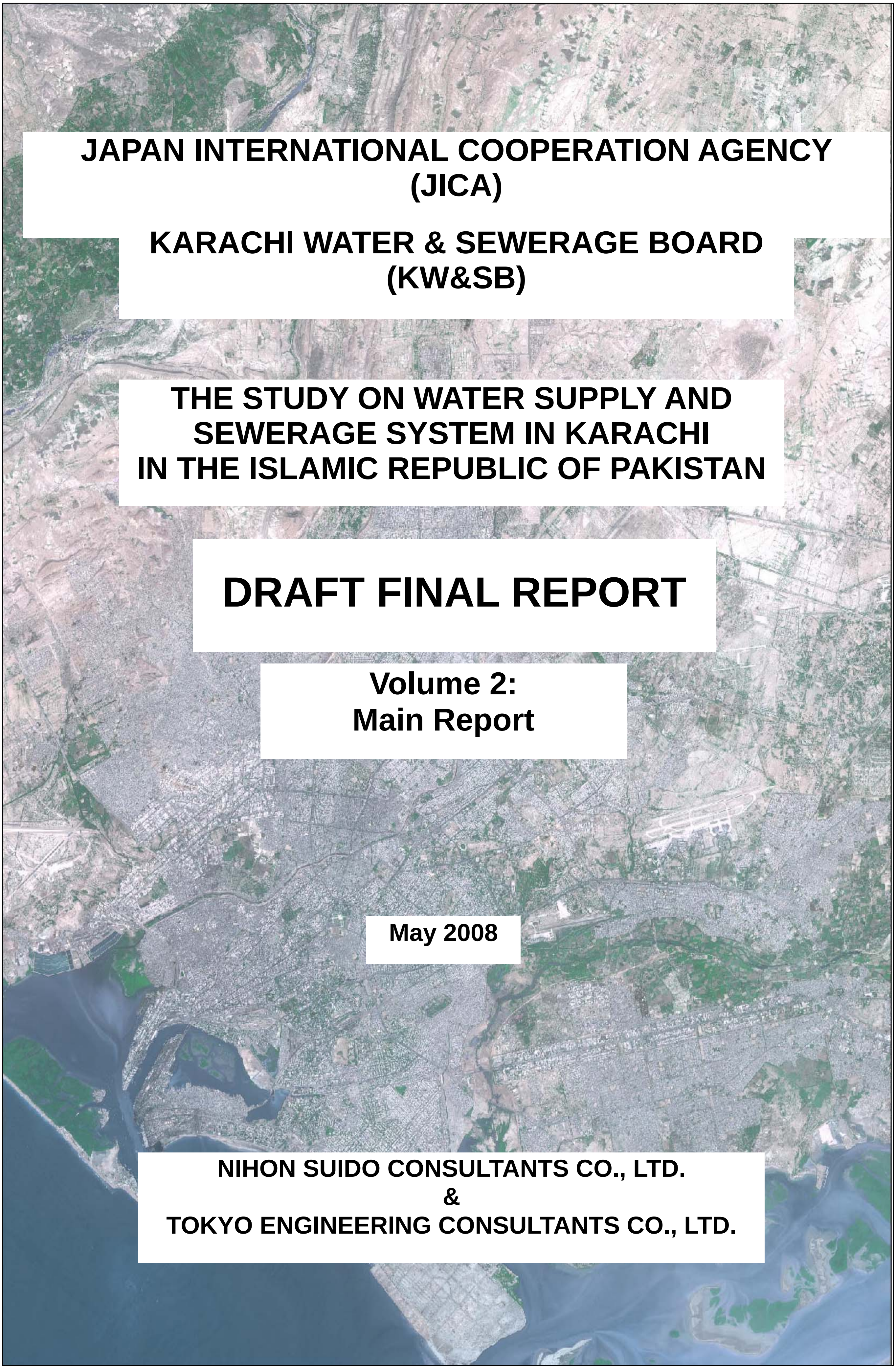

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

KARACHI WATER & SEWERAGE BOARD
(KW&SB)

THE STUDY ON WATER SUPPLY AND SEWERAGE SYSTEM IN KARACHI IN THE ISLAMIC REPUBLIC OF PAKISTAN

DRAFT FINAL REPORT

Volume 2:
Main Report

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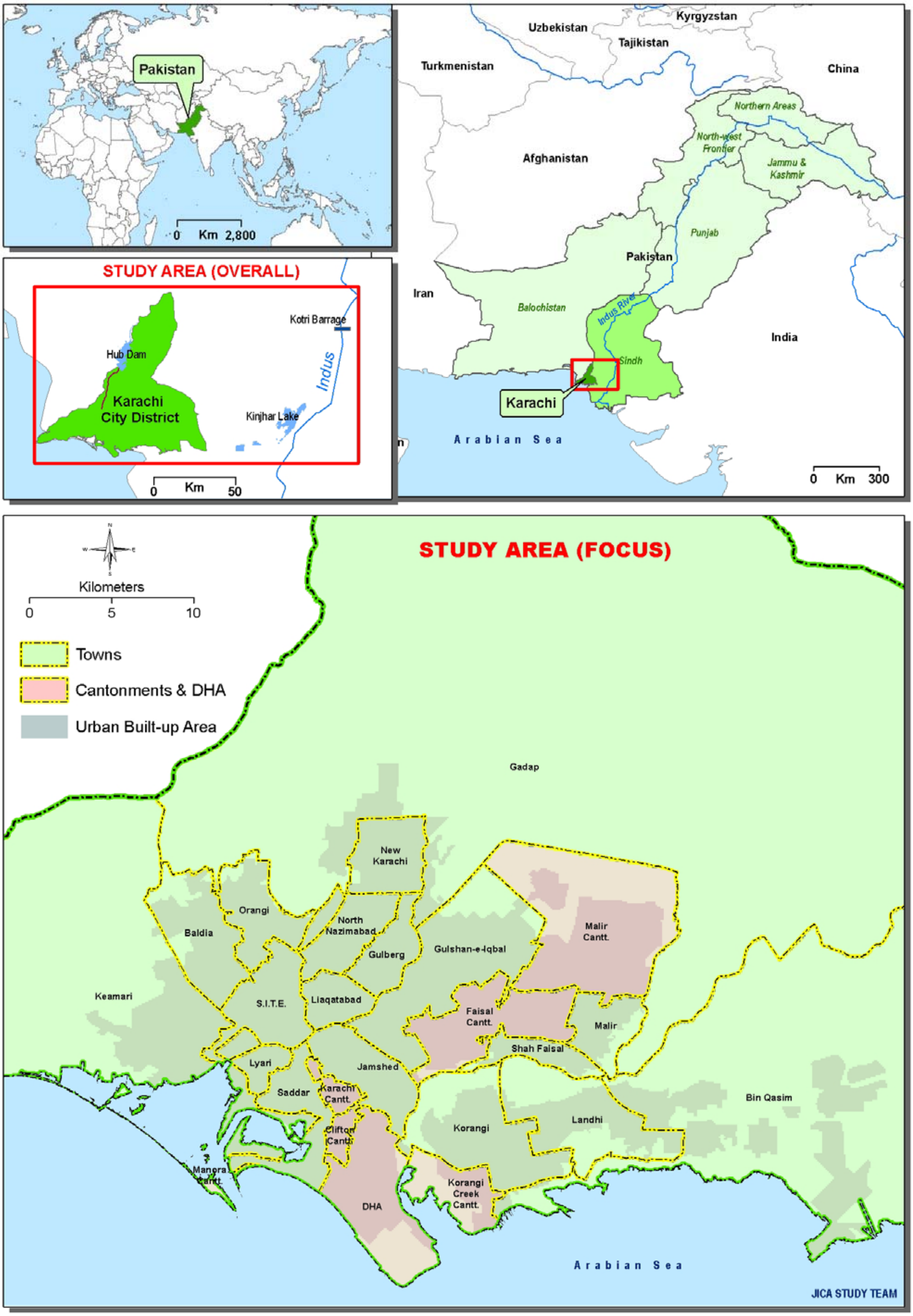
STUDY AREA LOCATION MAP



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Abbreviations

Abbreviation	Definition
AC	Asbestos Cement
ACR	Annual Confidential Report
AD	Anaerobic Digester Tank
ADB	Asian Development Bank
AEE	Assistant Executive Engineer
AERC	Applied Economic Research Centre
AP	Anaerobic Pond
APHA	American Public Health Association
B/C	Benefit-Cost Ratio
BOD	Biochemical Oxygen Demand
BOO	Build-Operate-Own
BOOT	Build-Operate-Own-Transfer
BOT	Build-Operate-Transfer
B/S	Balance Sheet
CAPEX	Capital Expenditure
CBO	Community-based Organization
CCB	Citizen Community Board
CDC	Commonwealth Development Corporation
CDGK	City District Government Karachi
CDWP	Central Development Working Party
CE	Chief Engineer
CETP	Common Effluent Treatment Plant
CIP	Cast Iron Pipe
CIS	Customer Information System
CMS	Complaints Management System
COD	Central Ordnance Depot
COD_{Cr}	Chemical Oxygen Demand (Cr)
CRC	Citizen Report Card
CRF	Capital Recovery Factor
CRO	Chief Revenue Officer
CSC	Consumers Service Centre
CWP	Cooling Water Pond
DA	Divisional Accountant
DDO	Drawing and Disbursement Officer
DGPS	Differential Global Positioning System
DHA	Defense Housing Authority
Dia	Diametre
DIP	Ductile Iron Pipe
DMA	District Metreing Area
DNI	Distribution Network Improvement
DNM	Distribution Network Main
DO	Dissolved Oxygen
DPS	Distribution Pumping Station
DSR	Debt-Service Ratio
E&M	Electrical & Mechanical
ECIL	M/s. Engineering Consultants International
ECNEC	Executive Committee of the National Economic Council

EDO	Executive District Officer
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
Elect. Cond.	Electric Conductivity
EOI	Expression of Interest
EPA	Environmental Protection Agency
EPA-Sindh	Environmental Protection Agency, Sindh Government
FFA	Framework Financing Agreement
FFC	Federal Food Commission
FIRR	Financial Internal Rate of Return
FIS	Financial Information System
FP	Facultative Pond
F/P	Filtration Plant
FST	Final Settling Tank
GDP	Gross Domestic Product
GIP	Galvanized Iron Pipe
GIS	Geographic Information System
GKBWS	Greater Karachi Bulk Water Supply
GOB	Government of Balochistan
GOP	Government of Pakistan
GOS	Government of Sindh
GPS	Global Positioning System
H&S	Health & Safety
HRD	Human Resource Development
HRM	Human Resource Management
HSR	High Service Reservoir
IDA	International Development Agency
IEE	Initial Environmental Examination
IRS	Integrated Revenue System
IRSA	Indus River System Authority
IS	Information Systems
ISO	International Organization for Standardization
IT	Information Technology
IWRM	Integrated Water Resource Management
JBIC	Japan Bank for International Corporation
JICA	Japan International Cooperation Agency
Katchi Abadis	Squatter Settlement
KB	Kalri Baghar
KDA	Karachi Development Authority
KDPPA	Karachi Division Physical Planning Agency
KESC	Karachi Electric Supply Cooperation limited.
KG	Kinjhar – Gujjo
KMC	Karachi Metropolitan Corporation
KMCSDP	Karachi Mega City Sustainable Development Program
KPI	Key Performance Indicator
KPT	Karachi Port Trust
KMP	Karachi Master Plan - 2020
KSDP-2020	Karachi Strategic Development Plan 2020
KW&SB	Karachi Water & Sewerage Board
KWA	Karachi Water Authority
LIBOR	London Interbank Offered Rate

