

THE ISLAMIC REPUBLIC OF PAKISTAN
CAPITAL DEVELOPMENT AUTHORITY

FINAL REPORT
FOR
FEASIBILITY STUDY ON THE CONDUCTION OF WATER
FROM KHANPUR TO ISLAMABAD/RAWALPINDI

APPENDIX A, B & C

MARCH 1985

THE JAPAN INTERNATIONAL COOPERATION AGENCY

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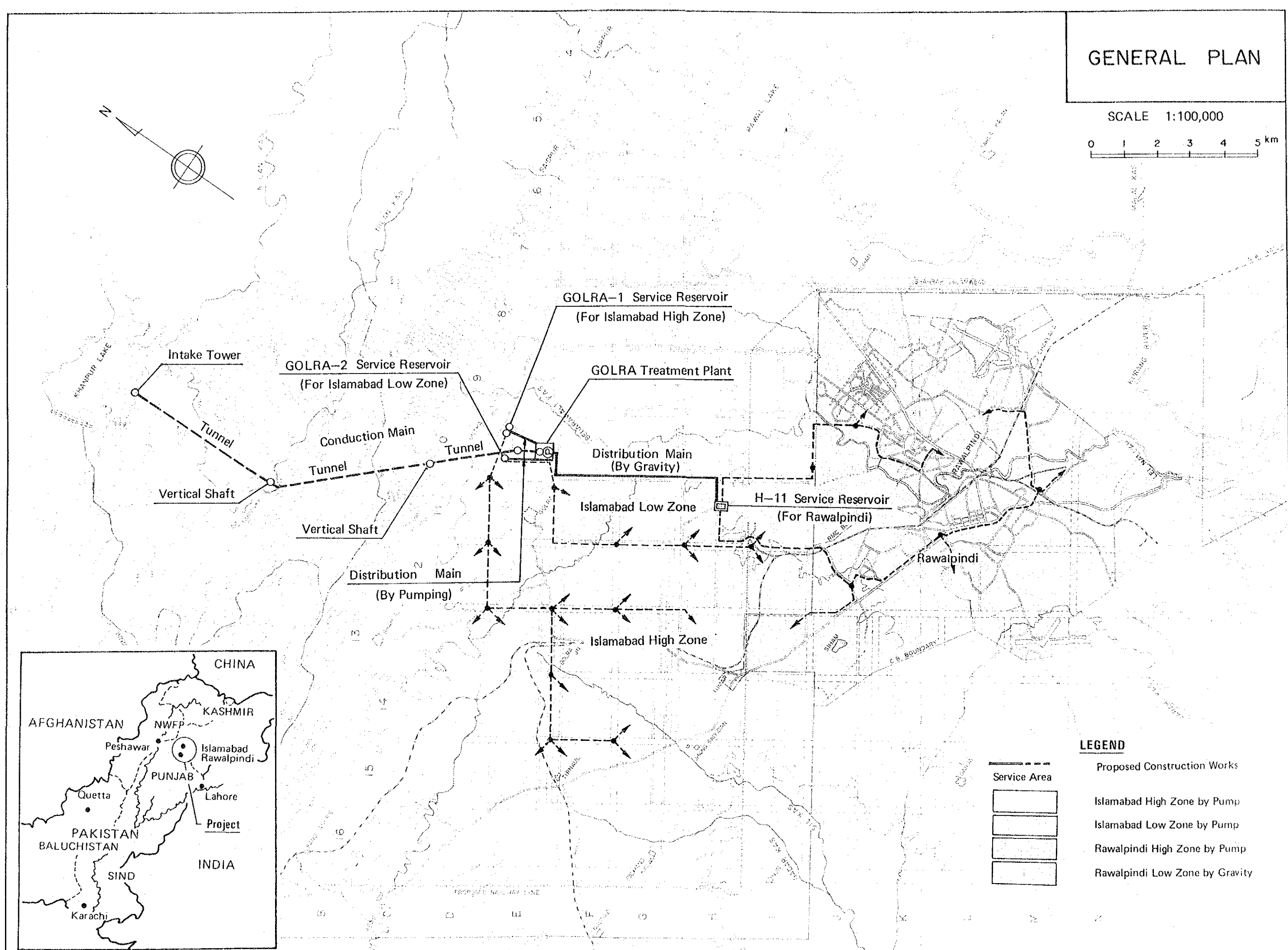
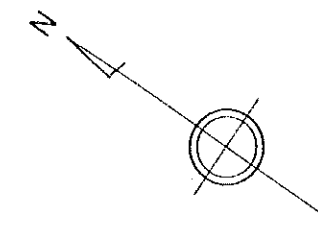
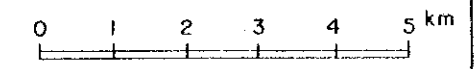
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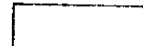
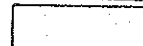


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GENERAL PLAN

SCALE 1:100,000



LEGEND

-  Proposed Construction Works
-  Islamabad High Zone by Pump
-  Islamabad Low Zone by Pump
-  Rawalpindi High Zone by Pump
-  Rawalpindi Low Zone by Gravity

CONTENTS

Appendix A

- Chapter I Population and Water Demand
- Chapter II Water Resources

Appendix B

- Chapter I Review of Existing Study
- Chapter II Investigation
- Chapter III Design Criteria
- Chapter IV Alternative Study
- Chapter V Proposed Facilities
- Chapter VI Changeability of Water Resources in Islamabad

Appendix C

- Chapter I Project Implementation
- Chapter II Project Cost Estimate
- Chapter III Operation and Maintenance
- Chapter IV Project Justification
- Chapter V Recommendations
- Chapter VI Major Records of Meeting and Confirmations

APPENDIX - A

APPENDIX - A

	<u>Page</u>
CHAPTER I. POPULATION AND WATER DEMAND	
1.1. City Development Plan	A.I-1
1.1.1. Islamabad	A.I-1
1.1.2. Rawalpindi	A.I-4
1.2. Population Projection and Population Served	A.I-8
1.2.1. Islamabad	A.I-8
1.2.2. Rawalpindi	A.I-18
1.3. Water Demand Projection	A.I-26
1.3.1. Islamabad	A.I-26
1.3.2. Rawalpindi	A.I-35
CHAPTER II. WATER RESOURCES	
2.1. Meteorology and Hydrology	A.II-1
2.2. Existing Water Resources	A.II-16
2.2.1. Khanpur Dam	A.II-16
2.2.2. Simly Dam	A.II-18
2.2.3. Rawal Dam	A.II-18
2.2.4. Other Rivers and Streams	A.II-19
2.2.5. Groundwater	A.II-20
2.3. Runoff	A.II-25
2.3.1. Haro River (Khanpur)	A.II-25
2.3.2. Soan River (Simly)	A.II-26
2.3.3. Kurang River (Rawal)	A.II-27
2.4. Sedimentation	A.II-38

	<u>Page</u>
2.5. Reservoir Operation	A.II-51
2.5.1. Khanpur Reservoir	A.II-51
2.5.2. Simly Reservoir	A.II-56
2.5.3. Rawal Reservoir	A.II-58
2.6. Availability of Stream Water	A.II-91
2.7. Availability of Grounwater	A.II-91
2.7.1. General Description	A.II-91
2.7.2. Well Field	A.II-94
2.7.3. Availability of Groundwater in Each Well Field	A.II-95
2.7.4. Development Plan of Groundwater	A.II-97
2.8. Balance of Water Availability and Demand	A.II-102

LIST OF TABLES

		<u>Page</u>
Table A.I-1	CDA 15 Years Development Programme	A.I-4
A.I-2	Population Census Records in Islamabad Urban and Rural Area	A.I-8
A.I-3	Population Census Data in Islamabad Proper Area	A.I-9
A.I-4	Population Projection of Islamabad	A.I-10
A.I-5	Projected Population Served in Islamabad Proper Area	A.I-11
A.I-6	Projected Population by Sector in Islamabad	A.I-14
A.I-7	Population Statistics in Islamabad Urban Area ..	A.I-15
A.I-8	Population Census Records in Rawalpindi	A.I-19
A.I-9	Population Projection of Rawalpindi	A.I-20
A.I-10	Housing Units by Drinking Water Source of Rawalpindi.....	A.I-21
A.I-11	Projected Population Served in Rawalpindi	A.I-21
A.I-12	Projected Population by Zone in Rawalpindi	A.I-23
A.I-13	Population Statistics by Ward in Rawalpindi	A.I-24
A.I-14	Estimated per Capita Consumption for Domestic Use of Islamabad	A.I-32
A.I-15	Projected Population and Water Demand of Islamabad	A.I-33
A.I-16	Projected Water Demand by Sector of Islamabad in 2000	A.I-34
A.I-17	Estimated per Capita Consumption for Domestic Use of Rawalpindi	A.I-41
A.I-18	Projected Population and Water Demand of Rawalpindi	A.I-42
A.I-19	Projected Water Demand by Zone of Rawalpindi in 2000	A.I-43
A.II-1	Climatic Elements Observed at Rawalpindi	A.II-7
A.II-2	Precipitation at Islamabad Airport	A.II-8
A.II-3	Mean Daily Temperature at Rawalpindi	A.II-9
A.II-4	Mean Daily Dew-point Temperature at Rawalpindi .	A.II-10
A.II-5	Mean Daily Relative Humidity at Rawalpindi	A.II-11

		<u>Page</u>
Table A.II-6	Mean Daily Sunshine Hours at Rawalpindi	A.II-12
A.II-7	Mean Daily Wind Speed at Rawalpindi	A.II-13
A.II-8(1)	Haro River Runoff at Khanpur (WAPDA)	A.II-14
A.II-8(2)	Soan River Runoff at Chirah (WAPDA)	A.II-15
A.II-9	Reservoir Specifications (Existing)	A.II-22
A.II-10	Present Groundwater Production in Islamabad/Rawalpindi	A.II-23
A.II-11	Phased Water Requirements of Beneficiaries ...	A.II-24
A.II-12	Haro River Runoff at Khanpur (Study)	A.II-31
A.II-13	Moving Averages of Annual Rainfall	A.II-32
A.II-14	CDA's Abstraction at Simly on Soan	A.II-33
A.II-15	Soan River Runoff at Simly	A.II-34
A.II-16	Rawal Dam Inflow Estimated by SDO	A.II-35
A.II-17	Spot and Areal Rainfalls	A.II-36
A.II-18	Kurang River Runoff at Rawal	A.II-37
A.II-19	Sediment Rating Curve of Haro River at Khanpur	A.II-44
A.II-20	Sediment Rating Curve of Soan River at Chirah.	A.II-45
A.II-21	Flow Duration and Suspended Sediment (Haro River at Khanpur)	A.II-46
A.II-22	Flow Duration and Suspended Sediment (Soan River at Simly)	A.II-47
A.II-23	Data from Sedimentation Surveys of Rawal Lake.	A.II-48
A.II-24	Reservoir Sedimentations and Effective Capacities	A.II-49
A.II-25	Comparison Study on Suspended Sediment Inflow.	A.II-50
A.II-26	Calculation Chart of Penman Reference Crop ETo	A.II-77
A.II-27	Field Irrigation Requirement (Wheat)	A.II-78
A.II-28	- do - (Rabi Fodder)	A.II-79
A.II-29	- do - (Rabi Vegetable) ...	A.II-80
A.II-30	- do - (Maize)	A.II-81
A.II-31	- do - (Tobacco)	A.II-82
A.II-32	- do - (Kharif Fodder) ...	A.II-83
A.II-33	- do - (Kharif Vegetable).	A.II-84

		<u>Page</u>
Table A.II-34	- do - (Sugarcane)	A.II-85
A.II-35	- do - (Orchard)	A.II-86
A.II-36	Unit Irrigation Diversion Water Requirement ..	A.II-87
A.II-37	Summary of Khanpur Reservoir Operation Study .	A.II-88
A.II-38	Summary of Simly Reservoir Operation Study ...	A.II-89
A.II-39	Summary of Rawal Reservoir Operation Study ...	A.II-90
A.II-40	Average per Day Production of Surface Water ..	A.II-92
A.II-41	Availability of Groundwater	A.II-100
A.II-42	Production of Groundwater in AD 2000	A.II-101
A.II-43	Existing and Proposed Yield of Water	A.II-106
A.II-44	Balance of Availability and Demand of Urban Water	A.II-107
A.II-45	Discharge from Tubewells	A.II-108
A.II-46	Dimensions of Wells (1)	A.II-117
A.II-47	Dimensions of Wells (2)	A.II-123
A.II-48	Annual Summary of Khanpur Reservoir Operation Study	A.II-129
A.II-49	Annual Summary of Simly Reservoir Operation Study	A.II-133
A.II-50	Annual Summary of Rawal Reservoir Operation Study	A.II-140

LIST OF FIGURES

	<u>Page</u>
Figure A.I-1	Land Use Plan for Metropolitan Area A.I-6
A.I-2	Land Use Plan and Zoning Chart of Rawalpindi .. A.I-7
A.I-3	Population Projection of Islamabad A.I-12
A.I-4	Served Area of Islamabad/Rawalpindi A.I-13
A.I-5	Population Projection of Rawalpindi A.I-22
A.I-6	Projected Population and Water Demand of Islamabad A.I-31
A.I-7	Projected Population and Water Demand of Rawalpindi A.I-40
A.II-1	River Basins in and around Metropolitan Area .. A.II- 5
A.II-2	Hydro-meteorological Data Collected A.II- 6
A.II-3	Moving Averages of Annual Rainfall A.II-29
A.II-4	Thiessen Polygons and Isohyetal Map A.II-30
A.II-5	Sediment Rating Curve at Khanpur on Haro River. A.II-41
A.II-6	Sediment Rating Curve at Chirah on Soan River . A.II-42
A.II-7	Ranking of River Discharge by Day A.II-43
A.II-8	Reservoir Capacity Curves A.II-60
A.II-9	Khanpur Reservoir Capacity Curve A.II-61
A.II-10	Simly Reservoir Capacity Curve A.II-62
A.II-11	Rawal Reservoir Capacity Curve A.II-63
A.II-12	Seasonal Variations of Muncipal Water Supply (for Both Islamabad and Rawalpindi) A.II-64
A.II-13	Cropping Pattern and Calender A.II-65
A.II-14	Cropping Calender A.II-66
A.II-15	Seasonal Variations of Inflow and Demand (Khanpur Reservoir) A.II-67
A.II-16	Khanpur Reservoir Storage, Spillage and Shortage (Case-1) A.II-68
A.II-17	Khanpur Reservoir Storage, Spillage and Shortage (Case-6) A.II-69
A.II-18	Frequency Analysis on Annual Shortage of Water Supply for Khanpur Reservoir A.II-70

	<u>Page</u>
Figure A.II-19 Simly Reservoir Storage, Spillage and Shortage (Case-1 & 2; before Raising Dam)	A.II-71
A.II-20 Simly Reservoir Storage, Spillage and Shortage (Case-8; after Raising Dam)	A.II-72
A.II-21 Frequency Analysis on Annual Shortage of Water Supply for Simly Reservoir	A.II-73
A.II-22 Rawal Reservoir Storage, Spillage and Shortage (Case-1 & 2; with 1984 Condition)	A.II-74
A.II-23 Rawal Reservoir Storage, Spillage and Shortage (Case 6; with 2000 Condition)	A.II-75
A.II-24 Frequency Analysis on Annual Shortage of Water Supply for Rawal Reservoir	A.II-76
A.II-25 Well Fields in Islamabad/Rawalpindi Area	A.II-99
A.II-26 Availability of Reservoir Water: After Treated in a Dry Year with 5-year Probability ..	A.II-103
A.II-27 Balance of Availability and Demand of Water (Islamabad)	A.II-104
A.II-28 Balance of Availability and Demand of Water (Rawalpindi)	A.II-105

CHAPTER I. POPULATION AND WATER DEMAND

CHAPTER I. POPULATION AND WATER DEMAND

1.1. City Development Plan

1.1.1. Islamabad

The master plan for the Capital City of Islamabad was prepared in 1960 by M/S. Doxiades Associates of Greece. The plan provided an outline and broad frame of concepts and criteria for the development. The implementation of the plan had been carried out with several amendments due to some limitations as well as over-provisions of certain functions of the original plan. Figure A.I-1 shows the up-to-date land use plan by CDA.

The administrative area of the new Capital is 906.5 sq.km and the City is composed of three parts, namely, Islamabad Proper covering 220.15 sq.km, Islamabad Park occupying 220.15 sq.km and Islamabad rural area of 466.20 sq.km. Islamabad Proper including institutional and industrial areas, located between the Margala Hills and Khyaban-e-Sir Syed highway, is planned that various sectors area located in parallel belts from the east to the west and they will develop simultaneously according to the necessity. The details of the land use plan are described as follows:

Administrative Sector

This sector is located at the eastern end of Islamabad Proper and is divided into three parts: Northern part consists of Central Secretariat, the central part is earmarked for the Presidency, the Parliament and the Supreme Court buildings and the southern part is reserved for cultural complex of buildings. The Presidency, the Parliament and the Cabinet-Establishment Division Block have been planned around the "Azadi Chowk", facing the Khyaban-e-Quaid-i-Azam.

Diplomatic Enclave

A special enclave is planned south of the Administrative Sector for the chanceries and residences of foreign missions. There are 70 embassies mostly located in the residential sectors. But some of the foreign mission have constructed their embassies and residences in the diplomatic enclave and the rest is planned to be shifted to the enclave in the future.

Public Buildings Area

This area is located to the west Administrative Sector and is meant for the Head offices of Autonomous and Semi-autonomous organizations. Its northern portion is reserved for the houses of federating units. Southern portion is reserved for residential accomodation. The Government Hostel, which provides accommodation for the government officers visiting Islamabad for short periods, and the State Bank of Pakistan also located here.

Residential Sectors

The residential sectors have been planned in rows on both sides of the main civic and commercial centre called as Blue Area and named as Khyaban-e-Quaid-i-Azam. Each sector is 3.1 sq.km and the plots vary in size from 125 to 1672 sq.m. These sectors are self-contained communities catering for all socio-economic needs. A sector is as such divided into smaller residential neighbourhoods which are served by various grades of community centres providing markets, dispensaries, playgrounds, parks etc., according to their requirements. Higher grades of services like cinema, restaurants, stores, have been located in the Class V Centres called Markaz.

Blue Area

The Blue Area has been designed in a linear form allowing its growth parallel to the residential sectors. This will have multi-storey commercial and office buildings along the main avenue the Khyaban-e-Quaid-i-Azam. This city centre will also have function like banks, hotels, restaurants, theatres and also certain types of cultural buildings.

The Industrial Zones

The separate zones for the location of manufacturing and light industry have been established. The industrial zone, located in close proximity to Rawalpindi, will enable the industries to serve both Islamabad and Rawalpindi and also to draw the labour force. Properly laid out labour colonies have been planned in the vicinity. Light industries and handicrafts with its own retail have been located in a belt on the two lane service road skirting the southern edge of the residential sectors. Both zones are today humming with construction activity and a large number of commercial and industrial units have gone into production.

CDA is presently undertaking the development of new sectoral areas from series 11 up to 16 in accordance with the 15 Years Development Programme. The schedule of the Programme is presented in Table A.I-1.

Besides planning, designing, other coordination and administrative activities, various project are required for the construction of highways and roads, housing, water distribution system, drainage and sewerage system, electrical supply system, etc. Several years for the above construction will be required for the arrangement of the above.

TABLE A.I-1. CDA 15 YEARS DEVELOPMENT PROGRAMME

<u>Sector</u>	<u>Start of Construction</u>	<u>Sector</u>	<u>Start of Construction</u>
E-10	1985	E-14	1997
D-11	1985	F-14	1990
F-11	1984	G-14	1989
G-11	1985	C-15	1995
D-12	1984	D-15	1995
E-12	1984	E-15	1991
F-12	1985	F-15	1989
G-12	1986	G-15	1985
D-13	1993	C-16	1999
E-13	1992	D-16	1996
F-13	1988	E-16	1998
G-13	1987	F-16	1996
C-14	1994	G-16	1997
D-14	1994		

1.1.2. Rawalpindi

The Master Plan, target year of 1990, for the city development of Rawalpindi is available at present. The plan was prepared in 1970 by the Department of Housing and Physical Planning. Since then no revision of the Master Plan was attempted. The development of both Municipal Corporation and Cantonment was projected beyond the existing administrative boundary by 1990 in the Master Plan. The actual development of Rawalpindi is, however, differed from the said plan in some aspect.

However, the concept of the Master Plan, especially on the land use plan, is utilized for the study with some modifications especially on development area and demographic aspect which is one of the basic factor for future water demand projection.

Study area of the Master Plan covered around 150 sq.km including both Municipal Corporation and Cantonment. As mentioned in the above, the development area was not extended as projected in the Master Plan, and the area is planned to be still limited within in the present administrative boundary even up to 2000 in this study

considering the past trend of the development and as the result of consultation with officials concerned. As for the future population, the Plan estimates future population at 1,035,972 in 1990.

Land Use

The future land use plan was projected as the regional urban core in the light of the Islamabad Master Plan. The land use was categorized by various sectors of residential, commercial, governmental, industrial, hospital, park and airport as shown in Figure A.I-5.

Population Distribution

The Master Plan proposed the population distribution by such manner that the density will decrease from the present congested central part of the Municipal Corporation to surrounding areas in proportion to the distance from the center in lines with land cost and needs of intensive land utilization of surrounding areas. The whole area is classified into six zones by density, R-25 (25 persons/acre), R-50, R-75, R-100, R-150 and R-250.

Commercial and Industry

Commerce and industry are two main important elements for development of the city. Rawalpindi is the important city as a regional commercial center in particular.

The present over congestion in the central part of the City with heavy traffic is mainly due to the existence of wholesale markets. To ameliorate this condition, the Master Plan proposes to shift a part of wholesale markets such as vegetable, fruit, grain, timber and leather markets, to Shah Allah Ditta Road, located next to the Bus Stand, or to sector I-11 in Islamabad. This is expected to promote the redevelopment of the area with proper schemes undertaken.

