEWAGE TREATMENT PLANT
  - EXISTING
  - PROPOSED

PROPOSED SEWAGE TREATMENT PLANTS

Sewage treatment plant	Capacity (MLD)	Type of treatment	Treated effluent to be disposed into
Vasna II	76	Secondary	River
Pirana II	182	Secondary	River

Scale: 0 2.5 5 10 20 Km

N

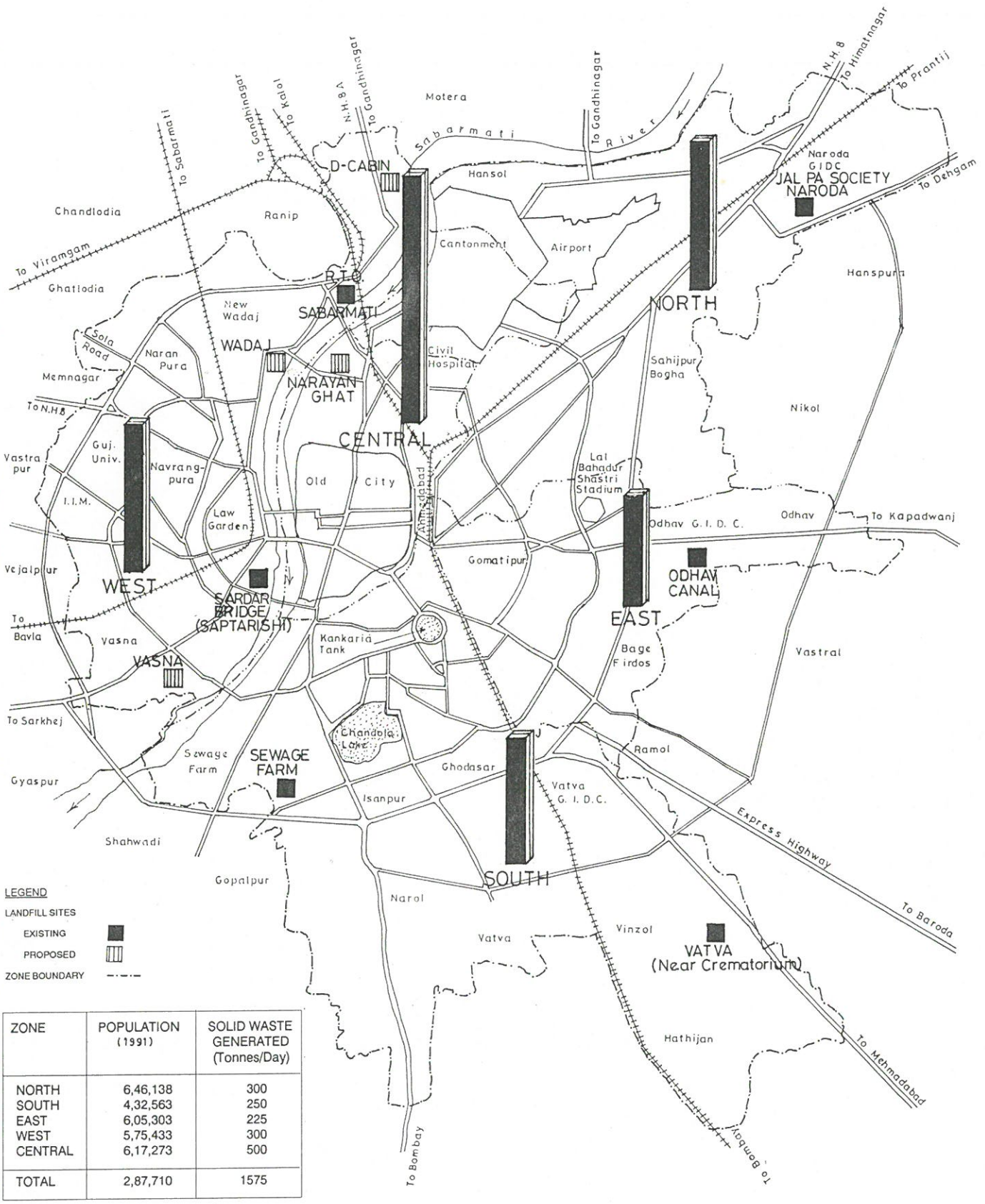
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: AMC (1993).

AHMEDABAD

Landfill Sites



LEGEND

LANDFILL SITES

EXISTING

PROPOSED

ZONE BOUNDARY

ZONE	POPULATION (1991)	SOLID WASTE GENERATED (Tonnes/Day)
NORTH	6,46,138	300
SOUTH	4,32,563	250
EAST	6,05,303	225
WEST	5,75,433	300
CENTRAL	6,17,273	500
TOTAL	2,87,710	1575

Scale 0 · 2 · 5 1·0 2·0 Km

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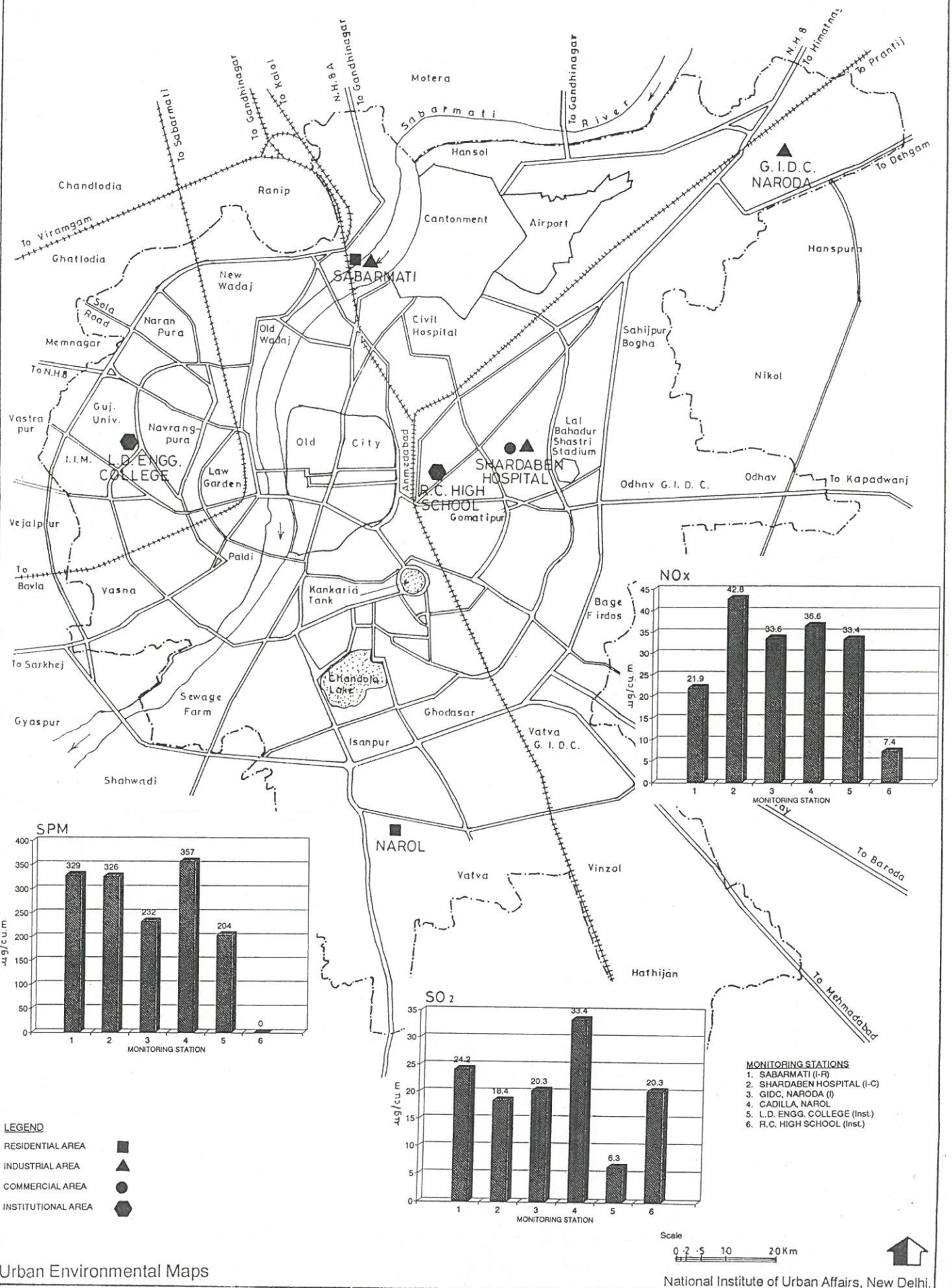
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: AMC (1993).

AHMEDABAD

Ambient Air Quality - 1990
(Annual Mean Values)



Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: CPCB (1990 & 1991).

AHMEDABAD

3.1 The City

The city of Ahmedabad was founded by Sultan Ahmed Shah Abdali in 1411 A.D. on a site close to the old village of Asaval. It grew in wealth and splendour for more than a century. Under the Mughal Empire, the city expanded and many landmarks were created. From 1738 to 1753, the city was ruled jointly by Marathas and Muslims. During this period, the city economy was brought to a standstill due to invasions from Marathas. Under the British rule, Ahmedabad grew as the 'Manchester of India'. The modern textile industry took roots in the city. Growing from 5.72 sq.km. in 1857, the city has expanded to 190.84 sq.km. at present.

3.2 Demography

At the beginning of this century, the city had a population of 1,85,889. In the last ninety years the population of the city has increased to 28,76,710. Although, city's population increased by about 50% during 1971-81 decade, during last decade (1981-91) the population growth rate retarded, registering a growth rate of only about 21%. This has been the lowest rate of growth after independence.

Table 3.1: Population Growth in Area under Ahmedabad Municipal Corporation

Year	Population	Decadal Variation	Decadal Growth Rate (%)
1901	1,85,889	-	-
1911	2,16,777	+30,888	+16.62%
1921	2,74,007	+ 57,230	+ 26.40%
1931	3,82,768	+ 1,08,761	+ 39.69%
1941	5,91,267	+ 2,08,499	+ 54.47%
1951	8,37,165	+ 2,45,890	+ 41.59%
1961	11,49,918	+ 3,12,753	+ 37.36%
1971	15,86,544	+ 4,36,626	+ 37.88%
1981	23,81,655	+ 7,95,111	+ 50.12%
1991	28,76,710	+ 4,95,055	+ 20.79%

Source: Census of India (1991)

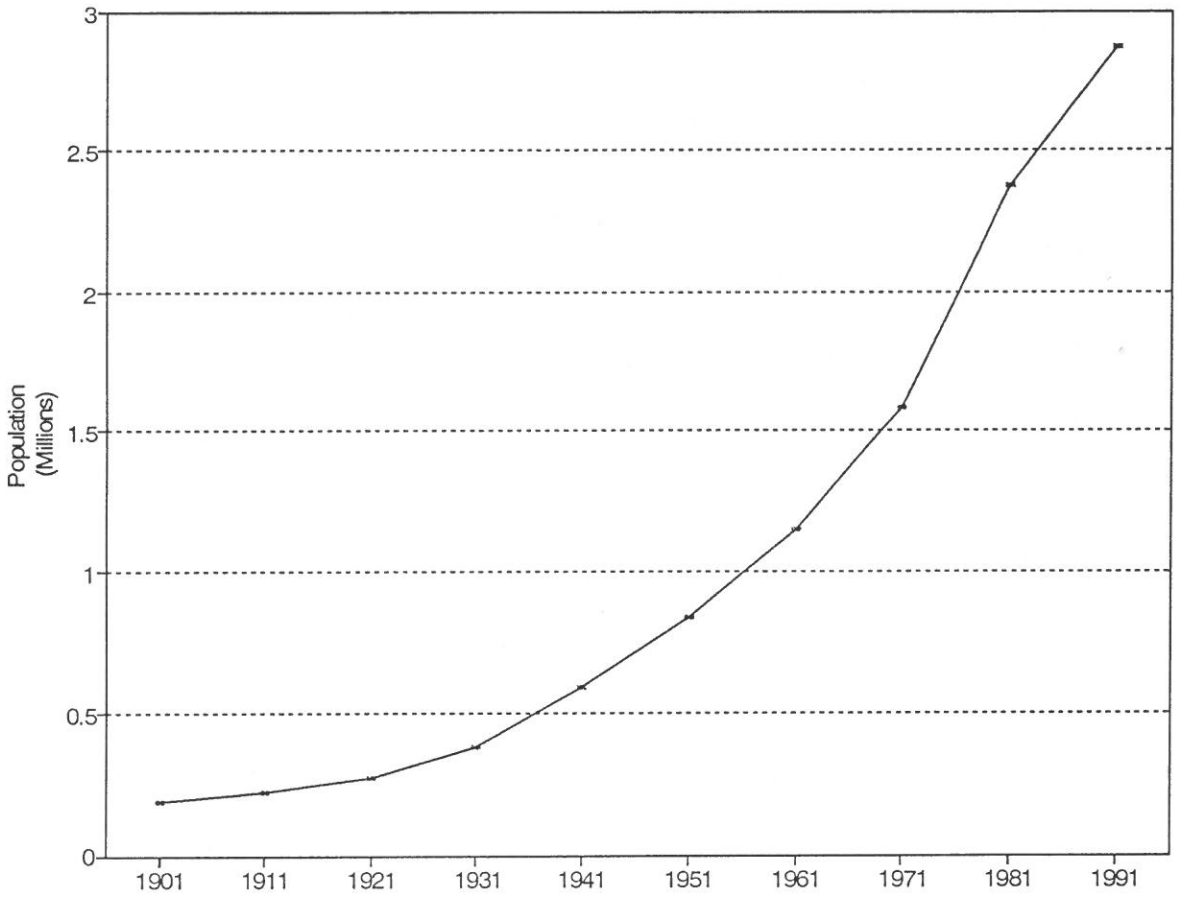


Figure 3.1: Population Growth in Ahmedabad

The entire city is divided into five zones. The central zone has the highest population density of 35013 persons per sq.km and the lowest density in south zone with 6,629 persons per sq.km. The average density for the city is 15,074 persons per sq.km. There are a total of 43 wards in the city - 16 wards in central zone, 6 wards in west zone, 7 wards in north zone, 8 wards in east zone and 6 wards in south zone.

The walled city area (comprising of ward numbers 1 to 12) accommodates 3,98,410 persons (13.9% of the city's population). The walled city, spread over an area of 5.72 sq.km., has a population density of 69652 persons per sq.km.

Table 3.2: Zonewise Area, Population and Density (1991)

S.No.	Zone	Area (sq.km.)	Population	Population Density (persons per sq.km.)
1.	Central Zone	17.63	6,17,273	35013
2.	West Zone	36.38	5,75,433	15817
3.	North Zone	41.92	6,46,138	15414
4.	East Zone	29.66	6,05,303	20408
5.	South Zone	65.25	4,32,563	6629
	Total	190.84	28,76,710	15074

Source: Statistical Outline of Ahmedabad City (1991-92), Ahmedabad Municipal Corporation.

Saijpur Bogha ward has the maximum population in the city - 1,61,349 persons and Kalupur south ward in the walled city has the minimum population - 20,232 persons.

Table 3.3: Wardwise Population in Ahmedabad (1991)

Ward No.	Ward	Population
1	Khadia-1	23155
2	Khadia-2	29575
3	Kalupur-South	20232
4	Kalupur-North	21109
5	Ghee Kanta	24639
6	Dariyapur	26893
7	Vadigam	37172
8	Shahpur	46315

Ward No.	Ward	Population
9	Khanpur	49238
10	Manekchowk	29981
11	Jamalpur	43026
12	Raikhad	47075
13	Paldi	40633
14	Vasna	113793
15	Gandhigram	99001
16	Vadaj	139584
17	Naranpura	101465
18	Sabarmati	80957
19	Dudheshwar	48059
20	Madhupura	50159
21	Girdharnagar	86075
22	Asarwa	34570
23	Chamanpura	98059
24	Naroda	73438
25	Saraspur	27197
26	Potaliya	112112
27	Bapunagar	78442
28	Rakhial	57410
29	Gomtipur	41090
30	Rajpur	85706
31	Amaraiwadi	115821
32	Khokhra-Mehmdabad	91360
33	Maninagar	80158
34	Kankaria	45492
35	Behrampura	80634
36	Danilimda	67639
37	Sardarnagar	116379
38	Saijpur Bogha	161349
39	Naroda Muthiya	57604
40	Odhav	86695
41	Bage Firdaus	48779
42	Vatva	52816
43	Isanpur	105824
	Total	2876710

Source: Statistical Outline of Ahmedabad City (1991-92), Ahmedabad Municipal Corporation

3.3 Slums

In 1990, the total number of slums and chawls in the city was 1023 and 1409 respectively. Behrampura ward had the maximum number of slums (116) and Rajpur ward had maximum number of chawls (173). Out of the total housing stock of 6,15,316 in AMC, 2,28,94 (37.20%) houses are in slums and chawls. Chamanpura ward in north zone has 84.7% dilapidated houses. Out of the total 43 wards in the city, 14 wards have more than 50% of houses which are dilapidated.