L.I.T.E	Landhi Industrial Trading Estate
LSR	Low Service Reservoir
LSU	Local Support Unit
M/P	Master Plan
MCA	Monopoly Control Authority
MD	Managing Director
MFF	Multitranche Financing Facility
MIS	Management Information System
MMP	Mott MacDonald Pakistan
MNF	Minimum Night Flow
MPGO	Master Plan Group of Offices
MPN	Most Probable Number
MS	Mild Steel
MSCL	Millennium Systems & Consultants (Pvt) Ltd
MSF	Multi-stage Flash
MWP	Ministry of Water & Power
NA	(Information) Not Available
Nadra / NADRA	National Database Registration Authority
NCS	National Conservation Strategy
NEK	North East Karachi
NEPRA	National Electric Power Regulatory Authority
NEQS	National Environmental Quality Standards (for Municipal and Liquid Industrial Effluent)
NGO	Non-Governmental Organisation
NLC	National Logistic Cell
NPV	Net present Value
NRW	Non Revenue Water
ODA	Official Development Assistance
O&M	Operation & Maintenance
OGRA	Oil and Gas Regulatory Authority
OPEX	Operational Expenditure
OPP-RTI	Orangi Pilot Project - Research and Training Institute
P & D	Planning & Development
P/L	Profit and Loss Statement
Pak-EPA	Pakistan Environmental Protection Agency
PC-1	Planning Commission-1
PCRWR	Pakistan Council for Research in Water Resource
PCSIR	Pakistan Council for Scientific and Industrial Research
PEMRA	Pakistan Electronic Media Regulatory Authority
PEPA 1997	Pakistan Environmental Protection Act 1997
PH	Power House
PI	Performance Indicator
PIU	Project Implementation Unit
PPP	Public-Private Partnership
PQA	Port Qasim Authority
PRCC	Pre-stressed Reinforced Cement Concrete
PS	Pumping Station
PS or P/ST	Pump Station
PSI	Pakistan Standard Institution
PSM	Pakistan Steel Mill
PSP	Private Sector Participation

PST	Primary Settling Tank
PTA	Pakistan Tanners Association
PTA	Pakistan Telecommunications Authority
PVC	Polyvinyl Chloride
RCC	Reinforced cement concrete
Res.	Reservoir
RFP	Request for Proposals
RTA	Regional Transport Authority
S.I.T.E	Sindh Industrial Trading Estate
SCADA	System Control and Data Acquisition
SCF	Standard Conversion Factor
SE	Superintendent Engineer
SEPA	Sindh Environmental Protection Agency
SITE	Sindh Industrial Trading Estate
SKAA	Sindh Katchi Abadis Authority
SLGO	Sindh Local Government Ordinance
SPM	Suspended Particulate Matter
SS	Suspended Solids
SSGC	Sui Southern Gas Company Limited
T/W	Treatment Works
TA	Technical Assistance
TCP	Technical Cooperation Project
TDM	Trunk Distribution Main
TDS	Total Dissolved Solids
TF	Trickling Filter
TKP	Tameer–e–Karachi Programme
TMA	Town Municipal Administration
ToR	Terms of Reference
TP	(Sewage) Treatment Plant
TPS	Transmission Pumping Station
TWL	Top Water Level
UASB	Upflow Anaerobic Sludge Blanket (Process)
UC	Union Council
UFW	Unaccounted for Water
UNDP	United Nations Development Programme
W&SS	Water & Sanitation Services
WAPDA	Water and Power Development Authority
WB	World Bank
WHO	World Health Organization
WLR & SS	Water Loss Reduction & System Strengthening
WS	Workshop
WSP-SA	Water and Sanitation Program – South Asia
WtP	Willingness to Pay

Units of Measurement

Abbreviation	Definition
%	percent
acft	acre feet
AF	acre feet
am	time between midnight and noon
℃	degree Celsius
cfu/ml	colony forming unit
cm	centimetre
cm^2	square centimetre
cusecs	cubic feet per second
dbt/d	dry basis ton per day
dl	decilitre
ft	feet
gpcd	gallon per capita per day
gpm	gallon per minute
gmcd	gram per capita per day
ha	hectare
hp	horsepower
in	inch
kg/d	kilogram per day
kg/m/h	kilogram per metre per hour
$kg/m^3/d$	kilogram per cubic metre per day
km	kilometre
km^2	square kilometre
KVA	kilovolt ampere
kW	kilowatt
kWh	kilowatt hour
l	litre
lpcd	litre per capita per day
m	metre
m/ha	metre per hectare
m/s	metre per second
m^2	square metre
m^3	cubic metre
m^3/d	cubic metre per day
m^3/h	cubic metre per hour
m^3/m	cubic metre per minute
$m^3/m^2/d$	cubic metre per square metre per day
m^3/s	cubic metre per second
m^3/y	cubic metre per year
MAF	million acre feet
MCM	million cubic metre
mg	million gallon
mg/l	milligram per litre
mgd	million gallon per day
ml	millilitre
mm	millimetre
Mm^3	million cubic metre

MMBTU	million British thermal unit
mph	miles per hour
MPN	most probable number
MW	megawatt
N/cm^2	newton per square centimetre
NTU	nephelometric turbidity unit
pm	time between 12 noon and 12 midnight
ppm	parts per million
Rs	Pakistan Rupee
TCU	true colour unit
US$	United States Dollar
wbt/d	wet basis ton per day
yd^2	square yard
μg/l	microgram per litre
μS/cm	micro-Siemens per centimetre

Unit Conversion

1 ft = 12 in = 0.304800 m
1 in = 0.025400 m = 0.083333 ft
1 m = 3.280840 ft = 39.370079 in

1 yd^2 = 0.000084 ha = 0.836127 m^2
1 ha = 10000 m^2 = 11959.900463 yd^2
1 m^2 = 1.195990 yd^2 = 0.000100 ha

1 AF = 0.271330 mg (imperial) = 1233.489000 m^3
1 mg (imperial) = 4546 m^3 = 4 AF
1 m^3 = 0.000811 AF = 0.000220mg (imperial)

1 cusecs = 0.5382 mgd (imperial) = 2447 m^3/d
1 mgd (imperial) = 4546 m^3/d = 1.858 cusec
1 m^3/d = 0.000409 cusec = 0.00022 mgd (imperial)

1 lpcd = 0.219969 gpcd (imperial)
1 gpcd (imperial) = 4.546090 lpcd

SUMMARY

S1 BACKGROUND OF THE STUDY

S1.1 FORMULATION OF JICA STUDY

Karachi is the capital of the province of Sindh and the largest city in Pakistan with a total present population of approximately 16 million. It is playing pivotal roles in the nation's economic and industrial activities. However, due mainly to the significantly large population growth rates (4 to 5% per annum) the city has experienced over the last three decades, the augmentation of the water supply system including water source, bulk conveyance system and distribution network has consistently lagged behind the fast growing water demand of the city. The consequence is the rationing of supply currently experienced in most areas of the city in that water is supplied only once in every two or three days and for the duration of two to three hours at a time. People are obliged to spend money on ground-level tanks, booster pumps, roof-top storage tanks and water filters and even then all water must be boiled prior to drinking. Many households are compelled to use secondary sources of water such as shallow wells or tanker supplies (costing in excess of US$ 1.50/m^3) just to meet their basic needs.

The existing sewerage system of which service coverage is said to be 30% at present has also a number of problems. They include low sewage flows received at existing sewage treatment plants resulting from the inadequate provisions of sewer trunk mains and the malfunctioning of pumping facilities, deterioration of water quality in rivers and canals, and clogging of waterways caused by damping of massive rubbish.

In Karachi, a master plan for the water supply system was prepared in 1985 and that for the wastewater management system in 1988. In the past, however, only a few projects were actually implemented based on the recommendations of these master plans mainly because of the financial constraints. After the elapse of almost two decades since preparation of these master plans, situations surrounding the city have changed so significantly that the development plans proposed by these master plans have largely become obsolete or greatly deviated from the actual needs of the city. This eventually lead to the formulation of a broad consensus in Pakistan that these master plans should be reviewed and revised for the future development of water supply and sewerage systems as well as for the optimization of the water services management.

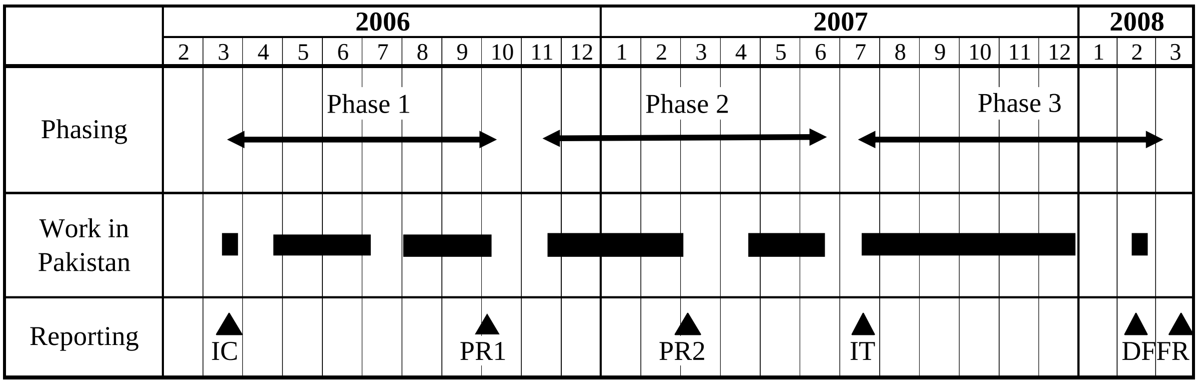
Against the background mentioned above, the Government of Pakistan officially requested the Government of Japan to conduct a master plan study to formulate a phased development plan of water supply and sewerage system for Karachi up to the year 2025.

In response to the request of the Government of Pakistan, the Government of Japan through the Japan International Cooperation Agency (hereinafter referred to as 'JICA') dispatched a preparatory study team to Pakistan in July 2005 and the "Scope of Work for the Study on Water Supply and Sewerage System in Karachi in the Islamic Republic of Pakistan (hereinafter referred to as the 'S/W')" was agreed upon on 13 July 2005 between JICA on one part and the City District Government Karachi (hereinafter referred to as "CDGK") and the Karachi Water and Sewerage Board (hereinafter referred to as 'KW&SB') on the other part.

S1.2 IMPLEMENTATION SCHEDULE OF JICA STUDY

It was originally agreed that the Study would be implemented in the following three phases over a total period of approximately two years as shown in **Figure S12.1.1**.

Phase 1: Basic Study (March 2006 to October 2006)
Phase 2: Master Plan (November 2006 to June 2007)
Phase 3: Feasibility Study (July 2007 through March 2008)



IC : Inception Report
PR1 : Progress Report No.1
PR2 : Progress Report No.2
IT : Interim Report
DF : Draft Final Report
FR : Final Report

Figure S12.1.1 Original Implementation Schedule of JICA Study

However, due to the additional work required during the Phase 3 for the finalization of the water supply and sewerage master plan, the Study period was extended for approximately 3 months until June 2008. The inclusion of this additional work and the extension of the Study period were agreed at the Steering Committee meeting held on August 8, 2007, which discussed the Interim Report of the Study. **Figure S12.1.2** shows the implementation schedule, according to which the JICA Study was actually carried out.

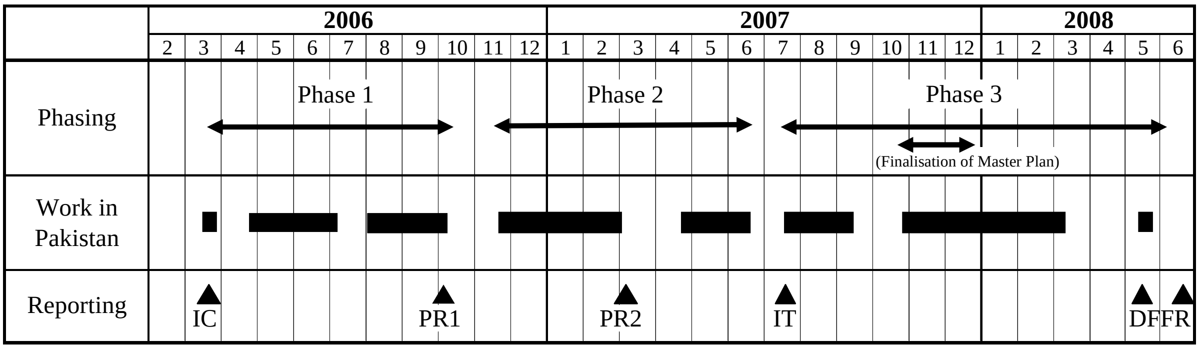


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Figure S12.1.2 Actual Implementation Schedule of JICA Study

S2 OBJECTIVES OF THE STUDY AND STUDY AREA

S2.1 OBJECTIVES OF THE STUDY

It was agreed in the S/W dated 13 July 2005 that the "Study on Water Supply and Sewerage System in Karachi in the Islamic Republic of Pakistan (hereinafter referred to as the 'Study')" would be conducted by a team of consultants appointed by JICA (hereinafter referred to as the 'JICA Study team') with the main objectives of (a) formulating a master plan for development of the water supply and sewerage systems in Karachi up to the target year of 2025, (b) conducting a feasibility study on the priority projects selected in the master plan, and (c) pursuing technical transfer to Pakistani counterpart personnel in the course of the Study. KW&SB, the organization currently responsible for the provision of water and sewerage services in Karachi, was the counterpart agency to the JICA Study team. KW&SB also acted as a coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

S2.2 STUDY AREA

The Study area covers the entire administrative area of the City District Government Karachi (CDGK) plus other areas administered by various agencies such as the Government of Pakistan, Government of Sindh, 6 Cantonment Boards, Defence Housing Authority, Port Qasim Authority, Karachi Port Trust, Pakistan Railways, Sindh Industrial Trade Estate, Lyari Development Authority, Malir Development Authority and Cooperative Housing Societies. In addition, it also covers areas outside the CDGK's administrative boundaries where water sources and bulk water transmission facilities currently exist or planned for future development.