FIGURE A.I-1 LAND USE PLAN FOR METROPOLITAN AREA

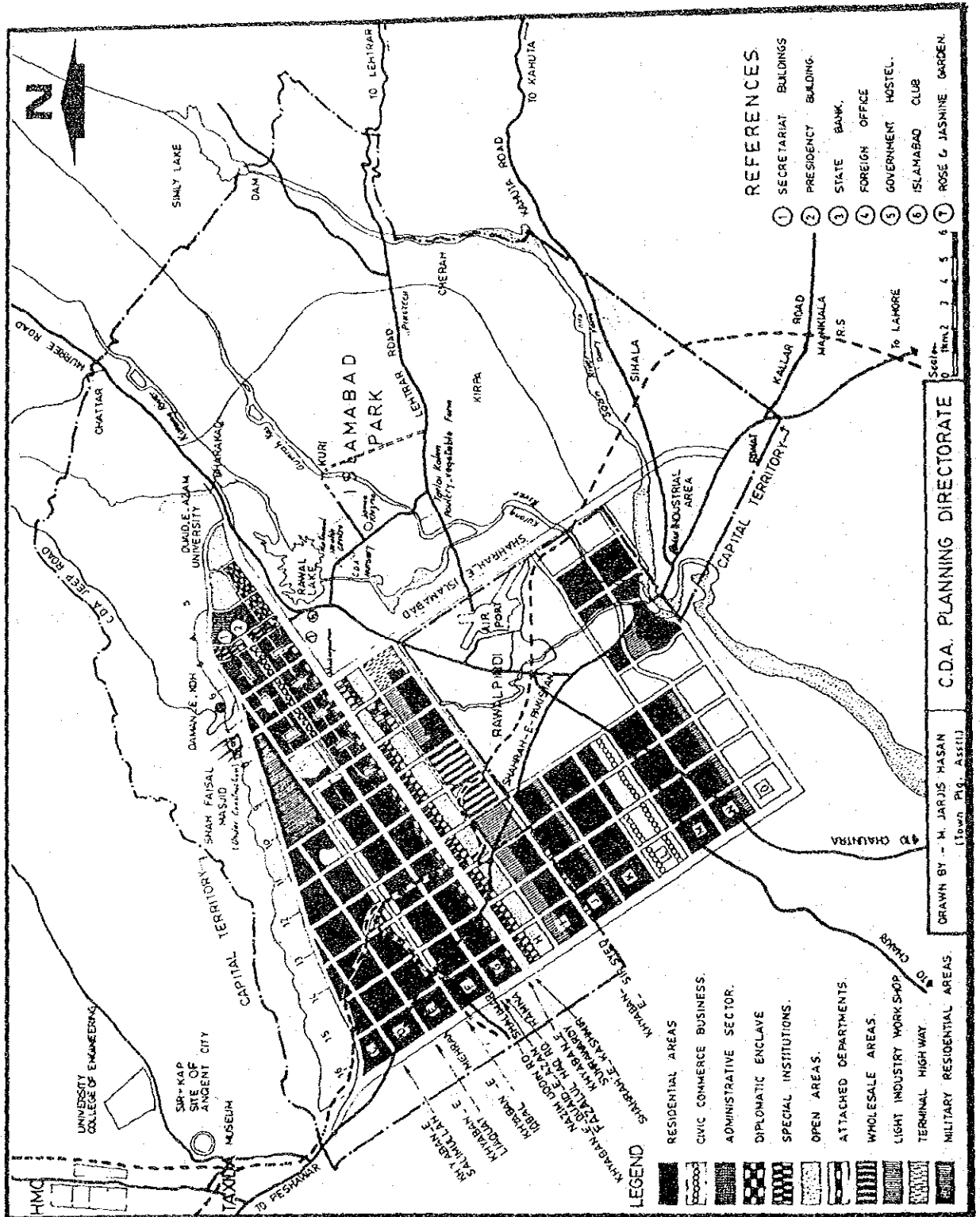
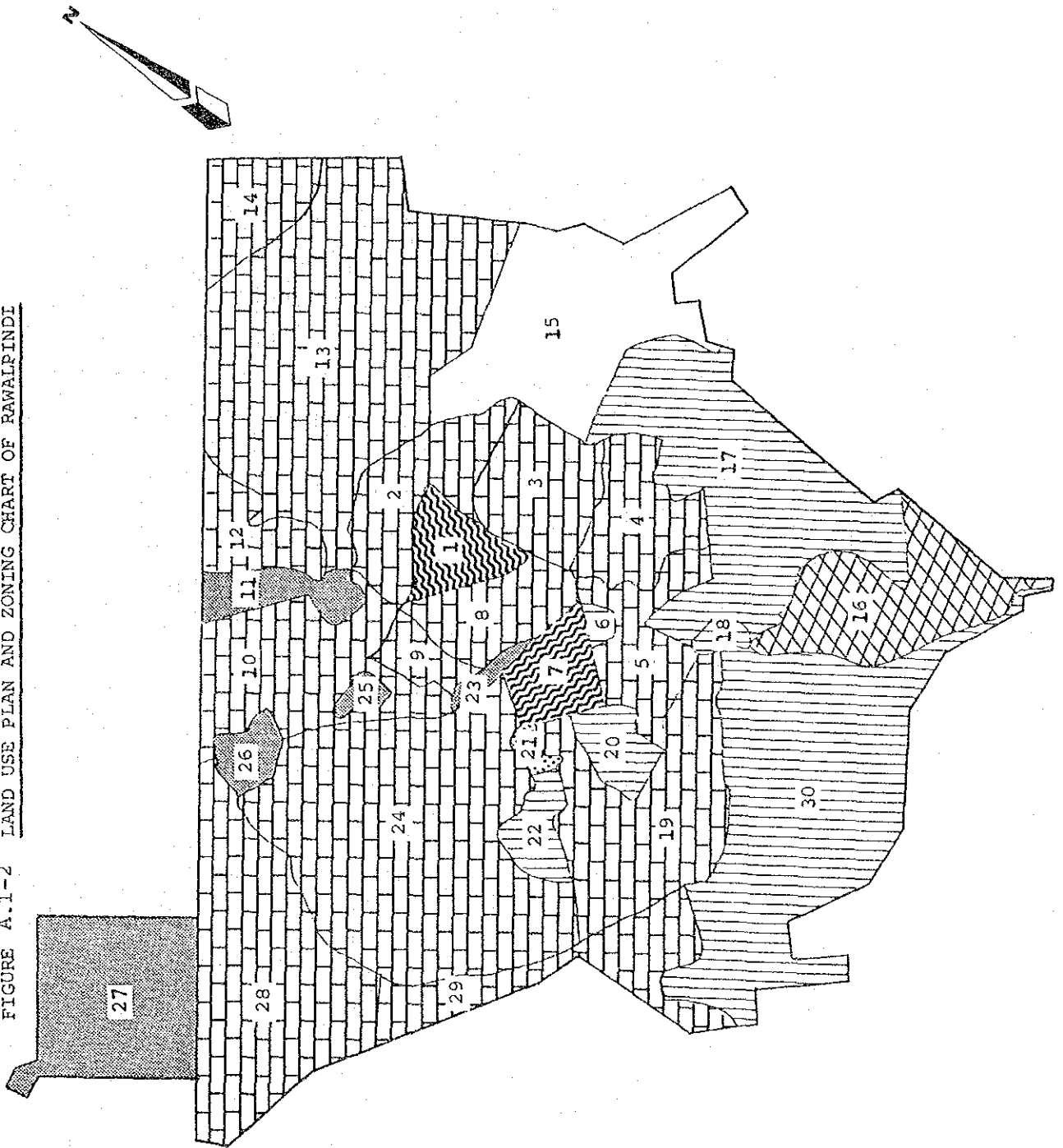









FIGURE A.I-2 LAND USE PLAN AND ZONING CHART OF RAWALPINDI



LEGEND

-  : Residential
-  : Park
-  : Government
-  : Commercial
-  : Industrial
-  : Hospital
-  : Airport

1.2. Population Projection and Population Served

1.2.1. Islamabad

A. Past Population Trend

The total population of Islamabad as of 1981 was 340,286 which is the latest official data by the Census. The population includes those in urban and rural areas. The past data on population is available every a decade from 1951. Before the establishment of the new Capital of Islamabad, the area was all rural area and was under the control mostly of Rawalpindi District. The past population trend of Islamabad is shown in Table A.I-2.

TABLE A.I-2. POPULATION CENSUS RECORDS IN ISLAMABAD
URBAN AND RURAL AREA

year	Population		
	Total	Urban	Rural
1951	83,170	-	83,170
1961	119,307	-	119,307
1972	234,813	76,641 ^{1/}	158,172
1981	340,286	204,364 ^{2/}	135,922

Note: ^{1/} population in proper area of 65 sq. km.

^{2/} population in developed and planned proper area of 311 sq.km.

As shown in the table, the annual population growth rate from 1951 up to 1981 was 4.8% in average. High growth rate of 6.3% by annum during 1961-72 period was mostly contributed by the migration due to the construction of the new Capital. Those migrants live in urban area. Such high growth rate decreased at 4.2% per annum during 1971-81 which is similar rate as 3.7% during 1951-61 period.

As for the census population in urban area in 1981, the population includes not only those in Islamabad Proper area already developed but also those in villages located in the Proper area to be developed and its surroundings. According to CDA's future city planning, villages in planned proper area are scheduled to be shifted to the outside according to the development plan. Therefore, the population in Islamabad Proper area in 1981 was adjusted at 143,902 based on the detailed area-wise population distribution in the Census as shown in Table A.I-7. The above population includes those in villages of Golra and Nurpur Shahan where important remains are located, and a part of Islamabad Park. The population in the Proper area in 1972 was also adjusted at 73,598 as of March 1972 from 76,641 in September 1972 using the growth rate during 1972-81.

The population adjusted in Islamabad Proper area in 1972 and 1981 are presented in Table A.I-3.

TABLE A.I-3. POPULATION CENSUS DATA IN ISLAMABAD URBAN AREA

<u>Year</u>	<u>Population</u>	<u>Percentage Increase (%)</u>	<u>Annual Growth Rate (%)</u>
1972	73,598	-	-
1981	143,902	96.5	7.79

B. Population Projection

For the purpose of water demand projection, only population in Islamabad Proper area is considered and future population projection of Islamabad will be made on the population of Islamabad Proper.

As for future population, there are various projections prepared by Doxiadis Associates in 1960, C.J. Price in 1968, Planning Commission in 1969, Shamsul Mulk in 1969 and AESL in 1980. Among others, projection by AESL made long term population

projection. According to the above projection, estimated population in 2000 and 2030 was 575,000 and 1,000,000 respectively on the basis of past population in 1972 and 1979 (by CDA population survey) and assumed saturated population as 1,000,000 by 2030 based on the future land use plan.

Three sets of calculation for future population projection was prepared using the linear formula, the power formula and the logistic curve formula based on the past population records. The results are presented in Table A.I-4 and Figure A.I-3.

TABLE A.I-4. POPULATION PROJECTION OF ISLAMABAD

<u>Equation</u>	<u>1984</u> (X=3)	<u>1990</u> (X=9)	<u>1995</u> (X=14)	<u>2000</u> (X=19)
$Y=143,902 + 7,812 X$	167,338	214,210	253,270	292,330
$Y=143,902 \times 1.0773^X$	179,919	281,253	408,114	592,193
$Y = \frac{1,000,000}{1 + e^{1.6971 - 0.1154X}}$	<u>205,723</u>	<u>341,077</u>	<u>479,636</u>	<u>621,401</u>

Taking into consideration the saturated population of around 1.0 million in the limited Proper area of 220 sq.km, the plan of the saturated population by sector and CDA Development Plan, the logistic curve based on the square method is considered the most applicable. The population in the year 1984, 1990, 1995 and 2000 are thus estimated at 206,000, 341,000, 480,000 and 621,000 respectively.

C. Served Area and Population Served

The present served area covers Islamabad Proper area from series 1 (Quaid-i-Azam University) up to 10 and Sports Complex in the Islamabad Park, as shown in Figure A.I-4. Villages of Golra and Nurpur Shahan are not included in the served area.

The future served area is projected on the basis of the CDA 15 years Development Programme, future population increase in the Proper area and planned saturated population in each sectoral area. Planned served area in the year 2000 is also presented in Figure A.I-4.

The presented service ratio is estimated based on the Housing Census Report of Islamabad in 1980. The served area is defined as already developed area. According to the Census Report, number of houses received piped water was 23,255 and average household size was 6.1 persons per household in Islamabad Proper area. Therefore, population served in 1980 is estimated at around 140,000 which is nearly the same as population in the same year. Service ratio is considered almost 100% at present.

The service ratio in the future is consequently to be 100% of the total population. Table A.I-5 shows projected population served in every five years up to 2000 including those in Golra and Nurpur Shahan.

TABLE A.I-5. PROJECTED POPULATION IN ISLAMABAD PROPER AREA

<u>Item Year</u>	<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Total Population	206,000	341,000	480,000	621,000
Population Served	195,000 ^{1/}	341,000	480,000	621,000
Service Ratio (%)	100	100	100	100

Note: ^{1/} excluding population of Golra and Nurpur Shahan.

D. Served Population by Sector in 2000

The served population by sector in 2000 in the Islamabad Proper area is estimated as show in in Table A.I-6, on the basis of the sector-wise planned saturated population and sector-wise timing for construction by CDA 15 Years Development Programme. Villages of

FIGURE A.I.-3 POPULATION PROJECTION OF ISLAMABAD

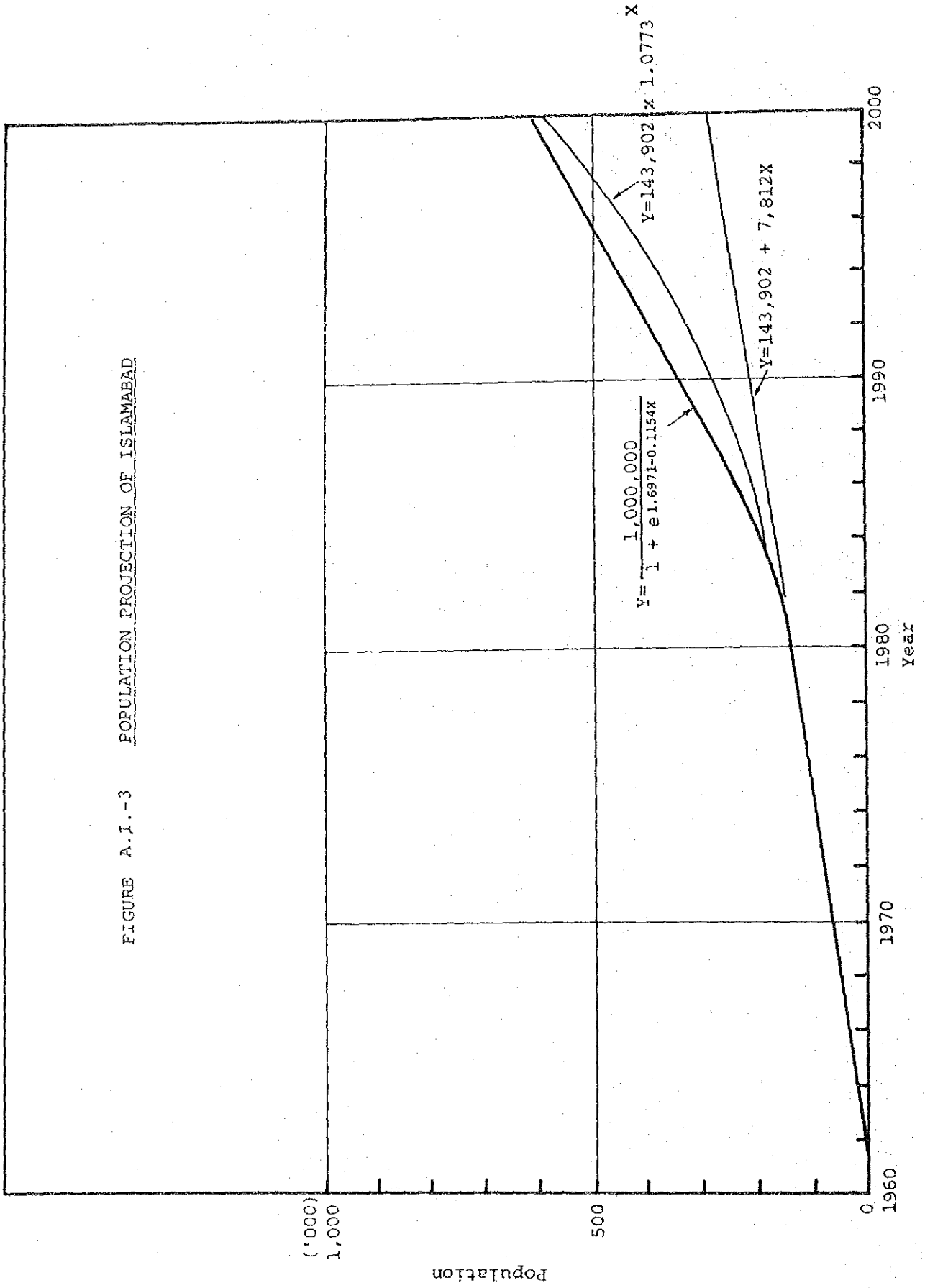


FIGURE A.I-4 SERVED AREA OF ISLAMABAD/RAWALPNDI

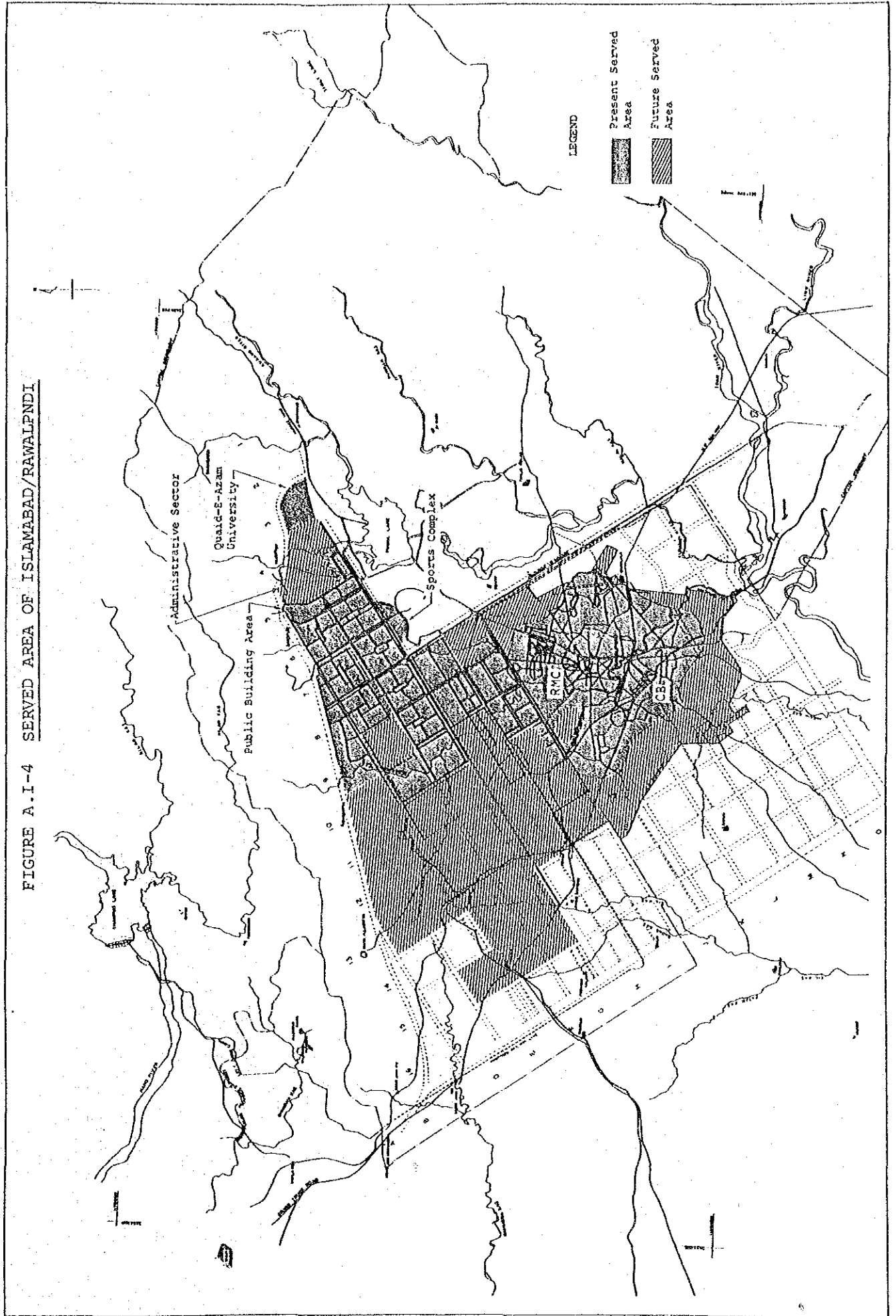


TABLE A.I.-6 PROJECTED POPULATION BY SECTOR IN ISLAMABAD

Sector No.	Land Use ^{1/}	1981	2000 ^{2/}	Saturated Population
Quaid-i-Azam University	G	755	3,400	3,400
Nurpur Shahan	R	5,157	9,100	9,100
Administrative Sector	G	802	4,000	4,000
Public Building Area & Diplomatic Enclave	G		15,100	15,100
Islamabad Park	P	1,066	12,000	12,000
F-6	R	13,856	16,500	16,500
G-6	R	31,503	32,300	32,300
E-7	R	1,051	2,200	2,200
F-7	R	6,971	16,700	16,700
G-7	R	38,818	40,100	40,100
E-8	R	3,762	6,500	6,500
F-8	R	6,448	16,600	16,600
G-8	R	10,116	45,100	45,100
H-8/I-8	G/C/P	2,430	5,000	5,000
E-9	R	-	10,900	10,900
F-9	P	-	300	300
G-9	R	11,103	70,000	70,000 ^{3/}
H-9	G/P	511	5,000	5,000
I-9	I/R	4,688	13,000	13,000
E-10	R	-	7,900	7,900
F-10	R	-	16,500	16,500
G-10	R	-	45,000	45,000
H-10	G/P	-	5,000	5,000
I-10	I/R	1,964	15,000	15,000
D-11	R	-	3,700	5,000
E-11 (Golra)	R	2,851	16,900	25,000
F-11	R	-	14,700	18,000
G-11	R	-	20,300	30,000
H-11	G/P	-	3,100	5,000
I-11	C	-	3,700	5,000
D-12	R	-	6,400	8,000
E-12	R	-	8,200	10,000
F-12	R	-	9,000	12,000
G-12	R	-	24,600	40,000
H-12	G/P	-	2,500	5,000
I-12	C	-	3,100	5,000
D-13	R	-	1,600	8,000
E-13	R	-	2,750	10,000
F-13	R	-	6,500	12,000
G-13	R	-	19,300	35,000
H-13	G/P	-	1,900	5,000
F-14	R	-	4,100	10,000
G-14	R	-	17,200	40,000
E-15	R	-	4,050	12,000
F-15	R	-	7,200	15,000
G-15	R	-	27,000	40,000
Total		143,902	621,000	768,200

Note : ^{1/} Abbreviations R: Residential; G: Government; C: Commercial
I: Industrial; P: Park or Green Area

^{2/} Projected population by sector is equal to population served.

^{3/} Adjusted based on the information from CDA.