Table 3.4: Wardwise Total Housing Stock, Percentage of Dilapidated Houses (Slum and Chawl Houses) - 1990

Ward no.	Ward Name	No.of Slums	No.of Chawls	Total housing stock	Percentage of houses as		Percentage dilapidated housing
					Slums	Chawls	
1.	Khadia I	1	0	3415	10.5	0.0	10.5
2.	Khadia II	0	0	5349	0.0	0.0	0.0
3.	Kalupur (South)	0	0	3068	0.0	0.0	0.0
4.	Kalupur (North)	1	0	4157	0.3	0.0	0.3
5.	Gheekanta	2	9	4781	0.5	7.4	7.9
6.	Dariapur	0	0	4084	0.0	0.0	0.0
7.	Vadigam	9	6	4882	3.3	2.4	5.7
8.	Shahpur	17	7	6970	7.1	2.9	10.0
9.	Khanpur	5	7	8981	0.2	1.6	1.8
10.	Manek Chowk	1	2	4567	4.6	5.1	9.7
11.	Jamalpur	7	11	5805	20.9	5.1	26.0
12.	Raikhad	22	5	8886	8.9	1.5	10.4
13.	Paldi	16	8	10256	38.8	0.3	39.1
14.	Vasna	56	1	17548	10.3	1.3	11.6
15.	Gandhigram	28	2	26004	42.3	7.7	50.0
16.	Wadaj	55	17	21633	11.2	4.1	15.3
17.	Naranpura	17	8	24492	19.6	22.6	42.5
18.	Sabarmati	55	72	16673	7.5	48.5	56.0
19.	Dudheshwar	15	40	9710	7.7	60.6	67.7
20.	Madhupura	18	65	10517	19.2	15.9	35.1
21.	Girdhar Nagar	35	37	17219	7.5	52.3	59.8
22.	Asarwa	23	32	7319	14.6	37.4	52.0
23.	Chamanpura	36	61	18602	31.1	53.6	84.7
24.	Naroda Road	38	74	16378	10.8	16.5	27.3
25.	Saraspur	10	13	4697	7.6	42.6	50.2
26.	Potalia Talav	24	83	21333	1.8	22.8	24.6
27.	Bapu Nagar	3	28	14771	6.9	63.2	70.1
28.	Rakhial	18	57	13776	3.5	64.9	68.4
29.	Gomtipur	3	47	7817	5.2	65.0	70.2
30.	Rajpur	20	110	21028	3.7	57.9	61.6
31.	Amraiwadi	23	173	31759	11.5	31.5	43.0
32.	Khokhra Mehmdabad	36	62	17929	16.2	2.5	18.7
33.	Maninagar	29	11	11913	32.2	22.1	54.3
34.	Kankaria	49	23	8850	56.7	11.6	68.3
35.	Behrampura	116	31	18853	38.8	12.6	51.4
36.	Dani Limda	55	36	16717			
37.	Sardar Nagar	22	64	28982	8.5	31.1	39.6
38.	Saijpur Bogha	21	128	35728	6.4	22.0	28.4

Ward no.	Ward Name	No.of Slums	No.of Chawls	Total housing stock	Percentage of houses as		Percentage dilapidated housing
					Slums	Chawls	
39.	Naroda (Muthia)	21	20	13216	10.9	10.2	21.1
40.	Odhav	29	41	239358	6.6	16.5	23.1
41.	Bage-Firdaus	3	14	13085	3.4	6.4	10.0
42.	Vatva	23	1	20220	9.8	0.3	10.1
43.	Isanpur	61	3	29209	27.8	1.3	29.1
	City Total	1023	1409	615316	15.0	22.2	37.2

Source : ASAG (1992), List of Slums and Chawls in Ahmedabad, Prepared for Ahmedabad Municipal Corporation.

Table 3.5: Zonewise Number of Slums and Chawls (1990)

Zone	No.of Slums	No.of Chawls
North Zone	172 (16.8%)	443 (31.4%)
South Zone	333 (32.6%)	105 (7.4%)
East Zone	135 (13.2%)	532 (37.8%)
West Zone	227 (22.2%)	108 (7.7%)
Central Zone	156 (15.2%)	221 (15.7%)
Total	1023 (100%)	1409 (100%)

3.4 Water Supply

Systematic water supply system for the city was completed at Dudheshwar in the year 1891. As a result of rapid population growth, the demand for water has been increasing. To fulfill the demand the Ahmedabad Municipal Corporation (AMC) had to augment the water suply at periodic intervals. At present, AMC is supplying 432 mld water to a population of about 29 lakhs.

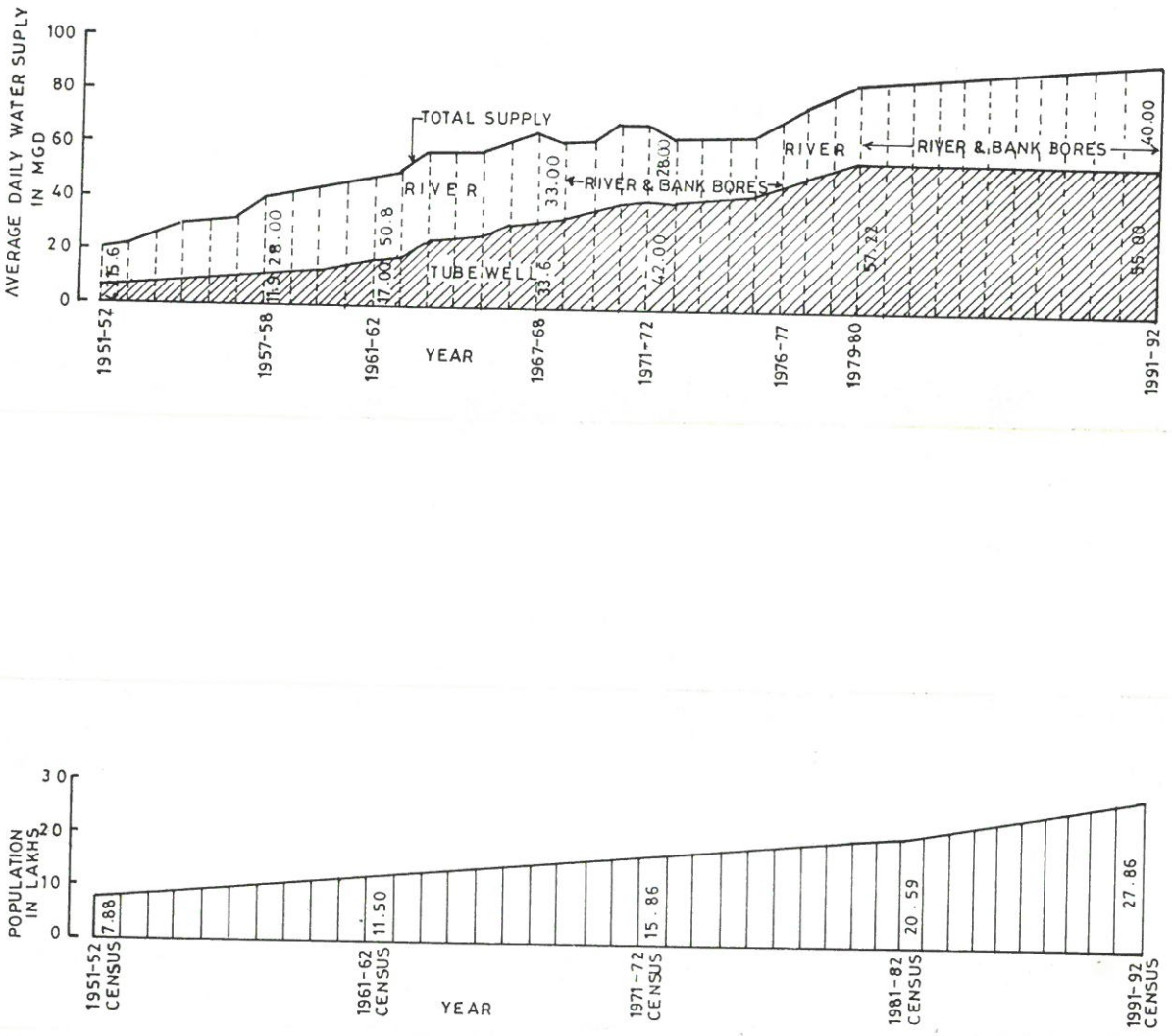


Fig. 3.2 : Average daily water supply from tube wells and river bank bores (Top) and population (Bottom) from 1951 to 1991, for the city of Ahmedabad.

Source: Bhandari, N., et. al., Hydrological Investigations in Sabarmati and Mahi Basins.

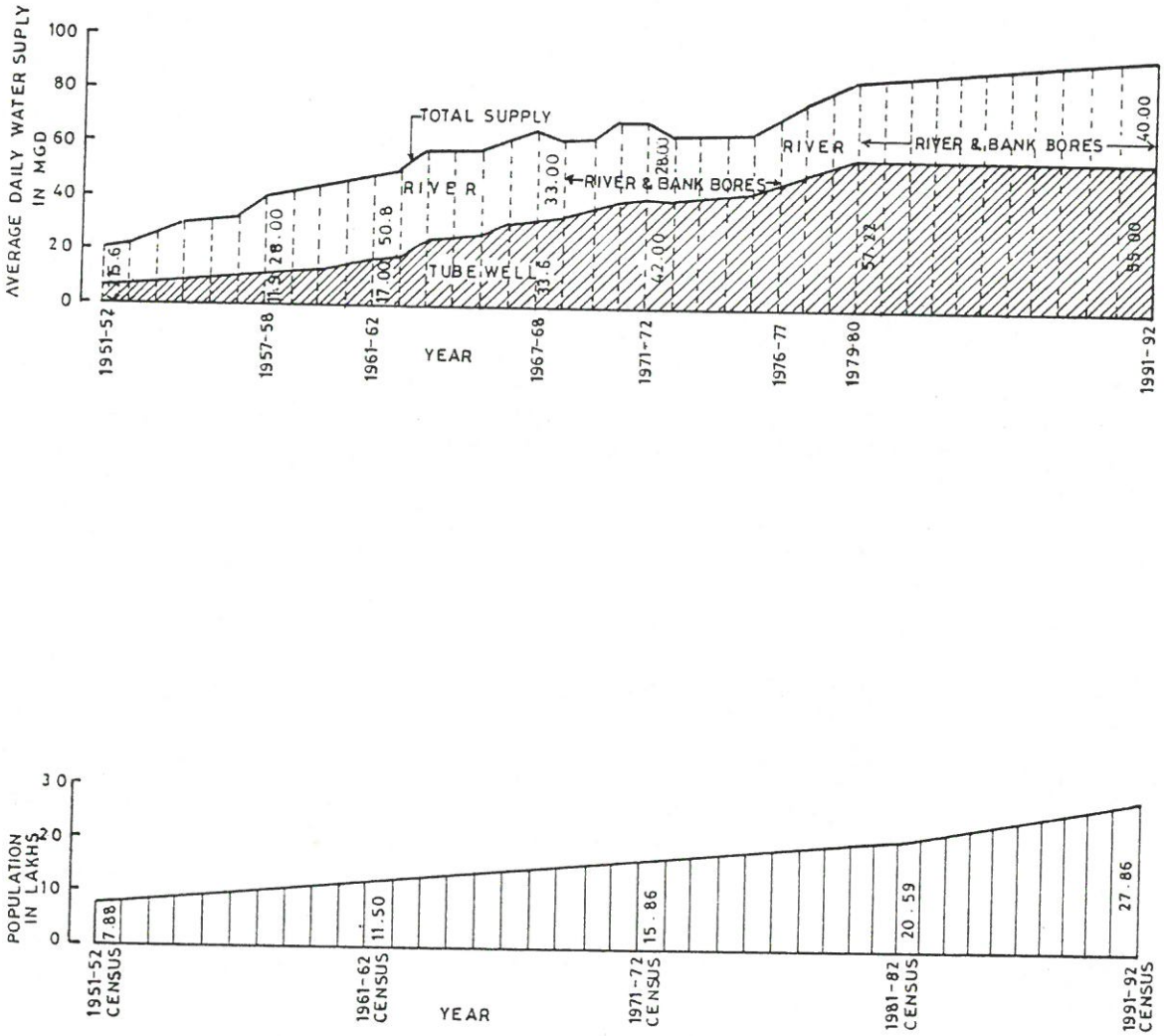


Fig. 3.2 : Average daily water supply from tube wells and river bank bores (Top) and population (Bottom) from 1951 to 1991, for the city of Ahmedabad.

Source: Bhandari, N., et. al., Hydrological Investigations in Sabarmati and Mahi Basins.

Table 3.6: Existing Sources of Water Supply

	Source	Supply (mld)
1.	River Sabarmati at Dudheshwar Water Works	68
2.	Radial Collector Wells - 5 Nos. (Constructed in the bed of river Sabarmati)	114
3.	Tubewells (250 nos.) scattered all over the city through Zonal tubewells stations (48 nos.)	250
	Total	432

Source : AMC (1993)

Table 3.7: Per Capita Water Availability

Year	Per capita supply (litres/day)
1951	82
1961	182
1971	209
1981	167
1991	141

Source: AMC (1993)

Table 3.8: Length of Pipeline, Number of Connections and Water Consumption Pattern in Ahmedabad

Year	Length of Pipeline (km)	Number of Water Connections	Average Daily Consumption of Filtered Water (Million Litres)			
			Total	Non-Metered	Metered	Others (Public Taps etc.)
1979-80	1,543	1,40,895	385.5	345.7	8.2	31.6
1984-85	1,818	1,75,256	459.1	409.9	11.3	37.9
1989-90	2,034	1,96,467	431.3	418.4	3.5	9.4

Source: Statistical Outline of Ahmedabad City (1991-92), Ahmedabad Municipal Corporation

Because of phenomenol growth in population and in view of the vagaries of rainfall affecting the availability of water in Sabarmati river, the usage of ground water in Ahmedabad has been increasing. The industries also started getting their supply by constructing tubewells. The use of ground water by the industries increased from 11.35 mld during 1951-51 to 45.44 mld in 1961-62.

Figure 3.2 shows the average daily water supply by the AMC. It is to be noted that the ground water component which was 4.7 mgd in 1951-52 had increased to 57.22 mgd in 1979-80. As of today, out of a total supply of 495 mgd, 40 mgd (42%) is being supplied from river and bank bores and the rest 55 mgd (58%) is from tubewells scattered all over the city.

The ground water level in the city is continuously going down because of excessive withdrawl of ground water. (Table 3.9). In the central zone, from are average water level of 100 feet in 1965, the water level has gone down to about 300 feet in 1990. Similarly in the western and eastern zones, there has been an increase in the depth of ground water table. At Lal Darwaja in central zone, the water level has fallen by more than eight feet every year during the period 1965 to 1990. The energy consumption has also been increasing considerably as the water is to be pumped from a greater depth. Also the tubewells have to be deepened every few years, which again add to the cost.

Table 3.9: Ground Water Level

	Name of Station	Static Water Level (Feet)					
		1965	1970	1975	1980	1985	1990
A.	**Central Zone**						
1.	Madhubag	115	150	210	250	275	310
2.	New Subborn	100	160	190	215	272	285
3.	Lal Darwaja	85	150	186	224	252	295
4.	Kankaria	110	165	205	252	260	310
B.	**Western Zone**						
1.	Jawahar Nagar	70	120	150	170	200	250
2.	Gulbai Tekra	75	115	150	170	220	260
3.	Usmanpura	65	120	165	190	240	275
4.	Sabarmati	80	120	150	185	238	260
C.	**Eastern Zone**						
1.	Meghani Nagar	100	160	100	210	260	275
2.	Bapu Nagar	90	150	175	225	266	280
3.	Subhas Nagar	90	160	195	228	270	285
4.	Khokhra	120	160	190	224	270	300

Source: AMC (1991)

Confronted with over withdrawl of ground water and less flow of Sabarmati river at Ahmedabad, the AMC has participated with the Govt. of Gujarat in the construction of Dharoi Reservoir on river Sabarmati 150 km upstream of Kotarpur. On completion in 1995, this will release 680 mld of water for Kotarpur Water Works. The estimated cost of this project is Rs.72 crores.

3.5 Sewerage

At present, there are two sewage treatment plants in the city viz. Vasna and Pirana. These plants are located on western and eastern banks of river Sabarmati.

Almost the entire newly added East Ahmedabad is devoid of any distribution network. Most of the area of East Ahmedabad is covered by a number of industries in three industrial estates of Naroda, Odhav and Vatva.

Table 3.10: Existing Sewage Treatment Plants

Sewage Treatment Plant		Capacity (MLD)	Type of Treatment	Treated effluent disposed into
1.	Vasna	54.47	Secondary	River
2.	Pirana	327.31	Secondary	River
	Total	381.78		

Source: AMC (1993)

The newly added East Ahmedabad in the AMC does not have any sewerage network. At Vasna and Pirana, two more Sewage Treatment Plants are being constructed with a capacity of 75.8 mld and 181.8 mld respectively, adding 257.6 mld capacity to the existing sewage treatment capacity. The city has, at present, 20 pumping stations. Seven new pumping stations are being constructed to improve the present sewerage network.

Table 3.11: Length of Sewer Lines and Storm Water Drains(SWD) in Ahmedabad

Year	Length of Sewer Lines (km)	Length of Sewer Lines Per sq.km	Length of Strom Water Drains (km)	Length of SWD Per sq.km.
1979-80	905	9.22	214	2.18
1984-85	969	9.87	252	2.57
1989-90	1,041	5.47	260	1.37

Source: Statistical Outlines of Ahmedabad City (1991-92), Ahmedabad Municipal Corporation.

3.6 Solid Waste

The solid waste collected by the AMC is 1575 tonnes/day, giving an average of about 550 grams per capita per day. Almost all the waste is disposed on landfill sites.

Table 3.12: Collection of Solid Waste (April '92 - March '93)

Month	Avg. Daily Collection (Tonnes)
1992	
April	1372
May	1588
June	1744
July	1521
August	2029
September	1558
October	1587
November	1668
December	1244
1993	
January	1035
February	1502
March	1450
Annual Average	1542 tonnes/day

Source: AMC (1993)

Table 3.13: Landfill sites

	Existing		Future
1.	R.T.O. Sabarmati	1.	Vasna
2.	Sardar Bridge	2.	'D' Cabin
3.	Vatva near Crematorium	3.	Wadaj
4.	Sewage Farm	4.	Narayan Ghat
5.	Odhav Canal		
6.	Jalpa Society, Naroda		

Source: AMC (1993)

The solid waste collection service is not extended to slums and chawls on a regular basis where cleaning is done periodically. The industrial waste from various industries is quite often disposed off in open areas which ultimately find their way to sanitary landfill sites.

Almost all the hospital waste generated by various hospitals and private nursing homes is also dumped alongwith municipal solid waste. The sanitary landfill sites thus pose a serious threat to the health of the citizens of Ahmedabad.

3.7 Ambient Air Quality

The annual mean values of SPM for the residential areas in Ahmedabad are higher than the standard limit, while those for industrial areas are well within the standard limits. For SO_2 and NO_X, the annual mean values are well within the limit for residential and industrial areas.

Table 3.14: Ambient Concentration of Air Pollutants

	Monitoring Station	Year	Annual Mean Concentration (ug/cu.m)		
			SPM	SO_2	NO_x
1.	Cadilla, Narol	1989	327	54.5	35.8
	(Ind.)	1990	357	33.4	36.6
2.	L.D. Engg. College	1989	251	10.1	40.4
	(Resi)	1990	204	6.3	33.4
3.	Shardaben Hosp.	1989	340	26.1	50.8
	(Ind.)	1990	326	18.4	42.8
4.	GIDC, Naroda	1989	232	24.7	50.1
	(Ind - Comm.)	1990	232	20.3	27.9
5.	AECO, Sabarmati	1989	363	19.5	36.9
	(Ind - Resi)	1990	329	24.2	21.9

Source : CPCB.

Vehicular Pollution

With the growing number of vehicles, there has been an increase in vehicular emission. Many roads in the walled city area such as Relief Road and Gandhi Road have become polluted. As per an estimate of CPCB, the total vehicular pollution load in Ahmedabad was 209.13 tonnes/day in 1987-88 (Table 3.15).