The CDGK's administrative area occupies an area of 2,787 km^2. It is administratively divided into 18 Towns which are further sub-divided into 178 Union Councils (UCs). **Table S22.1.1** provides the names and areas of the 18 Towns and the number of UCs included in each Town.

Table S22.1.1 18 Towns and 178 Union Councils

Sr No	Town	Area			No. of Union Councils[2]
		Acres[1]	km^2	%	
1	Keamari	106,217	429.84	15.4%	8
2	SITE	6,286	25.44	0.9%	9
3	Baldia	7,217	29.21	1.0%	8
4	Orangi	5,803	23.48	0.8%	13
5	Lyari	1,977	8.00	0.3%	11
6	Saddar	5,967	24.15	0.9%	11
7	Jamshed	5,790	23.43	0.8%	13
8	Gulshan-E-Iqbal	13,260	53.66	1.9%	13
9	Shahfaisal	2,901	11.74	0.4%	7
10	Landhi	9,670	39.13	1.4%	12
11	Korangi	10,247	41.47	1.5%	9
12	North Nazimabad	4,127	16.70	0.6%	10
13	North Karachi	5,058	20.47	0.7%	13
14	Gulberg	3,417	13.83	0.5%	8
15	Liaqatabad	2,685	10.87	0.4%	11
16	Malir	4,395	17.78	0.6%	7
17	Bin Qasim	137,961	558.31	20.0%	7
18	Gadap	355,798	1,439.86	51.7%	8
Total		688,776	2,787.37	100.0%	178

Source: 1) KSDP-2020, Page 43; 2) JICA Fact Finding & Recommendation Study on Water Supply and Sewerage System in Karachi - Final Report March 2005, Table 2.1, Page 2-2

S3 EXISTING WATER SUPPLY AND SEWERAGE SYSTEMS

S3.1 WATER SOURCES

S3.1.1 Existing Water Sources

(1) Indus River

The Indus River, the main source of water for Karachi, is severely constrained by dry season demand, but has abundant wet season discharges. Except during the summer flood season, very little water escapes to the sea. The quota for urban supplies in Karachi from the River Indus was first sanctioned on May 11, 1957, which allowed Karachi to take 450 cusecs (242 mgd or 1,100,000 m^3/d) from 16 October to 15 April (rabi) and 520 cusecs (280 mgd or 1,270,000 m^3/d) from 16 April to 15 October (kharif) from the tail of the system at Kotri, through storage in Kinjhar Lake. Later, a presidential decree in 1988 increased this quota to 1,200 cusecs (645 mgd or 2,940,000 m^3/d).

In March 1991, representatives of the four provinces held a series of meetings in Lahore and Karachi and agreed on the apportionment of the waters of the Indus River System as shown in **Table S31.1.1**.

Table S31.1.1 1991 Water Apportionment Accord

Province	Kharif		Rabi		Total	
	MAF	MCM	MAF	MCM	MAF	MCM
Punjab	37.07	45,725	18.87	23,276	55.94	69,001
Sindh*	33.94	41,865	14.82	18,280	48.76	60,145
N.W.F.P (a)	3.48	4,293	2.30	2,837	5.78	7,130
(b) Civil Canals**	1.80	2,220	1.20	1,480	3.00	3,700
Balochistan	2.85	3,515	1.02	1,258	3.87	4,773
Total	77.34	95,398	37.01	45,651	114.35	141,049
	1.80	2,220	1.20	1,480	3.00	3,700

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi
** Ungauged Civil Canals above the rim stations
MAF: Million Acre Feet. MCM: Million Cubic Metre

Source: Water Apportionment Accord, 1991

Water from the Indus River is distributed over the Sindh Province through three barrage systems, namely, Guddu, Sukkur and Kotri. **Table S31.1.2** presents the allocation of the provincial quota to each of these three barrage systems. Urban and industrial water for Karachi is taken from the Kotri Barrage and discharged through the Kalri Baghar Feeder Upper (KB Feeder Upper) to Kinjhar Lake. Kotri Barrage is the lowest barrage on the River Indus.

Table S31.1.2 Allocation of Provincial Quota in Sindh State

Month	Period	Barrage System (1,000 cusec)			
		Guddu	Sukkur	Kotri	Total
April	1	0.00	34.00	6.20	40.20
	2	0.20	34.30	6.80	41.30
	3	1.40	31.60	6.90	39.90
May	1	3.70	35.10	12.30	51.10
	2	6.50	39.50	15.70	61.70
	3	12.60	43.10	21.70	77.40
Jun	1	22.70	49.10	26.90	98.70
	2	31.10	56.00	32.60	119.70
	3	35.20	60.60	33.80	129.60
Jul	1	41.10	61.20	34.20	136.50
	2	36.20	57.10	29.80	123.10
	3	30.10	54.30	31.00	115.40
Aug	1	28.50	54.00	27.60	110.10
	2	27.80	54.40	28.40	110.60
	3	28.70	54.60	23.80	107.10
Sep	1	26.50	55.10	27.60	109.20
	2	26.80	57.50	25.10	109.40
	3	25.80	55.80	23.30	104.90
Oct	1	17.60	43.60	18.00	79.20
	2	10.20	37.80	14.50	62.50
	3	6.30	33.00	11.30	50.60
Nov	1	4.10	31.40	9.60	45.10
	2	3.50	31.40	7.50	42.40
	3	3.20	31.10	5.70	40.00
Dec	1	2.60	31.40	5.00	39.00
	2	1.99	31.80	4.70	38.49
	3	1.99	26.30	4.50	32.79
Jan	1	5.40	12.30	3.10	20.80
	2	10.40	5.40	8.60	24.40
	3	5.50	20.30	11.70	37.50
Feb	1	1.30	31.90	8.80	42.00
	2	1.70	31.10	4.90	37.70
	3	2.30	30.00	5.20	37.50
Mar	1	2.70	29.70	4.40	36.80
	2	3.40	29.40	4.20	37.00
	3	2.00	28.50	4.70	35.20

Source: Water Apportionment Accord, 1991, Annexure - II

Kinjhar Lake is a natural reservoir, the storage of which has been increased by constructing nearly 20 km of embankments having a maximum height of 9 m. The lake has a catchment area of 910 km^2. The lake has a surface area of about 30,000 acres (12,000 ha or 120 km^2) and a useable storage capacity of 390,000 acft (481,000,000 m^3). Water leaves the lake through the KG (Kinjhar - Gujjo) Canal which supplies settled water directly to the intake at Gujjo.

The Indus River System Authority (IRSA) is being responsible for the implementation of the 1991 Water Apportionment Accord while Kotri Barrage, KB Feeder and Kinjhar Lake are being maintained by the Irrigation Department of the Government of Sindh. The existing quota for the KW&SB from the River Indus is 1,200 cusec (645 mgd or 2,940,000 m^3/d) and it has already been exhausted by the completion of the K-III Project in May 2006.

The existing quota for the KW&SB from the River Indus (1,200 cusecs or 645 mgd or 2,940,000 m^3/d) has already been exhausted by the completion of the K-III Project in May 2006.

At present, the KW&SB is supplying approximately 580 mgd (2,640,000 m^3/d) of Indus water to Karachi through various schemes shown in **Table S31.1.3**.

Table S31.1.3　Present Supply from Indus River

Raw Water Bulk Supply	Pakistan Steel Mill (PSM)	26 mgd
	Port Qasim Authority (PQA)	7 mgd
Gharo		28 mgd
GKBWS		480 mgd
Army Pump House		40 mgd
Total		581 mgd

Source: KW&SB

At present, KW&SB is supplying approximately 580 mgd (2,640,000 m^3/d) of Indus water to Karachi through various schemes.

(2) Hub Dam

The Hub Dam is a multi-purpose dam (municipal, industrial and irrigation purposes) constructed on the Hub River approximately 50 km to the north-west of Karachi City. The construction of the dam started in September 1963 and completed after 18 years in September 1981. The catchment area of the dam extends across two provinces namely Sindh and Balochistan covering a total area of 3,410 sq miles (8,730 km^2). There has been an agreement between the two provinces that, at the Regulator located at the end of the Hub Main Canal, 63.3% of the total flow from the dam will be diverted to the Karachi Water Supply Canal (Sindh) while 36.7% to the Lasbela Canal (Balochistan).

Completed in 1981, the dam was first filled up in 1984. It was again filled up in 1989, 1992, 1994, 1995 and 2003. The last time the dam was filled up was August 2007. During the 8 years from 1995 to 2003, the dam was never filled up. As a result, the supply from the dam reduced to almost zero during the four years from July 1999 till June 2003. The dam has a design capacity of 717,000 acft (884, 000, 000 m^3) with the following operational properties.

Maximum Water Level　: 339 ft (103.3 m)above the mean sea level
Lowest Water Level　: 276 ft (84.1 m) above the mean sea level
Effective Water Depth　: 63 ft (19.2 m)

In 1985, a yield analysis of the Hub River was conducted based on the 18 years discharge data collected at the Bund Murad Khan gauging station. The analysis indicated that at the 95% level of reliability the corresponding yield from the dam was 124,000,000 m^3 /yr (340,000 m^3/d or 75 mgd).

The yield analysis of the Hub River conducted in 1985 indicated that at the 95% level of reliability the corresponding yield from the dam was 75 mgd (340,000 m^3/d).

(3) Dumlottee Well Field

In the later half of the 19th century, water for Karachi was supplied from the Dumlottee Well Field, located on the banks of Malir River in the Dumlottee area about 30 km to the northeast of the city. A number of large diametre shallow wells constructed in the Malir river alluvium provided about 8 mgd (36,340 m^3/d) of water to Karachi through a gravity conduit. For many years since then, the well field remained as the main source of supply for Karachi.

The capacity of the system was increased to 20 mgd (90,800 m^3/d) in 1923 by adding some more wells, a 15 mgd gravity conduit and two 6 mgd reservoirs. However, the supply from this system has gradually decreased over time to 4 mgd by 1985, and to 1.5 mgd in 2002 and afterwards. At present, this system can produce merely 1.4 mgd (6,300 m^3/d) of water during only a few months after the rainy season. The system is almost dry in the rest of the year. Excessive quarrying of sand from the river bed of Malir River combined with the extensive use of groundwater by farmers in the area is considered to be the main reason for the depletion of the well yield. The overall picture of the Dumlottee Well Field is that it is no longer a reliable source of supply for Karachi.

The overall picture of the Dumlottee Well Field is that it is no longer a reliable source of supply for Karachi.

S3.1.2 Future Development of Water Sources

It was agreed in the Minutes of Meeting on S/W of JICA Study signed on 13 July 2005 that the JICA Study would not embrace any new studies on the development of water sources in its scope of work, but it would examine existing relevant data and reports to explore the possibility of alternative resources including storage, desalination, reuse of wastewater and other options.