TABLE A.I.-7

POPULATION STATISTICS IN ISLAMABAD URBAN AREA

(as of 1981)

Locality	Population			Religion		House Hold
	Both Sexes	Male	Female	Muslim	Others	Size
ISLAMABAD						
URBAN AREA	204,364	113,341	91,023	196,076	8,288	5.7
BADIA QADIR						
BAKSHSH (G-11)	350	169	181	349	1	6.1
BADIA RUSTAM						
KHAN (G-12)	779	420	359	774	5	5.9
BARKHANZADA (F-09)	251	119	132	251		7.2
BHAIKAR AKHU (E-11)	663	336	327	663		4.7
BHAIKAR FATEH						
BAKSHSH (E-12)	282	134	148	282		5.9
BHAKHA SAIYDAN						
(F-11)	862	424	438	862		5.3
BOKRA (H-12)	301	154	147	301		7.0
CHAHAN (H-10)	770	403	367	770		6.4
CHAUNTRA	598	379	219	580	18	4.3
CHHELD (G-14)	560	293	267	560		4.9
DHAREK MOHRI (F-12)	1,492	830	662	1,486	6	5.1
DHERI QILA (E-09)	341	170	171	341		4.9
DHERMIAN (F-11)	295	158	137	295		10.5
DHOK ABDULLAH (G-12)	84	41	43	84		5.6
DHOK HASHU (I-15)	409	212	197	409		6.5
DHOK JORI	1,626	845	781	1,626		4.7
DHOK KASHMIRI (E-15)	442	234	208	442		5.3
DHOK MAKHANWALI (H-16)	295	168	127	295		5.6
DHUK MIAN ABDULLAH						
(I-14)	103	50	53	103		5.7
DHOK MOHRA MALAH	150	85	65	150		5.8
DHOK MUNDEYWALI (H-16)	67	37	30	67		4.2
DHOK NOOR KHAN	729	388	341	728	1	7.0
DHOK PARACHA (G-15)	1,159	613	546	1,159		5.5
DHOK SAIYDAN (I-16)	913	470	443	913		6.1
DHOK SANDEMAR	707	356	351	707		5.9
DHOK SAWAIYAN (F-14)	299	152	147	299		4.5
SHOK TAMMAN	762	395	367	762		5.9
DHOK ZAKARI (H-10)	116	66	50	116		4.0
DORA	1,000	526	474	1,000		5.4
GARH (E-10)	489	247	242	487	2	5.1
GLIEA	1,028	524	504	830	198	4.5
*GOLRA (E-11)	2,851	1,475	1,376	2,846	5	6.0
GOVT. TECHNOLOGY						
COLLEGE (H-14)	705	348	357	681	24	5.9
JHANG BAGIAL	1,108	589	519	1,105	3	6.1
JHANGI SAIYDAN (H-15)	1,286	654	632	1,286		6.4
JOND (E-14)	675	344	331	666	9	4.8

Cont'd -

Locality	Population			Religion		House Hold
	Both Sexes	Male	Female	Muslim	Others	Size
KALANJAR	576	322	254	576		6.8
KAMIAL (E-09)	372	194	178	372		5.6
KHATAR (G-10)	97	52	45	97		4.0
KOKA (F-10)	732	392	340	731	1	6.7
KORAK (G-11)	231	112	119	231		6.2
LABOUR COLONY (F-09)	2,219	1,271	948	2,218	1	5.2
LUNDA (H-10)	248	128	120	248		5.6
MADRASA (G-10)	191	95	96	191		4.7
MAIRA	1,252	666	586	1,251	1	6.8
MAIRA BERI (D-11)	579	293	286	577	2	4.5
MAIRA SAMBAL AKKU (F-12)	2,183	1,172	1,011	2,169	14	5.2
MAIRA SAMBAL JAFFAR (G-12)	2,670	1,330	1,340	2,571	99	5.5
MALPUR	1,318	660	658	1,309	9	6.4
NIRA DHOK (G-13)	21	11	10	21		3.5
MUSLIM COLONY	1,915	1,187	728	1,873	42	4.7
NAUGAZI	1,058	532	526	1,046	12	5.3
NOON	1,586	813	773	1,586		6.4
*NURPUR SHAHAN	5,157	2,804	2,353	5,147	10	5.7
OJHRI KALAN	333	181	152	322	11	7.1
OJHRI KHURD	336	175	161	336		6.9
PADDO REMAS	615	333	282	614	1	6.2
PADHANA KALAN (G-16)	2,215	1,212	1,003	2,215		5.7
PARI (D-11)	256	135	121	256		4.7
PIND HANNA (I-15)	396	209	187	396		7.3
PIND PARACHA (G-15)	1,191	614	577	1,191		6.1
PIND PARIAN	670	346	324	670		6.2
PIND SANGRAL (D-13)	746	387	359	744	2	4.8
POONA FAQIRAN	678	388	290	674	4	6.7
*QUAID-E-AZAM UNIVERSITY CAMPUS	755	469	286	746	9	4.7
RUPPAR (F-09)	482	226	256	482		7.4
SAIDPUP	3,839	2,138	1,701	3,649	190	4.9
SANG JANI	825	439	386	811	14	5.5
SARAI KHARBUZA (D-15)	1,037	521	516	1,037		4.8
SARAI MADHO (D-16)	423	220	203	423		5.9
*SECTOR E-07	1,051	840	211	1,014	37	8.3
*SECTOR E-08	3,762	1,973	1,789	3,542	220	4.5
*SECTOR F-05, G-05 & DEP. ENCLAVE	802	602	200	756	46	3.9
*SECTOR F-06	13,856	7,897	5,959	12,394	1,462	5.0
*SECTOR F-07	6,971	4,038	2,933	6,099	872	5.5
*SECTOR F-08	6,448	3,675	2,773	6,334	114	5.6
*SECTOR G-06	31,503	17,137	14,366	30,272	1,231	6.2
*SECTOR G-07	38,818	22,016	16,802	36,146	2,672	6.1
*SECTOR G-08	10,166	5,662	4,504	9,637	529	5.7
*SECTOR G-09	11,103	6,384	4,719	10,864	239	5.6
*SECTOR H-08	821	497	324	813	8	6.0
*SECTOR H-09	511	322	189	504	7	4.3
*SECTOR I-08	1,609	894	715	1,607	2	5.3

Locality	Population			Religion		House Hold
	Both Sexes	Male	Female	Muslim	Others	Size
*SECTOR I-09	4,688	2,757	1,931	4,628	60	6.5
*SECTOR I-10	1,964	1,086	878	1,899	65	5.4
SERI SAIHAL (D-12)	1,188	610	578	1,188		4.9
SHAH ALLAH DITTA	2,241	1,200	1,041	2,227	14	6.2
SIMALA (F-10)	300	147	153	300		5.2
*SPORTS COMPLEX/ ISLAMABAD CLUB	1,066	822	244	1,055	11	5.9
SURRAIN (I-11)	641	336	305	640	1	7.5
TALI MOHRI	1,269	660	609	1,265	4	5.9
TARNOL (F-15)	1,055	551	504	1,055		5.2
THATTA GUJRAN (G-10)	281	137	144	281		6.0
THATTA SAIYDAN (G-14)	494	256	238	494		4.9
TIAL	7	7	0	7		1.4

Note: * Populations of localities with mark remain in Islamabad Proper area, but those without mark is planned to shift toward outside.

Source : Population Census Report of Islamabad in March 1981.

Golra and Nurpur Shahan are planned to be included in the served area from 1990. For the estimation of sector-wise served population, an assumption is adopted, that is, the area up to sectoral series 10 is saturated condition of population by the year 2000.

1.2.2. Rawalpindi

A. Past Population Trend

The City of Rawalpindi grew out of a small village over a period of many years. There have been many economic and administrative incentives responsible for its growth. The conducting of census of population was not known until 1900 when the British introduced the decennial system and for the first time authentic data was made available.

Population census data of Rawalpindi, consisting of the Rawalpindi Municipal Corporation and Rawalpindi Cantonment, are available for 1901 up to 1981, as presented in Table A.I-8. Except for the initial setback from 1901 to 1911 when the city lost population due to the spread of plague, population had been growing steadily. At the time of partition in 1947, Rawalpindi lost its population when Hindus and Sikhs migrated but in return received a large number of refugees. The establishment of GHQ of the Pakistan Army brought the increase in military personnel to the Cantonment. These factors contributed to the 28% growth rate in the decade 1941-51. The decade of 1961-72 recorded much more population growths which was because of Rawalpindi's recognition as an important administration and commercial center of the region. Shifting of the Federal Capital next to Rawalpindi and the interim capital in the intervening time from 1959 to 1968.

TABLE A.I-8. POPULATION CENSUS RECORDS IN RAWALPINDI

<u>Year</u>	<u>Population</u>	<u>Percentage Increase (%)</u>	<u>Annual Growth Rate (%)</u>
1901	87,638		
1911	86,483	- 1.4	-0.14
1921	101,142	17.0	1.58
1931	119,284	17.9	1.66
1941	185,042	55.1	4.49
1951	237,219	28.2	2.52
1961	340,175*	43.4	3.67
1972	598,023	75.8	5.26
1981	794,843	32.9	3.21

Note: * The population in 1972 is adjusted as of March 1, 1972, based on the population of 641,809 on September 16, 1972 and the percentage increase during the 1961-72 period.

B. Population Projection

To estimate the future population in the study area, which is one of the basic factors of demand projection, the census made by the Population Census Organization of Pakistan is used as the most reliable demographic data.

The existing population projection for Rawalpindi was made by AESL for Rawalpindi Water Supply and Sewerage Project in May 1980, ADB. Their estimation of population in 2000 and 2030 is 1,400,000 and 1,700,000 respectively. The estimation was made on the basis of the old data of 1972 population Census. So in the study, the population projection for Rawalpindi is made based on the up-to-date population census in 1981 presented previous section. Five sets of calculations are prepared in Table A.I-9, using the linear formula, the power formula and the logistic curve formula.

TABLE A.I-9. POPULATION PROJECTION OF RAWALPINDI

Equation	1984 (X=3)	1990 (X=9)	1995 (X=14)	2000 (X=19)
$Y=774,398 + 19,107X$	831,719	946,361	1,041,896	1,137,431
$Y=797,686 + 22,759X$	865,963	1,002,517	1,116,312	1,230,107
$Y=794,843 \times 1.0322^X$	874,124	1,057,197	1,238,726	1,451,425
$Y = \frac{1,700,000}{1 + e^{0.2976 - 0.445X}}$	780,414	893,694	987,088	1,077,202
$Y = \frac{1,700,000}{1 + e^{0.0994 - 0.00631X}}$	888,182	1,045,549	1,167,121	1,275,283

Considering the saturated population of around 1.7 million the logistic curve based on the least square method is the most applicable. The population in the year 1984, 1990, 1995 and 2000 is estimated at 888,000, 1,046,000, 1,167,000 and 1,275,000 respectively.

C. Served Area and Population Served

The present served area is estimated using drawing of the existing distribution pipelines and under the consultation with officials concerned. No exact drawing on served area is available. Figure A.I-4 shows the served area for both Municipal Corporation and Cantonment. While area of zones 1-9, 11, 12, 18, 20-23, 25 and 26 are covered by the supply system and zones partly supplied are 10, 13, 15-17, 19, 24, 28 and 30 (refer to Figure A.I-2 and A.I-4).

The future served area is projected to cover whole administrative area up to 2000 including planned industrial area in zone 27.

The present service ratio is estimated based on the Housing Census Report of Punjab in 1980. Table A.I-10 shows the water sources of house units. The present service ratio is estimated at about 70% considering the expansion of the distribution networks by PHED since then and the informations obtained from PHED, RMC and MES.

TABLE A.I-10. HOUSING UNITS BY DRINKING WATER SOURCE OF RAWALPINDI

<u>Item</u>	<u>RMC</u>	<u>Contonment</u>	<u>Total</u>
Housing Units	66,728	54,825	121,553
House Connection	33,274	17,143	50,417
Public Standpipe	12,862	12,329	25,191
Shallow Well (with hand pump)	699	527	1,226
Shallow Well (without hand pump)	19,760	24,713	44,473
Other Surface Water Source	133	113	246

Source: Housing Census Report of Punjab, December 1980.

The service ratio in the future is estimated every five years based on the present one and 90% in 2000. It is assumed that in 2000 there will still exist population derived water from well especially in the fringe area. The estimated service ratio in 1990, 1995 and 2000 is 80%, 85% and 90% respectively. Future population served is estimated as shown in Table A.I-11.

TABLE A.I-11. PROJECTED POPULATION SERVED IN RAWALPINDI

<u>Item</u>	<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Total Population	888,000	1,046,000	1,167,000	1,275,000
Population Served	622,000	837,000	992,000	1,148,000
Service Ration (%)	70	80	85	90

D. Served Population by Zone in 2000

The served population by zones in 2000 is estimated based on the zone-wise planned population density in the Master Plan and future propose service ratio by zone as shown in Table A.I-12.

FIGURE A.I.-5 POPULATION PROJECTION OF RAWALPINDI

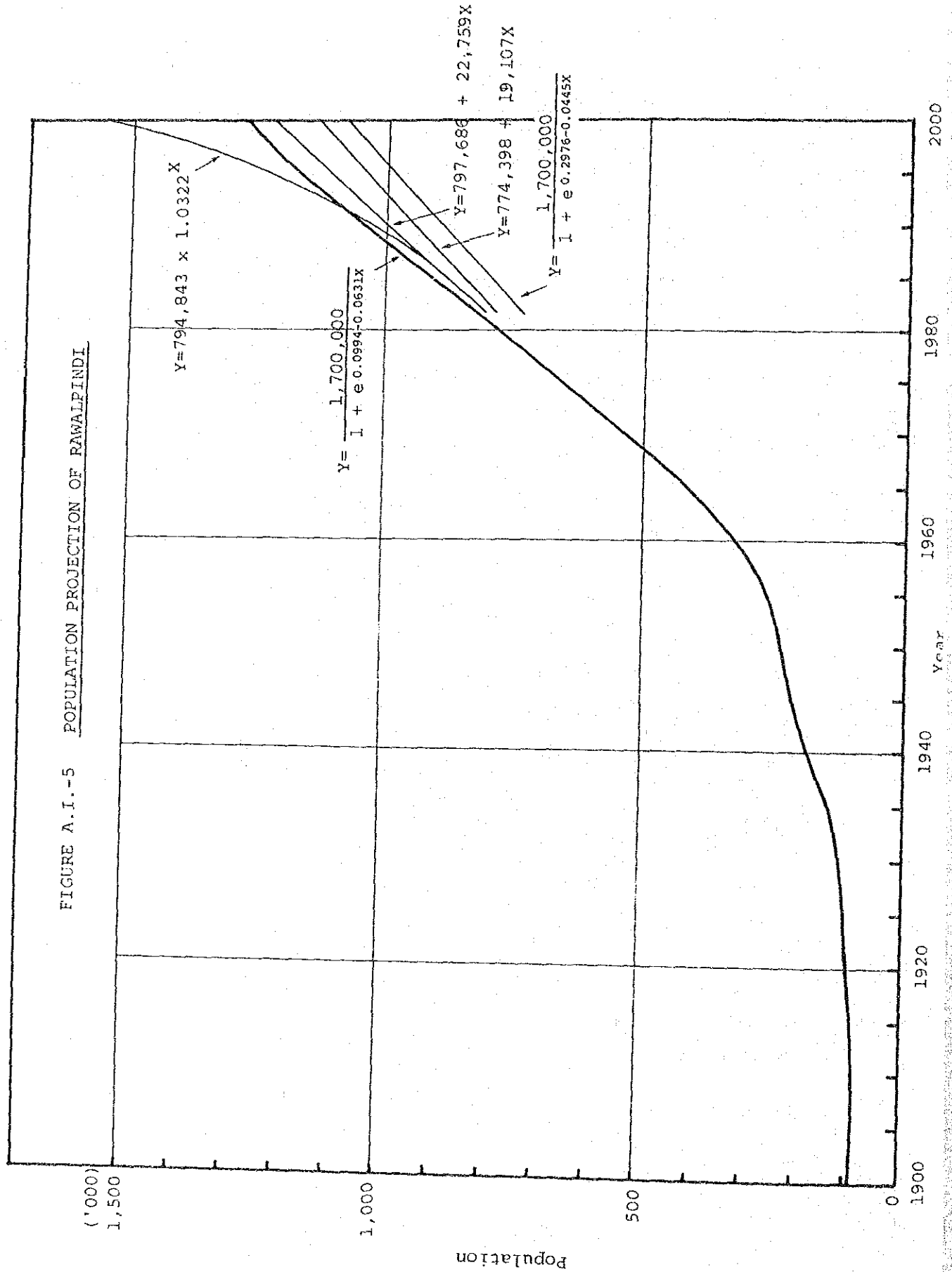


TABLE A. I.-12

PROJECTED POPULATION BY ZONE IN RAWALPINDI

Zone	Land ^{1/}	1981 ^{2/}	2000		
No.	Use	Total Population	Total Population	Service ^{3/} Ratio	Population Served
1	C	73,679	73,800	100%	73,800
2	R	92,752	99,100	100	99,100
3	R	53,588	67,800	100	67,800
4	R	19,335	28,500	100	28,500
5	R	29,671	29,850	100	29,850
6	G	2,019	2,550	100	2,550
7	C	18,986	20,200	100	20,200
8	R	35,795	39,600	100	39,600
9	R	28,599	31,100	100	31,100
10	R	45,268	61,000	87	53,100
11	I	-	-	-	-
12	R	11,585	26,700	87	23,200
13	R	122,419	272,900	87	237,400
14	R	11,471	38,400	87	33,400
15	A	-	-	-	-
16	P	-	-	-	-
17	G	29,546	88,500	87	77,000
18	G	-	-	-	-
19	R	61,173	73,300	87	63,800
20	G	8,700	10,700	87	9,300
21	H	-	-	-	-
22	G	10,129	16,000	87	13,950
23	I	-	-	-	-
24	R	54,379	155,100	87	134,900
25	I	-	-	-	-
26	I	-	-	-	-
27	I	-	-	-	-
28	R	34,918	76,600	78	59,900
29	R	11,037	18,700	78	14,650
30	G	39,794	44,600	78	34,900
Total		794,843	1,275,000	90%	1,148,000

Note: 1/ Abbreviations R: Residential; C: Commercial; P: Park;
G: Government; I: Industrial; A: Airport;
H: Hospital

2/ Adjusted population based on the District Census Report of Rawalpindi in March 1981.

3/ Service ratio is assumed as three cases of 100%, 87% and 78% considering the present service condition and future state of urbanization by zone.

TABLE A.I.-13

POPULATION STATISTICS BY WARD IN RAWALPINDI

(as of 1981)

Locality	Population			Religion		House Hold
	Both Sexes	Male	Female	Muslim	Others	Size
RAWALPINDI						
CANTI	337,752	185,845	151,907	326,612	11,140	6.1
WARD NO. 01	45,456	24,572	20,884	44,844	612	6.2
WARD NO. 02	38,876	21,653	17,223	37,609	1,267	6.0
WARD NO. 03	32,594	17,860	14,734	30,607	1,987	6.0
WARD NO. 04	29,099	15,928	13,171	26,891	2,208	6.6
WARD NO. 05	36,771	19,928	16,843	35,680	1,091	6.1
WARD NO. 06	36,036	19,699	16,337	35,762	274	6.2
WARD NO. 07	31,778	17,123	14,655	29,089	2,689	6.1
WARD NO. 08	35,644	19,975	15,669	35,239	405	6.4
WARD NO. 09	20,376	11,268	9,108	20,265	111	5.7
WARD NO. 10	31,122	17,839	13,283	30,626	496	5.7
RAWALPINDI						
MUNICIPAL CORP.	457,091	242,981	214,110	444,952	12,139	7.0
WARD NO. 01	11,585	6,252	5,333	11,403	182	6.9
WARD NO. 02	15,444	8,212	7,232	13,187	2,257	7.3
WARD NO. 03	10,248	5,431	4,817	8,977	1,271	7.3
WARD NO. 04	13,849	7,197	6,652	13,605	244	7.2
WARD NO. 05	10,856	5,657	5,199	10,761	95	7.2
WARD NO. 06	5,930	3,170	2,760	5,916	14	7.2
WARD NO. 07	9,801	5,190	4,611	9,758	43	6.6
WARD NO. 08	18,306	9,896	8,410	17,735	571	6.6
WARD NO. 09	23,429	12,975	10,454	22,874	555	7.0
WARD NO. 10	16,269	8,629	7,640	15,519	750	6.4
WARD NO. 11	6,168	3,374	2,794	6,074	94	6.1
WARD NO. 12	10,771	5,697	5,074	10,658	113	6.9
WARD NO. 13	9,202	4,841	4,361	9,081	121	7.5
WARD NO. 14	7,973	4,256	3,717	7,942	31	6.7
WARD NO. 15	6,136	3,211	2,925	6,131	5	6.8
WARD NO. 16	8,960	4,723	4,237	8,806	154	7.7
WARD NO. 17	8,394	4,409	3,985	8,332	62	6.9
WARD NO. 18	11,367	5,987	5,380	11,147	220	7.2
WARD NO. 19	19,066	10,032	9,034	16,570	2,496	7.0
WARD NO. 20	15,942	8,880	7,062	14,266	1,676	7.4
WARD NO. 21	4,914	2,527	2,387	4,833	81	7.7
WARD NO. 22	4,219	2,226	1,993	4,216	3	7.0
WARD NO. 23	5,000	2,641	2,359	4,778	222	7.3
WARD NO. 24	7,522	4,051	3,471	7,435	87	8.1
WARD NO. 25	6,737	3,465	3,272	6,716	21	7.7
WARD NO. 26	9,955	5,295	4,660	9,939	16	8.5
WARD NO. 27	5,411	2,912	2,499	5,222	189	6.3
WARD NO. 28	5,792	3,503	2,739	5,690	102	6.6
WARD NO. 29	6,013	3,121	2,892	5,990	23	7.1
WARD NO. 30	22,765	12,259	10,506	22,696	69	6.8
WARD NO. 31	6,394	3,419	2,975	9,363	1	6.2

Cont'd -

Locality	Population			Religion		House Hold
	Both Sexes	Male	Female	Muslim	Others	Size
WARD NO. 32	9,387	5,124	4,263	9,363	24	6.1
WARD NO. 33	12,164	6,487	5,677	12,154	10	6.8
WARD NO. 34	4,176	2,202	1,974	4,176		6.2
WARD NO. 35	7,473	3,915	3,558	7,440	33	8.3
WARD NO. 36	13,109	6,751	6,358	13,068	41	6.3
WARD NO. 37	7,022	3,654	3,368	7,022		6.4
WARD NO. 38	7,411	3,886	3,525	7,337	74	7.4
WARD NO. 39	8,960	4,770	4,190	8,960		6.9
WARD NO. 40	7,843	4,136	3,707	7,818	25	7.1
WARD NO. 41	6,411	3,394	3,017	6,411		7.9
WARD NO. 42	5,853	3,045	2,808	5,832	21	8.0
WARD NO. 43	4,578	2,390	2,188	4,575	3	7.5
WARD NO. 44	5,301	2,809	2,492	5,284	17	7.0
WARD NO. 45	5,031	2,664	2,367	5,001	30	6.6
WARD NO. 46	4,361	2,242	2,119	4,360	1	7.1
WARD NO. 47	3,818	2,094	1,724	3,762	56	7.2
WARD NO. 48	6,811	3,525	3,286	6,804	7	7.3
WARD NO. 49	5,545	2,919	2,626	5,528	17	7.3
WARD NO. 50	7,419	3,986	3,433	7,407	12	7.4

Source : 1981 District Census Report of Rawalpindi

1.3. Water Demand Projection

1.3.1. Islamabad

Water demand includes water consumption and leakage/wastage of the water supply system in Islamabad urban area. The water consumption is classified into the following categories of consumer:

- Domestic,
- Public, and
- Commercial and Industrial.

Present water consumption of Islamabad is estimated on the basis of the metered consumption recorded and amount charged as water tariff of each category of users obtained from CDA. Those figure are adjusted by the site investigations and informations from officials concerned. Present water supply conditions is also taken into account for the estimation.

A. Domestic Consumption

The domestic consumption of Islamabad is classified into two classes, Class A and Class B, by consumption level of each classification of houses as described below:

- Class A: High standard of living in large private house with roof tank or government house (style H & I), 3 or more taps, 2 or more WCs and bathrooms, large garden, and connection provided to the sewerage system; and
- Class B: Medium standard of living in government house or apartment (style A to G), 1 or 2 taps, 1 WC, connected to the sewerage system.

The present per capita consumptions by class are estimated at 300 l (66 gal) for Class A and 150 l (33 gal) for Class B on the basis of the metered consumption records. The present water consumption for domestic use is estimated multiplying the above per capita consumption by population served and arrives at about 37.9 MLD (8.3 MGD) which is about 40% of the total consumption.

The future per capita consumption by class will increase according to the increment of income. The per capita consumption will gradually increase when the proposed new tariff system is applied such as specific tariff system with metering.

Distribution of population by class are made according to the ratio in sectoral series E and F and other residential areas. Population classified as Class A is planned to be located in the former areas and other residential areas are more or less occupied by Class B. Population distribution by class is estimated as shown in Table A.I-14 together with per capita consumption by class.

WATER CONSUMPTION OF DOMESTIC USE

Unit: MLD (MGD)

<u>Item</u>	<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Class A	17.1 (3.7)	34.9 (7.7)	53.9 (11.9)	73.9 (16.2)
Class B	20.8 (4.6)	37.1 (8.1)	53.8 (11.8)	72.7 (16.0)
<u>Total</u>	<u>37.9 (8.3)</u>	<u>72.0 (15.8)</u>	<u>107.7 (23.7)</u>	<u>146.6 (32.2)</u>

B. Public Consumption

The public consumer includes government offices, educational institutions, embassies, hospitals, mosques and parks. The present consumption for public uses is estimated at about 35% of a total based on water consumption and the amount charged to them. This

consumption is projected by using number of establishments, employee or workers and metered consumption record. Metered consumption record is available but metered consumers are rather minor portion of a total. The present consumption of public uses thus estimated at 33.1 MLD (7.3 MGD).

The future water consumptions of educational institutions, hospitals and mosques are assumed to increase at the same rate as the increase rate of population served. On the other hand, increase rate of consumption for governmental offices is supposed to be less than that. The rate is estimated at about half of increase rate of population served. As for water consumption of embassies, small rate of 1% by annum is applied for the future consumptions. At present, already 70 embassies are established. The future water consumption for public uses is thus estimated as follows:

WATER CONSUMPTION OF PUBLIC USE

Unit: MLD (MGD)

<u>Item</u>	<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Government Office	1.8(4.8)	29.9(6.6)	42.1(9.3)	54.4(12.0)
Educational Institution	3.3(0.7)	5.5(1.2)	7.7(1.7)	10.0(2.2)
Embassy	6.1(1.4)	6.6(1.4)	7.0(1.5)	7.4(1.6)
Hospital	0.9(0.2)	1.6(0.3)	2.2(0.5)	2.9(0.6)
Mosque	0.5(0.1)	0.8(0.2)	1.1(0.2)	1.4(0.3)
Park	0.5(0.1)	0.8(0.2)	1.1(0.2)	1.4(0.3)
<u>Total</u>	<u>33.1(7.3)</u>	<u>45.2(9.9)</u>	<u>61.2(13.4)</u>	<u>77.5(17.0)</u>

C. Commercial and Industrial Consumption

Water consumption by commercial and industrial uses is composed shops, hotels, restaurants, factories and manufacturers. The present consumption is estimated at about 25% of a total consumption or 23.7 MLD (5.2 MGD) using the same approach as the above.