There are about 37,000 auto-rickshaws in Ahmedabad which are supposed to use petrol as fuel but in practice a large majority of them mix kerosene with petrol creating to serious air pollution problem in the city.

Another major source of air pollution in Ahmedabad is the large number of industries in the three industrial estates of Naroda, Odhav and Vatva and textile mills spread all over the city.

Table 3.15: Vehicular Pollution Load in Ahmedabad (1987-88)

S.No	Category of Vehicles	No.of Registered Vehicles	Pollution Load (Tonnes/day)				
			PM	SO2	NOX	CO	HC
A.	**Petrol Driven**						
	Two Wheelers	2,16,338	0.74	0.074	0.259	59.61	37.05
	Three Wheelers	27,652	0.28	0.028	0.097	29.73	13.99
	Four Wheelers	43,766	0.32	0.077	3.110	38.88	5.80
	Total (A)	2,87,756	1.34	0.179	3.466	128.22	56.84
B.	**Diesel Driven**						
	Buses	18,469	0.134	0.268	3.757	2.270	0.376
	Light and Medium Goods Vehicles	5,219	0.140	0.122	0.310	0.344	0.087
	Trucks	11,147	0.220	0.440	6.237	3.770	0.624
	Total (B)	34,835	0.494	0.830	10.304	6.384	1.086
	Grand Total (A+B)	3,22,591	1.834	1.009	13.770	134.604	57.926

Total Vehicular Pollution Load = 209.13 tonnes/day

Source: CPCB (1988-89), Assessment of Vehicular Pollution in Metropolitan Cities, Part XIII, Ahmedabad

3.8 Health

In city of Ahmedabad has a number of general hospitals and specialised hospitals. It has municipal dispensaries (allopathy, ayurvedic and unani), maternity homes and dental clinics. There are also 408 registered nursing homes in different parts of the city.

Table 3.16: Hospitals, Number of Beds and Cases Treated in Ahmedabad (1991)

	Hospital	Number of Beds	Number of Indoor Patients
1.	Civil Hospital	1,470	62,672
2.	V.S. General Hospital	945	50,639
3.	L.G. General Hospital	403	25,722
4.	Shardaben Hospital	406	22,394
5.	Nagari Eye Hospital	100	4,978
6.	Infections Diseases Hospital	110	2,001
7.	New Chest Clinic	32	720
	Total	3,466	1,69,126

Source: Statistical Outline of Ahmedabad City (1991-92), Ahmedabad Municipal Corporation.

There are a total 3,466 beds available in various general and specialised hospitals. In addition to this, another 460 beds are available in 18 municipal maternity homes and 3,703 beds in registered nursing homes.

Table 3.17 indicates that during the period 1989 to 1992 the maximum cases and deaths have occured due to gastro-enteritis. Another prevelant disease is viral-hepatitis. The number of cases of typhoid have increased considerably during last two years viz 1991 and 1992.

Table 3.17: Yearwise Cases and Deaths due to Various Diseases in Ahmedabad

	Disease	1989		1990		1991		1992	
		Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
1.	Typhoid	91	7	144	10	1227	9	1133	9
2.	Cholera	172	6	78	1	38	0	35	0
3.	Gastro-Enteritis	7263	148	6760	134	4938	58	4916	28
4.	Diptheria	381	29	222	11	244	9	169	7
5.	Measles	392	86	15	1	260	14	102	5
6.	Viral Hepatitis	2001	140	2109	131	933	48	854	24
	Total	10300	416	9328	288	7640	138	7209	73

Source: Ahmedabad Municipal Corporation (1993)

Summing Up

Ahmedabad, the Manchester of India, is not among the fast growing cities of the country. Its walled city area is very congested and has very high densities. The newer parts of the city, however, are much more open and have lower densities. Ahmedabed also has about one-third of its population living in slums and chawls.

Water supply in Ahmedabad is increasingly becoming problematic. Due to the vagaries of rainfall in the catchment area of river Sabarmati, the ground water has been exploited to a greater extent. Consequently, the ground water level has gone down significantly. The entire eastern part of Ahmedabad is devoid of any sewerage system while the western part is much better served be sewerage system. Solid waste collection system in the city is reasonably good. However, hospital wastes are not disposed off separately.

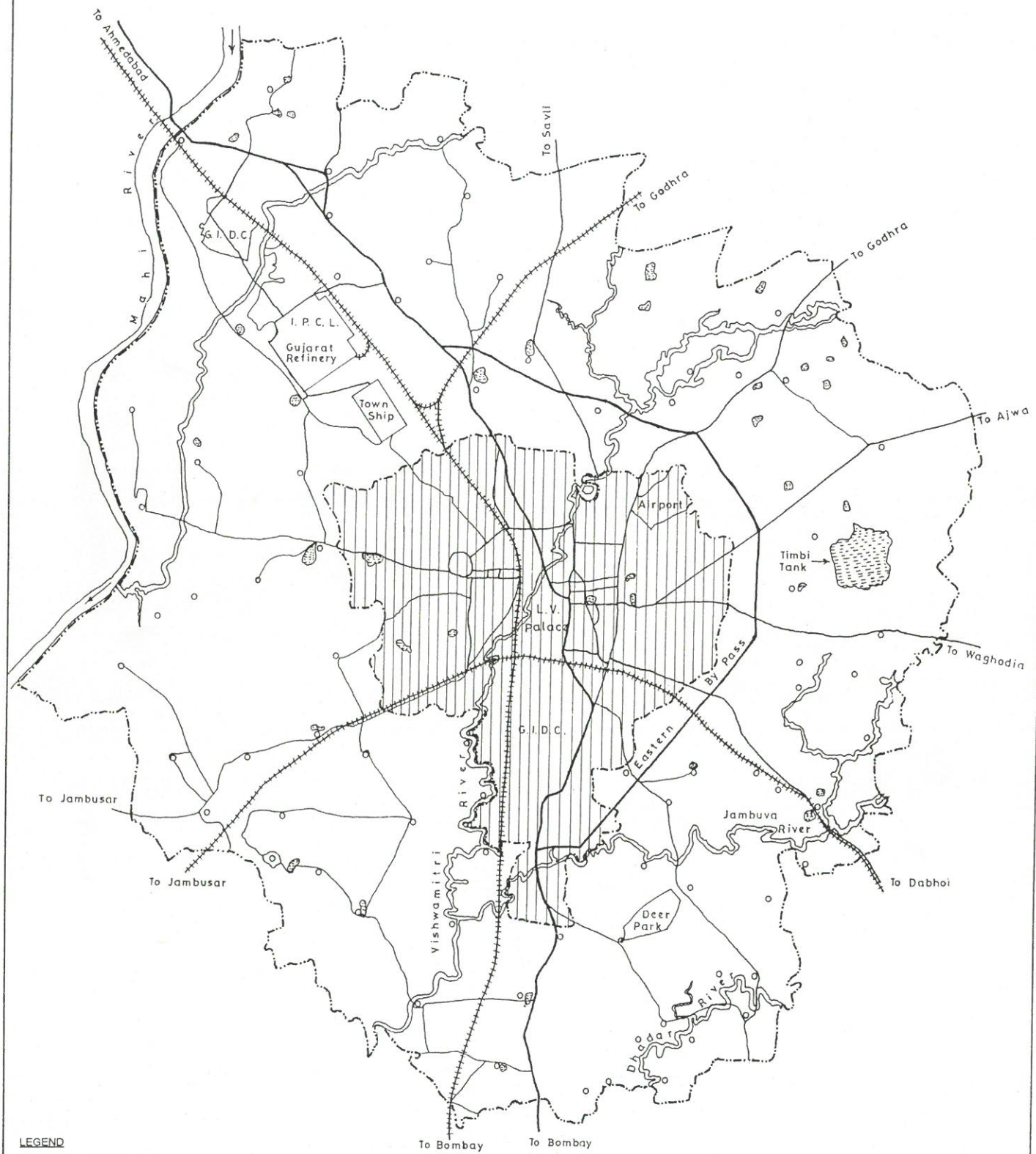
Ahmedabad has a very large number of two-wheeler vehicles. The number of motorised vehicles is also incereasing continuously. Due to an increase in the number of vehicles, the average speed in the city has come down significantly. This is adsversely affecting the city's quality of air. Most of the three-wheelers mix kerosene with petrol as fuel, which makes the air quality much worse.

Overall, the eastern part of the city predominantly exhibits poor living conditions when compared to the westen part of the city.

VADODARA

VADODARA

Urban Development Area



LEGEND

- VADODARA URBAN DEV. LIMIT
- VADODARA MUNICIPAL CORP. LIMIT
- MAJOR ROADS
- OTHER ROADS
- RAILWAYS
- RIVER
- WATER BODIES
- VILLAGE

Scale .5 0 1 2 3 4 Km.

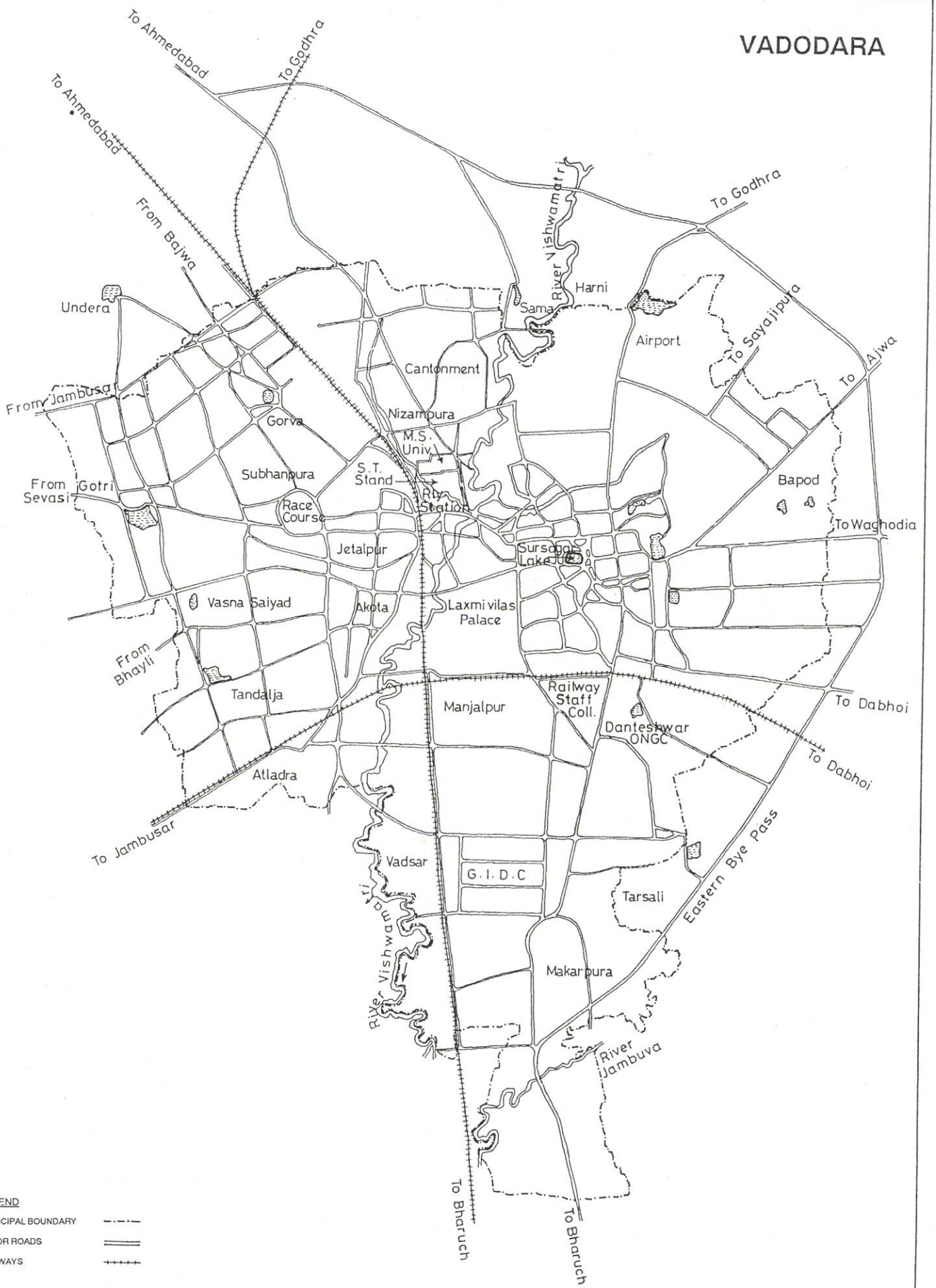
N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: VUDA Atlas (n.d.).

VADODARA



LEGEND

MUNICIPAL BOUNDARY

MAJOR ROADS

RAILWAYS

Scale

1·0 0·5 0 1 2 Km.

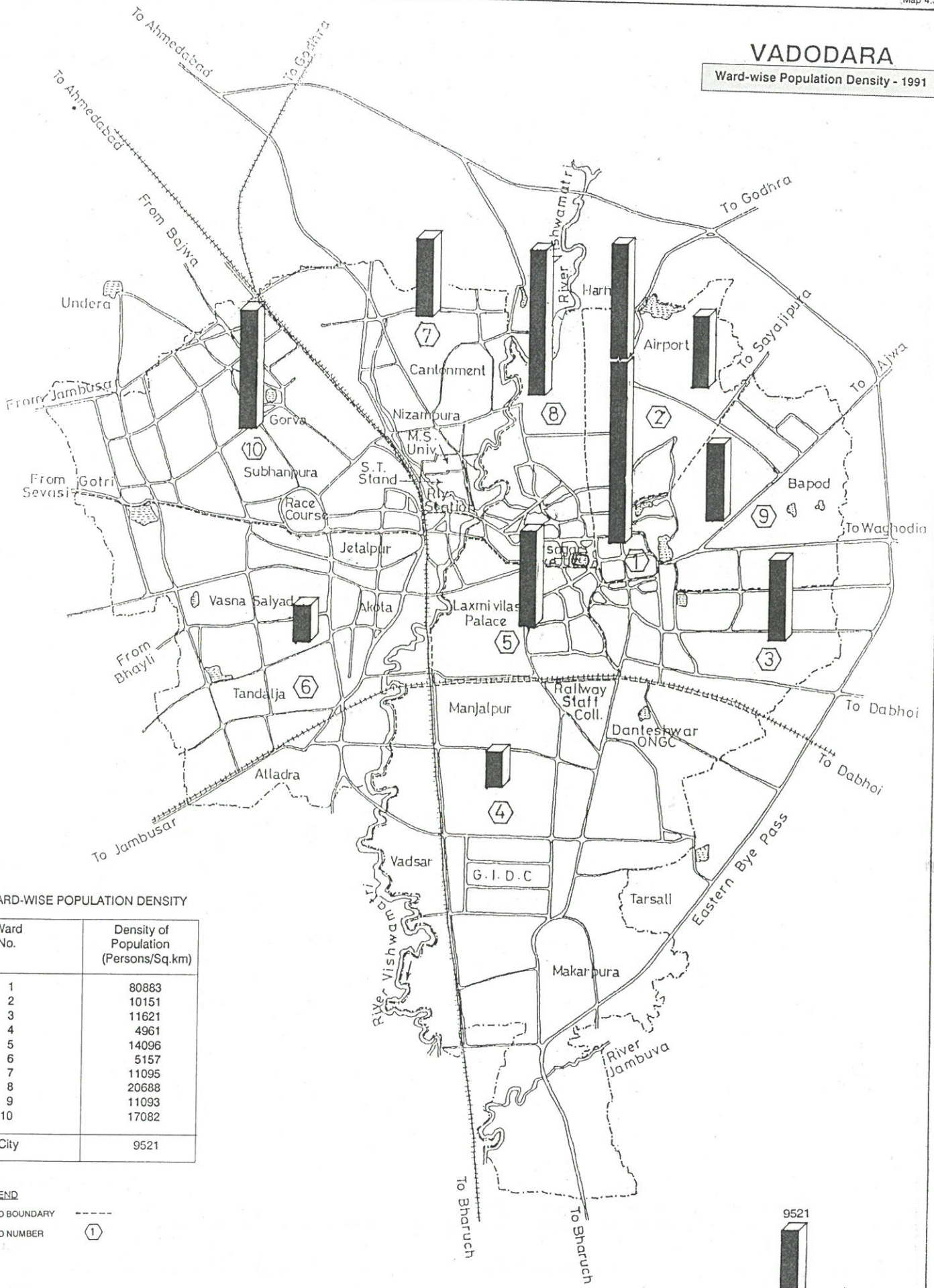
N

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

VADODARA

Ward-wise Population Density - 1991



WARD-WISE POPULATION DENSITY

Ward No.	Density of Population (Persons/Sq.km)
1	80883
2	10151
3	11621
4	4961
5	14096
6	5157
7	11095
8	20688
9	11093
10	17082
City	9521

LEGEND

WARD BOUNDARY -----

WARD NUMBER (1)

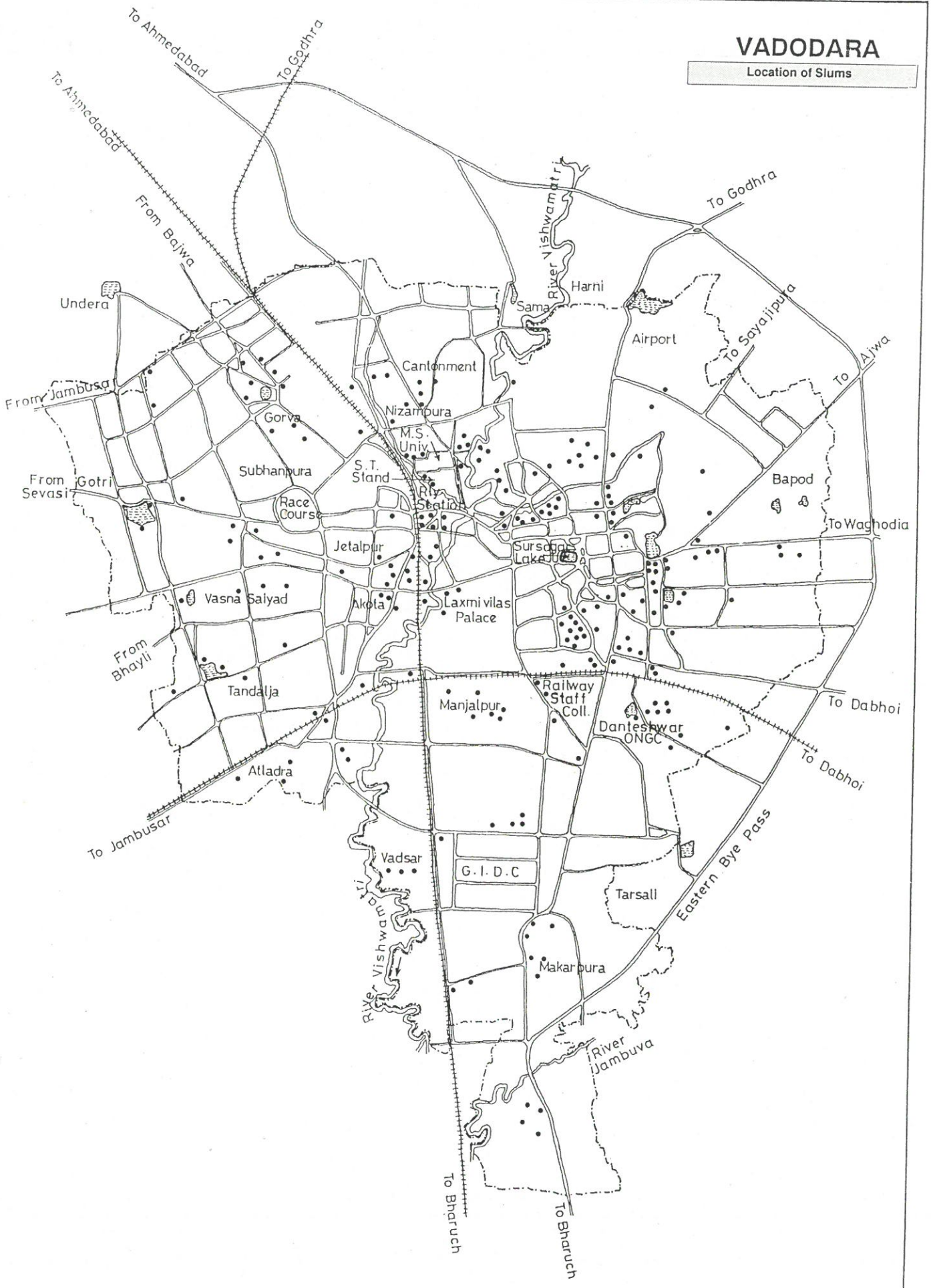
Urban Environmental Maps

Source: Based on data provided by BMC (1993).