(1) Surface Water

The 1985 water supply master plan study conducted by Sir M. MacDonald and Partners (principal consultant) and Associated Consulting Engineers (local associated consultant) made a review of all potential water sources in the Karachi region, which included the Indus River and other surface water and groundwater sources, seawater desalination, and the indirect reuse of treated sewage effluents for the recharge of aquifers and substitution of existing non-potable uses. As a result, the study indicated that the Indus River and desalination are the only two sources that could technically meet a large water demand in Karachi. The study also indicated that the cost of desalination for the foreseeable future was prohibitive and that desalination should therefore be considered as a last resort. The study then concluded that the Indus River was the only viable water source for Karachi.

The 1985 water supply master plan study concluded that the Indus River was the only viable water source for Karachi.

In 2002, in response to the Central Development Working Party (CDWP), GOS established an ad-hoc committee comprising of representatives from the Planning and Development Department of GOS, Irrigation and Power Department of GOS, and Karachi Water & Sewerage Board (KW&SB). The committee prepared a report on long term water supply plan for Karachi up to the year 2025 and submitted the report to the CDWP on November 14, 2002. In summary, the report provided the following major findings and recommendations.

(Findings)

- Existing allocation of 1,200 cusecs from Indus would be fully utilized in 2005 with completion of the 100 mgd K-III project. The population of Karachi was ever growing and additional requirement up to year 2025 was estimated to be another 1,200 cusecs thus the total requirement would be 2,400 cusecs.
- The present scheme of assured water supply for Karachi should be treated as Phase-I to cater short-term Assured Water Supply for Karachi City up to year 2005. The Phase-II of this scheme would be required for long-term requirement of water supply to Karachi to cater requirements beyond 2005 and up to 2025.

(Recommendations)

- For growing water demand of Karachi the allocation for Karachi up to Vision 2025 may be increased by another 1,200 cusecs raising the total allocation to 2,400 cusecs by the Government under a national cause without affecting supply of water quota of the Thatta District for agriculture purposes. Once additional allocation was allowed then a 2-stage study programme for expansion of system would have to be initiated.
- Stage-I: Study by the Irrigation and Power Department of GOS for increasing capacity in the system from the KB Feeder Upper up to the Kinjhar Lake without affecting the stability of the Kotri Barrage.

- Stage-II: Feasibility study by KW&SB in consultation with the Irrigation and Power Department of GOS from the Kinjhar Lake to Karachi determining the most economically viable, technically feasible and secure route.

In November 2002, an ad-hoc committee constituted by the Government of Sindh prepared a report on long term water supply plan for Karachi up to the year 2025. The committee concluded in the report that Karachi would need additional quota of 1,200 cusecs (total 2,400 cusecs) from the Indus River to meet the city's future water requirement up to the year 2025.

Based on the recommendations of the above committee, the KW&SB initiated a feasibility study titled 'Feasibility Study for Future Alternative Route of Bulk Water Supply and Long Term Expansion of Karachi Water Supply System from Kinjhar Lake – K-IV Project of Karachi Water and Sewerage Board' in December 2005, and issued "Executive Summary" in May 2007 (see **S4.2** in detail).

Past operation records of the Hub dam indicate that the dam is not an entirely dependable water source. Many now observe that the dam could serve as a standby reservoir for the best. There is no real prospect of expanding this surface water source in the future.

There is no real prospect of expanding the Hub water source in the future.

Meanwhile, no studies examining the exploitability of local surface water sources have been conducted to date. Potential local surface sources would include the Thadoo, Mole and Khadeji Nallahs, and the reactivation of the Haleji Lake. Although the exploitability of these sources as a reliable source of water supply for Karachi appears to be very low, it would be worth conducting studies to examine the potentiality of these sources if accurate flow records covering at least 25 years in the past are available.

(2) Groundwater

The 1985 water supply master plan study made a review of all potential water resources in the Karachi region including groundwater. This review concluded that other groundwater sources in the region were of relatively small magnitude with the total potential yield of all the groundwater sources within 100 km of Karachi being as insignificant as 4 mgd (18,000 m^3/d).

In 2004, KW&SB conducted a study to explore the possibility of developing groundwater sources in the region as a source of water supply for Karachi. The study was titled "Feasibility Study to Explore Groundwater Source in Karachi District" and explored the availability of groundwater from the basins of Malir, Gadap, Lyari and Hub to supplement the existing supplies. The scope of the study included a) reconnaissance survey, b) 160 probes of resistivity survey, c) drilling of 30 investigation boreholes, and d) construction of 5 tube wells and 10 piezometres.

After extensive surveys and analyses, this study concluded that since there was a little precipitation and a little groundwater recharge in Karachi, the sustainable yield of groundwater was already in balance with the existing pump discharge from about 1,000 existing wells and it was difficult to develop new wells. The conclusion of this study is quite similar to that of the 1985 water supply master plan.

Based on the foregoing, it is concluded in this JICA Study that the capacity of groundwater resources in Karachi is small that it can barely meet the present level of withdrawal. Under the circumstances, there is no realistic prospect of developing new groundwater resources which can be used to cater for the future water requirement of Karachi. It is rather recommended that more stringent controls should be put in place on the construction of new wells in order to maintain the current groundwater balance in the region.

It is concluded in this JICA Study that there is no realistic prospect of developing new groundwater resources which can be used to cater for the future water requirement of Karachi.

(3) Desalination

The 1985 water supply master plan study assessed the possibility of seawater desalination as a means of meeting future water supply requirements. As a result, the study concluded that:

- The cost of desalination for the foreseeable future was prohibitive and only if technological advances were made to considerably reduce the costs of energy then desalination could become an attractive option for Karachi.
- Given the very high capital and operating costs, desalination should be considered as a last resort.
- Since it was essential to use clean, unpolluted seawater the distiller would have to be located on the coast some distance from the city centre.
- Development of desalination plants to serve smaller, isolated consumers might be attractive, particularly where revenue from sales could cover costs; such consumers would include the Karachi Port Trust (KPT), Port Qasim Authority (PQA) and Pakistan Steel Mill (PSM).

The 1985 water supply master plan study concluded that the cost of desalination for the foreseeable future was prohibitive.

During the last two decades, there has been no remarkable technical breakthrough which could substantially reduce the capital and recurrent costs of seawater desalination. As such, the conclusion of the 1985 water supply master plan study is still effective at present. During the past five years, however, several agencies and authorities in the coastal region have tried to install seawater desalination plants to cope with water shortages in their areas of jurisdiction using the Private Sector Participation (PSP) modalities. However, due to the high price of desalinated water indicated by the private sector, contract negotiations on almost all of these schemes were either cancelled or suspended indefinitely. The only exception is the 3 mgd (13,500 m^3/d) MSF distillation plant currently under construction in the DHA Phase-VIII area under a BOT contract. The plant, upon its scheduled completion in April 2008, is expected to generate 94 MW of electricity with the use of natural gas while also producing 3 mgd of desalinated water at the same time. It has been agreed that the BOT contractor will operate the plant for a concession period of 20 years before handing it over to DHA, and that, during the concession period, the contractor will sell 80 MW of electricity to the Karachi Electricity Supply Corporation (KESC) and 3 mgd of desalinated water to the Clifton Cantonment Board (CCB) at the immediate exit of the plant. The price of water was set to be Rs 95/1,000 gallons at the base year which would be subjected to an automatic annual increase of 5% every year onward.

Based on the foregoing, it is concluded in this JICA Study that seawater desalination will not be able to provide a viable solution for a mega city like Karachi in the foreseeable future unless there is a significant technical breakthrough substantially reducing the cost of desalinated water. Nonetheless, it would continue to remain as an option for a limited number of organizations and industries located in the coastal region which can afford to pay the high cost of desalinated water in order to alleviate water shortages persisting in their areas of jurisdiction.

During the last two decades, there has been no remarkable technical breakthrough which could substantially reduce the capital and recurrent costs of seawater desalination. As such, the conclusion of the 1985 water supply master plan study is still effective at present, and it will continue to remain effective in the foreseeable future.

(4) Reuse of Treated Effluents/Raw Sewage

Reuse of treated effluent is practiced in TP-3 and Pakistan Steel Mill sewage treatment plant. In TP-3, 4,500 m^3/d of effluent is pumped to nearby Pakistan Air Force (PAF) premise to water the plants there. While no tariff is charged for treated effluent, necessary costs are borne by PAF.

Pakistan Steel Mill treats the domestic sewage generated in its company housing and a part of industrial wastewaters and to sell the treated effluent to a nearby golf course and orchard where treated effluent is sprayed to trees and grasses.

Apart from treated effluent reuse, CDGK's Works and Services Department withdraws the raw sewage and sprays it to grasses and trees at road dividers. The necessary cost for watering is borne by the Department.

Other raw sewage applications are found in some areas. One is a golf club that has its own arrangement to take the sewage from a trunk sewer. The other is housing development area where generated sewage is partly used to water trees and grasses there.

There are several applications of raw sewage as well as treated effluent to trees and grasses. Raw sewage application on trees and grasses is not recommended from hygienic viewpoints, since it possibly is contaminated by pathogenic bacteria from its nature.

A study titled "Effluent Water Reuse for Karachi" is planned under Technical Assistance (TA) loan of Asian Development Bank. This TA loan amounts to US$ 10 million and is planned to be disbursed in four years from early 2007. The outcome of the Study is expected to include the cost comparison of treated effluent reuse with other sources and the establishment of reuse plan.

Treated effluent can be used for various purposes such as watering plants/grasses in parks and similar facilities, irrigation, agriculture, industrial use and groundwater recharge.

In any case, a large scale reuse of treated effluent requires careful investigation whether the reuse is viable or not from technical, hygienic, financial and economic viewpoints, especially if additional and/or advanced level treatment is needed. Trial application of treated effluent is recommended prior to its full application.

S3.2 WATER SUPPLY AND SEWERAGE SYSTEMS

S3.2.1 Water Supply System

The water supply system of the KW&SB as of the end of year 2006 supplies bulk water of about 630 mgd to the citizen of Karachi City from the Indus River, Hub Dam and Dumlottee Wells as shown in **Figure S32.1.1** through the Grater Karachi Bulk Water Supply System (see **Figure S32.1.2**), Karachi Water Supply Canal and Dumlottee Conduit respectively.