Water consumption of commercial and industrial uses is considered to increase at higher rate than the growth rate of population served because of accelerated economic activity in the future. According to the 6th Five-Year Plan of Pakistan, projected annual growth rate of DGP is 6.5%. The future consumption is estimated to increase at the rate of 4% or around considering the above growth rate of DGP and population served and shown below:

WATER CONSUMPTION OF COMMERCIAL/INDUSTRIAL USE

Unit: MLD (MGD)

<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
23.7 (5.2)	36.9(8.1)	50.8(11.2)	66.1(14.5)

D. Leakage and Wastage

Leakage and wastage at present is estimated at about 50% of consumption or 33% of production as the balance of water production and consumption.

The future leakage and wastage in every five years is estimated as shown in the below table on the basis of proposed target as 20% of production. It should be noted that every efforts are to be made to reduce leakage and wastage for the future sound operation of the system together with establishment of metering system.

LEAKAGE AND WASTAGE

(% of the demand)

<u>1984</u>	<u>by 1990</u>	<u>by 1995</u>	<u>by 2000</u>
33%	28%	24%	20%

E. Maximum Water Demand

According to the monthly production record in 1983, seasonal fluctuation of production is low which will be derived from the limited production capacity of the system. The maximum day demand is estimated at 125% of average demand taking into consideration weather condition with fluctuation of temperature and rainfall and the size of the city. According to the information of Lahor City, similar to Islamabad/Rawalpindi on the scale of water demand in 2000, the ratio of maximum/average demand is 1.22 at present.

The summary of water demand projection of Islamabad is presented in Table A.I-15 and shown in Figure A.I-6.

F. Distribution of water Demand by Zone

The water demand in 2000 is distributed by zone. The domestic demand is distributed according zone-wise estimated population served. Distribution of water demand for public and commercial/industrial uses are made based on the land use plan and population served by zone. Water demand of each zone in 2000 is presented in Table A.I-16.

FIGURE A.I.-6 PROJECTED POPULATION AND WATER DEMAND OF ISLAMABAD

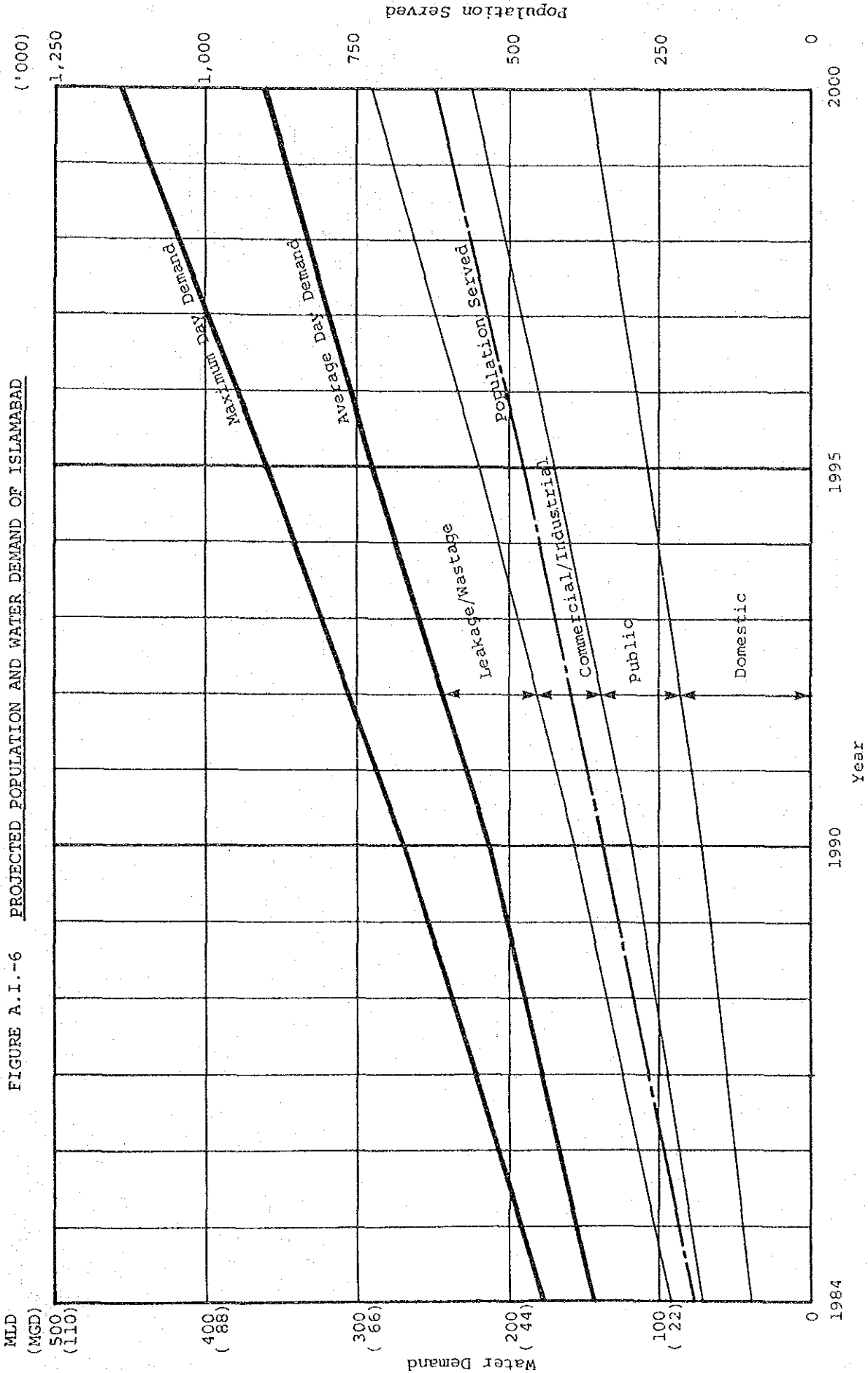


Table A.I.-14 ESTIMATED PER CAPITA CONSUMPTION FOR DOMESTIC USE OF ISLAMABAD

Year	Class A		Class B	
	Per Capita Consumption (l) (gal)	Percentage of Population Using (%)	Per Capita Consumption (l) (gal)	Percentage of Population Using (%)
1984	300 (66)	29	150 (33)	71
1990	320 (70)	32	160 (35)	68
1995	330 (73)	34	170 (37)	66
2000	340 (75)	35	180 (40)	65

TABLE A. I. -15 PROJECTED POPULATION AND WATER DEMAND OF ISLAMABAD

Item	Year	1984	1990	1995	2000
Total Population		206,000	341,000	480,000	621,000
Population Served		195,000 ^{1/}	341,000	480,000	621,000
Service Ratio (%)		100	100	100	100
Water Demand					
		Unit : MLD (MGD)			
Domestic Use		37.9 (8.3)	72.0 (15.8)	107.7 (23.7)	146.6 (32.2)
Public Use		33.1 (7.3)	45.2 (9.9)	61.2 (13.4)	77.5 (17.0)
C/I Use ^{2/}		23.7 (5.2)	36.9 (8.1)	50.8 (11.2)	66.1 (14.5)
Leakage/Wastage (%) ^{3/}		47.3 (10.4)	59.9 (13.2)	69.4 (15.2)	72.5 (16.0)
		(33)	(28)	(24)	(20)
Total		142.0 (31.2)	214.0 (47.0)	289.1 (63.5)	362.7 (79.7)
Average Day Demand		142.0 (31.2)	214.0 (47.0)	289.1 (63.5)	362.7 (79.7)
Maximum Day Demand		177.5 (39.0)	267.5 (58.8)	361.3 (79.4)	453.2 (99.6)
Daily Per Capita Demand					
		Unit : l (gal)			
Domestic Use		194 (43)	211 (46)	224 (49)	236 (52)
Total		728 (160)	628 (138)	602 (132)	584 (128)

Note : ^{1/} excluding population of Golra and Nurpur Shahan.

^{2/} C/I Use : Commercial and Industrial Use.

^{3/} Percentage of leakage/wastage to demand.

TABLE A. I. -16 PROJECTED WATER DEMAND BY SECTOR OF ISLAMABAD IN 2000

(Unit: m³/day)

Sector No.	Domestic Use	Public Use	Commercial & Industrial Use	Leakage & Wastage	Average Day Demand
Quaid-i-Azam University	964	1,505	-	617	3,086
Nurpur Shahan	1,638	97	298	508	2,541
Administrative Sector	720	7,043	-	1,941	9,704
Public Building Area & Diplomatic Enclave	2,974	21,161	-	6,034	30,169
Islamabad Park	2,160	460	-	655	3,275
F-6	5,594	804	773	1,793	8,964
G-6	6,166	1,445	1,346	2,239	11,196
E-7	748	23	22	198	991
F-7	5,630	792	1,383	1,951	9,756
G-7	7,458	1,650	1,139	2,562	12,809
E-8	2,210	1,211	65	872	4,358
F-8	5,596	205	1,382	1,796	8,979
G-8	8,358	2,935	1,422	3,179	15,894
H-8/I-8	1,700	6,146	10,754	4,650	23,250
E-9	3,706	135	109	988	4,938
F-9	54	440	1,219	428	2,141
G-9	13,720	1,920	1,764	4,351	21,755
H-9	1,700	6,146	50	1,974	9,870
I-9	2,340	138	8,042	2,630	13,150
E-10	2,654	98	1,600	1,088	5,440
F-10	5,578	226	1,748	1,888	9,440
G-10	8,324	1,611	906	2,710	13,551
H-10	1,700	6,146	50	1,974	9,870
I-10	2,700	160	6,893	2,438	12,191
Sub-total	94,392	62,497	40,965	49,464	247,318
D-11	1,258	46	37	335	1,676
E-11	4,978	209	1,097	1,571	7,855
F-11	4,966	204	935	1,526	7,631
G-11	3,894	958	509	1,340	6,701
H-11	1,054	3,805	31	1,223	6,113
I-11	666	40	7,958	2,166	10,830
D-12	2,176	80	64	580	2,900
E-12	2,756	101	1,207	1,016	5,080
F-12	3,028	127	803	990	4,948
G-12	4,588	947	710	1,561	7,806
H-12	850	3,115	25	998	4,988
I-12	558	33	6,561	1,788	8,940
D-13	544	20	16	145	725
E-13	927	34	408	342	1,711
F-13	2,194	92	587	718	3,591
G-13	3,634	819	611	1,266	6,330
H-13	646	2,426	19	773	3,864
F-14	1,378	59	435	468	2,340
G-14	3,256	666	826	1,187	5,935
E-15	1,369	50	512	483	2,414
F-15	2,432	99	529	765	3,825
G-15	5,020	1,040	1,289	1,837	9,186
Sub-total	52,172	14,970	25,169	23,078	115,389
Total	146,564	77,467	66,134	72,542	362,707

1.3.2. Rawalpindi

Presently customers are mostly charged their water tariff by flat rate and most of connections are unmetered. Therefore, consumption data of each category is limited. The future water demand will be estimated based on the analysis of the present water consumption by categories and site investigation. Informations obtained during field survey and related report such as Rawalpindi Water Supply and Sewerage Project in 1980 are taking into consideration for the estimate.

A. Domestic Consumption

The present Domestic consumption seems to be low. The average water consumption is about 80 litre per capita per day (lpcd) according to the sample survey. Potential water demand will be higher than the present consumption level.

In this study, the consumer is classified into three classes according to the consumption level. They are Class C and D with direct connection from the system and Class E supplied through public standpipe as shown in below:

- Class C: Medium standard of living, 2 or 3 taps, 1 WC and bathroom, connected to the sewerage system;
- Class D: Low standard of living, 1 or 2 taps, 1 WC or bucket flush type toilet, occasionally connected to the sewerage system; and
- Class E: Lowest standard of living, public standpipe users.

The present per capita consumption of each class is assumed as 150, 100 and 70 lpcd for Class C, D and E respectively considering the consumption level of Islamabad and other similar cities. These per capita consumption are expected to increase gradually according to the increment of income. As for population distribution, the present distribution ratio is estimated using the Housing Census Report of Punjab in 1980. Ratio of Class C is expected to increase gradually from 25% at present to 40% in 2000. Ratio of Class E, on the other hand, will reduce to 5% in 2000. Population distribution of each class is estimated and presented in Table A.I-17 together with per capita consumption.

The future water demand of domestic use is estimated multiplying the above per capita consumption and population served as summarized below:

WATER CONSUMPTION OF DOMESTIC USE

<u>Item</u>	<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Class C	33.3(7.3)	53.3(11.7)	75.6(16.6)	102.0(22.4)
Class D	22.2(4.9)	43.9(9.7)	63.0(13.9)	86.1(18.9)
Class E	12.4(2.7)	11.0(2.4)	8.2(1.8)	4.5(1.0)
<u>Total</u>	<u>67.9(14.9)</u>	<u>108.2(23.8)</u>	<u>146.8(32.3)</u>	<u>192.6(42.3)</u>

B. Public

The public consumers in Rawalpindi includes such establishments as government offices, educational institutions, hospitals, mosques and parks. The present water consumption is estimated at 16.5 MLD (3.6 MGD) considering number of government employees, number of the above feature in public sector and the consumption estimated in the study in Islamabad, as shown below.

The future water consumption of educational institutions, hospitals and mosques are estimated on the basis of the increase in proportion to the served population growth. The future water consumption of government offices is estimated based on the increase in proportion to half of the served population growth. The future water consumption of parks is estimated based on the increase in proportion to the served population growth. The future water consumption of public use is estimated by the summation of the above each consumption, as presented below:

WATER CONSUMPTION OF PUBLIC USE

<u>Item</u>	<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Government Office	12.1(2.7)	14.2(3.1)	15.7(3.4)	17.1(3.8)
Educational Institution	2.2(0.5)	2.9(0.6)	3.5(0.8)	4.1(0.9)
Hospital	1.1(0.2)	1.5(0.3)	1.8(0.4)	2.0(0.5)
Mosque	0.6(0.1)	0.8(0.2)	0.9(0.2)	1.2(0.2)
Park	0.5(0.1)	0.7(0.2)	0.8(0.2)	1.0(0.2)
<u>Total</u>	<u>16.5(3.6)</u>	<u>20.1(4.4)</u>	<u>22.7(5.0)</u>	<u>25.3(5.6)</u>

Unit: MLD (MGD)

C. Commercial and Industrial

This refers to such consumers as hotels, restaurants, all factories and manufacturers. The present water consumption of commercial and industrial use is estimated at 28.6 MLD (6.3 MGD) considering the result of hearing survey and number of labours.

The future water consumption is estimated on the basis of the served population annual growth rate of Rawalpindi and the GDP annual growth rate of 6.5% in the 6th Five-Year Plan of Pakistan, as shown below:

WATER CONSUMPTION OF COMMERCIAL/INDUSTRIAL USE

Unit: MLD (MGD)			
<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
28.6 (6.3)	37.7 (8.3)	46.1 (10.1)	55.2 (12.1)

D. Military

This includes such consumers as Army, Air Force, their residential use and International Airport. Average day water consumption in August 1984 was 15.9 MLD (3.5 MGD). However, average day water requirement was estimated at 18.2 MLD (4.0 MGD) by MES in Rawalpindi.

Since no other future plan or data for the water demand projection of the military use is available, the future water consumption is estimated on the basis of the assumption that the water consumption will increase proportionately to the growths of the population and per capita consumption because there are assumed to be many military personnel but not so many military installations in GHQ of the Pakistan Army, as shown below:

WATER CONSUMPTION OF MILITARY USE

Unit: MLD (MGD)

<u>1984</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
15.9 (3.5)	24.6 (5.4)	29.7(6.5)	34.9 (7.7)

E. Leakage and Wastage

Leakage and wastage of the present water supply system in Rawalpindi is estimated at 36% of the production as the balance of water production and consumption.

The future leakage and wastage in every five years is estimated as shown in the below table on the basis of proposed target as 20% of production.

LEAKAGE AND WASTAGE

(% of the demand)

<u>1984</u>	<u>by 1990</u>	<u>by 1995</u>	<u>by 2000</u>
36%	30%	25%	20%

F. Distribution of Water Demand by Zone

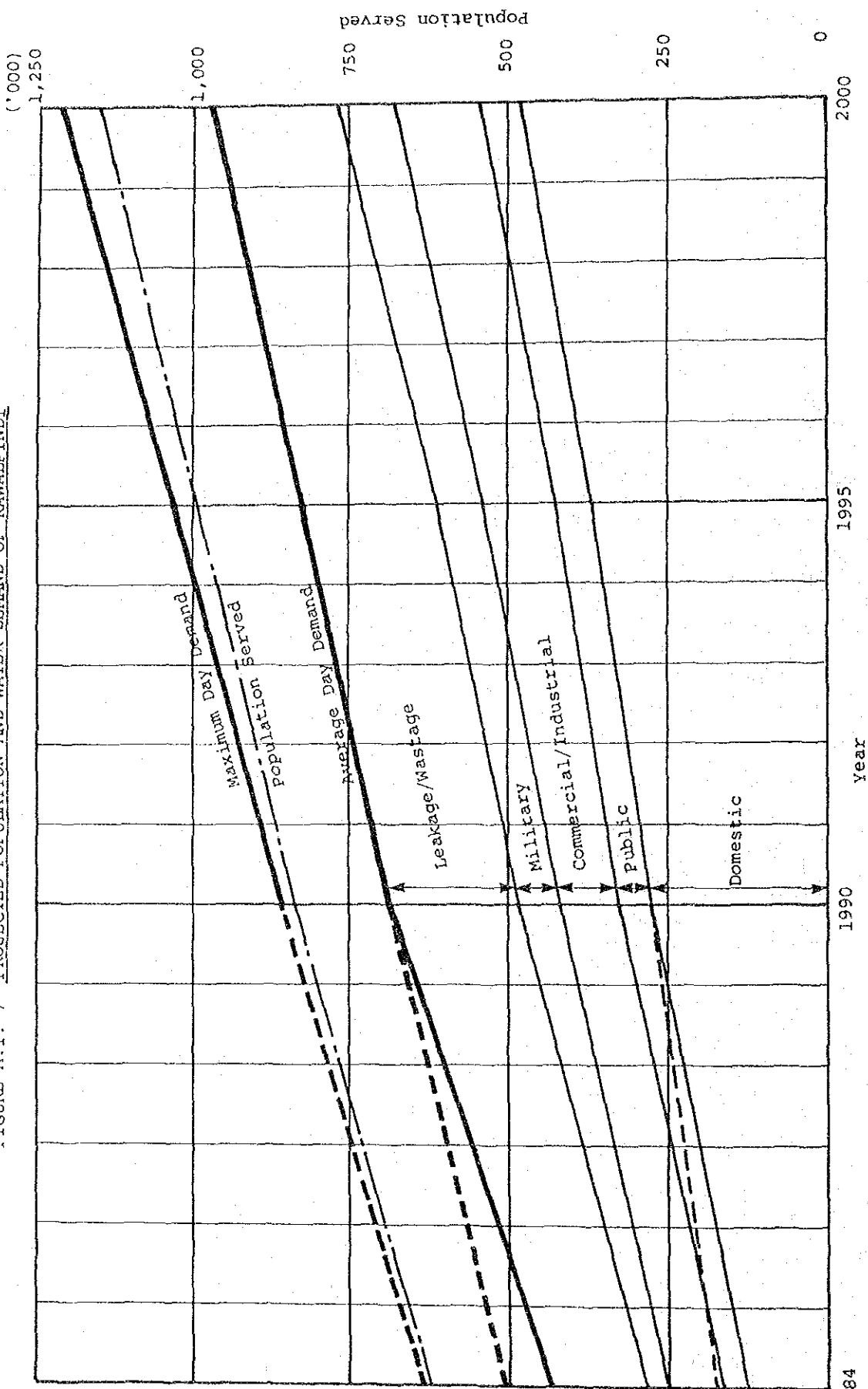
The water demand in 2000 is distributed by zone based on the land use plan and zone-wise population served distribution. Water demand of each zone in 2000 is presented in Table A.I-19.

MLD
(MGD)
500
(110)
400
(88)
300
(66)
200
(44)
100
(22)
0

A.I.-1'A

Water Demand

FIGURE A.I.-7 PROJECTED POPULATION AND WATER DEMAND OF RAWALPINDI



1984

1990

1995

2000

Year

Population Served

('000)
1,250
1,000
750
500
250
0

TABLE A.I.- 17 ESTIMATED PER CAPITA CONSUMPTION FOR DOMESTIC USE OF RAWALPINDI

Year	House Connection			Public Standpipe			Other Sources			
	Class C			Class D			Class E			
	Per Capita Consumption (1) (gal)	Percentage of Population Using (%)	Per Capita Consumption (1) (gal)	Percentage of Population Using (%)	Per Capita Consumption (1) (gal)	Percentage of Population Using (%)	Per Capita Consumption (1) (gal)	Percentage of Population Using (%)	Per Capita Consumption (1) (gal)	Percentage of Population Using (%)
1980 ^{1/}	-	21	-	20	-	21	-	38	-	-
1984	150 (35)	25	100 (24)	25	70 (15)	20	70 (15)	30	70 (15)	20
1990	170 (40)	30	120 (29)	35	70 (15)	15	70 (15)	20	70 (15)	10
1995	185 (43)	35	135 (31)	40	70 (15)	5	70 (15)	15	70 (15)	10
2000	200 (46)	40	150 (33)	45	70 (15)	5	70 (15)	10	70 (15)	5

Note: ^{1/} Source : Housing Census Report of Punjab in 1980.

TABLE A.I.-18 PROJECTED POPULATION AND WATER DEMAND OF RAWALPINDI

Item	Year	1984	1990	1995	2000
Total Population		888,000	1,046,000	1,167,000	1,275,000
Population Served		622,000	837,000	992,000	1,148,000
Service Ration (%)		70	80	85	90
<hr/>					
Water Deman		Unit : MLD (MGD)			
Domestic Use		67.9(14.9)	108.2(23.8)	146.8(32.3)	192.6(42.3)
Public Use		16.5(3.6)	20.1(4.4)	22.7(5.0)	25.3(5.6)
C/I Use 1/		28.6(6.3)	37.7(8.3)	46.1(10.1)	55.2(12.1)
Military Use		15.9(3.5)	24.6(5.4)	29.7(6.5)	34.9(7.7)
Leakage/Wastage		72.5(15.9)	81.7(18.0)	81.8(18.0)	77.0(16.9)
(%) 2/		(36)	(30)	(25)	(20)
Total		201.4(44.2)	272.3(59.9)	327.1(71.9)	385.0(84.6)
Average Day Demand		201.4(44.2)	272.3(59.9)	327.1(71.9)	385.0(84.6)
Maximum Day Demand		251.8(55.3)	340.4(74.8)	408.9(89.9)	481.3(105.8)
<hr/>					
Daily Per Capita Demand		Unit : 1 (gal)			
Domestic Use		109(24)	129(28)	148(33)	168(37)
Total		324(71)	325(71)	330(73)	335(74)

Note : 1/ C/I Use : Commercial and Industrial Use
 2/ Percentage of leakage/wastage to demand.