National Institute of Urban Affairs, New Delhi.

VADODARA

Location of Slums



Scale
1.0 0.5 0 1 2 Km.

N

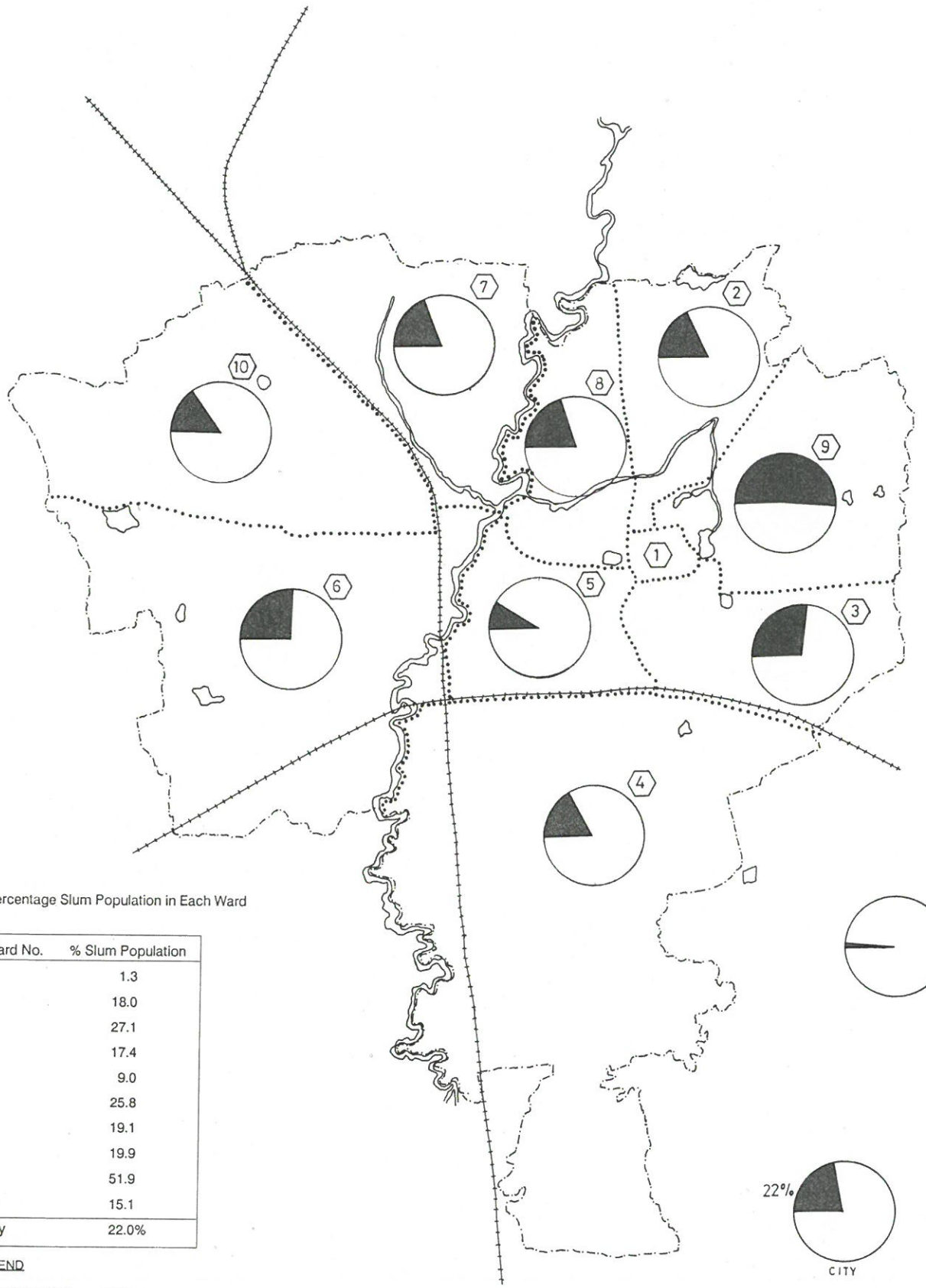
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Survey of Slums in Seven cities of Gujarat (1983).

VADODARA

Wardwise Slum Population (1992)
(As % of Wardwise population)



Percentage Slum Population in Each Ward

Ward No.	% Slum Population
1	1.3
2	18.0
3	27.1
4	17.4
5	9.0
6	25.8
7	19.1
8	19.9
9	51.9
10	15.1
City	22.0%

LEGEND

WARD BOUNDARY .....

WARD NUMBER (2)

Scale
1.0 0.5 0 1 2 km

N

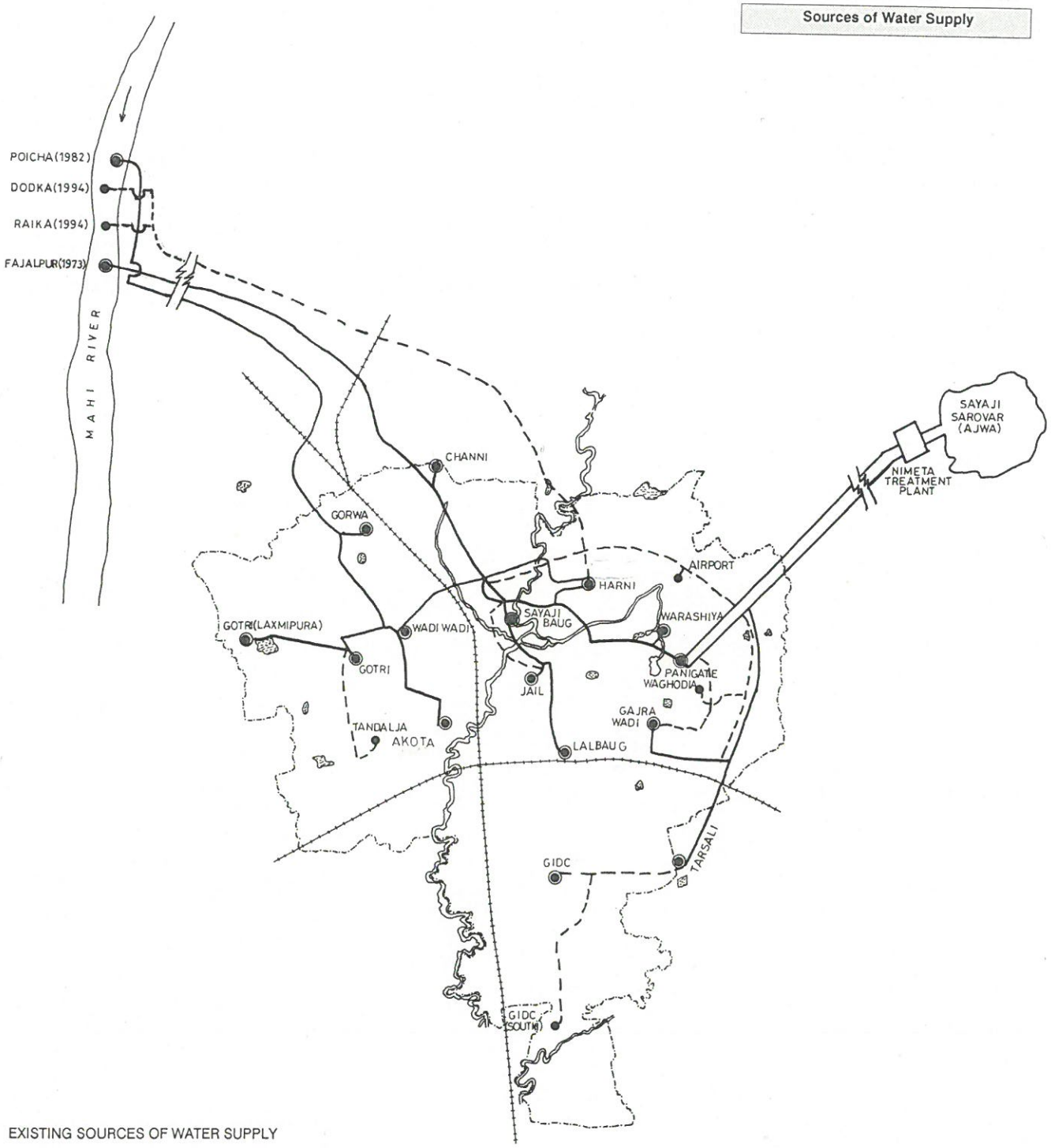
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Based on data provided by BMC (1993).

VADODARA

Sources of Water Supply



EXISTING SOURCES OF WATER SUPPLY

SOURCE	SUPPLY MLD (MGD)
SAYAJI SAROVAR (AJWA)	45 (10.0)
R.C.W. FAJALPUR	54 (12.0)
R.C.W. POICHA	65 (14.4)
TUBE WELLS (11 Nos.)	13 (2.8)
TOTAL	177 (38.4)

R.C.W. = Radial Collector Well

LEGEND

EXISTING WORKS ——

PROPOSED WORKS - - - -

EXISTING DISTRIBUTION STATION ◉

PROPOSED DISTRIBUTION STATION ●

PROPOSED SCHEME

SOURCE	CAPACITY MLD (MGD)	YEAR OF COMPLETION
R.C.W. DODKA	56 (12.6)	1994
R.C.W. RAIKA	56 (12.5)	1994

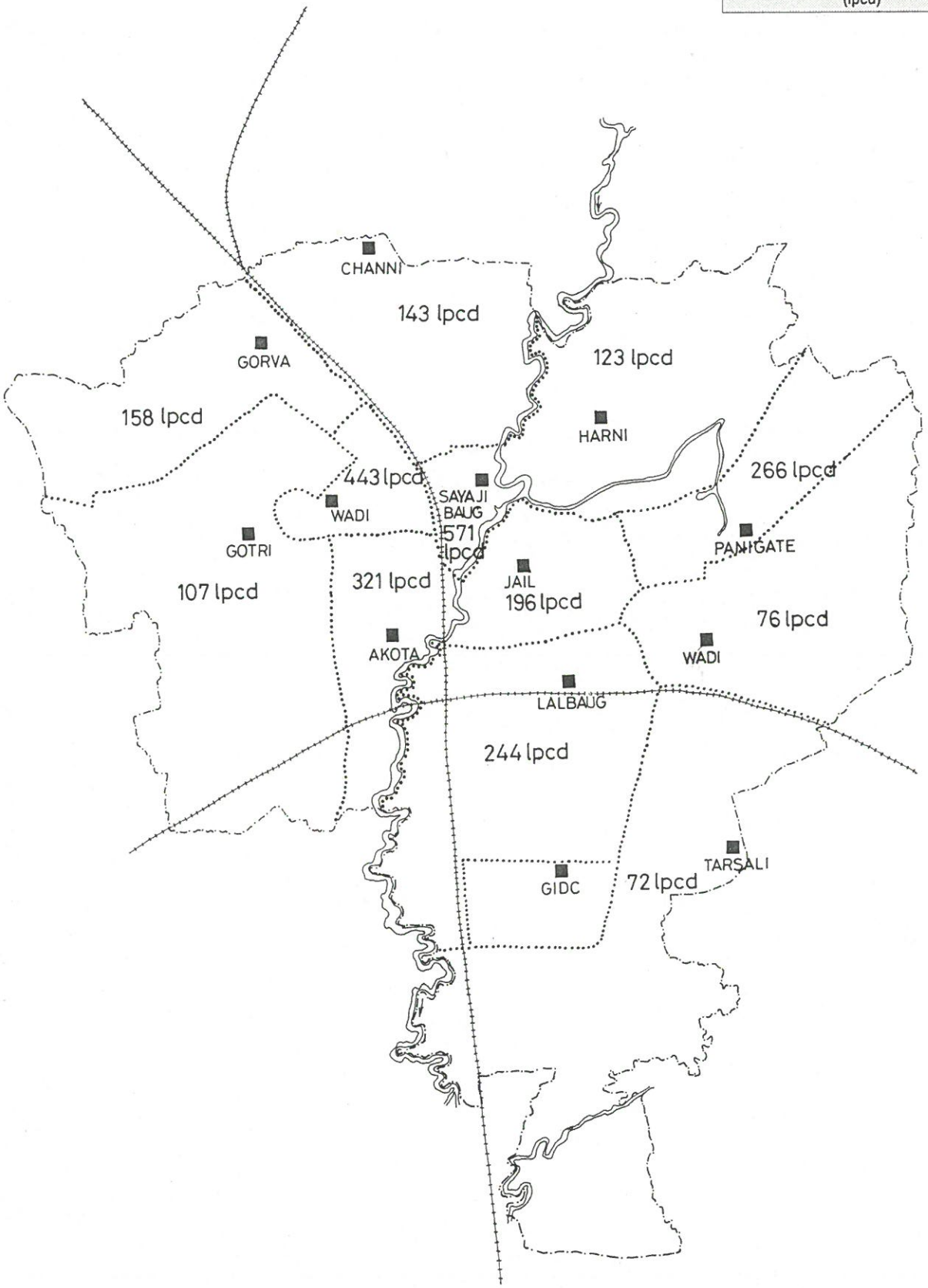
N

Not to Scale

Source: TCE (1992).

VADODARA

Per Capita Availability of Water (lpcd)



LEGEND

OVERHEAD TANK ■

COMMAND AREA BOUNDARY ·····

Scale 1.0 0.5 0 1 2 km

N

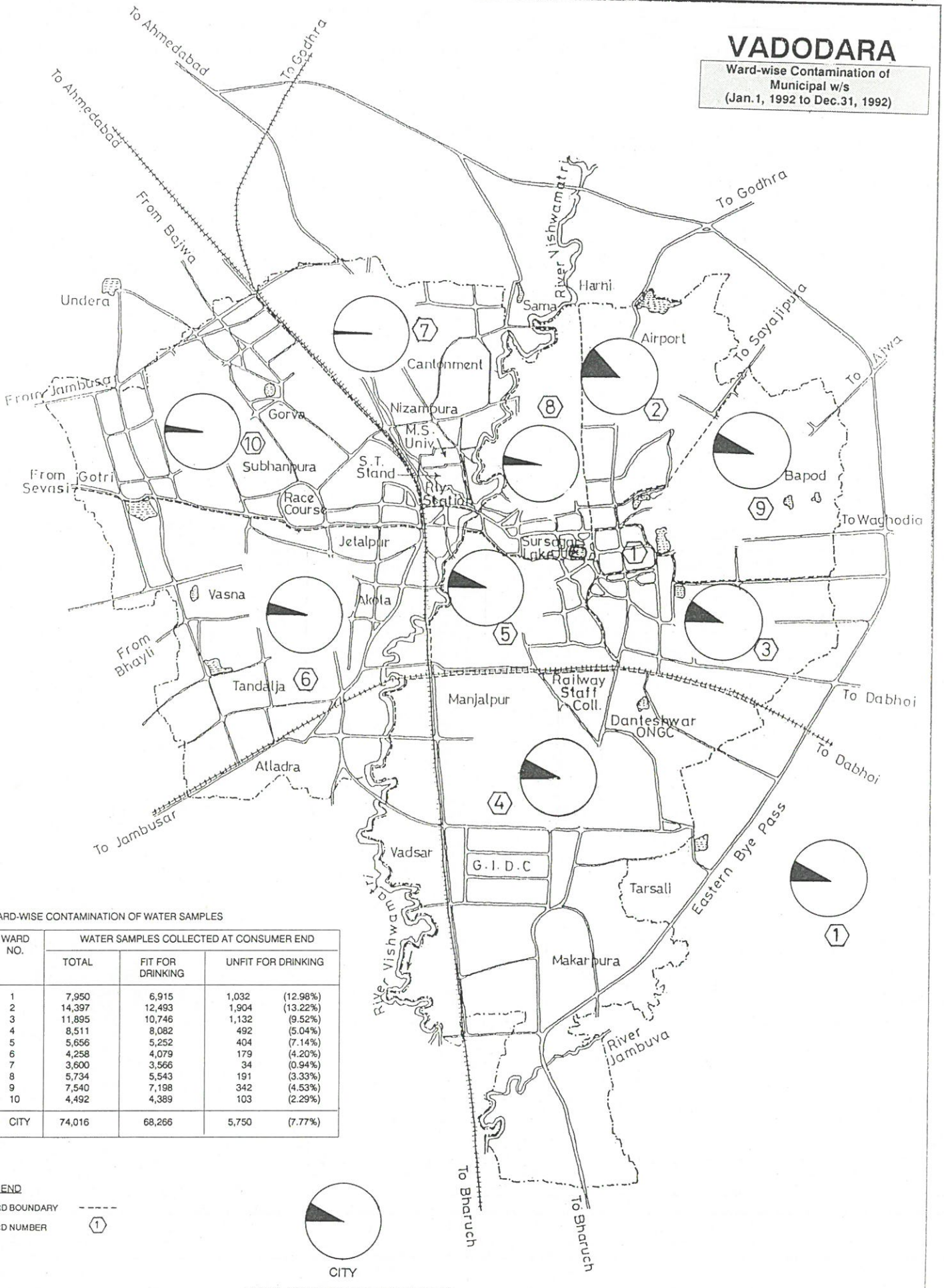
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: TCE (1992).