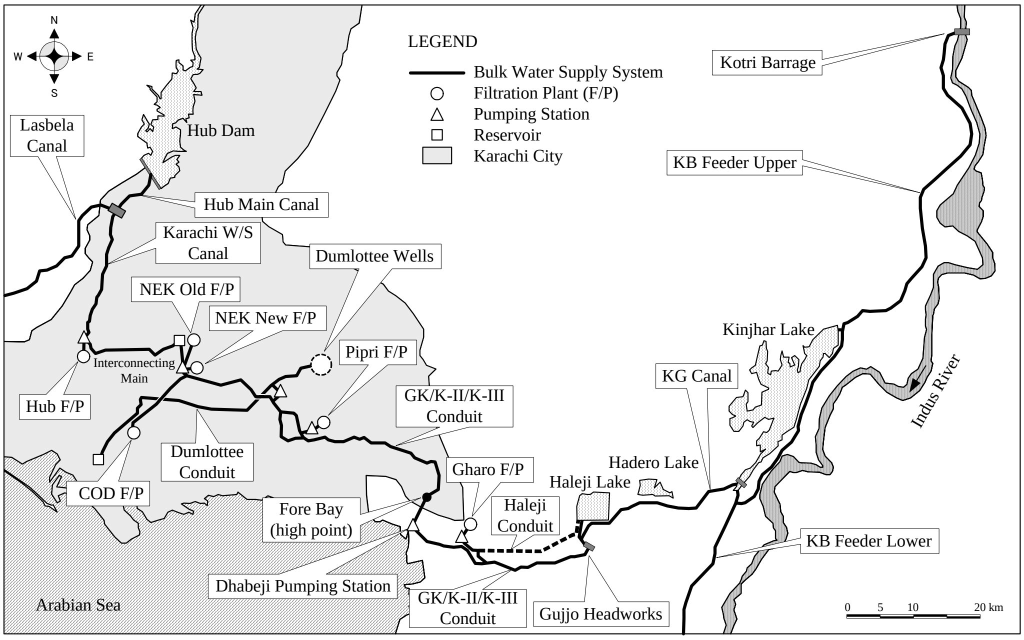


Figure S32.1.1 Existing Bulk Water Supply System

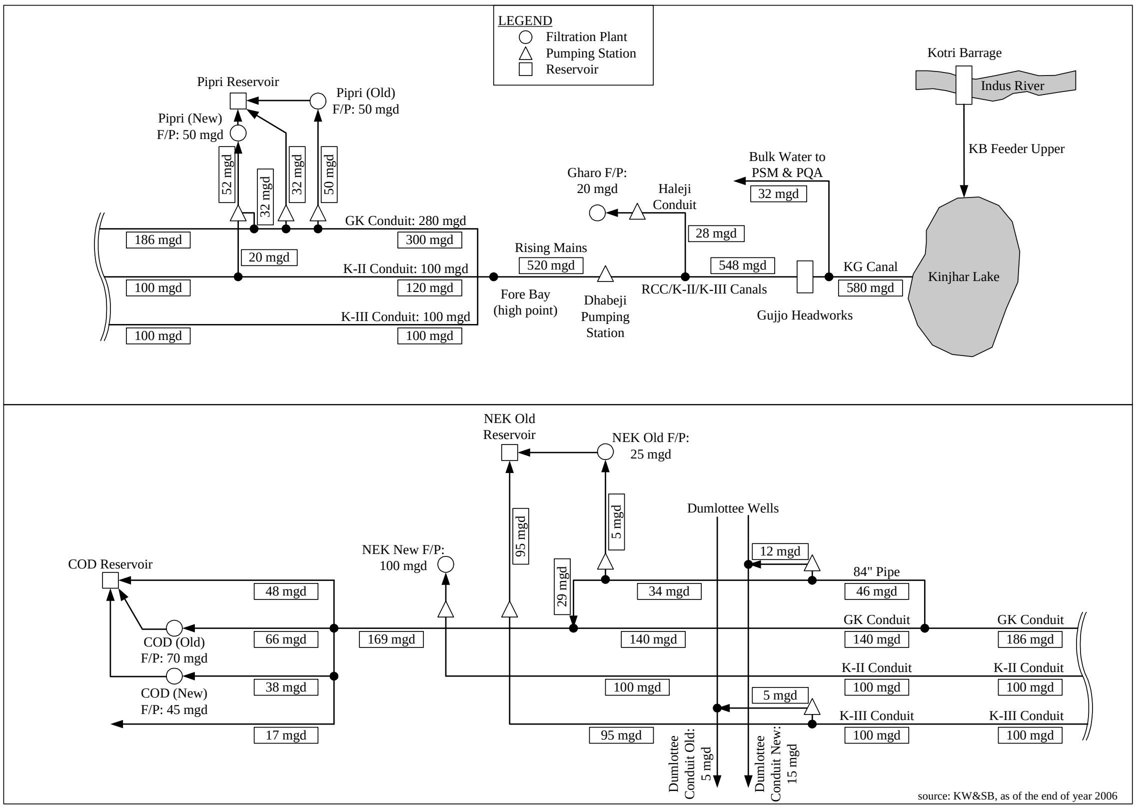


Figure S32.1.2 Existing Greater Karachi Bulk Water Supply System

Out of 630 mgd, water of 209 mgd is supplied without filtration as shown in **Table S32.1.1**, which is equivalent to one third of actual supply amount of 630 mgd.

Table S32.1.1 Present Water Supply Capacity

Supplied from		Rated Capacity	Actual Supply
Gharo Filtration Plant		20 mgd	30 mgd
Pipri Filtration Plant	with Filtration	100 mgd	102 mgd
	without Filtration	-	32 mgd
Dumlottee Conduit	from Wells	20 mgd	0 mgd
(without Filtration)	from GK/K-III Systems	-	17 mgd
NEK Old Filtration Plant		25 mgd	5 mgd
NEK New Filtration Plant		100 mgd	100 mgd
COD Filtration Plant	with Filtration	115 mgd	104 mgd
	without Filtration	-	48 mgd
Hub Filtration Plant		80 mgd	80 mgd
Supply without Filtration (from K-III System)		100 mgd	95 mgd
Supply without Filtration (from GK System)		-	17 mgd
Total		560 mgd	630 mgd

source: KW&SB

From filtration plants and reservoirs, water supplies through the water trunk mains and distribution pipelines. Major routes of the existing water trunk mains are shown in **Figure S32.1.3**.

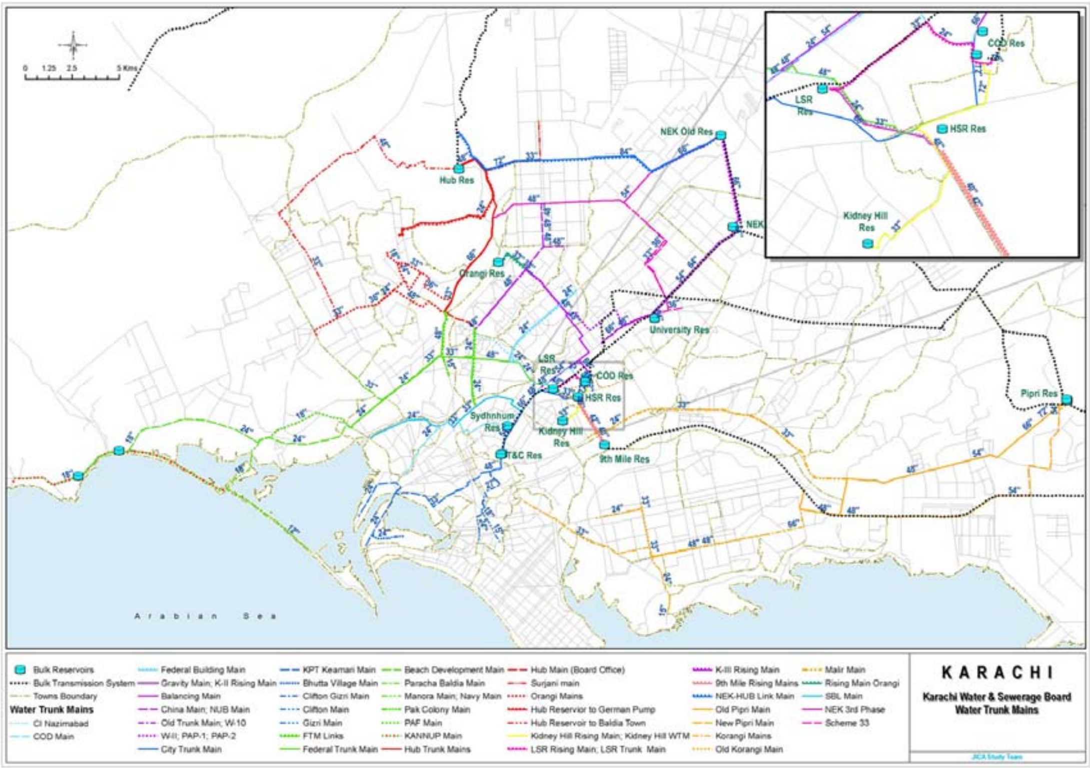


Figure S32.1.3 Existing Water Trunk Mains

The water trunk mains consist of approximately 400 km pipelines with diametres ranging from 12 in to 84 in as listed in **Table S32.1.2**. Main material of the water trunk mains is pre-stressed cement concrete (PRCC), which is about 80 % of the total length. A total length of the existing distribution pipelines is about 4,850km as of the year 2001 as listed in **Table S32.1.3**. About 70 % of the existing distribution pipelines are asbestos cements (AC) pipes. For even new pipe installation works, AC pipes had been used. Present City Nazim has, however, urged a plan of replacement of small size of the existing distribution pipelines which are mainly AC pipes with PE pipes by the “Tameer-e-Karachi Programme (TKP)” for improving and securing the water supply conditions.

Table S32.1.2 Water Trunk Mains

Diametre in	Diametre mm	Length (m)
12	300	5,720
15	375	4,266
18	450	36,106
24	600	72,268
32	800	27
33	825	77,235
36	900	15,311
40	1,000	2,644
42	1,050	2,631
48	1,200	88,113
54	1,350	39,667
64	1,600	6,112
66	1,650	30,960
72	1,800	13,693
84	2,100	10,409
Total		405,163

Source: KW&SB

Table S32.1.3 Distribution Pipelines

Diametre in	Diametre mm	Length (km)
3	75	1,636.2
4	100	1,531.9
5	125	60.0
6	150	609.0
8	200	199.0
9	225	34.6
10	250	130.6
12	300	317.0
15	375	107.1
16	400	20.1
18	450	96.8
21	525	1.0
24	600	58.1
27	675	5.2
30	750	2.5
33	825	25.2
36	900	6.3
48	1,200	8.9
54	1,350	3.0
60	1,500	2.0
Total		4,854.4

Source: KW&SB

A total of 139 distribution pumping stations are being operated and managed by the KW&SB due to a lack of water pressure caused by insufficient diametres of water trunk mains and no appropriate hydraulic calculation for the system. In addition some of the consumers install individual small suction pumps and suck water from distribution pipes forcibly. This is the one of reasons of serious water supply situation which makes low water pressure and water shortage, and also problems of water quality aggravation such as sewerage contamination caused by negative pressure in the pipes. According to the result of water quality analysis carried out by this study, residual chlorine was found in the outlet of clear water reservoirs at filtration plants. But there were no residual chlorine in the distribution pipelines.

Table S32.1.4 shows a number of service connections in the last 6 years. At present there are about 1.2 million connections in the water supply system in Karachi. However, number of the connections in Cantonments and DHA area is not included in this table, since these areas are supplied by bulk water supply system.

Table S32.1.4 Number of Service Connection

Category	Number of Service Connection					
	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007
Domestic*	816,259	823,931	853,710	879,935	899,270	910,709
Non-Domestic	226,638	230,046	241,214	255,833	264,298	282,048
Bulk	4,113	4,152	4,268	4,440	5,040	5,149
Total	1,047,010	1,058,129	1,099,192	1,140,208	1,168,608	1,197,906
Aug. Ratio	-	101.1%	103.9%	103.7%	102.5%	102.5%
				Average of Aug. Rate		102.7%

* : excluding number of "Addition Stories"
Source: Revenue Data 2001 - 2007, KW&SB

There is no water meter on individual service connection. Consumers pay water tariff on the basis of plot size hence they pay no attention to any wastage. Awareness for the usage and storage of water is very less in many parts of Karachi. It is, therefore, considered that a consumption rate per capita per day including the wastage and leakage inside the houses is relatively large comparing with essential water.

Conditions of existing service pipes are shown in **Photo S32.1.1** and **Photo S32.1.2**. **Photo S32.1.3** shows a community pumping station which is installed for sucking water from the distribution main forcibly. **Photo S32.1.4** shows illegal connections for Katchi Abadies (Squatter Settlement) across the channel.

Photo S32.1.1
3/4" GIP Service Connection

Photo S32.1.2
4" PVC Plugging by Rubber Tube

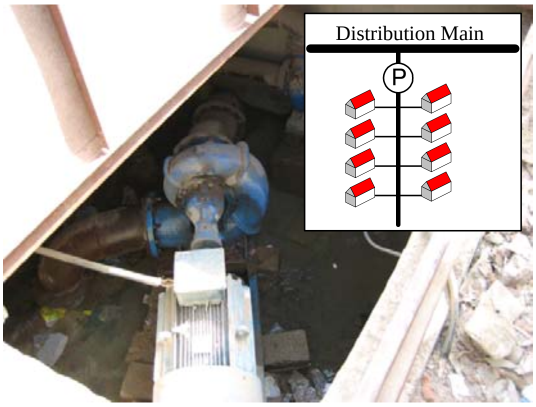


Photo S32.1.3
Suction Pump to suck Water forcibly

Photo S32.1.4
Piping for Illegal Connections across the Canal

The areas where are not in the service area by any water supply or low service quality of water supply are watered by Tank-Cars which belongs private sectors from 10 bases of Bowser Filling Stations in the city area. Total supply amount through this system in 2004 was estimated at 17 mgd, which was about 3 % of the total supply amount of 630 mgd. On the other hand, according to the KW&SB's report on Feasibility Study to explore Groundwater Source in Karachi District, 2004, average withdrawal of groundwater was estimated at about 30 mgd.