TABLE A.I.-19

PROJECTED WATER DEMAND BY ZONE OF RAWALPINDI IN 2000

(Unit: m³/day)

Zone No	Domestic Use	Public Use	Commercial & Industrial Use	Military Use	Leakage & Wastage	Average Day Demand
1	12,384	326	7,380	-	5,023	25,113
2	16,632	1,086	3,016	-	5,144	25,878
3	11,377	878	2,063	-	3,553	17,871
4	4,783	486	867	-	1,524	7,660
5	5,009	1,644	908	-	1,887	9,448
6	428	1,011	78	-	385	1,902
7	3,389	608	2,020	-	1,507	7,524
8	6,645	1,462	1,205	-	2,319	11,631
9	5,215	530	946	-	1,662	8,353
10	8,910	1,042	1,615	-	2,873	14,440
11	-	-	3,287	-	843	4,130
12	3,893	396	706	-	1,240	6,235
13	39,834	4,685	7,222	-	12,853	64,594
14	5,604	1,161	1,016	-	1,937	9,718
15	-	-	-	9,955	2,553	12,508
16	-	600	-	-	154	754
17	12,920	1,370	2,342	-	4,131	20,763
18	-	1,000	-	-	257	1,257
19	10,706	1,361	1,941	24,887	9,861	48,756
20	1,560	545	283	-	596	2,984
21	-	271	-	-	70	341
22	2,341	567	424	-	830	4,162
23	-	-	702	-	180	882
24	22,636	2,303	4,104	-	7,212	36,255
25	-	-	478	-	123	601
26	-	-	1,292	-	331	1,623
27	-	-	8,007	-	2,053	10,060
28	10,051	1,159	1,822	-	3,237	16,269
29	2,457	250	446	-	783	3,936
30	5,856	595	1,062	-	1,865	9,378
Total	192,630	25,336	55,232	34,842	76,986	385,026

CHAPTER II. WATER RESOURCES

CHAPTER II. WATER RESOURCES

2.1. Meteorology and Hydrology

Pakistan extends from 24°N to about 37°N. It's western border lies close to 62°E and northeastern border extends to about 72.5°E, with Kashmir extending up to 80°E. These physical feature have a great relation on the climatology of the area, not only modifying amount of rainfall and temperature pattern of Pakistan but also greatly affecting general circulation of the atmosphere in South Asia.

The Project Area, the twin cities of Islamabad and Rawalpindi, is located in the north-eastern corner of the Potwar Plateau, bounded by the Indus and Jhelum rivers, in the north of Punjab Province with the north latitude between 33°29' and 33°48' and the east longitude between 72°49' and 73°23'.

Being located at the southern foot of the Murree and Margala hills, the Capital Area is under relatively pleasant climate with cold winters and hot summers. There are two rainy periods a year; the summer monsoon originated from the East and winter rains caused by western disturbances.

The four well marked seasons are:

<u>Season</u>	<u>Period</u>	<u>Ave. Temperature</u>
Cold Season	Dec. - Mar.	12.8°C
Hot Season	Apr. - Jun.	27.3°C
Monsoon Season	Jul. - Sep.	28.7°C
Post Monsoon Season	Oct. and Nov.	19.6°C

Cold Season

The cold season sets in Pakistan by the middle of December. This period is characterized by fine weather, low humidity and large diurnal range of temperature. Western disturbances in this season accordingly cause fairly widespread rain. Pakistan has thus a winter rainfall season which is characteristic of the middle latitudes. In the Indus basin the amount of rainfall is not large as compared to the amount received during the monsoon period. These western disturbances which cause all this precipitation are extra-tropical in nature and have at times well marked warm and cold fronts associated with them. The cold waves extend to the whole of the Indus basin and far beyond. In these cold waves minimum temperatures below freezing point with frosts are reported even from plains. In some extreme cases minimum temperature as low as -4°C have been reported from Islamabad airport. Over the hill stations snow falls are common and sometimes very low temperatures are recorded. Murree, which is a popular summer resort of Pakistan, has been daily minimum and maximum temperature of -0.5°C and 7°C respectively in January. The lowest minimum temperature recorded at Murree is -11°C .

Hot Season

Pakistan is characterized by extreme continentality in hot season. The mean daily range of temperature is of the order of $16-17^{\circ}\text{C}$, relative humidity in May and June varies from about 50% in the morning to about 25% or less in the afternoon, and at any stations it is even less than 20%. The highest day temperature have been recorded in May and June when the hot weather continues stagnated for days together with the mean daily maximum temperature raging from 41°C to 46°C , while temperature of 50°C or above are not uncommon.

Any description of climatology in hot season would be incomplete without a brief reference to the pleasant climate of hill stations. The mean daily maximum and minimum temperature at Murree in June are 27°C and 16°C respectively. The month April to June are usually dry in Pakistan. The total rainfall of the season at different stations in the plains varies between 27-7 mm and is of the order of 102 mm to 127 mm in the sub-mountain districts. This is received generally in association of western disturbances which move in northerly latitudes and are occasionally associated with storms of dust, thunder and hail.

Monsoon Season

The southwest monsoon reaches the Area towards the beginning of July and establishes there by the middle of the month. The strength of the monsoon currents increases from June to July, it remains steady and begins retreating toward the end of August, but occasionally it continues active even in September when some of the highest floods in rivers have been recorded. A series of tropical depressions bring heavy rainfalls in the catchment of rivers causing high floods in them.

Post Monsoon Season

Beginning from the middle of September, October and early November are the transitory period and the most pleasant months with weather becoming increasingly cool with much sunshine. December becomes again cold with occasional rainfalls.

Meteorological data are available from Rawalpindi (Islamabad Airport). The annual rainfall ranges remarkably from season to season and from year to year amounting to 1,100 mm as an average in the past 30 years, of which about 60% concentrates during the monsoon season from July to September.

The daily mean temperature varies from 32°C in June to 10°C in January with annual average of 21.5°C at Rawalpindi. Major climatic elements, in terms of monthly averages observed at Rawalpindi, are summarized in Table A.II-1. Major climatic elements are collected as shown in Tables A.II-2 to A.II-7.

Within reasonable distance of the Islamabad-Rawalpindi area, there are three major resources of surface water, the Haro, Kurang and Soan rivers which drain the Margala hills and neighboring mountainous areas north of the Islamabad-Rawalpindi area flowing in a generally southwesterly direction to the Indus river, as is seen in Figure A.II-1. Generally, flows are greatest during the monsoon rainy period from July through September, with lesser increases in flow during March. The headwater reaches of these rivers are featured by steep gradients, peaky flow conditions and very high rates of sediment transport. On leaving the mountainous terrain and entering the Potwar Plateau, the gradient of each river is flattening with deposition of the coarser sediments, often resulting in braided channels of unstable location.

Hydrological data are available mainly from WAPDA, Surface Water Hydrology Project (SWHP). River runoff records collected from WAPDA on Haro river at Khanpur and on Soan river at Chirah are summarized as presented in Tables A.II-8 (1) and A.II-8 (2).

Meteorological and hydrological data requested and collected during the course of the study are listed in Figure A.II-2.

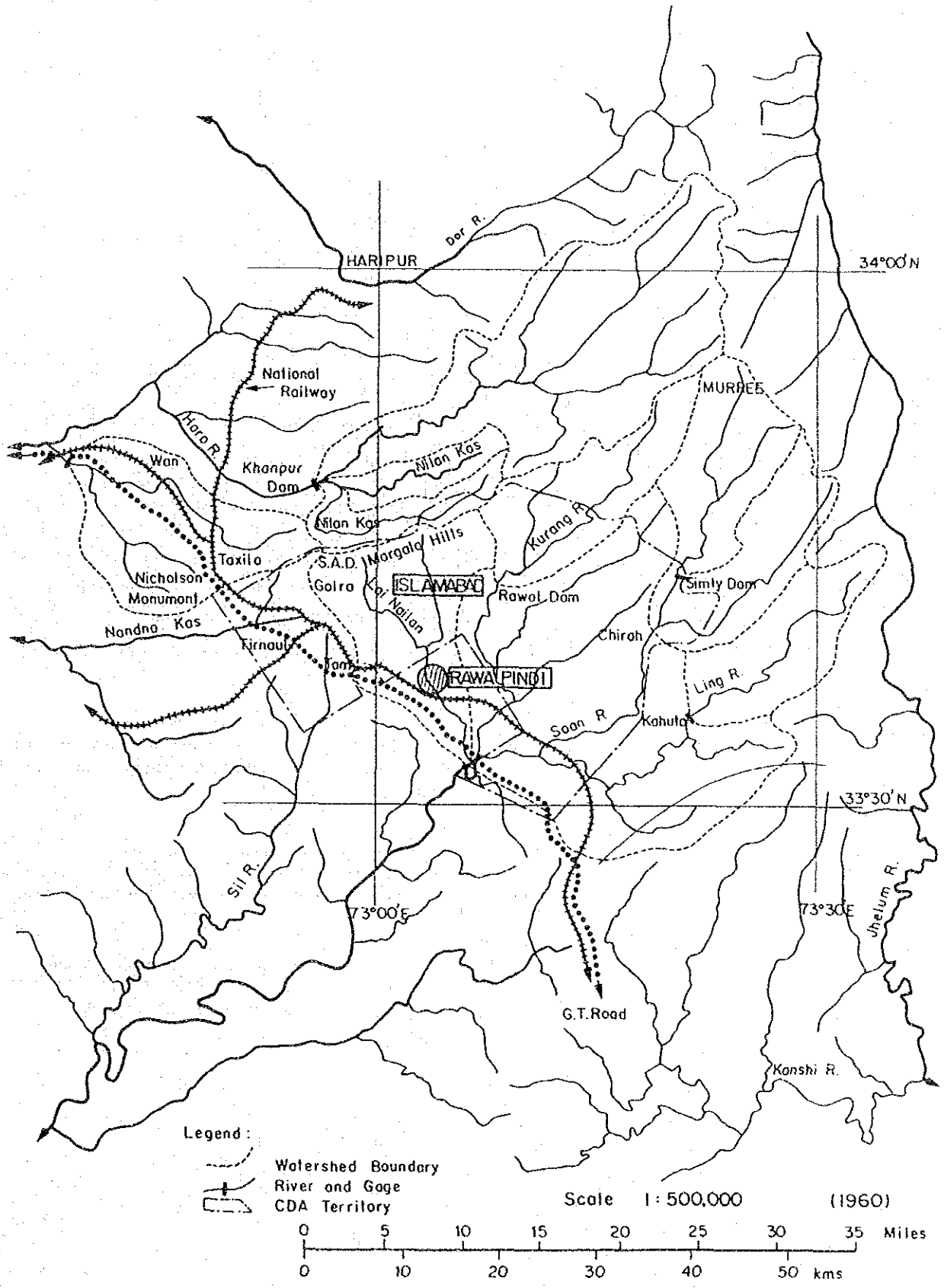
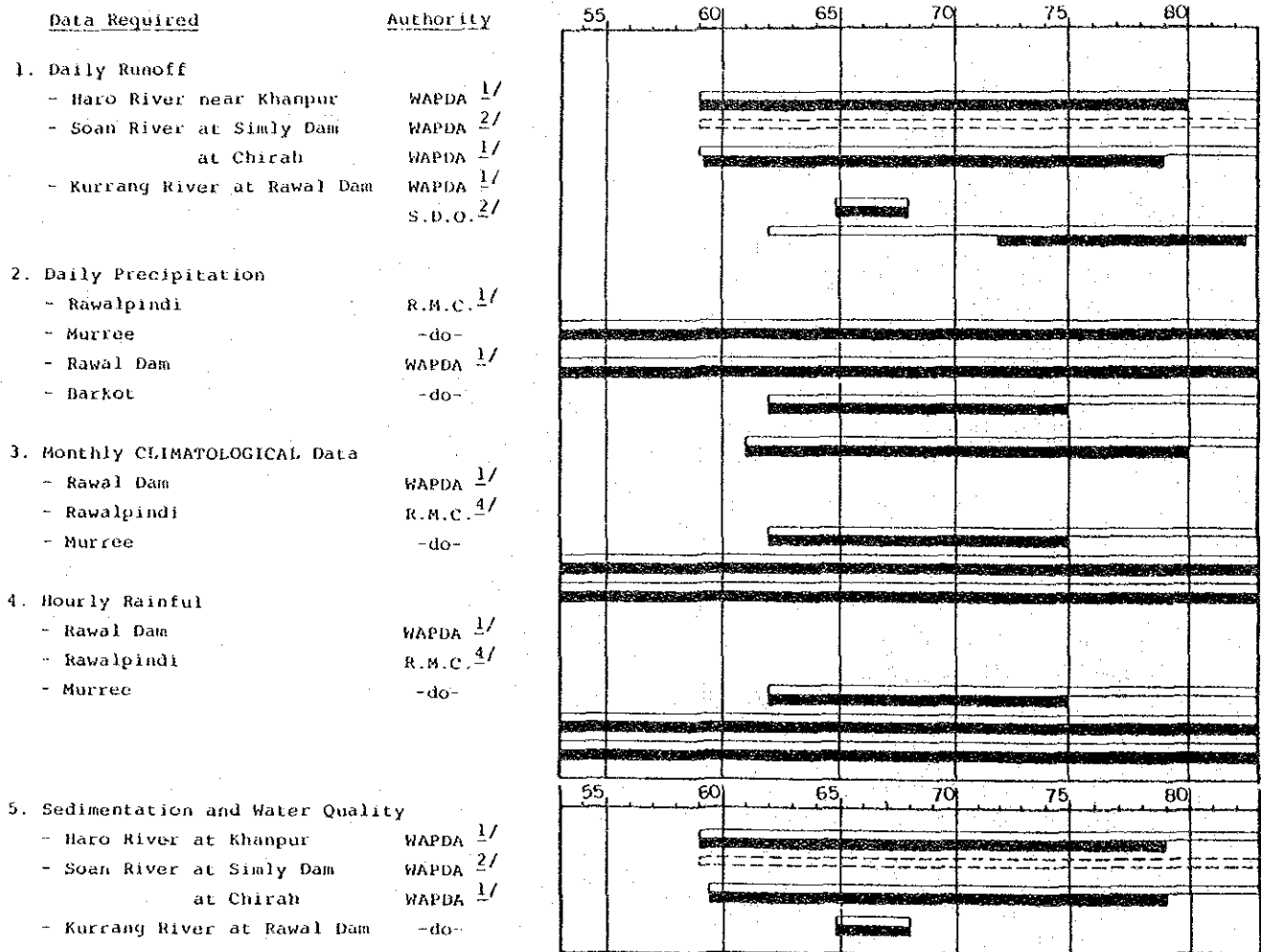


FIGURE A.II-1 RIVER BASINS IN AND AROUND METROPOLITAN AREA
A.II-5

FIGURE A.II-2 HYDRO-METEOROLOGICAL DATA COLLECTED



Note: 1/ ... Water and Power Development Authority, Lahore
 2/ ... Water and Power Resident Engineer at CDA
 3/ ... Small Dam Organization, Rawal Dam Colony
 4/ ... Regional Meteorological Centre, Lahore.



CLIMATIC ELEMENTS OBSERVED AT RAWALPINDI

TABLE A.II-1

<u>Climatic Element</u>	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>	<u>Jun.</u>	<u>Jul.</u>	<u>Aug.</u>	<u>Sep.</u>	<u>Oct.</u>	<u>Nov.</u>	<u>Dec.</u>	<u>Annual</u>
<u>Precipitation (1954 - 1983)</u>													
Average (mm)	67.9	65.1	80.7	62.1	39.5	52.7	245.1	298.8	108.4	30.6	21.1	30.1	1,102.2
Maximum (1981)	159.8	73.4	176.5	131.6	109.6	19.4	580.2	338.3	131.3	10.0	5.0	0.0	1,735.1
Minimum (1964)	143.3	13.7	20.6	43.9	45.7	24.6	263.7	91.9	47.0	0.0	1.8	12.4	708.7
<u>Temperature (1954 - 1983)</u>													
Average (°C)	10.0	12.3	17.1	22.7	27.6	31.6	30.0	28.8	27.4	22.7	16.5	11.6	21.5
Dew-point	2.0	4.1	7.5	10.3	11.2	14.8	21.5	22.3	18.8	11.5	5.6	2.6	11.0
<u>Relative Humidity (1954 - 1983)</u>													
Average (%)	71.4	698.8	65.3	54.2	41.5	41.5	65.8	74.8	69.5	63.2	66.3	70.7	62.8
<u>Actual Sunshine Hours (1957 - 1983)</u>													
Average (hrs)	6.3	6.8	6.8	8.5	10.0	10.3	8.6	8.5	8.6	9.0	8.2	6.7	8.2
<u>Pan-Evaporation (1966 - 1973)</u>													
Average (mm)	61.0	82.6	152.4	208.8	309.1	347.7	268.7	208.8	171.2	139.7	85.9	58.9	2,093.7

TABLE A.II-2 PRECIPITATION AT ISLAMABAD AIRPORT

 *** PRECIPITATION AT ISLAMABAD AIRPORT ***

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1954	166.9	130.6	39.1	10.9	17.0	12.7	163.3	190.0	128.0	79.8	3.0	11.4	952.8
1955	16.3	1.3	58.7	27.9	35.3	9.4	134.1	265.2	175.8	11.9	0.0	18.5	754.4
1956	34.8	74.4	88.1	14.2	0.0	118.1	261.9	329.9	76.5	18.3	0.0	6.9	1023.1
1957	214.1	34.5	90.7	103.9	60.5	48.5	33.0	247.9	27.2	95.2	53.6	82.5	1091.7
1958	9.1	6.6	95.0	14.2	3.6	12.2	257.3	188.2	132.1	6.6	13.0	115.3	853.2
1959	97.0	89.2	44.7	26.2	74.7	21.8	336.3	242.6	280.9	48.0	91.2	26.2	1378.7
1960	87.1	0.0	90.4	59.1	4.3	7.4	204.0	202.9	79.0	11.2	0.0	37.3	762.8
1961	145.0	43.4	21.1	124.7	12.7	25.7	246.6	154.7	279.9	39.1	43.7	8.6	1145.3
1962	13.7	53.1	68.6	25.9	23.9	52.3	199.1	421.6	78.0	5.1	26.7	82.0	1050.0
1963	0.0	30.2	73.9	57.4	51.6	8.9	220.5	336.3	92.5	0.0	47.2	44.2	962.7
1964	143.3	13.7	20.6	43.9	45.7	24.6	263.7	91.9	47.0	0.0	1.8	12.4	708.7
1965	38.6	92.7	90.9	210.1	115.3	20.6	111.0	119.1	13.5	10.9	25.7	10.7	859.0
1966	0.0	165.4	80.3	52.8	61.0	101.9	164.1	193.5	87.6	39.1	0.0	14.0	959.6
1967	0.0	66.5	134.9	38.9	23.1	18.5	261.6	342.4	36.9	19.8	3.6	152.4	1118.6
1968	69.3	81.5	64.5	36.6	49.8	14.2	249.4	401.3	20.8	36.8	45.7	44.4	1114.6
1969	2.8	62.7	54.4	35.3	55.9	15.0	85.3	274.3	50.3	95.8	6.3	0.0	738.1
1970	72.4	79.5	78.5	11.9	16.3	37.8	189.0	325.1	172.0	24.9	1.0	7.9	1016.3
1971	21.6	56.6	11.2	79.0	16.9	239.0	169.9	389.6	75.7	1.3	12.2	8.1	1091.2
1972	72.6	48.3	108.2	67.8	19.0	51.8	38.9	81.5	113.8	74.2	18.8	73.4	768.3
1973	62.7	80.3	75.7	24.6	52.1	111.3	370.1	403.4	93.5	14.2	3.6	19.3	1310.6
1974	12.9	21.2	35.8	15.9	27.0	99.8	477.9	210.1	56.8	0.0	0.0	32.7	990.1
1975	39.2	59.0	63.6	42.7	33.1	18.0	235.7	391.3	153.6	0.0	0.0	5.8	1042.0
1976	115.9	208.4	117.3	65.0	3.0	33.3	366.9	442.5	202.5	40.1	0.0	1.0	1595.9
1977	72.2	15.2	12.9	54.6	61.0	142.9	628.1	254.4	38.3	19.3	23.3	20.7	1342.9
1978	6.3	32.0	100.1	23.3	14.3	139.8	258.9	496.9	171.7	62.7	70.2	4.1	1380.3
1979	65.2	102.3	147.1	14.1	40.7	28.8	118.5	231.0	97.6	17.3	36.0	22.6	921.2
1980	92.8	93.4	125.8	15.6	23.6	80.0	309.8	189.7	86.2	36.6	14.6	16.0	1084.1
1981	159.8	73.4	176.5	131.6	109.6	19.4	580.2	338.3	131.3	10.0	5.0	0.0	1735.1
1982	74.4	87.3	173.2	191.0	99.2	18.9	159.1	625.2	40.5	25.7	83.0	24.3	1601.8
1983	131.3	51.5	80.7	264.7	24.2	49.4	258.3	582.2	193.0	74.0	2.5	0.0	1713.8
TOTAL	2037.5	1954.3	2422.4	1864.0	1184.2	1582.0	7352.5	8963.2	3252.3	917.9	631.6	902.9	33066.7
MEAN	67.9	65.1	80.7	62.1	39.5	52.7	245.1	298.8	108.4	30.6	21.1	30.1	1102.2

TABLE A.II-3 MEAN DAILY TEMPERATURE AT RAWALPINDI (CENTIGRADE)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1954	8.7	12.2	16.7	22.9	29.8	32.3	30.6	29.8	27.8	20.5	15.6	10.8	21.5
1955	9.7	13.5	18.8	21.8	26.1	33.4	31.2	29.2	26.6	22.3	17.1	12.2	21.8
1956	10.3	13.8	17.0	23.4	32.2	30.6	27.7	27.2	29.2	21.6	15.6	11.4	21.7
1957	10.3	10.8	15.7	19.6	25.0	30.4	32.2	29.1	27.1	22.1	15.9	11.7	20.8
1958	11.5	12.9	17.7	25.3	27.6	32.4	30.5	28.7	27.1	22.9	16.6	12.2	22.1
1959	9.8	10.8	18.3	23.1	28.3	33.3	28.9	29.4	28.2	24.5	15.6	11.2	21.8
1960	9.6	15.7	16.2	20.9	28.5	33.2	30.6	29.7	27.9	23.5	16.0	11.7	22.0
1961	10.3	10.3	17.3	21.5	28.8	32.8	29.9	29.8	28.5	22.3	14.3	9.9	21.3
1962	9.8	12.9	17.5	23.7	28.2	32.4	31.3	29.2	26.6	22.1	15.5	10.8	21.7
1963	10.3	14.9	16.7	22.1	25.9	33.8	32.4	29.1	27.1	24.6	16.8	12.2	22.2
1964	7.5	12.3	18.8	23.6	26.9	31.3	29.5	30.2	27.6	22.8	15.5	11.4	21.5
1965	11.3	11.6	17.0	19.4	25.4	31.3	30.7	28.5	28.1	24.1	17.3	10.1	21.2
1966	11.3	14.7	17.2	21.5	25.4	31.7	30.3	29.5	26.5	22.3	15.6	10.6	21.4
1967	9.7	14.2	16.6	21.7	26.9	32.8	30.8	28.4	28.2	21.7	15.7	11.2	21.5
1968	8.6	10.7	17.6	23.6	26.8	33.1	30.8	28.2	29.4	22.2	15.5	11.2	21.5
1969	9.6	12.2	19.4	21.7	26.0	31.8	31.1	29.2	27.1	22.8	16.7	12.1	21.6
1970	10.1	13.1	16.7	24.8	29.5	31.9	30.2	28.4	26.7	23.5	15.7	11.8	21.9
1971	9.4	12.8	18.4	24.1	28.1	30.1	28.1	28.1	25.5	22.2	16.4	-	22.1
1972	10.6	9.7	17.2	21.1	26.9	31.4	31.4	29.4	26.2	21.8	17.0	11.8	21.2
1973	9.5	12.3	16.6	24.1	29.2	31.7	29.3	30.9	27.3	21.7	16.4	10.9	21.7
1974	9.4	10.7	20.9	25.2	28.1	30.3	29.0	29.1	27.4	21.7	16.3	10.1	21.5
1975	10.3	11.3	16.0	23.1	27.9	30.7	28.9	28.9	28.5	26.7	23.6	15.5	22.6
1976	10.9	11.8	15.9	21.7	28.0	30.6	29.9	26.6	26.7	22.3	16.7	11.3	21.0
1977	9.5	12.7	19.9	23.3	26.3	30.1	28.0	28.3	27.4	23.3	17.9	12.5	21.6
1978	9.3	12.3	15.5	23.7	31.1	32.3	28.1	27.7	27.1	22.7	15.9	12.4	21.5
1979	10.7	12.3	15.1	24.2	25.7	31.1	29.9	28.3	26.1	23.3	17.5	12.5	21.4
1980	10.4	12.5	15.5	24.3	29.8	31.1	29.0	28.7	26.8	23.1	16.9	12.5	21.7
1981	10.3	10.7	16.3	23.3	28.1	30.7	29.3	28.5	26.6	21.7	16.0	11.6	21.1
1982	10.6	10.6	14.4	21.7	25.1	29.9	30.7	28.1	27.1	22.9	16.5	11.5	20.8
1983	10.1	11.9	15.4	19.3	26.1	29.5	29.1	28.8	28.2	21.5	16.9	11.6	20.7
MEAN	10.0	12.3	17.1	22.7	27.6	31.6	30.0	28.8	27.4	22.7	16.5	11.6	21.5