VADODARA

Ward-wise Contamination of Municipal w/s (Jan.1, 1992 to Dec.31, 1992)



WARD-WISE CONTAMINATION OF WATER SAMPLES

WARD NO.	WATER SAMPLES COLLECTED AT CONSUMER END			
	TOTAL	FIT FOR DRINKING	UNFIT FOR DRINKING	
1	7,950	6,915	1,032	(12.98%)
2	14,397	12,493	1,904	(13.22%)
3	11,895	10,746	1,132	(9.52%)
4	8,511	8,082	492	(5.04%)
5	5,656	5,252	404	(7.14%)
6	4,258	4,079	179	(4.20%)
7	3,600	3,566	34	(0.94%)
8	5,734	5,543	191	(3.33%)
9	7,540	7,198	342	(4.53%)
10	4,492	4,389	103	(2.29%)
CITY	74,016	68,266	5,750	(7.77%)

LEGEND

WARD BOUNDARY - - - - -

WARD NUMBER (1)

Urban Environmental Maps

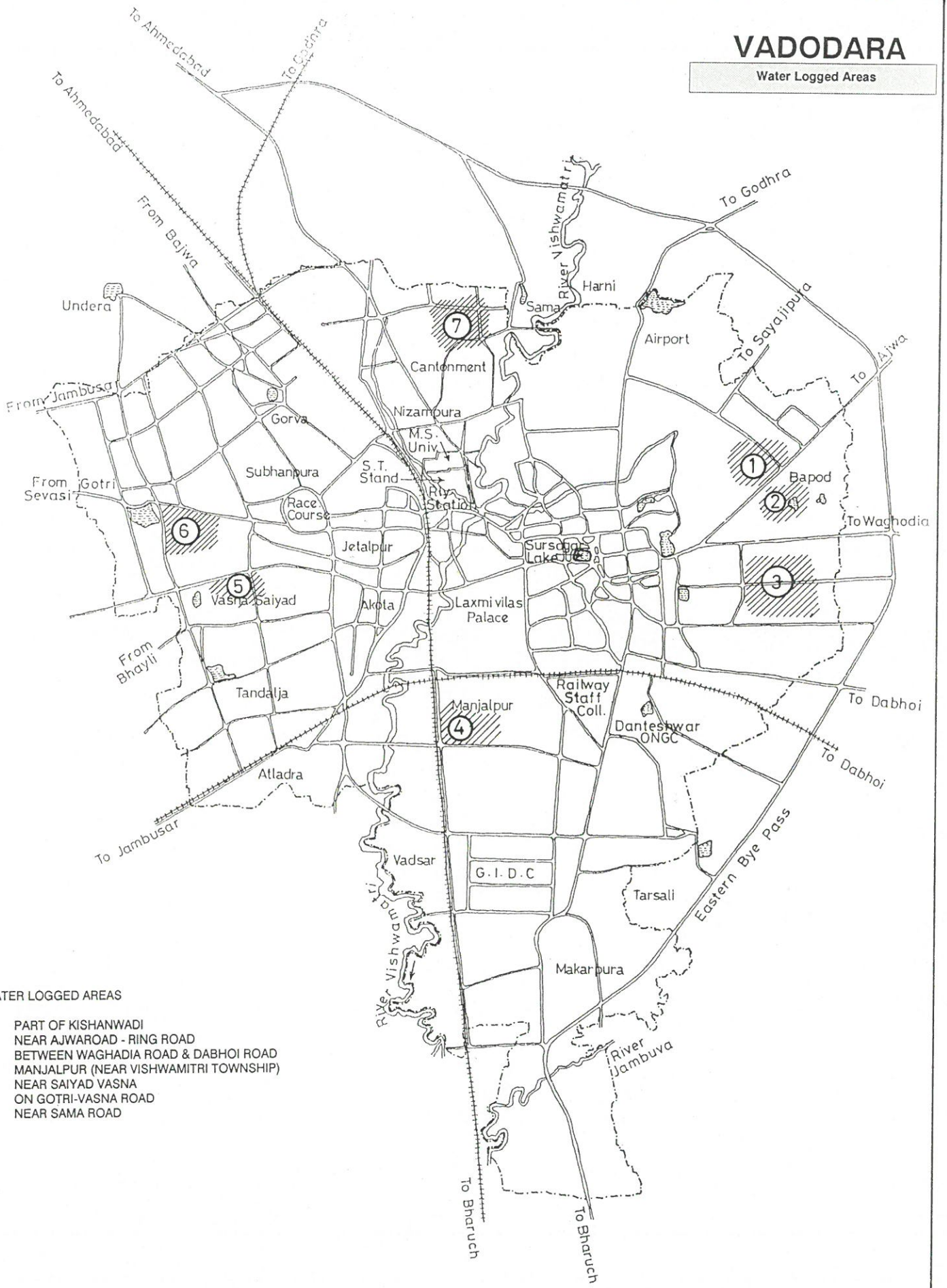
Note: *The Water Samples are tested for Sewage Contamination only*

Source: Based on data provided by BMC (1993).

National Institute of Urban Affairs, New Delhi.

VADODARA

Water Logged Areas



WATER LOGGED AREAS

1 - PART OF KISHANWADI
2 - NEAR AJWAROAD - RING ROAD
3 - BETWEEN WAGHADIA ROAD & DABHOI ROAD
4 - MANJALPUR (NEAR VISHWAMITRI TOWNSHIP)
5 - NEAR SAIYAD VASNA
6 - ON GOTRI-VASNA ROAD
7 - NEAR SAMA ROAD

Scale 1.0 0.5 0 1 2 Km.

N

Urban Environmental Maps

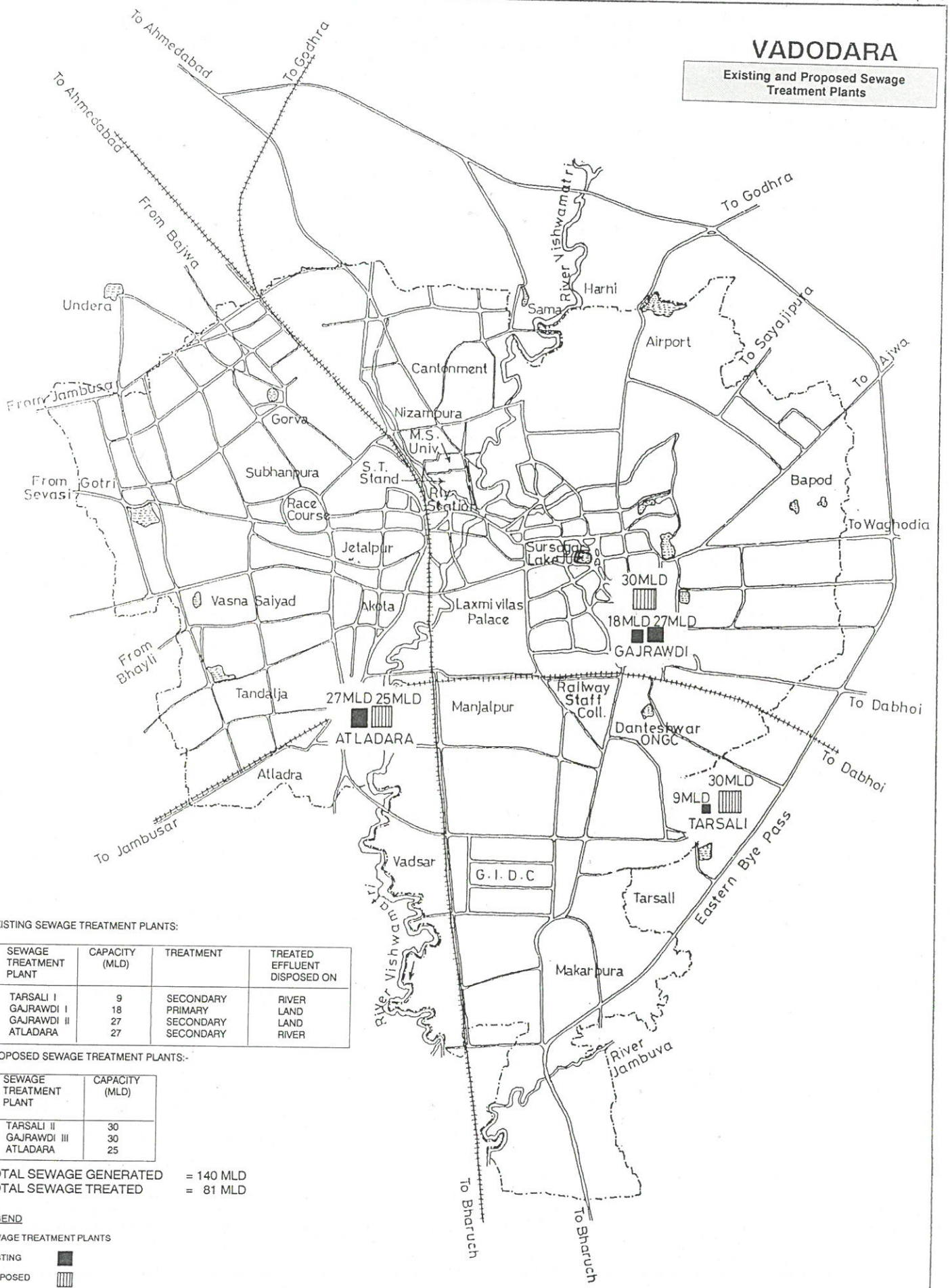
Note: Water Logged Areas are not shown on scale

National Institute of Urban Arrairs, New Delhi.

Source: Based on the discussion with BMC officials (1993).

VADODARA

Existing and Proposed Sewage Treatment Plants



EXISTING SEWAGE TREATMENT PLANTS:

SEWAGE TREATMENT PLANT	CAPACITY (MLD)	TREATMENT	TREATED EFFLUENT DISPOSED ON
TARSALI I	9	SECONDARY	RIVER
GAJRAWDI I	18	PRIMARY	LAND
GAJRAWDI II	27	SECONDARY	LAND
ATLADARA	27	SECONDARY	RIVER

PROPOSED SEWAGE TREATMENT PLANTS:-

SEWAGE TREATMENT PLANT	CAPACITY (MLD)
TARSALI II	30
GAJRAWDI III	30
ATLADARA	25

TOTAL SEWAGE GENERATED = 140 MLD
TOTAL SEWAGE TREATED = 81 MLD

LEGEND

SEWAGE TREATMENT PLANTS

EXISTING

PROPOSED

Scale 0 0.5 0 1 2 Km.

N

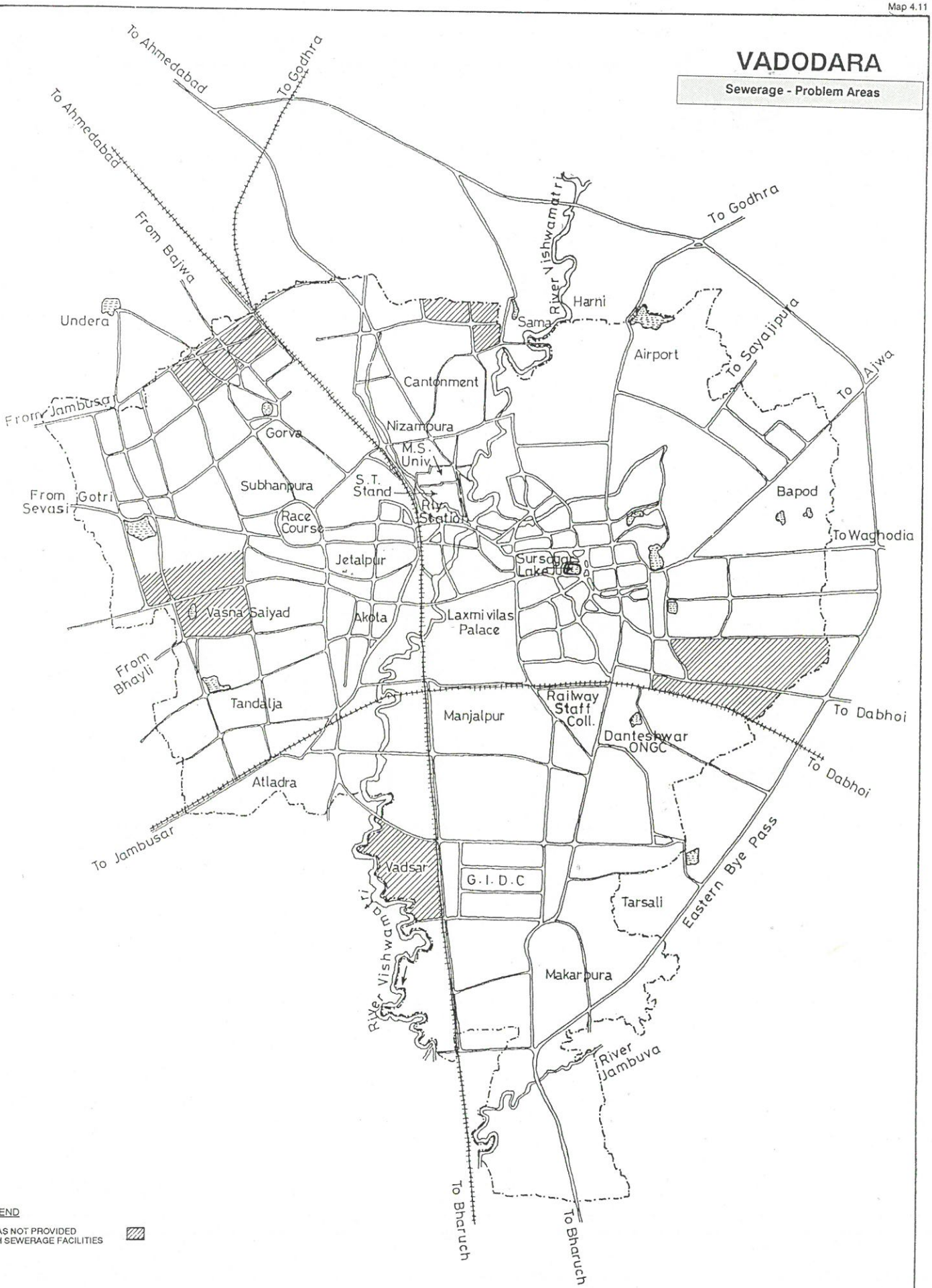
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: BMC (1993).

VADODARA

Sewerage - Problem Areas



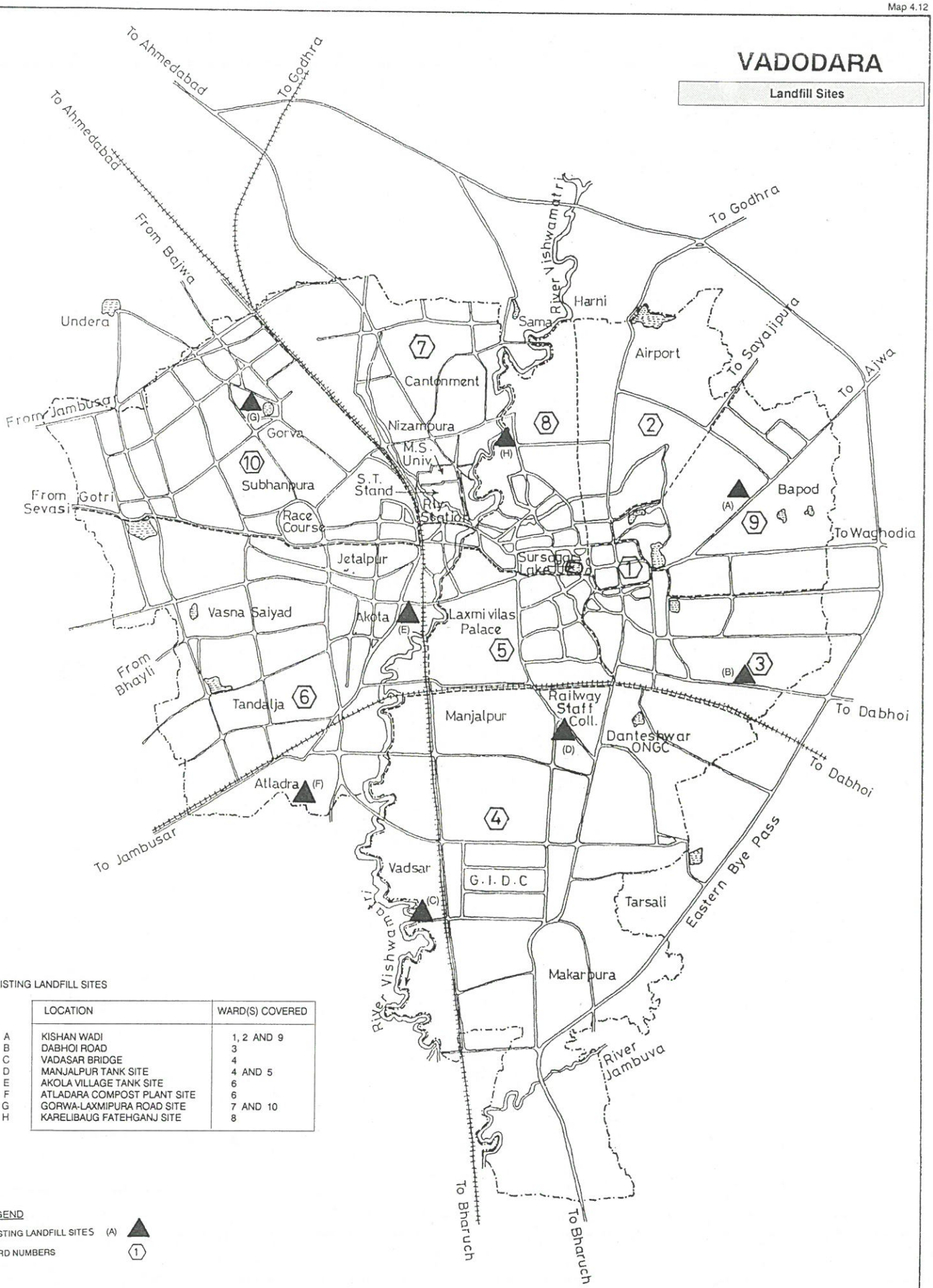
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Based on discussion with BMC officials (1993).