S3.2.2 Sewerage System

(1) Collection System

There are three sewer districts in Karachi City, namely TP-1, TP-2 and TP-3 districts. North Karachi and Orangi Towns both at the right bank side of Lyari River will be included in sewer district of TP-3 after construction of new sub main sewers connecting to Lyari Interceptor. Korangi and Landhi Towns at the left bank side of Malir River have been isolated from sewer district of TP-2 due to the destruction of the pressure main connected to TP-2. KW&SB has planned to implement a new sewage treatment plant for these towns at the left bank side of Malir River. **Table S32.2.1** outlines sewer districts in Karachi City.

Table 32.2.1 Sewer Districts

Sewer District	Area (ha)	Treatment	Remarks
TP-1 District	5,400	Partly	
TP-2 District	11,800	Partly	
TP-3 District	5,600	Partly	
Total	22,800		
(Korangi District)	8,900	No	Will be connected to proposed new TP
(Orangi District)	2,900	No	Will be connected to TP-3
(North Karachi District)	2,700	No	Will be connected to TP-3

Figure S32.2.1 shows geographical relation among these three sewer districts and the locations of three sewage treatment plants.
Trunk Sewers include three to TP-1, two to TP-2 and one box culvert to TP-3. Total length of branch sewers is 3,290 km. There are four large scale and 16 smaller scale pumping stations conveying the generated sewage directly or indirectly to one of three sewage treatment plants.

(2) Sewage Treatment Plants

Table S32.2.2 summarizes three existing sewage treatment plants (TPs).

Table S32.2.2 Summary of Three TPs

	TP-1 (SITE)	TP-2 (Mahmoodabad)	TP-3 (Mauripur)
Drainage Area	F.B. Area, Liaquatabad, Nazimabad & North Nazimabad, Part of Orangi Town, Pak Colony etc.	Old city areas, Clifton Societies, Mahmoodabad, part of Azam Basti, Dada Bhai, Sadder, Malir	Old Lyari, Garden East and West, Gulshan-e-Iqbal, PIB colony, Soldier Bazar, Baldia, Nazimabad, North Karachi
Site Area	120 acres (48.6 ha)	120 acres (48.6 ha)	545 acres (221 ha)
Year of Construction	1960/1995 (rehabilitated)	1960/1996 (rehabilitated)	1998
Incoming Trunk Sewers	Upper Lyari Main: 66" (2010mm) Upper Lyari 1: 54" (1650 mm)	Malir Trunk Sewer: 56" (1710 mm)	Lyari Interceptor (2 × 2500mm × 2000mm)
Treatment Process	Trickling filter process	Trickling filter process	Anaerobic + Facultative pond
Major Facilities	Influent pumps, PST, TF, FST Anaerobic digesters Sludge drying beds	Influent pumps, PST, TF, FST Anaerobic digesters, Sludge drying beds	Influent pumps, AP, FP Sludge drying beds
Planned Served Population	1,600,000	1,600,000	2,000,000
Present Served Population	NA	NA	NA
Capacity	51 mgd (232,000 m^3/d)	46 mgd (209,000 m^3/d)	54 mgd (245,000 m^3/d)
Present Flow Rate	25 mgd (114,000 m^3/d)	24 mgd (110,000 m^3/d)	30 – 35 mgd (136,000 – 159,000 m^3/d)
Design Influent Qualities	BOD 385 mg/l SS 555 mg/l	BOD 365 mg/l SS 530 mg/l	BOD 385 mg/l SS 450 – 500 mg/l
Present Influent Qualities	BOD 317 mg/l SS 319 mg/l	BOD 300 mg/l	BOD 370 mg/l SS 388 mg/l
Design Effluent Qualities	BOD 80 mg/l SS 200 mg/l	BOD 80 mg/l SS 200 mg/l	BOD 80 mg/l SS 200 mg/l
Present Effluent Qualities	BOD 80.8 mg/l SS 76.4 mg/l	BOD 100 mg/l	BOD 75 mg/l SS 69 mg/l

Source: KW&SB

As shown in the table, the actual flow to these three TPs is 79 to 84 mgd (360,000 to 380,000 m^3/d) which is around a half of their total capacity of 151 mgd (686,000 m^3/d). This is due to the absence of or damaged trunk sewers and malfunction of pumping stations.

Figure S32.2.1 Sewer Districts of Karachi City

(3) Design Criteria

There are no established design guidelines for sewerage planning in Pakistan. Instead, every consulting firm has its guidelines for several design parametres and uses them in preparing sewerage planning. These design parametres include water supply per capita per day, ratio of sewage generation to water consumption, peak flow factor, flow velocity formula, range of flow velocity and manhole interval.

S3.3 LAWS, POLICIES AND ADMINISTRATIVE FRAMEWORK

S3.3.1 Water Supply and Sewerage

(1) Legislative and Administrative Framework

According to the Constitution of Pakistan, water is a Provincial subject and the responsibility for water related issues rests with the Ministry of Water and Power (MWP). Within the Ministry, exists the 'Water Wing' (WAPDA) to discharge its water related responsibilities. For water related matters, the MWP coordinates efforts primarily between WAPDA, the Indus River System Authority (IRSA), the Federal Food Commission (FFC), as well as other Federal Ministries and Provincial Irrigation and Agriculture Departments amongst others.

The relevant legislation in force includes the WAPDA Act, 1958; the Environmental Protection Act (EPA), 1997 and the IRSA Act, 1992 amongst others; whilst at a more local level the Sindh Local Government Ordnance (SLGO), 2001 and the KW&SB Act, 1996 run in parallel. Whilst the SLGO, 2001 gives the City District Government of Karachi (CDGK) general powers for the provision of water and sanitation services, the KW&SB Act, 1996, provides a more detailed account of specific technical and administrative responsibilities and powers vested in KW&SB as an 'autonomous' body.

More recently the Government of Pakistan (GOP) have issued the 'National Environmental Policy, 2005'; the 'National Drinking Water Policy, 2006' and the draft 'National Sanitation Policy, 2006. In response to national policy, the GOS have issued the draft 'Sindh Water Supply Policy, 2006' and the draft 'Solid Waste & Sanitation Policy, 2006'.

Devolution of water and sanitation services (W&SS) from the Provincial Government of Sindh to the CDGK was enacted as a result of the SLGO, 2001. This was effected by setting up a 'Water & Sanitation Department' within the CDGK headed by an 'Executive District Officer' (EDO). 'EDO Water & Sanitation' is responsible to the CDGK and the people of Karachi via a system of Town Municipal Administration (TMA) and Union Councils (UC's). Due to the size of the city and considering the "essential services" nature of W&SS, it was decided to retain KW&SB as the 'executing agency' for W&SS. As such the KW&SB Act, 1996 was not revoked when the SLGO, 2001 came into force.

In accordance with SLGO, 2001; of which Sections 52 and 182 are particularly relevant, KW&SB are responsible for water and sanitation services for Karachi. KW&SB are also responsible for bulk supply of water to various agencies including 'Cantonments', such as the Defence Housing Authority (DHA), the Sindh Industrial Trading Estate (SITE), the Karachi Port Trust (KPT) and other major organisations/agencies. These organisations/agencies are responsible for onward distribution of water and collection/disposal of wastewater. There has been much discussion regarding KW&SB taking ownership of the water and sanitation infrastructure within these areas and for provision of services, however, due to poor asset condition, this is yet to be agreed.

Working alongside KW&SB is the 'Sindh Katchi Abadis Authority' (SKAA), various Non-Governmental Organisations (NGO's) and 'Citizen Community Boards' (CCB's) with the aim of improving W&SS and ensuring that all areas and communities throughout Karachi are represented. The idea of CCB's or 'beneficiary groups' taking an active role in the O&M of local schemes has been slow 'getting off the ground'.

Responsibility for compliance with 'drinking water standards', safe disposal of sewage and for compliance with environmental legislation/standards is placed on KW&SB, however, the fragmented nature and responsibility for W&SS provision as described above does not 'sit well' with this. KW&SB currently follow and are subject to compliance with the World Health Organisation (WHO), 1971 International Drinking Water Standards and the EPA Standards, however, due to lack of effective independent monitoring or 'policing', KW&SB are effectively 'self regulating'.

Whilst KW&SB constitute an autonomous body, in carrying out its duties, KW&SB interact with a number of CDGK departments having either advisory, political, administrative or sanctioning powers over their financial and operational activities. In this event, KW&SB have little 'autonomous freedom' and therefore, essentially continue to operate as an executing agency with a number of financial and operational constraints placed on them coupled with a high level of political interference in day to day operations. The Government of Sindh through Legal Notification No. SOVIII/KW&SB/72/2002 re-constituted the Board of the KW&SB. KW&SB is governed by a board of directors of which the Managing Director (MD) of KW&SB is a member and the City Nazim is the Chairman. Other board members include representation from industry as well as government bodies. It is understood that whilst formal board meeting are conducted infrequently, the MD consults on a regular basis with the Chairman of the board and other related CDGK and GOS departments regarding approval/processing of major development projects, approval of budgets, funding, financing, loan repayment, tariff adjustments, water quality/effluent standards compliance etc.

(2) Sector Policy Framework
National policies relevant to the water supply and wastewater services in Karachi include the National Water Policy, the National Drinking Water Policy, and the National Sanitation Policy. The vision that forms the foundation of Pakistan's National Water Policy (Draft) is summarised as:
"By 2025, Pakistan should have adequate water available, through proper conservation and development. Water supplies should be of good quality, equitably distributed and meet the needs of all users through an efficient management, institutional and legal system that would ensure sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resources, ability to pay and participation of all stakeholders."

The overall goals of the National Drinking Water Policy are:

- To ensure safe drinking water to the entire population at an affordable cost in an equitable, efficient, and sustainable manner, and
- To ensure reduction in the incidence of mortality and morbidity caused by water borne diseases.

The overall objectives of the National Drinking Water Policy are outlines as follows:

- To provide a supportive policy and legal framework that facilitates access of all citizens to safe drinking water on a sustainable basis;
- To provide guidelines that will allow consistency and conformity between the drinking water policy and the overall water sector policy, environmental policy, health policy and drinking water quality standards that will facilitate the provision of safe water to all;
- To define an institutional framework within which the sector institutions can more

effectively address the challenges they face in the provision of drinking water in all areas of the country;
- To provide a financial framework within which the provision of water supply can be undertaken in a cost-effective, equitable and sustainable manner;
- To identify and facilitate the implementation of as set of key strategies that will help in enhancing access to safe drinking water supply; and
- To provide a framework within which local communities, women and vulnerable groups can be facilitated to enhance their access to safe drinking water.

Pakistan's National Sanitation Policy acknowledges that only about 42 percent of the total population has access to sanitation facilities, and aims to create a framework for "providing adequate sanitation coverage for improving quality of life of the people of Pakistan and to provide the physical environment necessary for healthy life.

At the Provincial level, the Sindh Water Supply, Solid Waste & Sanitation Policies have been drafted based on the national policy. However, these are currently under review (as of November 2007) by a Technical Review Committee constituted by Government of Sindh (GOS) and are thus yet to come into force.

S3.3.2 Environment

(1) Policy and Legal Framework

Laws finding relevance with the modern definition of 'environment' were first enacted in Pakistan in the late 1950's and in the first half of the 60's. Further, the Environment Ministry was established in 1975, as a follow up of Stockholm Declaration of 1972. The most effective period for environmental legislation in the country runs from 1983 to 1997. The first Environmental Protection Ordinance was promulgated in 1983. With this enactment, a series of legislation making process was initiated that culminated in the enactment of the Pakistan Environmental Protection Act, 1997. The National Environmental Quality Standards (NEQS) became effective in 1997. More recently the Ministry of Environment have issued the 'National Environmental Policy, 2005'

a) The National Conservation Strategy (NCS)

The Pakistan NCS is a broad based policy statement aimed at achieving environmentally sustainable economic and social development in Pakistan. The three overriding objectives of the NCS are a) Conservation of Natural Resources b) Sustainable Development and c) Improved Efficiency in the use and management of resources. The NCS specifies the broad guidelines for an integrated effort aimed at protecting the environment and the natural resources of the country.

b) Pakistan Environmental Protection Ordinance 1983

The 'Ordinance' for the first time established the Pakistan Environmental Protection Council and the Federal and Provincial EPA's. It also pioneered in the Pakistan, the requirement of preparing Environmental Impact Assessment (EIA) reports.

c) Pakistan Environmental Protection Act (PEPA) 1997

The Pakistan Environmental Protection Act 1997 (PEPA 1997) is the most important environmental legislative instrument in Pakistan. The Act aims "To provide for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution and promotion of sustainable development".