TABLE A.II-4 MEAN DAILY DEW-POINT TEMPERATURE AT RAWALPINDI (CENTIGRADE)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1954	3.8	8.5	9.1	10.9	15.7	16.4	21.8	22.1	20.2	9.1	2.6	-0.4	11.7
1955	0.2	2.4	1.5	5.2	10.4	10.2	18.9	23.2	19.8	9.1	2.2	2.2	8.8
1956	1.1	0.8	10.5	11.1	10.3	18.2	23.3	23.4	19.7	14.2	4.9	2.1	11.6
1957	4.4	3.7	8.4	11.4	13.2	14.1	18.8	22.3	15.7	11.1	9.1	6.6	11.6
1958	4.8	2.4	7.8	11.4	7.1	10.4	22.7	21.8	20.4	12.0	4.9	6.7	11.0
1959	4.4	5.1	8.6	7.1	12.5	15.4	22.6	24.3	23.2	16.2	8.8	4.1	12.7
1960	2.6	5.6	8.7	9.2	11.1	11.2	23.0	10.3	18.9	9.1	2.2	-1.3	9.2
1961	3.1	3.1	6.3	10.8	10.6	14.7	23.1	23.3	22.5	11.8	6.4	1.8	11.4
1962	1.3	5.3	8.5	7.5	10.3	12.6	20.1	22.6	18.8	10.6	4.6	2.2	10.4
1963	-1.3	3.9	8.2	11.8	11.5	13.7	19.3	22.4	18.0	10.4	8.6	3.2	10.8
1964	3.9	3.9	7.8	10.6	10.3	12.8	20.9	23.1	18.9	6.3	0.0	2.7	10.1
1965	3.2	5.2	6.9	11.6	12.0	12.3	19.4	19.4	15.1	11.6	7.7	-1.3	10.3
1966	-1.6	6.6	8.1	10.9	9.2	15.3	20.4	22.2	17.6	10.6	2.3	-1.7	10.0
1967	-1.8	3.7	6.0	8.9	7.9	12.1	22.2	22.7	13.1	9.6	5.4	4.4	9.5
1968	3.2	3.6	8.1	9.7	10.1	14.9	20.9	22.3	16.9	10.6	5.9	4.6	10.9
1969	1.2	4.3	8.6	9.2	11.2	11.6	20.8	22.5	18.1	13.1	7.3	0.3	10.7
1970	0.6	2.8	7.4	7.2	8.9	15.9	20.5	23.5	20.3	13.7	4.2	0.5	10.5
1971	-0.9	1.7	5.6	11.1	13.6	21.6	22.2	22.9	17.1	10.8	6.6	3.4	11.3
1972	1.8	3.9	8.6	10.4	10.3	14.2	20.1	20.6	16.9	6.3	6.3	5.3	10.4
1973	2.7	4.9	7.1	9.8	10.3	19.3	23.2	23.3	20.9	12.0	6.1	2.2	11.8
1974	0.8	2.7	7.3	8.8	9.6	14.2	20.9	22.5	17.7	7.8	1.9	3.2	9.8
1975	1.9	3.0	6.4	9.5	10.1	14.1	21.3	23.0	20.2	11.5	2.5	1.0	10.4
1976	2.8	5.6	7.7	11.1	10.2	13.8	22.4	22.1	19.4	12.6	5.8	1.0	11.2
1977	1.4	2.3	4.4	12.7	12.7	16.8	23.5	23.2	19.4	15.2	9.1	4.9	12.1
1978	1.9	3.9	7.1	10.7	8.9	16.9	23.7	23.6	20.1	13.8	8.0	3.5	11.8
1979	3.1	5.1	7.3	13.5	11.5	16.4	22.6	22.2	17.6	13.6	8.4	4.8	12.2
1980	3.1	5.4	8.9	11.7	11.9	18.2	23.2	22.7	18.7	13.6	7.8	4.4	12.5
1981	4.0	6.2	9.5	11.8	15.4	15.0	23.0	23.2	18.9	11.6	6.5	0.3	12.1
1982	2.6	4.2	8.6	12.3	12.7	15.8	19.6	23.1	17.8	13.9	5.7	5.1	11.8
1983	2.3	3.7	7.0	12.1	15.6	16.0	21.2	24.0	21.6	13.2	6.9	2.1	12.1
MEAN	2.0	4.1	7.5	10.3	11.2	14.8	21.5	22.3	18.8	11.5	5.6	2.6	11.0

TABLE A.II-5 MEAN DAILY RELATIVE HUMIDITY AT RAWALPINDI (%)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1954	81.0	85.0	58.0	54.0	48.0	40.0	63.0	69.0	69.0	59.0	57.0	62.0	62.1
1955	62.0	60.0	63.0	39.0	40.0	38.0	51.0	78.0	70.0	61.0	54.0	73.0	57.4
1956	72.0	55.0	75.0	52.0	30.0	51.0	79.0	81.0	64.0	73.0	66.0	68.0	63.8
1957	82.0	72.0	69.0	65.0	52.0	40.0	49.0	73.0	58.0	61.0	77.0	85.0	65.3
1958	78.0	63.0	69.0	47.0	31.0	27.0	68.0	70.0	72.0	60.0	61.0	82.0	60.7
1959	83.0	78.0	65.0	53.0	43.0	38.0	73.0	80.0	83.0	69.0	80.0	77.0	68.5
1960	76.0	63.0	80.0	54.0	36.0	31.0	70.0	78.0	67.0	51.0	50.0	58.0	59.5
1961	72.0	73.0	59.0	58.0	37.0	38.0	71.0	75.0	78.0	64.0	72.0	74.0	64.3
1962	71.0	76.0	66.0	52.0	35.0	35.0	58.0	50.0	70.0	61.0	61.0	71.0	58.8
1963	66.0	63.0	68.0	61.0	46.0	34.0	54.0	73.0	67.0	51.0	71.0	71.0	60.4
1964	81.0	70.0	60.0	53.0	40.0	36.0	65.0	73.0	67.0	46.0	48.0	68.0	58.9
1965	66.0	75.0	62.0	69.0	51.0	36.0	58.0	63.0	54.0	55.0	66.0	61.0	59.7
1966	57.0	68.0	67.0	60.0	37.0	43.0	60.0	73.0	76.0	60.0	58.0	61.0	60.0
1967	61.0	62.0	63.0	53.0	37.0	34.0	67.0	77.0	68.0	59.0	65.0	74.0	60.0
1968	79.0	76.0	66.0	50.0	41.0	32.0	57.0	73.0	61.0	74.0	82.0	65.0	63.0
1969	69.0	71.0	61.0	53.0	43.0	31.0	58.0	73.0	64.0	65.0	70.0	66.0	60.3
1970	65.0	67.0	65.0	41.0	32.0	42.0	61.0	78.0	76.0	66.0	66.0	65.0	60.3
1971	65.0	61.0	53.0	51.0	45.0	65.0	72.0	79.0	69.0	63.0	70.0	74.0	63.9
1972	70.0	67.0	67.0	56.0	40.0	41.0	57.0	65.0	63.0	59.0	65.0	77.0	60.6
1973	73.0	68.0	61.0	49.0	35.0	53.0	75.0	80.0	75.0	68.0	66.0	71.0	64.5
1974	67.0	69.0	56.0	43.0	37.0	42.0	64.0	72.0	63.0	54.0	50.0	75.0	57.7
1975	66.0	68.0	63.0	49.0	38.0	41.0	69.0	78.0	75.0	60.0	58.0	64.0	60.8
1976	70.0	76.0	68.0	57.0	40.0	42.0	70.0	79.0	73.0	67.0	67.0	66.0	64.6
1977	69.0	71.0	49.0	58.0	48.0	50.0	76.0	77.0	74.0	71.0	72.0	73.0	65.7
1978	66.0	68.0	67.0	51.0	30.0	46.0	81.0	82.0	74.0	71.0	74.0	73.0	65.3
1979	74.0	73.0	69.0	58.0	45.0	47.0	70.0	77.0	69.0	66.0	70.0	75.0	66.1
1980	73.0	73.0	74.0	51.0	36.0	49.0	76.0	74.0	71.0	68.0	72.0	75.0	66.0
1981	79.0	76.0	72.0	56.0	53.0	45.0	76.0	81.0	72.0	69.0	71.0	66.0	68.0
1982	72.0	76.0	75.0	62.0	61.0	49.0	57.0	81.0	67.0	71.0	79.0	81.0	69.3
1983	76.0	72.0	70.0	70.0	58.0	49.0	68.0	83.0	75.0	74.0	70.0	70.0	69.6
MEAN	71.4	69.8	65.3	54.2	41.5	41.5	65.8	74.8	69.5	63.2	66.3	70.7	62.8

TABLE A.II-6 MEAN DAILY SUNSHINE HOURS AT RAWALPINDI (HOURS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1957	-	-	6.5	7.0	8.2	11.2	10.4	8.7	9.5	8.5	6.9	6.8	8.4
1958	5.8	8.7	7.1	9.2	8.9	10.6	9.0	9.1	8.3	9.7	8.4	5.4	8.3
1959	6.4	7.1	7.4	9.3	8.8	11.4	8.4	9.2	7.6	8.7	6.8	7.1	8.2
1960	6.9	8.7	5.6	8.4	12.1	11.3	9.1	8.1	9.1	10.1	8.6	7.1	8.8
1961	6.8	7.4	7.5	8.7	10.8	10.3	8.0	9.4	8.4	8.8	7.9	7.3	8.4
1962	6.8	7.4	6.9	8.2	10.7	11.1	9.8	9.0	8.4	9.6	8.6	7.0	8.6
1963	9.0	8.8	5.4	7.4	9.8	11.0	10.0	9.1	9.5	9.7	7.5	8.1	8.8
1964	6.1	6.5	7.1	8.3	10.9	9.8	9.9	9.2	8.2	10.4	9.0	6.9	8.5
1965	5.8	6.0	6.6	6.8	9.5	11.0	-	-	-	8.7	7.7	8.2	7.8
1966	8.4	5.4	6.4	7.3	10.5	9.3	9.3	9.9	7.7	8.8	10.0	7.7	8.4
1967	7.9	5.8	6.7	8.3	11.3	8.9	8.4	8.5	8.1	8.3	6.9	4.4	7.8
1968	4.9	7.1	7.1	9.8	8.8	11.4	8.9	7.9	9.0	8.2	8.1	5.8	8.1
1969	5.9	6.4	8.1	7.4	9.3	10.5	8.5	7.9	8.1	8.2	8.3	7.4	8.0
1970	6.5	7.6	5.8	10.4	10.5	9.6	9.9	8.2	9.0	9.1	9.3	7.6	8.5
1971	6.9	7.0	8.3	8.9	10.0	8.4	7.1	7.7	8.4	9.2	7.9	-	8.2
1972	5.0	7.3	6.3	8.1	9.0	9.8	8.9	8.4	8.8	9.0	8.5	6.3	7.9
1973	6.0	6.0	5.5	8.4	9.2	7.6	7.1	7.1	7.8	9.7	9.1	7.1	7.5
1974	5.8	6.3	6.6	8.4	8.9	10.6	8.3	-	8.3	9.6	8.7	5.0	7.9
1975	-	7.4	7.8	7.9	10.5	10.9	9.4	7.5	8.8	10.4	9.7	6.4	8.8
1976	5.4	-	-	9.1	10.8	11.3	6.6	7.2	8.3	9.1	9.1	6.8	8.4
1977	4.4	9.0	9.5	7.5	10.2	10.5	8.2	8.4	9.2	8.4	7.9	6.4	8.3
1978	6.4	6.9	7.1	9.1	10.7	9.0	6.1	7.1	9.4	9.1	7.2	7.7	8.0
1979	6.4	5.7	6.5	8.5	9.4	11.7	8.0	8.9	9.6	9.6	8.8	5.6	8.2
1980	7.1	6.0	5.6	9.8	11.2	10.4	8.6	9.9	8.4	8.9	8.1	6.6	8.4
1981	5.3	5.8	6.0	9.4	10.6	8.9	7.6	8.4	9.6	9.1	8.1	7.8	8.0
1982	6.3	5.4	8.6	9.5	10.8	10.0	7.5	9.5	8.7	6.5	-	-	8.3
1983	6.3	5.4	5.4	8.6	9.5	10.8	10.0	7.5	9.5	8.7	6.5	4.8	7.7
MEAN	6.3	6.8	6.8	8.5	10.0	10.3	8.6	8.5	8.6	9.0	8.2	6.7	8.2

TABLE A.II-7 MEAN DAILY WIND SPEED AT RAWALPINDI (KNOTS)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1954	4.2	4.2	5.0	6.4	6.3	6.7	5.7	5.3	3.6	3.5	3.2	2.7	4.7
1955	3.3	4.8	6.1	5.9	6.5	5.4	5.8	5.7	3.3	3.5	3.7	2.8	4.7
1956	2.8	4.1	4.7	5.0	5.7	5.2	5.3	3.2	3.3	1.1	2.9	3.3	3.9
1957	4.1	6.0	5.6	7.0	5.4	5.2	5.3	4.5	4.3	4.6	3.6	3.0	4.9
1958	3.1	4.3	5.3	6.4	7.1	5.8	5.8	4.7	4.1	4.0	3.0	2.5	4.7
1959	3.2	4.6	5.0	4.2	6.5	5.8	4.1	4.2	3.3	2.3	2.1	2.4	4.0
1960	2.3	4.0	5.1	6.0	5.6	5.3	6.1	4.9	3.9	3.5	3.9	3.8	4.5
1961	4.5	5.2	5.7	6.2	5.5	5.2	5.1	4.0	3.2	3.5	3.0	2.8	4.5
1962	3.8	3.9	4.6	5.8	6.6	5.1	5.9	4.2	3.7	3.5	4.0	3.1	4.5
1963	2.9	4.3	5.3	5.0	5.9	5.3	6.0	3.2	3.6	2.7	2.9	3.1	4.2
1964	3.1	3.4	4.5	4.7	4.2	4.5	5.1	3.5	3.2	2.5	2.0	3.0	3.6
1965	2.8	3.6	4.4	4.4	4.4	4.0	4.6	3.7	3.5	3.1	2.4	2.5	3.6
1966	2.2	3.4	4.2	4.7	4.3	4.4	3.8	3.2	2.4	1.9	1.9	2.6	3.2
1967	3.2	5.9	5.7	5.8	3.8	5.0	5.3	3.7	3.6	2.0	2.8	3.0	4.1
1968	3.7	3.7	4.0	3.6	4.3	3.9	4.0	3.0	2.2	2.6	2.2	2.5	3.3
1969	2.3	3.2	3.5	3.6	3.7	3.5	3.5	2.7	2.0	2.5	1.7	1.3	2.8
1970	2.0	3.5	4.5	3.9	4.1	4.6	3.9	2.9	2.0	1.9	1.3	2.2	3.1
1971	1.6	3.6	3.0	2.6	2.7	2.6	1.5	1.1	0.6	0.5	-	-	2.0
1972	1.6	2.6	2.8	2.0	2.6	1.6	1.2	1.0	1.3	0.7	0.5	0.8	1.6
1973	1.1	1.7	2.0	1.5	1.5	0.9	0.6	0.5	0.2	0.2	0.2	0.4	0.9
1974	1.0	1.6	1.7	1.8	2.3	2.1	1.8	1.4	0.8	0.3	0.4	0.8	1.3
1975	1.2	1.5	2.4	1.4	1.7	2.0	1.5	1.3	0.7	0.5	0.3	0.8	1.3
1976	0.8	1.5	2.1	1.6	1.5	1.7	1.5	1.1	0.5	0.3	0.1	0.6	1.1
1977	1.2	1.3	1.3	1.1	1.0	1.1	0.9	0.6	0.4	0.3	0.1	0.1	0.8
1978	0.5	1.2	1.3	0.3	0.7	1.1	0.4	0.1	0.2	0.1	0.3	0.2	0.5
1979	0.6	1.0	1.4	1.0	1.1	1.0	1.2	0.5	0.3	0.1	0.1	0.2	0.7
1980	0.9	1.3	1.7	0.5	1.0	1.6	0.8	0.6	0.3	0.5	0.5	0.6	0.9
1981	1.2	1.6	1.9	1.9	1.8	1.4	1.3	0.6	0.4	0.5	0.3	0.4	1.1
1982	1.5	1.4	1.7	1.3	1.1	0.8	1.3	0.6	0.4	0.3	0.4	0.6	0.9
1983	0.9	1.1	1.9	1.6	0.8	1.3	0.8	0.4	0.3	0.2	0.1	0.5	0.8
MEAN	2.3	3.1	3.6	3.6	3.7	3.5	3.3	2.5	2.1	1.8	1.7	1.8	2.7

TABLE A.II-8 (1) HARO RIVER RUNOFF AT KHANPUR (WAPDA)

 *** HARO RIVER AT KHANPUR (WAPDA) ***

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1960	12032.	9352.	16183.	14412.	8813.	5014.	33618.	39505.	26787.	10136.	5431.	3505.	184786.
1961	14785.	20711.	11326.	31839.	16298.	9838.	34756.	39868.	112205.	24593.	13418.	7178.	336815.
1962	4733.	4520.	22957.	13166.	5161.	4070.	19476.	35744.	25763.	9880.	4731.	4374.	154574.
1963	3057.	3604.	22554.	13970.	8886.	3586.	16455.	48672.	31537.	8672.	6958.	5314.	173464.
1964	31388.	19188.	13510.	9312.	4294.	7025.	17564.	47570.	28169.	9949.	4808.	4356.	192143.
1965	4270.	17123.	31160.	94516.	62319.	21096.	17018.	34820.	13511.	6891.	3965.	4040.	310730.
1966	2678.	8063.	16949.	20561.	19801.	7000.	24214.	38517.	29433.	17272.	7137.	4921.	196544.
1967	3874.	27511.	55920.	38561.	21090.	5409.	9586.	36567.	34381.	9850.	3755.	15727.	262231.
1968	20237.	28389.	29336.	15269.	7563.	3122.	13333.	70145.	11006.	8579.	5260.	5266.	217505.
1969	3064.	11197.	13308.	13254.	5706.	7884.	5151.	26567.	11103.	16788.	5080.	1831.	115934.
1970	3721.	3644.	34592.	8608.	1874.	1765.	10088.	53895.	95693.	23766.	6218.	3112.	246976.
1971	2690.	4556.	813.	3481.	1335.	62362.	62828.	98380.	91829.	10286.	4374.	2255.	293189.
1972	4814.	9515.	23463.	16389.	17482.	4468.	6906.	16986.	19991.	7696.	4816.	9874.	149901.
1973	13916.	15933.	59524.	16132.	6750.	8291.	34306.	108513.	63457.	18210.	6748.	5074.	356914.
1974	4860.	13055.	6607.	2775.	1438.	3209.	15600.	20160.	8221.	3638.	1682.	1878.	83123.
1975	2216.	7045.	11607.	12305.	7932.	5230.	14590.	64963.	22806.	7601.	4437.	2567.	163299.
1976	7700.	32027.	52425.	33195.	13609.	7743.	35883.	197573.	75824.	25315.	9874.	5520.	496639.
1977	9263.	8674.	5319.	14378.	12532.	4340.	79773.	109924.	61825.	43718.	13771.	7581.	375296.
1978	10937.	8926.	29677.	13099.	5217.	5667.	127134.	155048.	51265.	21562.	12778.	5615.	446923.
1979	8283.	19035.	81023.	35845.	14333.	5750.	13868.	39053.	12549.	4352.	2668.	1593.	238352.
1980	12557.	16421.	36214.	18534.	6060.	19753.	22792.	58070.	23018.	10512.	5766.	2926.	232623.
TOTAL	181072.	288690.	587474.	439600.	248901.	198624.	614941.	1340597.	790375.	499464.	133622.	104505.	5227954.
MEAN	8622.	13747.	27975.	20933.	11857.	9458.	29283.	63838.	37637.	14260.	6363.	4976.	248950.

TABLE A.II-8 (2) SOAN RIVER RUNOFF AT CHIRAH (WAPDA)

 *** SOAN RIVER AT CHIRAH (WAPDA) ***

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1961	16034.	7853.	2481.	18028.	2063.	1862.	31067.	45564.	51251.	7228.	3265.	1583.	188279.
1962	1008.	1496.	5964.	2394.	706.	530.	17625.	27078.	7400.	891.	1595.	1799.	68485.
1963	603.	3507.	7075.	1738.	1133.	383.	23213.	31107.	21481.	805.	760.	565.	92368.
1964	12722.	3499.	1531.	2299.	946.	534.	23578.	39880.	25886.	2606.	980.	960.	115420.
1965	1688.	11915.	7821.	29482.	12377.	3205.	23954.	13646.	2465.	1029.	639.	399.	108621.
1966	288.	6419.	7267.	5119.	1349.	2190.	23254.	30329.	11389.	2945.	1103.	728.	92380.
1967	325.	6569.	31858.	14035.	2713.	660.	11131.	39039.	20882.	2719.	885.	9098.	139916.
1968	9136.	11657.	8985.	3644.	1801.	668.	13966.	46699.	4052.	1874.	934.	863.	104279.
1969	597.	4588.	3354.	1843.	1386.	250.	7767.	14059.	3059.	4403.	442.	135.	41883.
1970	2045.	2535.	8115.	510.	65.	1061.	15419.	77161.	78286.	6849.	1333.	603.	193983.
1971	430.	4159.	541.	8795.	2245.	52792.	27475.	80356.	13672.	1373.	1154.	432.	193416.
1972	1851.	5556.	10497.	7160.	1950.	1285.	7948.	22211.	18615.	2565.	1107.	3909.	84653.
1973	3646.	4621.	36475.	2543.	1047.	4046.	23143.	50493.	12180.	2707.	764.	686.	142403.
1974	811.	2769.	1317.	591.	274.	974.	20104.	30357.	3656.	704.	180.	399.	61936.
1975	258.	2634.	1981.	2432.	1204.	776.	28209.	103759.	42708.	2838.	986.	458.	188243.
1976	5169.	25813.	32045.	6056.	1886.	1543.	36198.	125177.	49497.	6869.	1386.	912.	292552.
1977	2884.	542.	391.	7218.	1706.	4895.	117995.	84430.	17756.	14394.	7995.	2313.	262919.
1978	5334.	3777.	8735.	2509.	446.	2858.	58651.	120075.	32021.	5129.	4447.	926.	244949.
1979	17213.	40670.	23294.	6906.	1787.	1317.	16469.	26009.	5437.	740.	637.	536.	140414.
TOTAL	82040.	150377.	199731.	123100.	37144.	81830.	527166.	1007430.	421693.	68670.	30591.	27304.	2757093.
MEAN	4318.	7915.	10512.	6479.	1956.	4307.	27746.	53023.	22194.	3614.	1610.	1437.	145110.

2.2. Existing Water Resources

Major water sources undertaking at present and near future supply of water requested in the cities of Islamabad and Rawalpindi are surface water drained by the Haro, Kurang and Soan rivers. Supported by the storage function of the Khanpur, Rawal and Simly reservoirs, these rivers would contribute towards the existing achievement of perennial water supply accounting for 60% and 80% of the total requirements respectively for Islamabad and Rawalpindi for drinking and domestic uses, while surface water from small streams would cover 20% of total demand for Islamabad and groundwater including springs would account for the remaining 20% for both the cities.