VADODARA

Landfill Sites



EXISTING LANDFILL SITES

	LOCATION	WARD(S) COVERED
A	KISHAN WADI	1, 2 AND 9
B	DABHOI ROAD	3
C	VADASAR BRIDGE	4
D	MANJALPUR TANK SITE	4 AND 5
E	AKOLA VILLAGE TANK SITE	6
F	ATLADARA COMPOST PLANT SITE	6
G	GORWA-LAXMIPURA ROAD SITE	7 AND 10
H	KARELIBAUG FATEHGANJ SITE	8

LEGEND

EXISTING LANDFILL SITES (A) ▲

WARD NUMBERS (1)

Scale 1.0 0.5 0 1 2 Km.

N

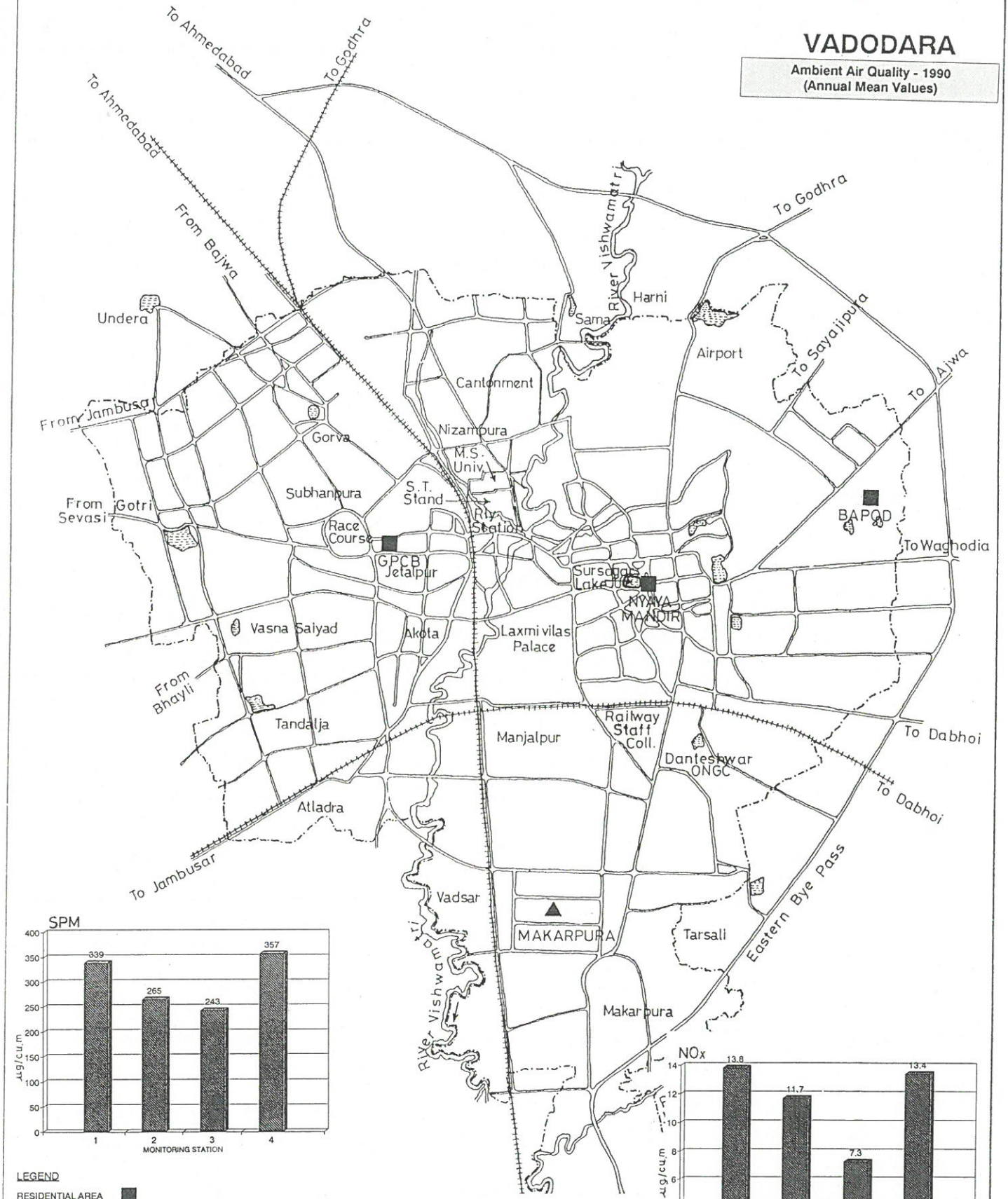
Urban Environmental Maps

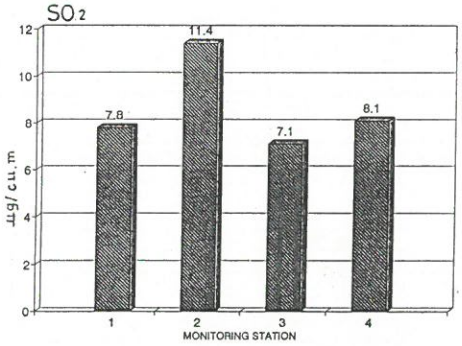
National Institute of Urban Affairs, New Delhi.

Source: BMC (1993).

VADODARA

Ambient Air Quality - 1990
(Annual Mean Values)





LEGEND

RESIDENTIAL AREA ■

INDUSTRIAL AREA ▲

MONITORING STATIONS
1. BAPOD (R)
2. MAKARPURA (I)
3. GPCD (R)
4. NAYA MANDIR (R)

Scale 1.0 0.5 0 1 2 Km.

N

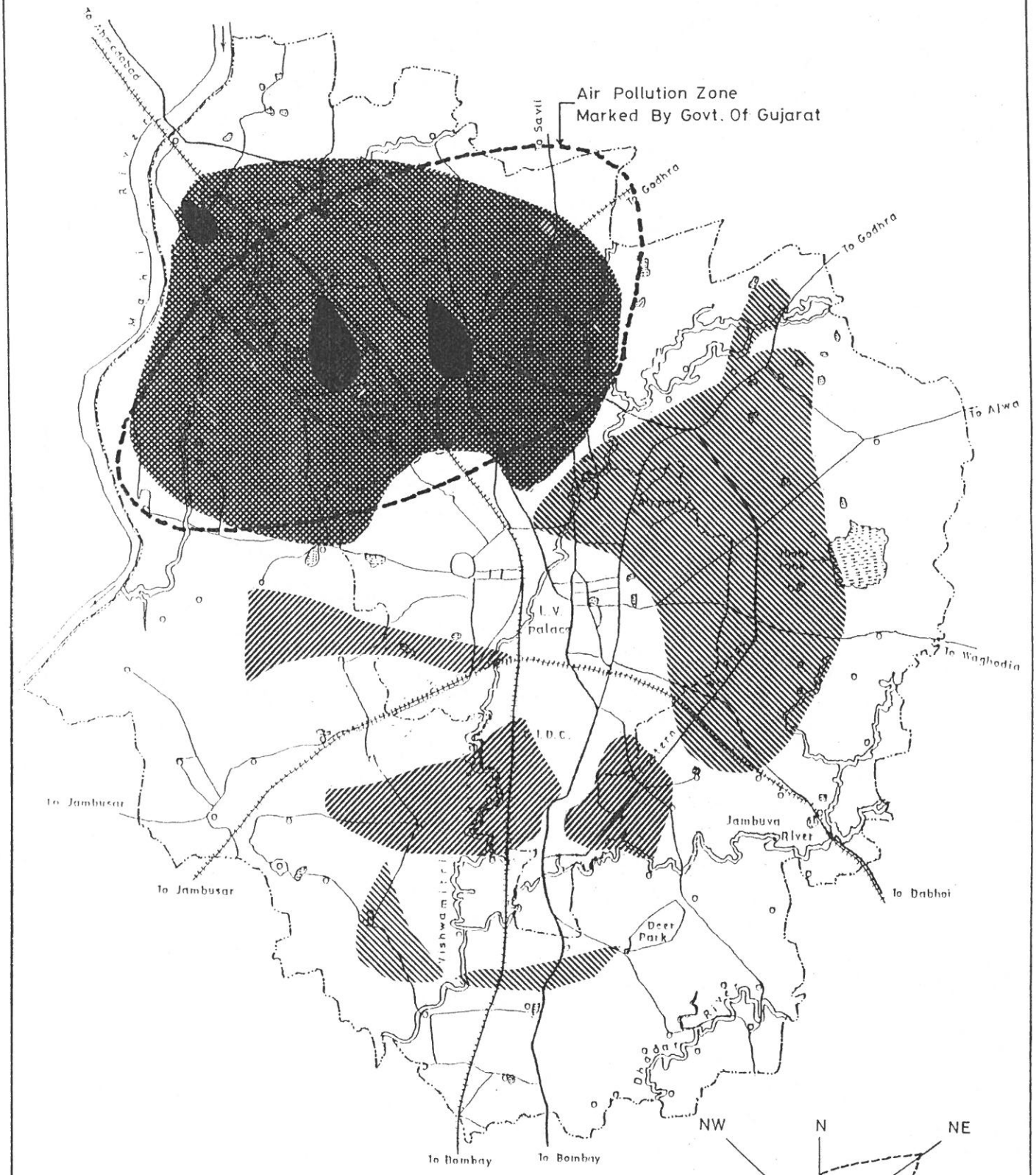
Urban Environmental Maps

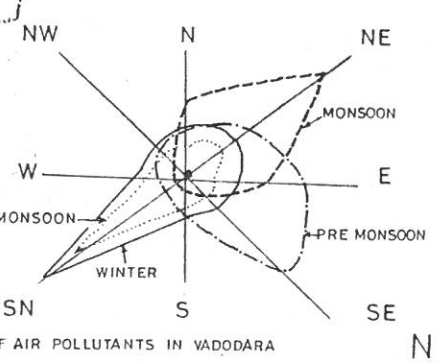
National Institute of Urban Affairs, New Delhi.

Source: CPCB (1990 & 1991).

VADODARA

Air Quality Pockets





DISSEMINATION OF AIR POLLUTANTS IN VADODARA

LEGEND

AIR POLLUTION ZONE

NO_2

SO_2

N

1 5 0 1 2 3 4 Km.

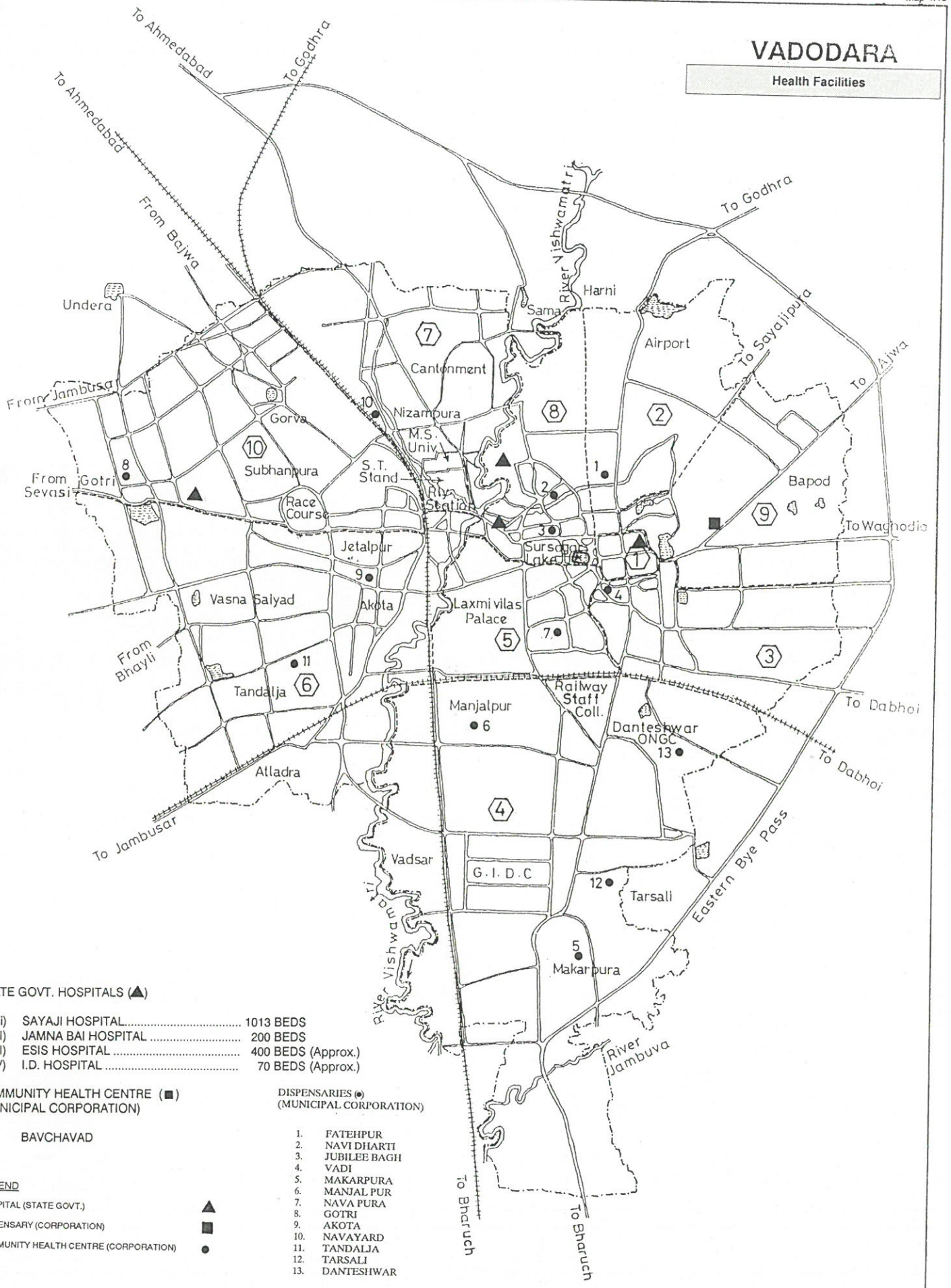
Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: NIOH (1989).

VADODARA

Health Facilities



STATE GOVT. HOSPITALS (▲)

i)	SAYAJI HOSPITAL	1013 BEDS
II)	JAMNA BAI HOSPITAL	200 BEDS
III)	ESIS HOSPITAL	400 BEDS (Approx.)
IV)	I.D. HOSPITAL	70 BEDS (Approx.)

COMMUNITY HEALTH CENTRE (■)
(MUNICIPAL CORPORATION)

BAVCHAVAD

DISPENSARIES (●)
(MUNICIPAL CORPORATION)

1. FATEHPUR
2. NAVI DHARTI
3. JUBILEE BAGH
4. VADI
5. MAKARPURA
6. MANJAL PUR
7. NAVA PURA
8. GOTRI
9. AKOTA
10. NAVAYARD
11. TANDALJA
12. TARSALI
13. DANTESHWAR

LEGEND

HOSPITAL (STATE GOVT.) ▲

DISPENSARY (CORPORATION) ■

COMMUNITY HEALTH CENTRE (CORPORATION) ●

Urban Environmental Maps

National Institute of Urban Affairs, New Delhi.

Source: Based on information provided by BMC officials (1993).

VADODARA

4.1 The City

Vadodara is an ancient settlement, founded on the banks of river Vishwamitri around 1000 B.C. Vadodara kingdom, being one of the major kingdoms in Western India, has a glorious past. The city was ruled by Maurya, Guptas, Chalukyas, Solankies and Marathas. The successive rules have left behind a rich heritage of culture and architecture.

Initially comprising the small settlement of Vadapadraka village, the settlement grew considerably during the Maratha reign in the 18th and 19th centuries. Maharaja Sayajirao Gaikwad III undertook planned development of the city and established many institutions. Being in close proximity to Ahmedabad and Bombay, Vadodara has become an industrial and trade centre. The major industries in the city are textiles, petrochemicals, oil refinery, fertilizers, automobile industries and other small and medium manufacturing units.

The old city of Vadodara was spread over 24.3 sq.km. In 1975, the area was extended to 108.22 sq.km. Since then, there has been no expansion of the city limits.

4.2 Demography

The population of the city has grown from 1,03,7980 in 1901 to 10,21,084 in 1991. Due to epidemics in the first two decades of this century, the population decreased. However, after 1931, the city has been growing at a rate of 35% or more every decade.