The apex body established under the PEPA 1997 is the Pakistan Environmental Protection Council that is headed by the Prime Minister of Pakistan. The functions of the Council include enforcement of the PEPA 1997, to establish national environmental policies, ensure their implementation, approve National Environmental Quality Standards, give directions to conserve bio-diversity and renewable and non-renewable resources and consider the national environment report. The Environmental Protection Agencies (EPA's), both at the Federal and provincial levels exist under the Pakistan Environmental Protection Council.

d) National Environmental Action Plan (NEAP)
The NEAP was approved by the Pakistan Environmental Protection Council in February 2001. The development objective of the NEAP was to initiate actions and programmes for achieving a state of environment that safeguards public health, promotes sustainable livelihoods and enhances quality of life of the people of Pakistan. It focused on taking immediate measures to achieve a visible improvement in the rapidly deteriorating quality of air, water and land, through effective cooperation between the government agencies and civil society.

(2) Administrative Framework
The following details some of the important administrative arrangements that have been put in place under the provisions of the Pakistan Environmental Protection Act, 1997:

a) The Pakistan Environmental Protection Council
The apex body established under Section 3 of the Pakistan Environmental Protection Act, 1997 is the Pakistan Environmental Protection Council. It is chaired by the Prime Minister and comprises of all the four provincial Chief Ministers, federal and provincial ministers of environment and up-to thirty five (35) persons, with at least twenty (20) non officials, including representatives of the Chamber of Commerce and Industry, agriculture, medical and legal professions, trade unions, NGO's, scientists, technical experts and educationists. The functions and powers of the 'Council' include the following:

- Approval of the National Environmental Quality Standards (NEQS)
- Approval of comprehensive national environmental policies, within the framework of the NCS
- Provision of guidelines for the protection and conservation of species, habitats and bio-diversity in general and for the conservation of renewable and non-renewable resources; and
- Coordination of the integration of principles of sustainable development into national development plans and policies

b) Pakistan Environmental Protection Agency
The Pakistan Environmental Protection Agency exists under the Pakistan Environmental Protection Council. It is headed by a Director General (DG). The DG may establish such advisory committees as he may deem fit to assist him. Section 5 of the Pakistan Environmental Protection Act 1997, constitutes the Pakistan EPA (The Federal Agency), which is the regulatory institution entrusted with the functions of administering and enforcing the Act and its rules and regulations. These include:

- Preparation, revision, establishment and enforcement of the NEQS
- Establishment of systems for surveys, monitoring, inspection and audit
- Certification of environmental laboratories
- Rendering of advice and assistance in environmental matters
- Encouraging the formation and working of NGO's, community organizations and village organizations
- Taking all necessary measures for the protection, conservation, rehabilitation and improvement of the environment, prevention and control of pollution and promotion of sustainable development

c) Sindh Environmental Protection Agency (SEPA)
Section 8 of the Pakistan Environmental Protection Act, 1997 establishes the provincial EPA's of which one is the Sindh Environmental Protection Agency. The provincial EPA is to exercise powers delegated under Section 26. Many of the federal agency's functions and powers under the Pakistan Environmental Protection Act, 1997 have already been delegated to the Provincial EPA's. Section 8 gives statutory cover to the Provincial EPA's, which were hitherto functioning under administrative arrangements.

S3.4 KWSB'S ORGANISATION AND FINANCIAL MANAGEMENT

S3.4.1 Organisation
Over the years, the provision of water and sanitation services has been undertaken by a variety of agencies. The 'Karachi Joint Water Board' was constituted in 1953, who were responsible for the first major expansion of Karachi's water supply system; taking bulk water from the Indus River.

From 1957, the Karachi Development Authority (KDA) took responsibility for bulk water supply and the Karachi Metropolitan Corporation (KMC) became responsible for water distribution and sewerage within the city. At that time a number of other agencies took responsibility for managing their own 'systems', including the 'Cantonment Board' and other major government organisations such as the Armed Forces, the Karachi Ports Trust (KPT) etc. This is still the case today.

As there was no single agency to plan and execute water and projects at that time, in 1983, the Sindh Government introduced the 'Sindh Local Government (amended) Ordinance, 1983' to bring responsibility within one agency, the KMC at that time, who became responsible for provision of services, the raising of funds and taxes and for the expansion of 'systems'.

The 'Karachi Water and Sewerage Board Act, 1996' was enacted, which served to separate KW&SB from KMC and placed them under the GOS as an autonomous body.

'Devolution Plan', the 'SLGO, 2001' was introduced which placed KW&SB under the CDGK. CDGK established the 'Water and Sanitation' Department' headed by an Executive District Officer (EDO). As the KW&SB Act, 1996 was not revoked, the Water and Sanitation Department – CDGK and KW&SB are one and the same entity; whereby the Managing Director of KW&SB is the EDO Water & Sanitation – CDGK.

To comply with the spirit of the SLGO, 2001, KW&SB have reorganised their operations geographically in-line with TMA's and UC's who have a 'say' in how services are provided within their jurisdictions.

KW&SB's prime responsibility is the development and regulation of water supply and collection and disposal in the city of Karachi. Based on the forgoing, KW&SB need to work in close cooperation with other city agencies to ensure efficient services, including those agencies that manage their own 'systems'.

A Board chaired by the City Nazim (CDGK), is responsible to the GOS for the functioning of KW&SB, whilst the MD-KW&SB takes responsibility for overall day-to-day operations.

The current high-level organisation structure showing the relationship of KW&SB with the CDGK is shown in **Figure S34.1.1**.

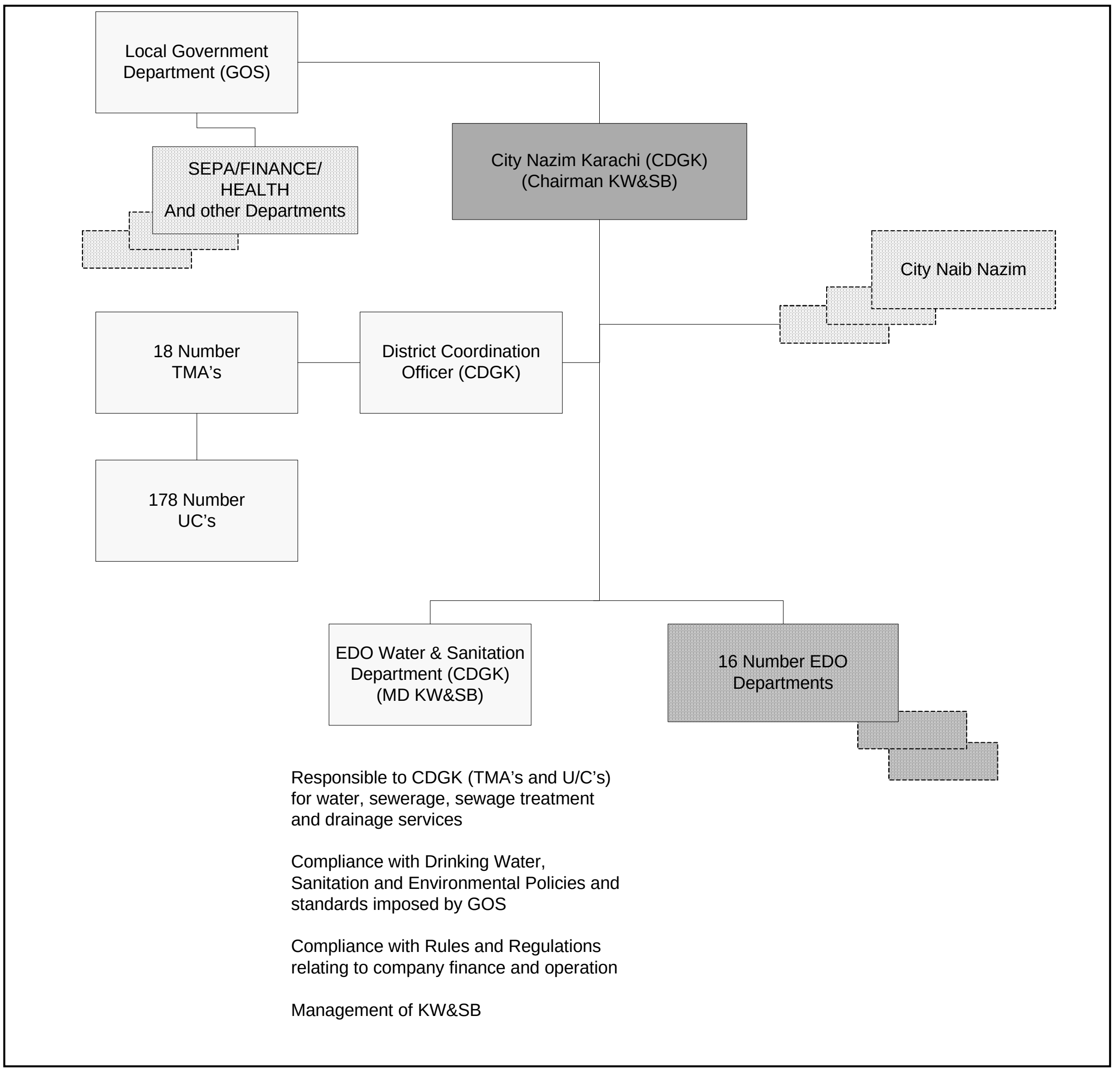


Figure S34.1.1 High Level Organisation Structure

KW&SB's main responsibilities (according to KW&SB Act, 1996 and SLGO, 2001) can be summarised as follows:

- Produce and supply potable water
- Sanction of water and sewerage connections and water supply to tankers
- Levy and collect fees for water and sewerage services
- Make regulations with approval from government
- O&M and construction of water and facilities
- Regulate water supply and inspect water and sewerage connections
- Prepare and submit to government for approval, tariffs and other charges

The number of employees budgeted (2006) is currently 9327 of which current staff in post is 8260. This is split 3230 staff at City level and 5030 staff distributed throughout the offices within the 18 Towns. An accurate up to date 'picture' of staff numbers is difficult to determine as staff records and payroll 'demands' are administered locally at Town offices by authorised 'Drawing & Disbursement Officers' (DDO's).

The latest (November 2007) high-level organisation structure with an indication of the main functional responsibilities is shown in **Figure S34.1.2**.