2.2.1. Khanpur Dam

The Haro river, originating from the Murree and Margala Hills and joining a number of affluents, traverses the hill range westwards, and flows into the Khanpur reservoir. The dam is located in Haripur Tehsil of Abbottabad District across the Haro river approximately 14.5 km (9 miles) upstream from Taxila-Haripur Road and downstream of confluence of river with its tributary of Nilan Kas in the vicinity of Khanpur Village.

Originally the Khanpur Dam Project was approved in 1963 envisaging construction of 41.8 m (137 ft) high earth-fill dam and a canal system to irrigate 31,150 ha (77,000 acres) of agricultural land situated both on the left and right bank of the river including some area on the eastern side of the Margala range of hills, and the construction work was started in the beginning of 1967. Due to growing need for municipal and industrial water supply in the terrain, irrigation water in the vicinity of twin city of Islamabad and Rawalpindi, heavy industrial complexes at Taxila and Wah, the Project was revised in 1973 converting the primary objective of the scheme from irrigation to water supply. Consequently, the Khanpur

Reservoir was designed with the raising of dam height to 50.9 m (167 ft), which is the maximum allowable from technical, geographic and geologic point of view, to supply 33.0 MGD of water to Islamabad and 69.37 MGD of water to Rawalpindi for domestic purposes, 28.5 MGD to the various industries at Wah and Taxila, and irrigation water for 14,770 ha (36,470 acres) of culturable command area of both the Left and Right Bank Canal. The projected requirements and yield from the reservoir, communicated by all beneficiaries on the request of the Expert Committee met on 20th October, 1972 at WAPDA house, Lahore and estimated on the basis of a long period of recorded rainfalls collected at Murree and Rawalpindi, are reported in P.C. I (1976) Proforma as under:

PROJECTED REQUIREMENT AND YIELD FOR YEAR 2000 AD

<u>Beneficiary</u>	<u>Requirement</u> MGD (MCM/yr)	<u>Yield</u> (MCM/yr)	
Rawalpindi Town	69.37	114.9	
POF (Wah)	15.00	24.8	
PIDC (Taxila)	13.50	22.5	
CDA (Islamabad)	33.00	54.6	
Right Bank Canal	34.72	57.7	
Left Bank Canal	20.44	33.9	
<u>Total</u>	<u>186.03</u>	<u>308.4</u>	<u>308.4 (250,000 AF)</u>
<u>Balance</u>			0.0

It is pointed out that the hydrological investigations examined in P.C. I Proforma (2nd revised, 1976 May) were based on the average annual amounts of inflow and demand. Since the average inflow involves flood runoff which is unavoidable to be spilled out, the Project, in consequence, allows frequent occasions of shortage of water of more than once in 2 years. Reservoir specifications are presented in Table A.II-9.

2.2.2. Simly Dam

The Simly dam is located at a distance 38.6 km (24 miles) northeast of Islamabad and at the place a small village Simly was originally situated on the right bank of the Soan river. The Simly Dam Project is recognized as an essential constituent of bulk water supply scheme for Islamabad. The reservoir stores not only the perennial low flows but also a considerable parts of flood water of the Soan river. Water released from the reservoir is conveyed to Islamabad through twin conduction main pipes after treatment and the reservoir is expected to provide 24.0 MGD of water for drinking and domestic uses to the Federal Capital of Islamabad.

In the original design, it has been mentioned that the normal conservation level of the reservoir will be raised from 2,295 ft to 2,315 ft level in order to increase the live storage of the reservoir after about 21 years of operation when almost all of the dead storage is lost due to sediment deposit. This will be done by providing three 7.62 m (25 ft) high gates, and may result an additional live storage of 11.8 MCM (9,600 acre ft) obtainable. It has become realized that the installation of gates can be advantageously progressed in near future to raise the conservation level to 2,315 ft thereby increasing live storage by 11.8 MCM resulting in gain of a substantial safe yield from the catchment.

2.2.3. Rawal Dam

The Kurang river rises from the Margalla range of hills, flows southwestwards across the land of mostly flat and rising gradually on all sides except a low ridge on the northwesterly flank where a saddle embankment was constructed to contain the storage area, and joins the Soan river at the point near from the city of Rawalpindi. The Rawal dam is sited across the Kurang river near Village Rawal, at a distance of about 14.5 km (9 miles) from Rawalpindi town along Pindi-Murree Road.

The Kurang river has been the source of domestic water supply for Rawalpindi since 1880, in which some seepage wells were constructed just upstream of the present Rawal dam site, on the right bank of the river. The Rawal Dam Project was conceived to meet chronic shortage of water supply having been experienced in Rawalpindi and Cantonment, and was formally inaugurated by the President of Pakistan on 17th May, 1962. In the original plan of the dam, the reservoir was proposed so as to provide 28.0 MGD of water to Rawalpindi and Cantonment, but the Project was revised due to the drought during the years 1972-73 with the conclusion that the supply of water be reduced to 21.0 MGD and the filtration plant was completed in 1979 with design capacity of 21.0 MGD.

The Rawal Lake formed by the dam spreads over an area of 780 ha (3 sq.miles) and with 3.0 m (10 ft) high gates installed on the top of the spillway crest has a gross storage capacity of 58.6 MCM (47,500 acres ft) out of which 46.9 MCM or 38,000 acre ft is provided at present as the net live storage. The annual inflow into the reservoir is estimated, on the basis of specific runoffs observed at Khanpur on the Haro river, to be about 92.4 MCM or 75,000 acre ft, and from this figure, the annual usable yield from the reservoir would be more than that at present utilized. Reservoir specifications are presented also in Table A.II-9.

2.2.4. Other Rivers and Streams

Besides storage dams, seven head works have been planned and constructed at the foot of the Margalla Hills as well as in the vicinity of the Capital area receiving surface water from streams and supplying treated water to Islamabad. The Saidpur and Nurpur Head Works commenced supplying water in 1963, following the progress of the Islamabad new city development project started in 1960. The Kurang, Old Golf Course, Shahdara and G-10 Head Works were constructed successively during the years 1966 to 1970. In addition, to cope with the chronic shortage of water supply, New

Golf Course Head Works was further expanded to receive water from the Rawal Lake for the interim period. According to the data on production of water prepared by CDA for the Period of 11 years from 1974 up to 1984, seasonal fluctuation of water production is appeared small throughout a year.

EXISTING HEAD WORKS

<u>Head Works</u>	<u>Source</u>	<u>Intake Capacity (MGD)</u>	<u>Actual^{1/} Production (MGD)</u>	<u>Facility</u>
Kurang	Kurang River	2.4	(-) ^{2/}	Shallow well & Pump
Shahdara	Shahdara River	1.7	1.2	Concrete Conduit
Nurpur	Nurpur Shahan N.	0.7	0.6	Collection Well
Saidpur	Saidpur Kas	0.8	0.6	- do -
Golf Course (Old)	Ojhr N.	2.2	2.2	Intake Pump
- do - (New)	Rawal Lake	2.7	2.2	- do -
G-10	Bedarawali Kas	2.0	1.9	- do -
<u>Total</u>		<u>12.5</u>	<u>(8.7)</u>	

Notes: ^{1/} Average in the last 11 years (1974 - 1984)

^{2/} Not in operation since 1983

2.2.5. Groundwater

The number and yield of the existing groundwater intake facilities in Islamabad and Rawalpindi as of August 1984 are tabulated in Table A.II-10. With exception of a few dug wells, majority of facilities are of tube wells and their locations, dimensions and yield are investigated in detail as shown in Table A.II-45 to A.II-47 and in an attached location map. Tube wells are distributed scattered mostly in the development areas of Islamabad and Rawalpindi, and in the National park area along the Kurang river downstream of Rawal lake.

The majority of wells has been developed during the past 15 years including 60% of those developed in the recent 10 years. Depth of wells vary with a wide range from 30 m (100 ft) to 140 m (450 ft) yielding groundwater from aquifers of gravel and sand layers intercalated between alluvium clay layers at the depth of 13 m and below. The strainer assembly diameter of tube well varies from 200 mm (8") to 300 mm (10") in Islamabad and 150 mm (6") to 200 mm (8") in Rawalpindi. All of strainers are of type of vertically slotted bronze pipe.

Line shaft turbine pumps are mostly in use and, including motors, they were manufactured in Pakistan. Pumping capacities are of 50 cu.m/hr (0.5 cusec) to 180 cu.m/hr (1.75 cusec), and in Rawalpindi, pumps of small capacities such as 10 to 35 cu.m/hr (0.1 to 0.35 cusec) are also in use. Operation hours of wells are reported as 20 to 22 hours in Islamabad. However in Rawalpindi, a considerable number of tube wells has been forced to reduce their operation to 8-16 hours due to fall of groundwater level. In addition, it is reported in Islamabad that the yields of groundwater during summer period have been reduced by 15 to 20%, due to seasonal fluctuation of groundwater tables.

TABLE A.II-9

RESERVOIR SPECIFICATIONS (EXISTING)

Item	Khanpur	Rawal	Simply
	Haro	Kurang	Soan
River			
Type of Dam	Earthfill	Gravity partly arched	Rockfill
Catchment Area (sq.km)	778	275	153
(sq.mile)	300	106	59
Elevation (ft)			
Full Water	1982	1752	2295
Dead Water	1902	1722	2229
Effective Depth	80	30	66
Storage Capacity			
Maximum Storage (MCM)	130.75	58.59	35.40
(AF)	106,000	47,500	28,700
Dead Storage (MCM)	18.50	14.93	10.79
(AF)	15,000	12,100	8,750
Effective Storage (MCM)	112.25	43.66	24.61
(AF)	91,000	35,400	19,950
Annual Inflow			
Average Inflow (MCM/yr)	327.0	92.4	87.1
(AF/yr)	265,000	75,000	71,000
Maximum Inflow (MCM/yr)	629.4	177.9	175.6
Minimum Inflow (MCM/yr)	126.9	35.9	26.9
Water Demand			
Average Demand (MCM/yr)	305.6	48.8	41.8
- Islamabad (MGD)	33.0	-	24.0
- Rawalpindi (MGD)	69.37	21.0	-
- Wah and Taxila (MGD)	28.5	-	-
- Irrigation (MCM/yr)	88.2	-	-
(Ha)	14,770	-	-
Shortage (MCM/yr)			
Maximum Shortage	163.4	-	11.5
Minimum Shortage	-	-	-
Spillage (MCM/yr)			
Average Spillage	41.1	34.6	37.8
Maximum Spillage	219.7	101.4	114.6
Minimum Spillage	-	-	-
Parameters by Mean Value			
Demand/Inflow	0.93	0.53	0.48
Spillage/Inflow	0.13	0.37	0.43
Shortage/Demand	0.16	-	0.02

TABLE A.II-10

PRESENT GROUNDWATER PRODUCTION
IN ISLAMABAD / RAWALPINDI

<u>Operating agency and Source Name</u>	<u>No. of Wells</u>	<u>Production</u>
ISLAMABAD		
CDA		MGD (MLD)
National Park Area	19*	6.5 (29.6)
Old Golf Course	3*	0.7 (3.2)
New Golf Course	3	0.8 (3.6)
Sectoral Area	35*	3.8 (17.3)
<u>Sub-total</u>	<u>60</u>	<u>11.8 (53.7)</u>
RAWALPINDI		
RMC	38	6.0 (27.3)
PHED		
Sohan Camp	6	3.5 (15.9)
Others	11	4.5 (20.5)
C.B.		
C.B.	7	2.5 (11.4)
MES (ARMY)	3	0.7 (3.2)
MES (PAF)	3	0.7 (3.2)
<u>Sub-total</u>	<u>68</u>	<u>17.9 (81.5)</u>
<u>Total</u>	<u>128</u>	<u>29.7 (135.2)</u>

* Abandoned wells and long resting wells not counted.

TABLE A.II-11 PHASED WATER REQUIREMENTS OF BENEFICIARIES

	1974		1980		1990		2000 A.D	
	ac.ft/yr	MGD	ac.ft/yr	MGD	ac.ft/yr	MGD	ac.ft/yr	MGD
o Municipal (Urban)								
Rawalpindi	10,736	8	38,918	29	62,483	46.56	93,094	69.37
Islamabad	-	-	5,368	4	44,286	33	44,286	33
o Industrial								
POF (Wah)	9,394	7	12,078	9	16,104	12	20,130	15
PIDC (Taxila)	8,760	6.5	10,220	7.5	13,870	10	18,250	13.5
o Irrigation								
Right Bank Canal ^{*/}	46,740		46,740		46,740		46,740	
Left Bank Canal ^{*/}	27,520		27,520		27,520		27,520	
	103,150		140,844		211,003		250,000	
							(307.5 MCM)	

Notes: ^{*/} Culturable command areas on Right and Left Bank Canal are 22785 acres and 13685 acres, respectively.

2.3. Runoff

2.3.1. Haro River (Khanpur)

The Khanpur dam with a catchment of 309 sq.miles is located in Hazara District of the North-West Frontier Province (NWFP) across the Haro river approximately 9 miles from Taxila town with the Buddhist University in the times of Ashoka and almost on the outskirts of Khanpur Village. Runoff observations of the Haro river near Khanpur have been recorded by Surface Water Hydrology Project, WASID, WAPDA since 1960 on the right bank about 400 m upstream from Taxila-Haripur Road Bridge. Daily mean runoffs vary with a wide range from 0.1 cu.m/sec (4 cusec) to 501 cu.m/sec (17,700 cusec), and the annual average runoff for the period of 21 years up to 1980 has been reported at 307.1 MCM (24,900 acre ft.)

Table A.II-8 (1), as previously referred to, presents the raw data of monthly runoff of Haro river near Khanpur collected from WAPDA. Since it is notified that the record excludes small irrigation diversion on the left bank for the existing irrigation systems which may carry considerable portion of low water discharge, the water balance computations for the Khanpur reservoir were conducted under assumption that 60% of the culturable command area on the Left Bank Canal was being irrigated by the Haro river water diverted upstream of the river gauging station. Thus, the Khanpur inflow would be WAPDA measurement plus irrigation requirement for 60% of CCA, that is equivalent to 327.0 MCM/yr or 265,000 AF/yr.

Irrigation water requirement for 60% of CCA was computed on a daily basis and added to the WAPDA's record. Haro river runoffs at Khanpur, in other words inflows into the Khanpur reservoir, were so generated on a daily basis and then summarized as presented in Table A.II-12.

In addition, available length of data of 21 years was considered to be sufficient because, as is apparent from Figure A.II-3 and Table A.II-13, that a long-term rainfall record shows distinct periodic pattern of ten year cycle, and so far as the drought is to be evaluated on the basis of once in five years return period.

2.3.2. Soan River (Simly)

There are two different measurements of runoff at and near the Simly dam site on Soan river. The data for the Soan at Simly were collected by the WAPDA Resident Engineer of CDA for the period of 10 years from 1964 to 1973. Additional runoff data are available from SWHP, WAPDA on the Soan at Chirah which is 13 km downstream from the dam. Comparison studies were made on runoff measurements and, consequently, WAPDA's measurements at Chirah was used to estimate inflow of the Simly Reservoir after treatment of data by means of areal conversion.

COMPARISON ON RUNOFF MEASUREMENTS (SIMLY)

	<u>Soan River</u>		<u>Haro River</u>
	<u>Simly 1/</u>	<u>Chirah 2/</u>	<u>Khanpur</u>
Observation Period	1964-73	1961-79	1960-80
Catchment Area (sq.mile)	59	126	300
Average Runoff (Acre ft)	238,800	145,000	265,000
(Acre ft/sq.mile)	4,050	1,150	883
Areal Rainfall (inch)	65.0	65.0	57.1
Runoff Coefficient (%)	116.7	33.2	28.9

Notes: 1/ Collected at Simly by WAPDA Resident Engineer

2/ Collected at Chirah by WAPDA, SWHP

It has been noted by CDA that the Simly inflow would be more than estimated because WAPDA's record of Soan river at Chirah, on which the study was based, does not include CDA's abstraction which has been made since 1969 at the site of the dam temporarily by pumping up. Since the study involves the analysis period of 19

years from 1961, in which observation commenced, to 1979, after that the data have not yet been processed, the CDA's abstraction could be considered to enable a sufficient investigation to be performed. After some time spent to collect reasonable data on abstraction of the Soan river discharge, the monthly and daily records of pumping done at Simly for the period May 1969 up to present were provided by CDA, as summarized in Table A.II-14. These data were added to the Soan runoffs to generate actual amount of inflow into the Simly reservoir. Table A.II-15 presents monthly runoffs of Soan river at Simly employed in the study.

2.3.3. Kurang River (Rawal)

Regarding runoffs of the Kurang river at Rawal dam, the Small Dams Organization of Punjab Government, which is responsible in operating the dam, has been collecting records of dam operation on monthly basis including storage elevations and releases from 1962 onwards. Table A.II-16 presents SDO's estimates on Rawal inflow. Although there are some potential sources of error in the SDO's data and so the data can not be directly used in water balance computation, the estimated figures of inflow, from which runoff coefficient of 17% is resulted, indicate possible negative margin of Kurang runoff as compared to those obtained from Haro and Soan rivers.

Rainfall studies made to grasp areal rainfalls over the catchments show, as is illustrated in Figure A.II-4, as well as in Table A.II-17, that the Rawal catchment has been receiving almost same amount of areal rainfall as compared with that of Khanpur catchment. The Khanpur runoff could, therefore, be useful measures to estimate Rawal runoff. On the contrary from inspection of rainfall-runoff relationships observed by WAPDA elsewhere in and around the basins between the Indus and Jhelum rivers, it could be concluded that there is some geographic effect on yield from drainage basins, with more mountainous catchments yielding more than catchments which contain more low-elevated and flat land.

During stages of the feasibility study on the Rawal dam, river gauges were installed at the Rawal dam site and observations were executed at three hours interval for about two years from September 1956 through August 1958. Although observation period was too short for drawing any conclusions with regard to the availability of water supplies in the river, measurements indicate an overall runoff coefficient of about 20%.

Consequently, the Rawal runoff has been estimated as 80% of Haro runoff at Khanpur with reduction in proportion to the catchment areas, resulting in 92.4 MCM/yr of annual runoff or 21.8% of annual precipitation within the catchment, taking into account the followings;

- (1) SDO's inflow may be underestimated due to the fact that, in many months, monthly inflows have been estimated negative meaning reservoir losses would be more than that presently expected.
- (2) Some of the river discharge was abstracted from the river upstream of Rawal dam by the existing head works which is not in operation since 1983.

Comparison studies made are as below:

COMPARISON STUDY OF RAWAL RUNOFF

	<u>Runoff</u> (MCM/yr)	<u>Rainfall during</u> <u>Corresponding</u> <u>Period</u> (mm/yr)	<u>Runoff</u> <u>Coefficient</u> (%)
(1) SDO Estimate (1962 - 1980)	73.7	1523	17.6
(2) Actual Measurement (1957 - 1958)	84.8	1574	19.6
(3) Khanpur Runoff (1960 - 1980)	327.0	1560	26.9
(4) New Estimate (1960 - 1980)	92.4	1540	21.8

FIGURE A.II-3 MOVING AVERAGES OF ANNUAL RAINFALL

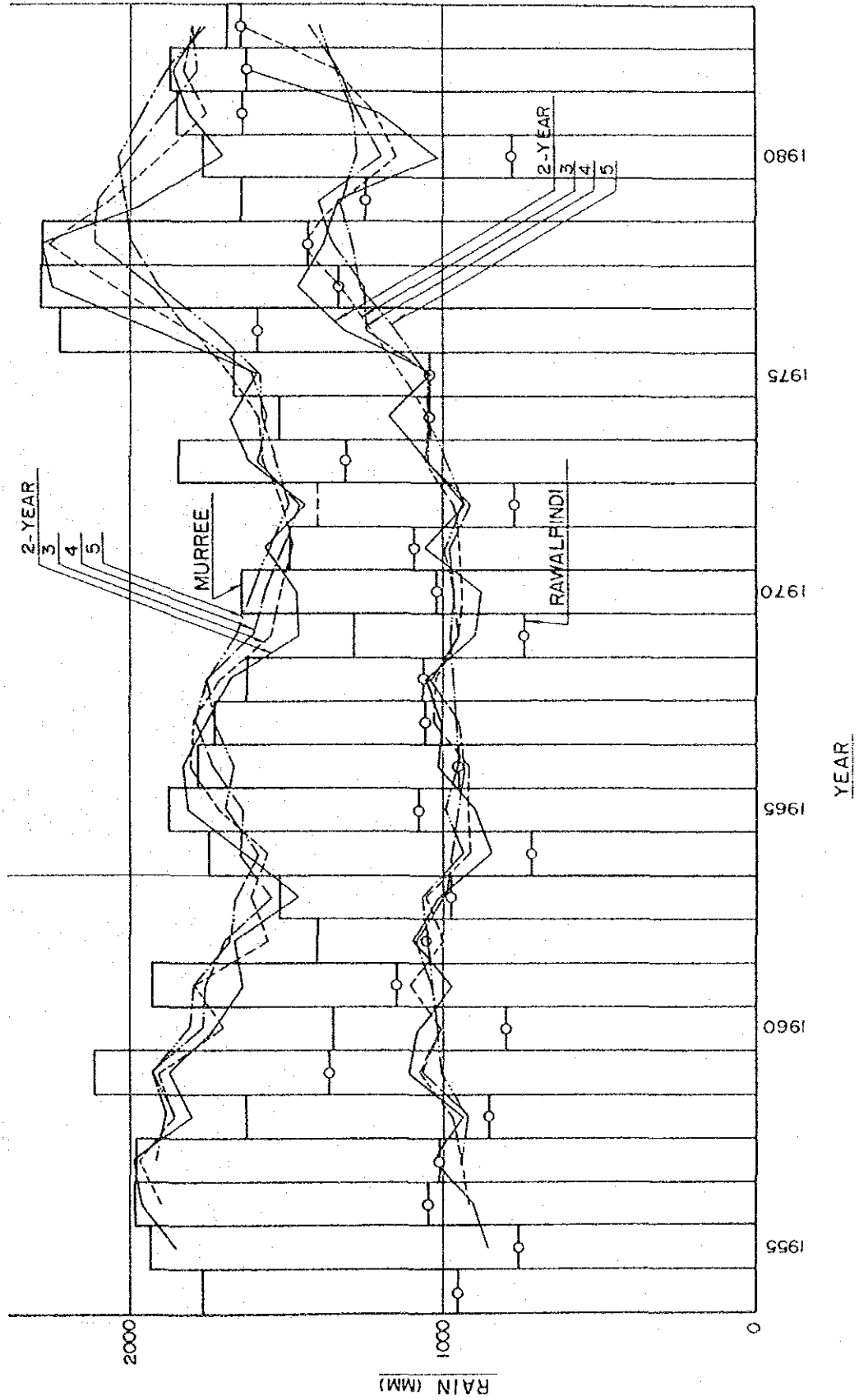
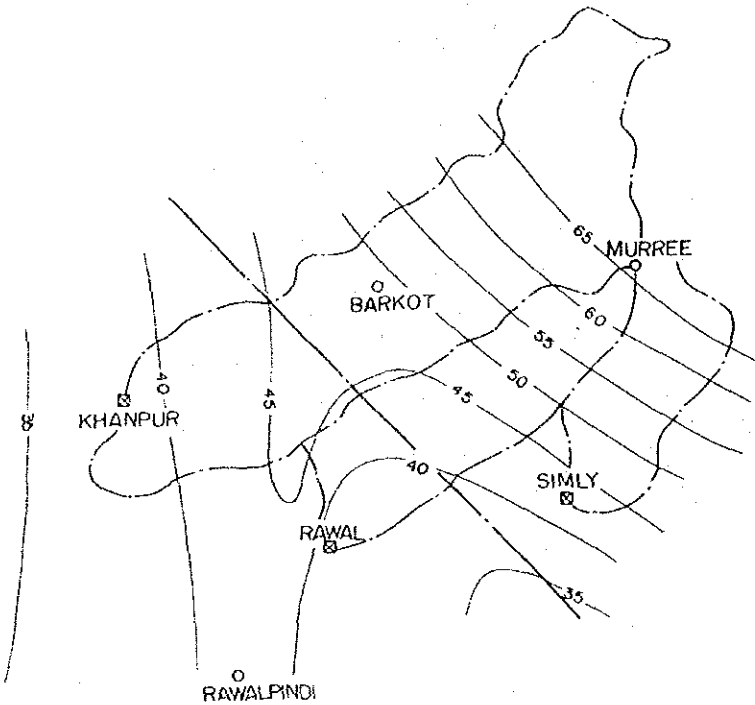