Table 4.1: Population Growth in Area under Baroda Municipal Corporation

Year	Population	Decadal Variation	Decadal Growth Rate (%)
1901	1,03,790	-	-
1911	99,345	- 4,445	- 4.20
1921	94,712	- 4,633	- 4.66
1931	1,12,860	+ 18,148	+ 19.16
1941	1,53,301	+ 40,441	+ 35.83
1951	2,11,407	+ 58,106	+ 37.90
1961	3,09,716	+ 98,309	+ 46.50
1971	4,78,422	+ 1,68,706	+ 50.94
1981	7,34,144	+ 2,55,722	+ 57.05
1991	10,30,346	+ 2,96,202	+ 40.35

Source: Census of India (1991)

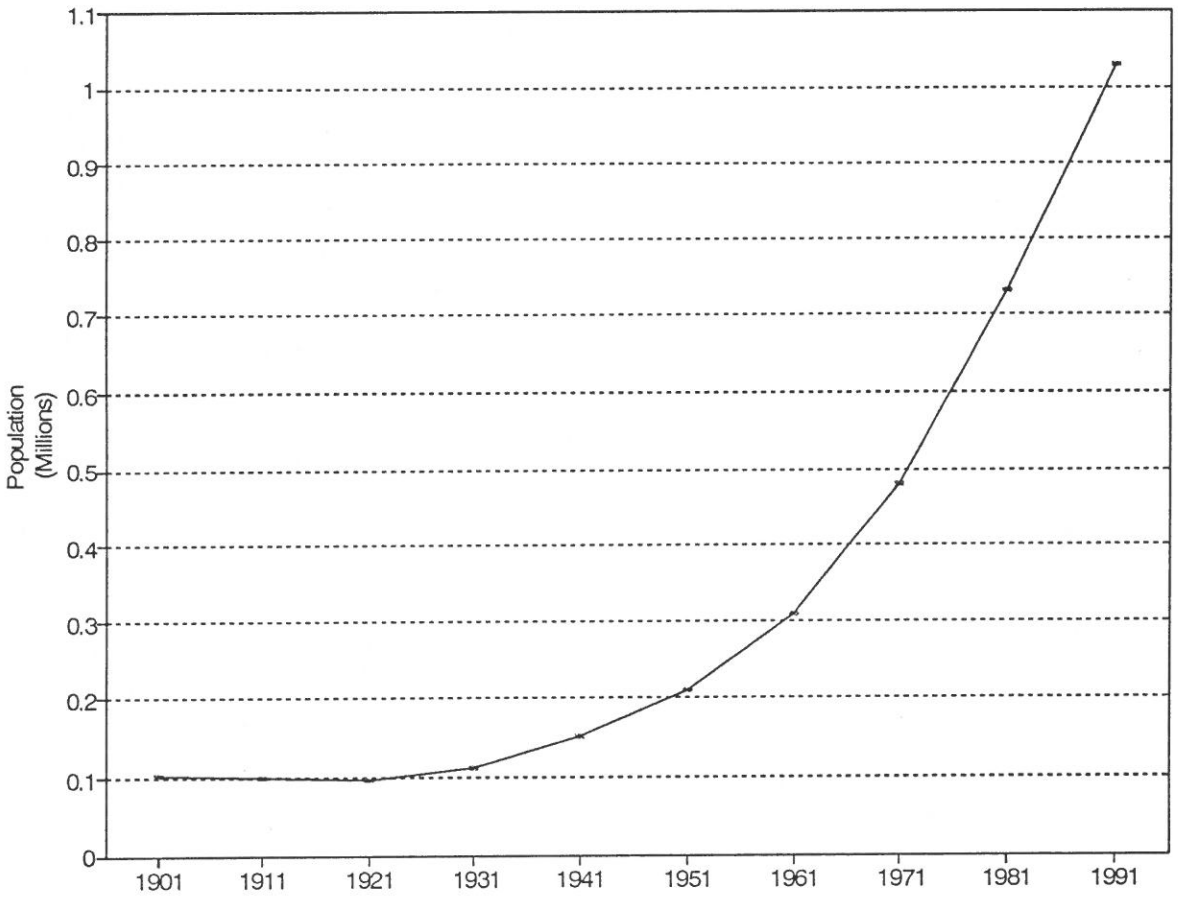


Figure 4.1: Population Growth in Vadodara

4.3 Slums

During the last four decades the city's population has grown five fold. The slum population in the city is increasing at an even faster pace. From a slum population of 49,950 in 1972, today there are 2,25,200 persons residing in slums in various parts of the city. In other words, the slum population has increased 4.5 times during the last two decades. During last decade, a growth rate of 138% was recorded in the slums of Vadodara (Table 4.4). The increase in industrial and commercial activities in the city has resulted in an increase in migration and hence in the growth of slums. In 1992, 22% of the city population was residing in slums. Ward number 9 (Gorva) has 52% population is slums. This ward also has the maximum number of slums, viz 94 out of a total of 335 in the entire city. (Table 4.5). Lack of proper drainage facilities, paved roads, sanitation facilities etc. have affected the quality of life of people living in slums.

Table 4.4: Growth of Vadodara Slums

Year	No.of Slums	No. of Families	Population	Decadal Growth (%)	Average Family Size	% of City Population
1972	192	11,130	49,950	-	4.49	10.4%
1982	210	21,292	94,700	90%	4.45	12.8%
1992	335	50,038	2,25,200	138%	4.50	22.0%

Source: ORG (1972), Slums in Gujarat
BMC/ORG (1982), Survey of Slums, Chawls and Khadkis
BMC (1992)

Table 4.5: Slum Population (1991)

Ward Number	No. of slums	Number of Households	Slum Population* (% of Ward Population)
1	1	151	680 (1.3%)
2	22	4526	20370 (18.0%)
3	29	5241	23587 (27.1%)
4	40	5173	23281 (17.4%)
5	7	1405	6323 (9.0%)
6	47	7406	33331 (9.0%)
7	35	4764	21441 (19.1%)
8	30	4997	22490 (19.9%)
9	94	12782	57526 (51.9%)
10	30	3593	16171 (15.1%)
Total	335	50038	225200 (22.0%)

* Calculated taking average family size of 4.50.

Source: Baroda-2001, Report Submitted to ODA.

The corporation is divided into ten wards. The largest ward is GIDC (No.4) spread over an area of 27.00 sq.km. and having a population of 1,33,947. The smallest ward is city (No.1), spread over an area of 0.66 sq.km. and having a population of 53,383 (Table 4.2).

Table 4.2: Wardwise Area, Population and Density (1991)

Ward No.	Ward Name	Area (sq.km.)	Population (1991)	Population Density (Persons/sq.km.)
1	City	0.66	53,383	80,883
2	Fatehpura	11.16	1,13,289	10,151
3	Wadi	7.50	87,158	11,621
4	G.I.D.C.	27.00	1,33,947	4,961
5	Babajipura	4.97	70,057	14,096
6	Sayajiganj (S)	25.08	1,29,343	5,157
7	Sayajiganj (N)	10.13	1,12,389	11,095
8	Raopura	5.45	1,12,750	20,688
9	Gorwa	10.00	1,10,926	11,093
10	Kishanwadi	6.27	1,07,104	17,082
	Total	108.22	10,30,346	9,521

Source: BMC (1993)

The City ward has the highest population density of 80,883 persons per sq.km, while the GIDC ward has a density as low as 4,961 persons per sq.km. as against the average population density of the Corporation of 9,521 persons per sq.km.

Table 4.3: Area of Vadodara

Year	Area (sq.km)	Population	Population Density (Persons/sq.km.)
1941	24.3	1,53,301	6,307
1951	24.3	2,11,407	8,700
1961	39.0	3,09,716	7,941
1971	78.0	4,78,422	6,134
1981	108.22	7,34,144	6,784
1991	108.22	10,30,346	9,521

Source: BMC (1993)

4.4 Water Supply

Sayaji Sarovar was the first source of water for the city of Vadodara. It was commissioned in the year 1892. It is 22 km north-east of Vadodara city, near Ajwa village. The difference between the level of the reservoir and the city is around 30 meters. Due to this level difference, water flows under gravity. To cope with the growing demand, the first Radial Collector Well (RCW) was constructed at Fajalpur in the Mahi river in the year 1963. Another RCW was constructed in 1982 in river Mahi to supply 65 mld of water. Two more RCWs are expected to be commissioned in the river by the year 1994. Both the RCWs (Dodka and Raika) are expected to provide 56 mld of water each to the Vadodara city. After commissioning of the two RCWs (Dodka and Raika) in 1994, the total available supply to the city would be 289 mld. At present, there are 11 tubewells yielding about 13 mld. The villages within the Corporation limits are supplied water from these tubewells.

Table 4.6: Existing Sources of Water

Source	Year of Commissioning	Supply mld (mgd)
Sayaji Sarovar	1892	45 (10)
* RCW Fajalpur	1963	54 (12)
* RCW Poicha	1982	65 (14.4)
Tubewells (11 Nos.)	-	13 (2.8)
		Total = 177 (38.4)

* RCW = Radial Collector Well

Source: BMC (1993)

There are 14 distribution stations within the BMC limit, each having a ground service reservoir and an overhead tank. The details of ground service reservoir and overhead tank is given in Table 4.7.

Table 4.7: Storage Capacity of Existing Reservoirs

S.No.	Reservoir	Storage Capacity (ML)		
		Ground Service Reservoir	Over Head Tank	Total
1.	Panigate	13.62	1.81	15.43
2.	Gajrawadi	7.20	1.81	9.01
3.	Tarsali	5.44	1.36	6.80
4.	Harni	6.81	1.81	8.62
5.	Channi	6.81	1.81	8.61

(Table 4.7 contd.)

S.No.	Reservoir	Storage Capacity (ML)		
		Ground Service Reservoir	Over Head Tank	Total
6.	Sayaji Baug	0.90	0.27	1.17
7.	Jail Road	6.81	1.81	8.62
7.	Jail Road	6.81	1.81	8.62
8.	Lalbaug	6.81	1.81	8.62
9.	Warashiya	2.72	0.00	2.72
10.	Gorwa	5.44	1.36	6.80
11.	Wadi	2.72	0.45	3.17
12.	Gotri	2.72	1.36	4.08
13.	Akota	5.44	1.36	6.80
14.	GIDC*	0.90	0.45	1.35
	Total	73.44	17.02	90.46

* At present, supply to GIDC reservoir is from Lalbaug reservoir.

Source: Baroda Water Supply, Master Plan (1992), Tata Consulting Engineers, Bombay.

It is evident from Table 4.8 that there is a great variation in per capita availability of water across the city. The lowest supply is in the command area of Warashiya reservoir which gets only 45 lpcd of water while the highest supply of 571 lpcd is in the command area of Sayaji Baug Reservoir.

Table 4.8: Flow Rates in Reservoir Command Areas

S.No.	Reservoir	Flow (mld)	Population Served (1991)	Flow Rate (lpcd)	Supply Time (hrs)	Flow Rate (lpch*)
1.	Panigate	36.00	1,35,000	266	1.5	177
2.	Gajrawadi	9.08	1,20,200	76	1.5	50
3.	Tarsali	7.26	1,01,200	72	2.0	36
4.	Harin	17.25	1,40,100	123	1.5	82
5.	Channi	12.25	85,400	143	1.0	143
6.	Sayaji Baug	0.12	10,740	571	1.5	381
7.	Jail Road	15.43	78,800	196	1.5	131
8.	Lalbaug	20.43	83,600	244	1.5	163
9.	Warashiya	1.81	40,000	45	2.0	23
10.	Gorwa	8.62	54,700	158	1.5	105
11.	Wadi	7.26	1,64,000	443	1.5	296
12.	Gotri	13.16	1,22,600	107	1.5	72
13.	Akota	10.21	31,800	321	1.5	214

* litres per capita per hour

Source: Baroda Water Supply, Master Plan (1992), Tata Consulting Engineers, Bombay.

Table 4.9: Per Capita Supply

Year	Gross Supply (Litres per capita per day)
1961	145
1971	180
1981	200
1991	173

Taking the norm of 135 lpcd and 45 lpcd for residential and non-residential uses respectively, the water demand for the year 2001 has been estimated to be around 253 mld.

Table 4.10: Water Demand (2001)

Year	Population	Daily Demand (mld)		Total Demand (mld)
		Residential @ 135 lpcd	Non-residential @ 45 lpcd	
1991	10,21,084	137.85	45.95	183.80
2001*	14,04,000	189.54	63.18	252.72

* Projected population

Source: Baroda Water Supply, Master Plan (1992), Tata Consulting Engineers, Bombay.

Contamination of Drinking Water

The Public Health Laboratory of Baroda Municipal Corporation collects random water samples from all possible sources of drinking water such as municipal water at consumers' end, hand pumps, wells etc. These water samples are tested in the laboratory for sewage contamination only.

Table 4.11: Wardwise Contamination of Drinking Water (Jan 1,1992 to Dec 31,1992)

Ward No.	Municipal Water Supply			Hand Pump			Well		
	Total Samples	Fit for Drinking	Unfit for Drinking	Total Samples	Fit for Drinking	Unfit for Drinking	Total Samples	Fit for Drinking	Unfit for Drinking
1	7,950	6,915	1,032	91	83	8	3	2	1
2	14,397	12,493	1,904	105	100	5	-	-	-
3	11,895	10,746	1,132	44	44	-	1	-	1
4	8,511	8,082	492	23	23	-	-	-	-
5	5,656	5,252	404	105	104	1	-	-	-
6	4,258	4,079	179	67	67	-	1	-	1
7	3,600	3,566	34	29	24	5	-	-	-
8	5,734	5,543	191	114	112	2	1	1	-
9	7,540	7,198	342	8	8	-	-	-	-
10	4,492	4,389	103	28	27	1	-	-	-
Total	74,016	68,266	5,750 (7.77%)	615	593	22 (20%)	6	3	3 (50%)

Source: BMC (1993)

Waterlogging

The difference between city's highest (Salatvada area) and lowest (Mandir area) levels is about 2.5-3.0 m. During average rainfall, the rain water gets drained through the system. If heavy rain fall occurs, then many parts of the city remain waterlogged for some period, until the rain water is drained through the system. Certain areas in the city remain waterlogged for most part of the year and these are more prone to waterlogging because of either no drainage facility or poor drainage facility. Such areas, based on discussions with BMC officials, are marked on map 4.10. Approximately 10 sq.km. area out of 108 sq.km of city area remains waterlogged.

4.5 Sewerage

At present, there are four treatment plants operating in the city. Out of 140 mld of sewage generated, only 81 mld is treated at these plants. Rest 59 mld either goes to other rivulets or water bodies.

There are 12 major industries in the Corporation area generating 4.5 mld of wastewater. These industries have their own treatment plants. After treatment the industrial wastewater is discharged into the city's sewerage system.

Table 4.12: Exisiting Sewage Treatment Plants

Sewage Treatment Plant		Capacity (mld)	Type of treatment	Treated effluent disposed on
1.	Tarsali	9	Secondary	River
2.	Gajrawadi	18	Primary	Land
3.	Gajrawadi	27	Secondary	Land
4.	Atladara	27	Primary	River
	Total capacity	81	mld	

Source : BMC (1993)

Table 4.13: Proposed Sewage Treatment Plants

Sewage Treatment Plant		Capacity (mld)
1.	Tarsali	30
2.	Gajrawadi	30
3.	Atladara	25
	Total	85

Source: BMC (1993)

4.6 Solid Waste

At present, about 300 tonnes of solid waste is collected every day by the Corporation giving an average of 300 grams of solid waste per capita per day. There are eight landfull sites in operation and the solid waste collected from the different parts of the city is dumped on these sites. These landfill sites have no proper arrangements for leachate, methane gas control and covering of refuse by inert material.

Some of the waste, such as paper, glass bottles, plastic bags and tins etc. are collected by "pickers" and sold directly for re-cycling. In addition, paper, plastics, tins, iron-materials etc. are removed from the landfill sites by waste pickers from poor families, who need to do it for their survival. Some of the poor families allow their cattle and pets to feed on the waste at the collection and disposal sites. All these activities together reduce the quantity of refuse received for disposal.

Table 4.14: Details of Existing Landfill Sites

	Location	Ward(s) covered	Future Life
1.	Kishan Wadi	1,2 & 9	The future life of these landfill sites varies from 6 months to over 15 years.
2.	Dabhoi Road	3	
3.	Vadasar Bridge	4	
4.	Manjalpur Tank Site	4 & 5	
5.	Akota Village Tank Site	6	
6.	Atladara Compost Plant Site	6	
7.	Gorwa-Laxmipura Road Site	7 & 10	
8.	Karelibang Fatehgunj Site (Just Completed)	8	

Source: BMC (1993)

There is one composting plant operated by the Corporation at Atladara. At present, the plant produces about 15 tonnes of compost per day with an input of 30 to 40 tonnes of solid waste per day. The density of solid waste collected by the Corporation is about 500-600 kg/cu.m.

Non-domestic waste comprising of commercial, industrial and hospital waste is not collected separately. Part of the commercial waste is utilised in recycling and the rest is dumped on the landfill sites alongwith the other solid waste. Some industries listed as hazardous or dangerous have their own arrangements for the disposal of their wastes. The Corporation does not allow such hazardous waste for disposal alongwith the municipal solid waste.

Sayaji Rao General Hospital has its own incineration unit at the hospital for the disposal of clinical waste. The remaining hospitals and maternity homes do not have any separate system for disposing the clinical waste. All the waste generated in these hospitals and maternity homes is collected alongwith the municipal waste.

There are about 2000 'Safai Sevaks'in the Corporation each entrusted with a specific area of operation for the collection of solid waste. Each Safai Sevak is provided with a wheelbarrow, a broom, a scraper and a cane basket. After collecting waste from allotted areas, the Safai Sevak takes it to the community solid waste collection centre which is generally within a range of 500 metres. The community solid waste collection centre is either a shed, an open area or a bottomless large RCC circular container. Since the refuse is dumped in the open, it creates health hazards and a very unpleasant sight. There are about 8 to 12 community solid waste collection centres in each ward. From these community collection entres, the waste is directly taken to final disposal sites within a distance of 5-6 km.

4.7 Air Pollution

The Central Pollution Control Board has been monitoring air quality in the city since 1987. The values of SPM, SO_2 and NO_X at these monitoring stations is given in Table 4.15. Annual mean values of SPM in residential areas viz. Bapod and GPCB are above the standard limit (200ug/cu.m.). For industrial areas, the annual mean concentration of SPM, SO2 and NO_X is below the standards.

Table 4.15: Ambient Concentration of Air Pollutants (1987-90)

	Monitoring station	Year	Annual mean concentration (ug/cu.m)		
			SPM	SO_2	NO_X
1.	Bapod (Resi.)	1987	267	11.6	23.2
		1988	276	10.2	28.8
		1989	350	14.9	11.6
		1990	339	7.8	13.8
2.	Makarpura (Ind.)	1987	217	24.3	32.0
		1988	240	20.7	34.7
		1989	302	22.9	15.0
		1990	265	11.4	11.7
3.	GPCB (Resi.)	1987	203	14.7	24.9
		1988	225	14.3	25.4
		1989	299	16.9	11.6
		1990	243	7.1	7.3
4.	IPCL (Ind.)	1987	300	16.5	30.7
		1988	332	13.7	32.8
		1989	423	17.8	16.4
		1990	357	8.1	13.4

Source: CPCB (1990 &1991), Ambient Air Quality Statistics of India.

After oil exploration during 1960s, a number of public sector units like Gujarat Refinery, Indian Petrochemicals Corporation Limited, Gujarat Alkalis and Chemicals Limited and other medium and small scale industries have come up in North West region of VUDA.

In a study done by NIOH at 22 monitoring stations in Vadodara Urban Development Area (VUDA), air quality was recorded for the period 1982-86. The arithmetic mean values of SPM, SO_2 and NO_X recorded in the survey are presented in the Table 4.16 for the year 1985-86. The NIOH study has identified Air Quality Pockets, which cover these highly industrialized areas and has high concentration of air pollutants. The North-West region is obviously the most polluted zone.

Table 4.16: Daily Average Concentration of SPM, SO_2 and NO_X (1985-86) in ug/cu.m.