FIGURE A.II-4 THIESSEN POLYGONS AND ISOHYETAL MAP



Station	Area (%)	Rain (mm)
<u>Khanpur</u>		
Murree	68.3	1651.5
Rawalpindi	31.7	1006.8
Total	100.0	1452.5

<u>Rawal</u>		
Murree	65.5	1651.5
Rawalpindi	34.5	1006.8
Total	100.0	1434.9

<u>Simly</u>		
Murree	100.0	1651.5
Rawalpindi	-	-
Total	100.0	1651.5

Station	Area (%)	Rain (mm)
<u>Khanpur</u>		
Murree	33.1	1651.5
Barkot	59.5	1256.8
Rawalpindi	7.4	1006.8
Total	100.0	1370.1

<u>Rawal</u>		
Murree	32.1	1651.5
Barkot	60.4	1256.8
Rawalpindi	7.5	1006.8
Total	100.0	1365.9

<u>Simly</u>		
Murree	100.0	1651.5
Barkot	-	-
Rawalpindi	-	-
Total	100.0	1651.5

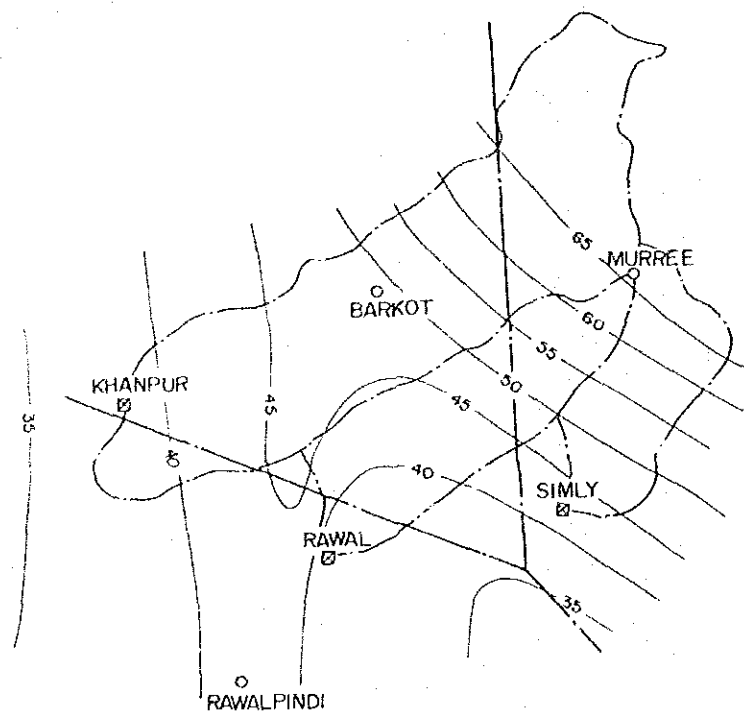


TABLE A. II-12

HARO RIVER RUNOFF AT KHANPUR (STUDY)

 HARO RIVER AT KHANPUR (STUDY) *****

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1960	15.514	13.745	21.730	20.071	13.094	8.256	42.185	49.451	35.264	15.275	8.807	5.747	249.138
1961	19.299	26.706	17.099	40.792	22.229	14.122	43.746	50.120	138.991	32.390	17.242	10.425	433.159
1962	6.871	7.404	30.071	19.142	8.322	6.879	24.941	44.538	33.916	15.116	7.316	6.116	210.632
1963	5.701	6.343	29.858	19.806	12.364	6.491	21.591	60.209	40.820	13.985	9.479	7.269	233.917
1964	39.052	25.549	19.804	13.961	7.228	4.479	22.292	60.138	37.926	15.391	8.038	6.861	260.719
1965	6.695	21.790	40.040	116.929	77.935	28.009	22.286	44.877	19.993	11.223	6.317	6.331	402.425
1966	5.518	10.983	22.261	27.504	26.225	10.271	30.785	48.542	38.374	23.267	10.543	7.462	261.736
1967	5.974	35.425	70.344	49.938	27.787	8.718	12.563	45.537	45.198	14.670	6.739	19.808	342.701
1968	26.153	35.926	37.927	21.245	11.098	5.913	17.356	86.833	16.892	12.866	7.280	7.066	286.556
1969	5.982	15.041	18.699	19.133	8.587	5.567	7.637	33.623	16.582	22.714	6.716	3.871	164.154
1970	6.247	5.686	43.791	13.653	4.461	4.120	13.386	67.122	119.081	31.511	9.612	5.257	323.926
1971	5.120	7.806	13.297	6.679	3.169	74.217	78.469	121.886	41.405	15.833	7.169	4.397	383.443
1972	6.973	12.510	36.534	21.944	24.185	9.796	10.685	23.690	26.353	11.092	7.028	12.579	203.369
1973	18.382	21.376	74.846	22.785	10.275	11.842	42.799	134.280	80.249	24.955	10.431	7.408	459.627
1974	8.064	18.529	10.973	6.299	3.867	5.529	19.900	25.965	13.168	7.221	4.183	3.194	126.891
1975	4.821	9.634	16.342	17.914	11.263	8.505	18.752	80.776	29.995	12.503	7.581	4.656	222.791
1976	10.334	39.733	65.640	42.775	19.038	11.514	45.079	243.887	95.805	32.983	14.182	8.424	629.395
1977	12.779	12.719	9.737	19.766	16.894	11.921	98.632	136.553	79.511	56.794	18.376	10.566	484.248
1978	15.604	12.985	38.073	19.126	3.619	8.948	157.391	191.334	64.826	28.282	15.842	8.383	569.414
1979	10.995	24.872	101.137	47.172	19.632	9.032	18.275	48.626	17.756	7.687	4.670	3.005	312.878
1980	15.929	21.386	45.797	25.536	9.524	26.106	28.585	72.219	30.422	15.213	9.021	4.831	304.569
TOTAL	252.009	386.148	764.068	592.167	345.794	284.234	777.331	1670.205	1022.527	420.970	196.574	153.658	6865.672
MEAN	12.000	18.368	36.384	28.198	16.466	13.535	37.016	79.534	48.692	20.046	9.361	7.317	326.937

TABLE A. II-13 MOVING AVERAGES OF ANNUAL RAINFALL

Year	RAWALPINDI					MURREE				
	ANNUAL	2-YR	3-YR	4-YR	5-YR	ANNUAL	2-YR	3-YR	4-YR	5-YR
1954	950.7					1,771.9				
1955	754.4	852.6				1,938.8	1,855.4			
56	1,045.0	899.7	916.7			1,987.3	1,963.1	1,899.3		
57	1,010.9	1,028.0	936.8	940.3		1,983.0	1,985.2	1,969.7	1,920.3	
58	851.4	931.2	969.1	915.4	922.5	1,633.7	1,808.4	1,868.0	1,885.7	1,862.9
59	1,365.3	1,108.4	1,075.9	1,068.2	1,005.4	2,119.4	1,876.6	1,912.0	1,930.9	1,932.4
1960	793.5	1,079.4	1,003.4	1,005.3	1,013.2	1,348.0	1,733.7	1,700.4	1,771.0	1,814.3
61	1,144.5	969.0	1,101.1	1,038.7	1,033.1	1,930.1	1,639.1	1,799.2	1,757.8	1,802.8
62	1,050.3	1,097.4	996.1	1,088.4	1,041.0	1,400.3	1,665.2	1,559.5	1,699.5	1,686.3
63	975.1	1,012.7	1,056.6	990.9	1,065.7	1,524.8	1,462.6	1,618.4	1,550.8	1,664.5
64	713.7	844.4	913.0	970.9	935.4	1,756.4	1,640.6	1,560.5	1,652.9	1,591.9
1965	1,076.5	895.1	921.8	953.9	992.0	1,879.3	1,817.9	1,720.2	1,640.2	1,698.2
66	948.7	1,012.6	913.0	928.5	952.9	1,786.1	1,832.7	1,807.3	1,736.7	1,669.4
67	1,058.7	1,003.7	1,028.0	949.4	954.5	1,733.0	1,759.6	1,799.5	1,788.7	1,735.9
68	1,062.2	1,060.5	1,023.2	1,036.5	972.0	1,627.9	1,680.5	1,715.7	1,756.6	1,756.5
69	737.9	900.1	952.9	951.9	976.8	1,284.0	1,456.0	1,548.3	1,607.8	1,662.1
1970	1,020.3	879.1	940.1	969.8	965.6	1,648.5	1,466.3	1,520.1	1,573.4	1,615.9
71	1,091.2	1,055.8	949.8	977.9	994.1	1,489.7	1,569.1	1,474.1	1,512.5	1,556.6
72	770.1	930.7	960.5	904.9	936.3	(1,400.0)	1,444.9	1,512.7	1,455.6	1,490.0
73	1,310.6	1,040.4	1,057.3	1,048.1	986.0	1,844.0	1,622.0	1,577.9	1,595.6	1,533.2
74	1,041.9	1,176.3	1,040.9	1,053.5	1,046.8	1,526.5	1,685.3	1,590.2	1,565.1	1,581.7
1975	1,041.4	1,041.7	1,131.3	1,041.0	1,051.0	1,669.3	1,597.9	1,679.9	1,610.0	1,585.9
76	1,595.4	1,318.4	1,226.2	1,247.3	1,151.9	2,226.6	1,948.0	1,807.5	1,816.6	1,733.3
77	1,333.5	1,464.5	1,323.4	1,253.1	1,264.6	2,289.3	2,258.0	2,061.7	1,927.9	1,911.1
78	1,429.0	1,381.3	1,452.6	1,349.8	1,288.2	2,284.5	2,286.9	2,266.8	2,117.4	1,999.2
79	1,250.7	1,339.9	1,337.7	1,402.2	1,330.0	1,646.9	1,965.7	2,073.6	2,111.8	2,023.3
1980	780.0	1,015.4	1,153.2	1,198.3	1,277.7	1,769.4	1,708.2	1,900.3	1,997.5	2,043.3
81	1,643.4	1,211.7	1,224.7	1,275.8	1,287.3	1,856.2	1,812.8	1,757.5	1,889.3	1,969.3
82	1,632.5	1,638.0	1,352.0	1,326.7	1,347.1	1,876.0	1,866.1	1,833.9	1,787.1	1,886.6
83	1,650.0	1,641.3	1,642.0	1,426.5	1,391.3	1,694.4	1,785.2	1,808.9	1,799.0	1,768.6
Mean	1,104.4					1,790.1				

TABLE A.II-14 CDA'S ABSTRACTION AT SIMLY ON SOAN

 *** CDA'S ABSTRACTION AT SIMLY ON SOAN ***

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1969	0.0	0.0	0.0	0.0	50.0	47.4	39.5	81.9	137.1	105.9	77.8	44.9	584.5
1970	48.3	64.5	79.4	114.3	52.8	78.8	137.7	59.8	68.5	172.2	167.0	163.9	1207.4
1971	108.4	94.1	157.2	89.1	66.9	120.5	100.6	107.8	152.7	158.4	109.8	86.4	1351.9
1972	100.9	157.7	135.7	104.6	54.8	69.8	65.6	57.2	94.8	126.8	133.8	161.8	1263.5
1973	113.1	124.6	93.0	130.9	113.4	111.9	95.5	75.0	111.3	99.3	131.6	95.4	1295.0
1974	70.4	69.9	92.4	56.2	46.0	74.2	79.9	81.6	100.2	97.2	54.7	55.2	877.9
1975	51.1	83.3	93.0	88.2	83.4	64.6	95.4	69.4	116.8	138.0	106.0	78.0	1067.2
1976	70.9	89.3	149.0	149.0	150.0	107.5	126.0	115.0	105.6	132.5	146.7	111.5	1453.0
1977	69.9	118.9	100.5	125.0	139.4	115.8	108.3	125.5	100.6	106.1	141.5	120.3	1371.8
1978	109.0	97.5	155.0	142.5	91.5	73.0	130.4	135.5	115.0	135.5	146.0	144.9	1469.8
1979	135.0	129.0	154.5	150.0	142.0	109.8	126.3	146.2	150.0	139.5	108.5	94.1	1584.9
1980	135.7	142.4	149.7	148.8	128.1	125.6	147.6	174.4	189.3	267.1	219.0	176.7	2004.5
TOTAL	1006.8	1171.2	1359.4	1298.6	1118.3	1098.9	1252.9	1229.3	1441.9	1678.5	1542.4	1333.1	15531.4
MEAN	83.9	97.6	113.3	108.2	93.2	91.6	104.4	102.4	120.2	139.9	128.5	111.1	1294.3

UNIT = M.G.

TABLE A.II-15 SOAN RIVER RUNOFF AT SIMLY

 *** SOAN RIVER AT SIMLY (STUDY) ***

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1961	9.261	4.535	1.433	10.413	1.191	1.076	17.944	26.317	29.601	4.175	1.886	0.914	108.746
1962	0.582	0.864	3.445	1.383	0.408	0.306	10.180	15.640	4.274	0.514	0.921	1.039	39.556
1963	0.348	2.025	4.086	1.004	0.654	0.221	13.407	17.967	12.407	0.465	0.439	0.327	53.350
1964	7.348	2.021	0.884	1.328	0.546	0.308	13.618	23.034	14.951	1.505	0.566	0.554	66.665
1965	0.975	6.882	4.517	17.028	7.149	1.851	13.836	7.882	1.424	0.595	0.369	0.230	62.737
1966	0.166	3.707	4.198	2.957	0.779	1.265	13.431	17.518	6.578	1.701	0.637	0.420	53.357
1967	0.188	3.794	18.401	8.106	1.567	0.381	6.429	22.548	12.061	1.571	0.511	5.255	80.813
1968	5.277	6.733	5.190	2.104	1.040	0.386	8.066	26.972	2.340	1.083	0.540	0.498	60.230
1969	0.345	2.650	1.937	1.064	1.028	0.360	4.666	8.493	2.390	3.025	0.609	0.282	26.850
1970	1.401	1.758	5.049	0.814	0.278	0.971	9.533	44.839	45.528	4.740	1.530	1.094	117.535
1971	0.742	2.831	1.028	5.485	1.596	31.040	16.327	46.903	8.592	1.513	1.166	0.643	117.865
1972	1.528	3.926	6.880	4.612	1.375	1.060	4.889	13.089	11.183	2.058	1.248	2.994	54.643
1973	2.620	3.236	21.491	2.064	1.149	2.846	13.802	29.505	7.542	2.016	1.040	0.830	88.142
1974	0.789	1.917	1.181	0.481	0.367	0.900	11.976	17.905	2.567	0.849	0.353	0.481	39.767
1975	0.381	1.900	1.568	1.806	1.075	0.742	16.727	60.245	25.199	2.267	1.052	0.620	113.581
1976	3.308	15.315	19.186	4.176	1.772	1.380	21.481	72.823	29.069	4.570	1.468	1.034	175.584
1977	1.984	1.085	0.683	4.738	1.619	3.354	68.644	49.336	10.713	8.797	5.262	1.883	158.099
1978	3.549	2.625	5.751	2.098	0.697	1.983	34.469	69.970	19.018	3.579	3.233	1.194	148.165
1979	10.556	23.731	14.157	4.672	1.678	1.260	10.087	15.688	3.823	1.062	0.861	0.737	88.312
TOTAL	51.348	91.536	120.865	76.332	25.971	51.692	309.510	586.672	249.262	46.084	23.690	21.032	1653.995
MEAN	2.703	4.818	6.361	4.017	1.367	2.721	16.290	30.877	13.119	2.425	1.247	1.107	87.052

TABLE A. II-16 RAWAL DAM INFLOW ESTIMATED BY SDO

Year	Storage Difference (Acft)	Outflow			Inflow-Loss (Acft)	Losses (Acft)	Inflow (Acft)	Inflow (MCM)
		Canal (Acft)	Spillage (Acft)					
1962-1963	-4,612	15,954	28,600	39,942	8,544	48,486	59.8	
-1964	2,836	17,610	1,156	21,602	8,254	29,856	36.8	
-1965	11,665	13,796	44,194	69,655	6,620	76,275	94.1	
-1966	-22,088	14,928	45,310	38,150	8,543	46,693	57.6	
-1967	11,301	30,158	-	41,459	2,943	44,402	54.8	
-1968	-1,106	25,616	38,336	62,846	3,051	65,897	81.3	
-1969	-16,351	35,318	32,692	51,659	4,567	56,226	69.4	
-1970	-7,689	27,358	-	19,669	7,065	26,734	33.0	
-1971	3,412	27,472	3,796	34,680	5,860	40,540	50.0	
-1972	1,948	33,240	65,726	100,914	1,727	102,641	126.6	
-1973	-8,175	22,734	-	14,559	2,417	16,976	20.9	
-1974	2,686	37,552	23,922	64,160	5,239	69,399	85.6	
-1975	-2,417	30,734	-	28,317	1,402	29,719	36.7	
-1976	22,652	25,522	-	48,174	7,149	55,323	68.2	
-1977	1,548	29,602	98,041	129,191	3,213	132,404	163.3	
-1978	1,548	30,084	30,926	62,558	3,213	65,771	81.1	
-1979	9,619	29,380	107,046	146,045	1,154	147,199	181.6	
1979-1980	-16,658	35,626	-	18,968	1,343	20,311	25.1	
Mean				55,142	4,572	59,714	73.7	

TABLE A.II-17

SPOT AND AREAL RAINFALLS

Year	Rainfall in mm			Areal Rainfall in mm				
	Murree	Rawalpindi		Khanpur		Rawal		
		Barkot	Barkot	(1)	(2)	(3)	(4)	Simly (5)
1960	1,348.0	-	793.7	1,172.3	-	1,156.8	-	1,348.0
61	1,927.9	-	1,194.4	1,695.4	-	1,674.8	-	1,927.9
62	1,400.3	-	1,050.3	1,289.4	-	1,279.6	-	1,400.3
63	1,524.8	1,312.4	975.4	1,350.6	1,357.8	1,335.3	1,355.3	1,524.8
64	1,756.4	1,327.2	699.5	1,421.4	1,422.8	1,391.8	1,417.9	1,756.4
1965	2,148.6	1,359.2	1,077.2	1,809.0	1,599.6	1,779.0	1,591.4	2,148.6
66	1,786.1	1,309.6	948.9	1,520.7	1,440.6	1,497.3	1,435.5	1,786.1
67	1,733.0	1,488.2	1,058.6	1,519.2	1,537.4	1,500.3	1,534.6	1,733.0
68	1,627.9	1,242.3	838.9	1,377.8	1,340.1	1,355.7	1,335.8	1,627.9
69	1,284.0	1,079.0	697.6	1,098.1	1,118.6	1,081.7	1,116.2	1,284.0
1970	1,648.5	1,441.7	1,020.4	1,449.4	1,479.0	1,431.8	1,476.5	1,648.5
71	1,489.7	1,119.6	1,591.1	1,521.8	1,277.0	1,524.7	1,273.8	1,489.7
72	-	1,258.1	820.1	-	-	-	-	-
73	1,640.8	1,357.1	1,310.7	1,536.2	1,447.6	1,526.9	1,444.7	1,640.8
74	1,526.3	786.6	1,042.6	1,373.0	1,050.4	1,359.4	1,043.2	1,526.3
1975	1,665.2	-	1,042.0	1,467.6	-	1,450.2	-	1,665.2
76	2,226.4	-	1,595.9	2,026.5	-	2,008.9	-	2,226.4
77	2,256.5	-	1,332.8	1,963.7	-	1,937.8	-	2,256.5
78	2,327.4	-	1,430.2	2,043.0	-	2,017.9	-	2,327.4
79	1,647.0	-	1,250.7	1,521.4	-	1,510.3	-	1,647.0
1980	1,769.4	-	780.0	1,455.8	-	1,428.1	-	1,769.4
81	1,856.2	-	1,643.4	1,788.7	-	1,782.8	-	1,856.2
82	1,876.0	-	1,632.5	1,798.8	-	1,792.0	-	1,876.0
83	1,694.4	-	1,650.0	1,680.3	-	1,679.1	-	1,694.4
Average	1,746.1	1,256.8	1,144.9	1,560.0	1,370.1	1,543.6	1,365.9	1,746.1
1963-74	1,651.5	1,256.8	1,006.8	1,452.5	1,370.1	1,434.9	1,365.9	1,651.5
Average								

Notes:

- (1) 68.3% Murree + 31.7% Rawalpindi
(2) 33.1% Murree + 59.5% Barkot + 7.4% Rawalpindi
(3) 65.5% Murree + 34.5% Rawalpindi
(4) 32.1% Murree + 60.4% Barkot + 7.5% Rawalpindi
(5) 100% Murree

TABLE A.II-18 KURANG RIVER RUNOFF AT RAWAL (STUDY)

 *** KURANG RIVER AT RAWAL (STUDY) ***

YEAR	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEP.	OCT.	NOV.	DEC.	ANNUAL
1960	4.385	3.885	6.142	5.673	3.701	2.334	11.924	13.978	9.968	4.318	2.489	1.624	70.423
1961	5.455	7.549	4.833	11.531	6.283	3.992	12.365	14.167	39.288	9.155	4.874	2.947	122.440
1962	1.942	2.093	8.500	5.411	2.352	1.944	7.050	12.590	9.587	4.273	2.068	1.729	59.539
1963	1.611	1.793	8.440	5.599	3.495	1.835	6.103	17.019	11.539	3.953	2.679	2.055	66.121
1964	11.039	7.222	5.598	3.946	2.043	1.266	6.301	16.999	10.721	4.351	2.272	1.939	73.697
1965	1.892	6.159	11.318	33.052	22.030	7.917	6.300	12.685	5.651	3.172	1.786	1.790	113.752
1966	1.560	3.104	6.292	7.775	7.413	2.903	8.702	13.721	10.847	6.577	2.980	2.109	73.984
1967	1.689	10.013	19.884	14.116	7.855	2.464	3.551	12.872	12.776	4.147	1.905	5.599	96.870
1968	7.393	10.155	10.721	6.005	3.137	1.672	4.906	24.545	4.775	3.637	2.058	1.997	81.000
1969	1.691	4.252	5.286	5.408	2.427	1.574	2.159	9.504	4.687	6.421	1.898	1.094	46.401
1970	1.766	1.607	12.378	3.859	1.261	1.165	3.784	18.973	33.660	8.907	2.717	1.486	91.563
1971	1.447	2.207	3.758	1.888	0.896	2.109	22.180	34.453	11.704	4.475	2.026	1.243	108.387
1972	1.971	3.536	10.327	6.203	6.836	2.769	3.020	6.696	7.449	3.135	1.987	3.556	57.486
1973	5.196	6.042	21.156	6.441	2.804	3.347	12.098	37.956	22.684	7.054	2.949	2.094	129.921
1974	2.279	5.238	3.102	1.781	1.093	1.563	5.625	7.340	3.722	2.041	1.182	0.903	35.868
1975	1.363	2.723	4.633	5.064	3.184	2.404	5.301	22.833	8.479	3.534	2.143	1.316	62.976
1976	2.921	11.231	18.554	12.091	5.381	3.255	12.742	68.939	27.081	9.323	4.009	2.381	177.909
1977	3.612	3.595	2.752	5.587	4.775	3.370	27.880	38.599	22.475	16.054	5.194	2.987	136.881
1978	4.411	3.671	10.762	5.406	2.436	2.529	44.489	54.084	18.324	7.994	4.478	2.370	160.954
1979	3.108	7.031	28.594	13.334	5.549	2.553	5.166	13.745	5.019	2.173	1.320	0.850	88.441
1980	4.503	6.045	12.945	7.218	2.692	7.379	8.080	20.414	8.599	4.300	2.550	1.366	86.092
TOTAL	71.234	109.151	215.977	167.386	97.745	30.344	219.726	472.111	289.034	118.995	55.565	43.434	1940.701
MEAN	3.392	5.198	10.285	7.971	4.655	3.826	10.463	22.481	13.764	5.666	2.646	2.068	92.414

UNIT = MCM/MON