S.No.	Monitoring Station	SPM	SO_2	NO_X
1.	Asoj	348	2.8	40.9
2.	Bajuva	340	16.9	54.4
3.	Bapod	223	3.7	40.3
4.	Bhaniyara	183	4.7	32.8
5.	Bhayoli	204	6.6	34.9
6.	Chapad	388	8.5	40.3
7.	Chikhodra	430	3.1	42.0
8.	Fajalpur	433	6.9	46.3
9.	Gorava	329	13.5	55.0
10.	H.W.P.	220	11.0	70.9
11.	Jesingpura	225	3.8	26.0
12.	Kelanpur	380	4.4	37.1
13.	Nandesari	211	27.3	42.0
14.	Podara	288	6.1	33.1
15.	Sankarda	377	7.7	29.7
16.	Samiyala	378	5.9	38.7
17.	Sevasi	230	5.5	33.1
18.	Sindhrot	424	4.5	28.7
19.	Sokhada	359	3.3	33.4
20.	Tatarpur	606	5.2	30.8
21.	Vadsala	249	4.0	36.9
22.	Virod	185	3.9	28.9

Source: NIOH (1989), Integrated Air Quality Surveillance Study over Vadodara Urban Development Area.

4.8 Health

There are four hospitals run by the State Government in the city. In addition to these hospitals there are a number of hospitals run by various trusts. The Corporation does not own any hospital in the city.

The Corporation maintains fourteen dispensaries and one community health centre in the city. These dispensaries cover all the wards of the city. The health facilities available in the city are shown on map 4.16.

During the year 1992, 1823 cases of various diseases were reported in the city with maximum cases relating to Viral Hepatitis and Diptheria. Out of a total of 11 deaths in 1992, 10 were of those having Viral Hepatitis.

Table 4.17: Hospitals in Vadodara (1993)

	Name of Hospital	Number of Beds
1.	Sayaji Hospital	1013
2.	Jamuna Bai Hospital	200
3.	ESIS Hospital	400 (Approx.)
4.	I.D. Hospital	70 (Approx.)
	Total	1683

Source: BMC (1993)

Table 4.18: Health Profile of Citizens of Vadodara (Jan 1,1992 to Dec. 31,1992)

Disease	January		February		March		April		May		June		July	
	C	D	C	D	C	D	C	D	C	D	C	D	C	D
Gastroenteritis	14	-	11	-	9	-	18	-	3	-	10	-	-	-
Cholera	-	-	-	-	-	-	-	-	-	-	6	-	2	-
Viral hepatitis	54	-	61	1	57	-	66	1	64	1	72	-	66	1
Typhoid	1	-	1	-	-	-	2	1	-	-	1	-	-	-
Measles	-	-	1	-	-	-	5	-	1	-	-	-	-	-
Chickenpox	-	-	18	-	9	-	16	-	2	-	1	-	-	-
Meningitis	-	-	-	-	-	-	3	-	-	-	1	-	-	-
Rabis	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Mumps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diptheria	504	-	291	-	-	-	1	-	2	-	-	-	-	-
Total	574	1	383	1	75	-	111	2	72	1	91	-	68	1

(Table 4.18 Contd/..)

Disease	August		September		October		November		December		Total	
	C	D	C	D	C	D	C	D	C	D	C	D
Gastroenteritis	1	-	4	-	-	-	-	-	-	-	70	-
Cholera	-	-	1	-	-	-	-	-	-	-	9	-
Viral hepatitis	79	-	102	1	109	3	74	1	75	-	879	10
Typhoid	-	-	-	-	-	-	-	-	-	-	5	1
Measles	-	-	-	-	-	-	-	-	-	-	7	-
Chickenpox	1	-	1	-	-	-	-	-	-	-	48	-
Meningitis	-	-	-	-	-	-	-	-	-	-	4	-
Rabis	-	-	-	-	-	-	-	-	-	-	1	-
Mumps	1	-	-	-	-	-	1	-	-	-	2	-
Diptheria	-	-	-	-	-	-	-	-	-	-	798	-
Total	82	-	108	-	109	3	75	1	75	-	1823	11

C = Cases
D = Deaths

Source: BMC (1993)

Summing Up

Growing with a rich cultural and architectural heritage, today's Vadodara is surrounded by modern industries such as petrochemicals, oil refinery, fertilizers etc. With the spatial expansion and growth of population, the city has started following the path of other metropolitan cities.

Vadodara has become a million plus city only during the last decade. The city centre or the old city has very high density of population while densities are lower in the other areas. A little less than one-fourth of the city's population resides in slums spread all over the city.

The water supply situation in the city is better than many other metropolitan cities. However, there are very large intra-city variations in the supply. Nearly two-fifths of the waste water generated does not get treated. Solid waste collection in the city is quite good. A part of the city refuse is recycled. There is a composting plant in the city. There is also a plant which makes fuel pellets from city waste. Industries with hazardous waste have their own arrangements for the disposal of their waste.

Air pollution in the city is increasing, as is the case with other cities. The north-west region of VUDA has a number of large scale industries and the air quality in the region has deteriorated to a great extent.

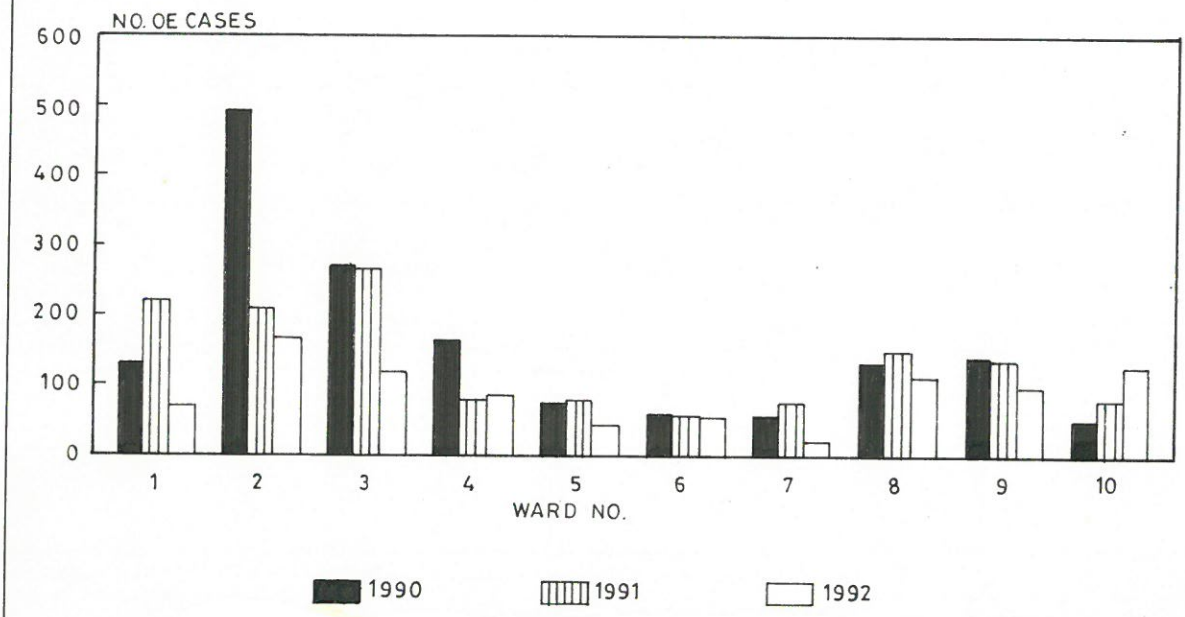


Fig. 4.2 : Wardwise Cases of Viral Hepatitis

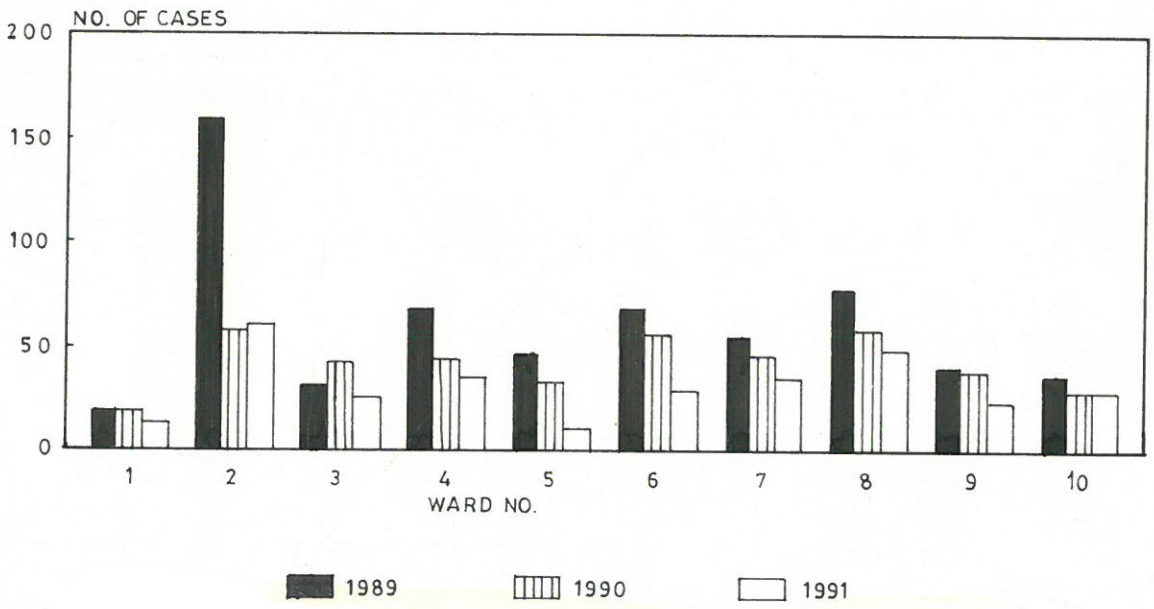


Fig. 4.3 :

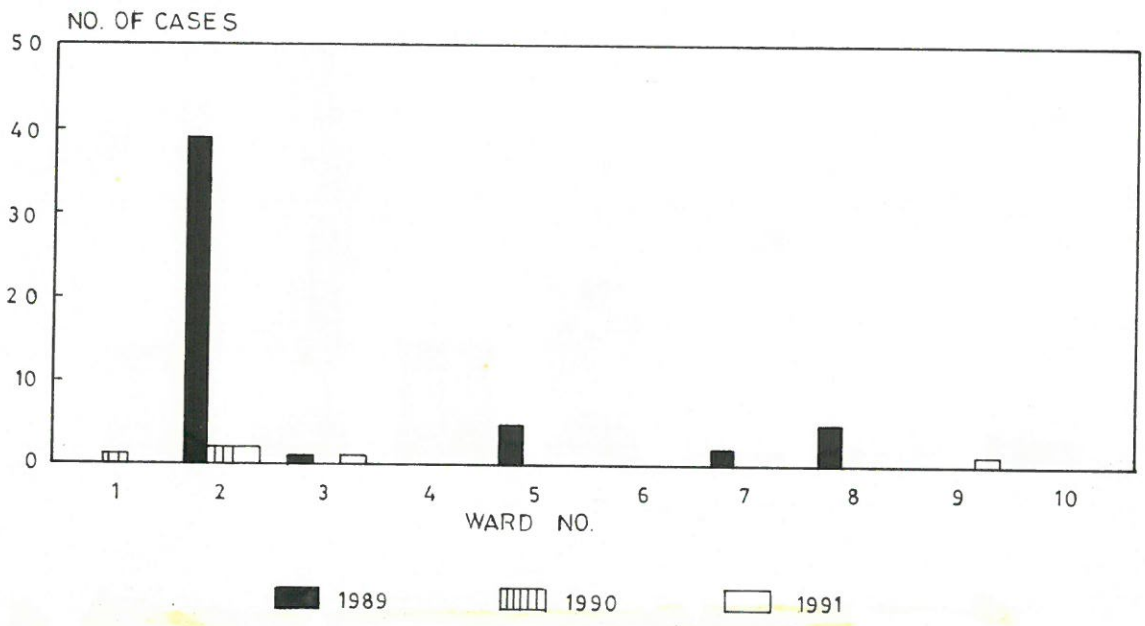


Fig. 4.4 : Wardwise Cases of Cholera

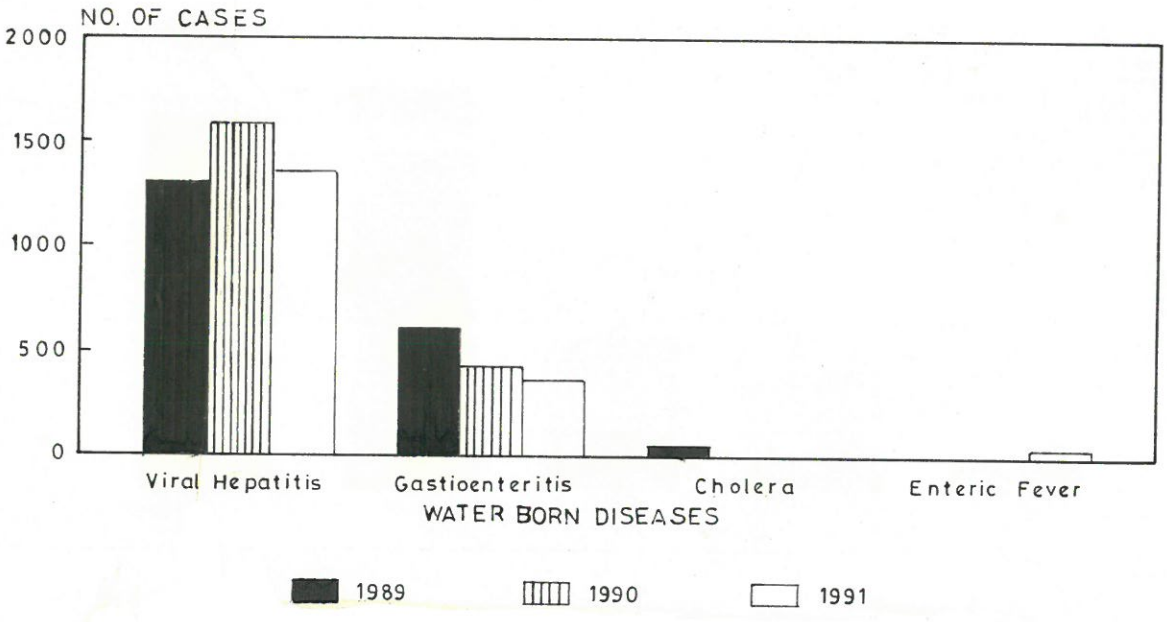


Fig. 4.5 : Yearwise Cases of Water Borne Diseases

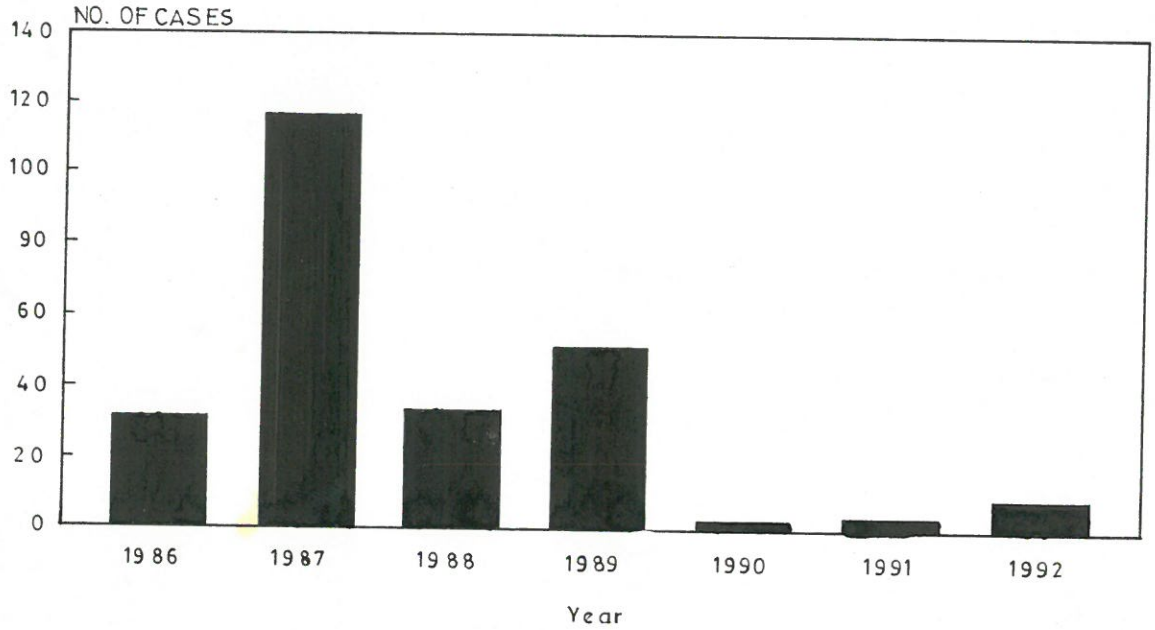


Fig. 4.6 : Yearwise Cases of Cholera

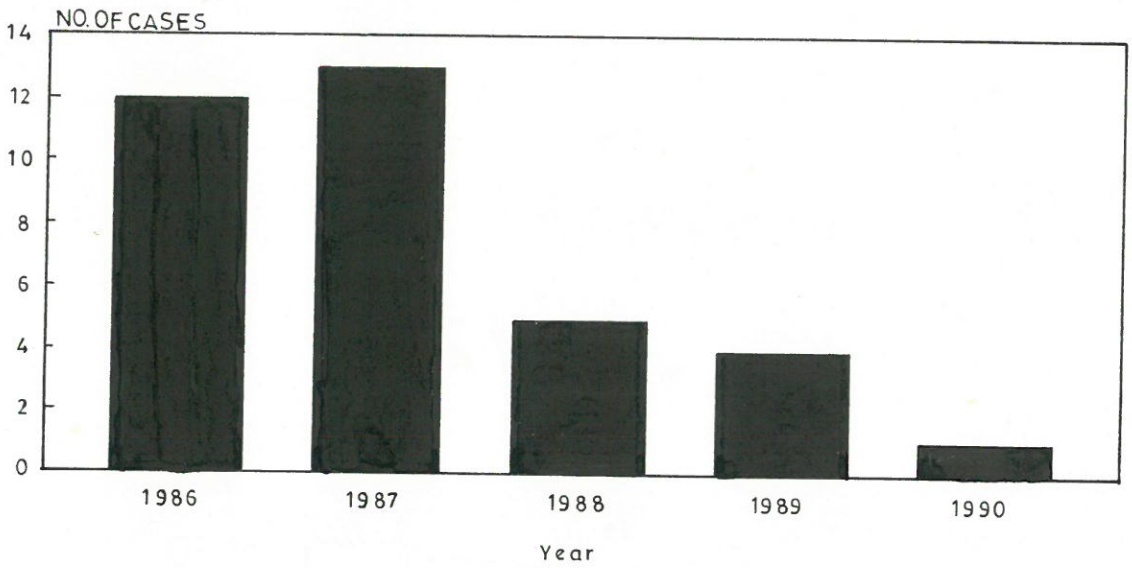


Fig. 4.7 :

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