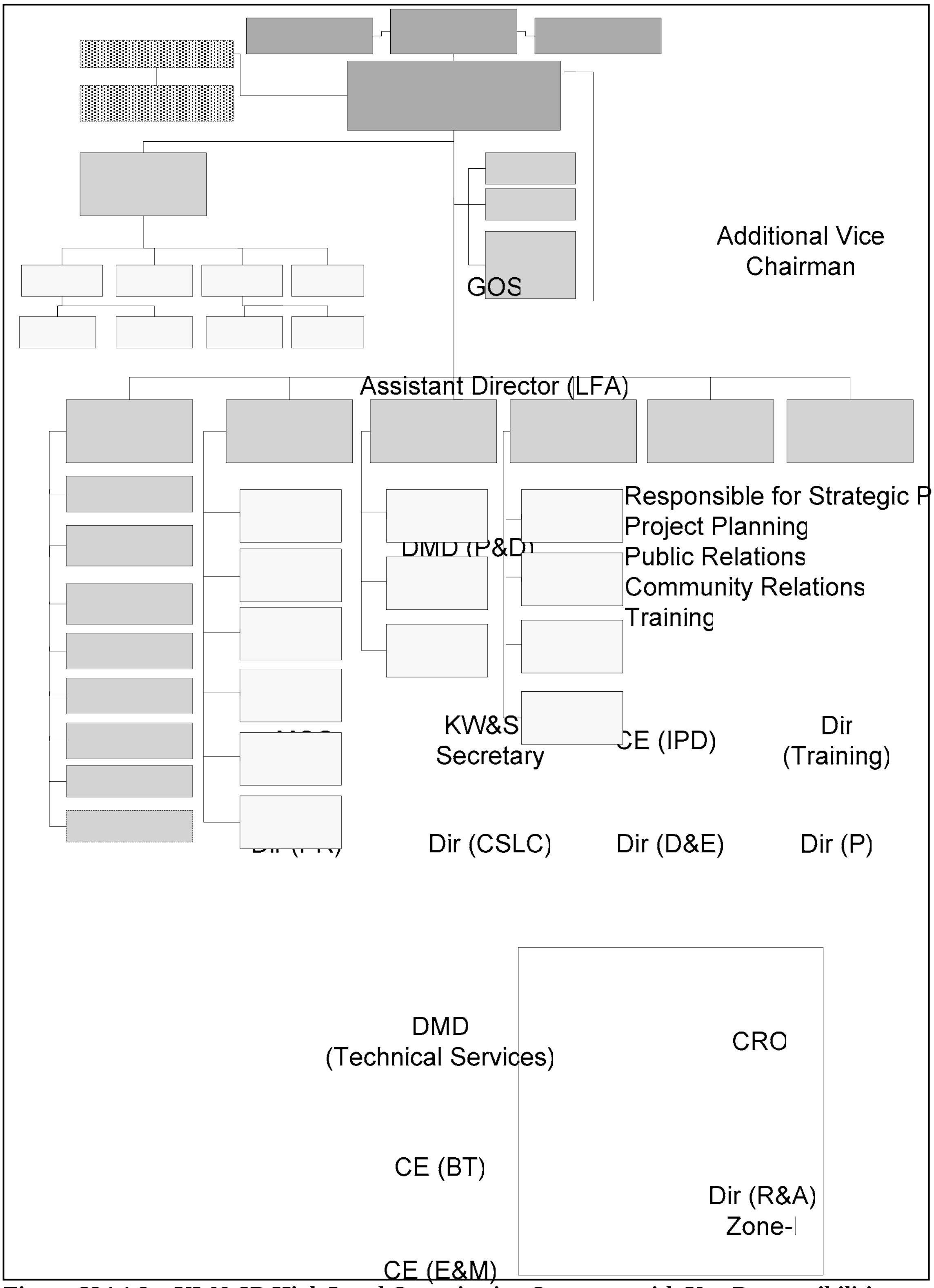


Figure S34.1.2 KW&SB High Level Organisation Structure with Key Responsibilities

Responsibility for operations and maintenance rests primarily with the 5 zonal CE's, the CE (BT), CE (E&M) and the CE (DD&C). They are responsible for the conveyance of bulk raw water from source as well as for conveyance systems (canals/conduits), reservoirs, trunk mains, transmission mains, distribution networks, pumping stations, drainage systems and sewerage networks, as well as for the O&M of water and treatment facilities. Staff associated with these activities, are dispersed at the various operational sites as well as at the 18 Town offices. Management and administrative staff associated with O&M are also placed at the '9th Mile' and 'HQ' offices.

Currently responsibility for large and mega projects rests with the CE (Projects) and CE (Mega Projects). This includes development of K-IV, major sewerage schemes (S-III), desalination and effluent reuse investigations. Invariably, consultants are used for outline design, bid documentation, detailed design and construction supervision. Smaller scale projects, refurbishments, overhauls, major breakdowns etc. are managed by the respective CE's.

S3.4.2 Financial Management

(1) Financial Conditions

The financial conditions of KW&SB were figured out through the recent five year financial statements between 2000/01 and 2004/05. KW&SB recorded consecutively deficit. Although for the beginning two years the revenue covered the direct expenses, it could not cover even the direct expenses for the rest three years.

The ordinary results including the both operating and non-operating results recorded the serious deficit. The annual deficit in 2004/05 was Rs.2.36 billion, although that was Rs.0.82 billion only in 2000/01. Thus, the accumulated deficit reached to Rs.10.44 billion at the end of the fiscal year 2004/05. This deficit corresponds to the total revenue for almost four years of the annual revenue in 2004/05. This trend of the ordinary deficit for the recent five years was illustrated in **Figure S34.2.1**.

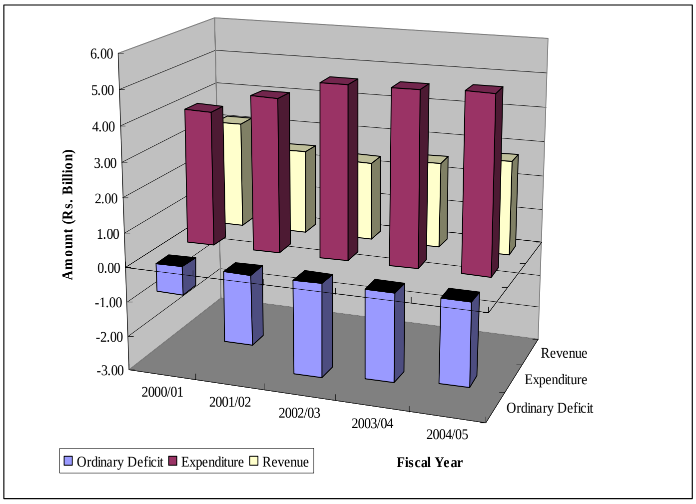


Figure S34.2.1 Management Performance of KW&SB for Recent Five Years

Of the total water revenue, that from the bulk water consumers accounted for 64% in 2004/05, in spite that the number of the bulk users' connections (4,440 connections) occupies only 0.32% of the total (1.40 million connections) in the same year. The revenue from the retail consumers was only 36% of the total, although the number of the retail consumers accounted for more than 99% of the total. On the other hand, the revenue of sewerage service from the bulk users accounted for 42%. Then, that of the retail users was 58%. Overall percentage shares of the total revenue were broken down as: 54% of water revenue from bulk consumers, 30% from retail consumers, 7% of sewerage service from bulk users, and 9% from retail users.

The operating expenditure in the fiscal year 2004/05 was Rs.3.90 billion. Among various expenditure items, the top five expenditure items were: (1) Rs.1.64 billion of electricity charges or 42% of the total expenditure, (2) Rs.874 million of compensation (salaries and benefits), 22%, (3) Rs.865 million of depreciation, 22%, (4) Rs.161 million of repair and maintenance, 4%, and (5) Rs.133 million of bad debts expenses, 3%. In addition, a large expenditure item in non-operating expenditure was recorded as Rs.1.18 billion of financial charges. The total expenditure was estimated at Rs.5.08 billion, so the financial charges accounted for 23% of the total.

In the B/S of the fiscal year 2004/05, the total assets of KW&SB were estimated at Rs.36.9 billion. The total assets were broken down to Rs.29.4 billion of fixed assets and Rs.7.5 billion of current assets. As a matter of course, liabilities and equity were Rs.36.9 billion. They consist of Rs.25.1 billion of long term liabilities, Rs.29.9 billion of current liabilities and Rs. 7.1 billion of stockholders' equity.

The debtors (consumers' balance) in the current assets are an account receivable from consumers. Their amount consecutively increased from Rs.4.8 billion in 2000/01 to Rs.6.0 billion in 2004/05. Its annual increase rate was 5.8% on average. Moreover, the total amount of Rs.3.2 billion was already written off as bad debts by the end of 2004/05. Accordingly, the debtors were aggregated to Rs.9.2 billion in 2004/05, if the bad debts had not been written off.

At the end of the fiscal year 2004/05, the foreign loans were recorded as shown in **Table S34.2.1**.

Table S34.2.1 Foreign Loans in B/S at End of 2004/05

(Unit: Rs. Billion)

Item	Long Term Liabilities	Current Liabilities	Total
Total of Foreign Loan Liabilities	24.8	3.5	28.3
Principal	14.5	0.6	15.1
Accrued Financial Charges	10.3	2.9	13.2

The outstanding of principal was Rs.14.5 billion in total. The accrued financial charges were an accumulation of financial charges which were the sum remaining after subtracting paid financial charges from the entire financial charges in the year. The accrued financial charges mounted up to Rs.10.3 million, accounting for 71% of the principal outstanding. Once adding the current foreign liabilities to them, the total foreign liabilities reached at Rs.28.3 billion. The accrued financial charges were Rs.13.2 billion, 87% of the total outstanding principal of Rs.15.1 billion. The total outstanding of Rs.28.3 billion was equivalent to more than 10 years' annual sales of 2004/05.

(2) Management Characteristics

Through financial diagnosis on the financial statements of KW&SB for the recent three years from 2002/03 to 2004/05, the management characteristics are brought into the open by means of management indices. Referring to these indices, the management conditions were discussed from the following viewpoints: profitability, safety and productivity.

"Turnover of capital" (net sales over total capital) was 0.07 for the three years. This rate of turnover was smaller than the Japanese index (an average of water supply systems in more than 300,000 residents) of 0.11. Among the total capital, the equity is recorded as Rs.3.77 billion, but it is completely withdrawn to cancel of the accumulated deficit for long time. In fact, the accumulated deficit was much more than the stockholders' equity. Thus, the actual rates are considered as negative because of the huge accumulated deficit. In consequence of this negative, grants in aid were appropriated for making up for this condition.

In 2004/05, an average unit price of water was estimated at Rs.21 per 1000 gallon. On the other hand, an average unit production cost of water was estimated at Rs.40 per 1000 gallon. The unit price was only 53% of the unit cost. Incidentally, the Japanese case shows that the percentage was 99%, i.e., Rs.350 per 1000 gallon of unit price to Rs.354 per 1000 gallon of unit production cost. This phenomenon gives KW&SB a warning of reconsideration on structure of revenue and expenditure.

"Turnover of account receivable" (net sales over account receivable) indicates speed of bill collection. The larger index means the better efficiency for capital utilisation. KW&SB recorded a quite worse index like 0.42 to 0.45. These figures were considerably low as compared with the Japanese index of 7.4. These indices mean that KW&SB spend more 16~18 times to collect bill than the Japanese water supply enterprises. The index 0.45 means that it takes 810 days or around 2.2 years to collect bills on average. In general, the turnover should be kept between 6.0 and 8.0, to manage the business in safe condition.

The ratio of interest to net expenses indicates static safety of financial procurement. The smaller index shows the better soundness of management. The ratio of KW&SB was calculated as between 23.2% and 23.5%, which were more serious than that of the Japanese index of 18.5%. Moreover, KW&SB could not pay a part of interests within due time and carried forward it to the next year, which was reckoned in "accrued financial charges" in the B/S. These accrued charges have increased year by year.

Main check points of productivity are (1) ratio of compensation to net sales and (2) ratio of compensation to net expenses. The former ratio of KW&SB was between 32.9% and 34.0%. This was higher than the Japanese index of 22.5%. The latter ratio was between 15.5% and 17.2%. This was lower than the Japanese one of 22.7%. These phenomena were caused by the huge difference between annual sales and expenditure of KW&SB. The number of employee per supplied water volume seems to be considerably larger than the Japanese average. It was 22 persons per mgd, which were more than three times of the Japanese index of 6.4 persons per mgd (14 persons per 10,000 m^3 per day).

(3) Financial Problems

The following financial problems were identified through the analysis of financial conditions and the diagnosis of financial statements. These problems should be considered in the master plan and also in the feasibility study.

1) Too small operating revenue: The huge deficit in every year mainly would come from too small operating revenue. For the latest few years in particular, the revenue covers only a half of the total expenditure.
2) Too large operating expenditure: The operating expenditure for last four years has consecutively increased year by year. For the recent three years in particular, the total expenditure including non-operating expenditure reached more than double of the total revenue. In spite of that, the total expenditure seems to be small for proper operation and maintenance on the water supply and sewerage systems.
3) Financially ailing structure: KW&SB confronts structural fiscal deficits. In order to solve this structural problem, it has to bring about a much more radical reform of the management system.
4) Excessive account receivable: KW&SB has huge account receivable at present. In 2004/05, its amount was Rs.6.0 billion, corresponding to 2.2 times of the annual sales in the same year. This heavy outstanding might blunt its management improvement strategy.
5) Undercapitalisation: Equity of KW&SB is Rs.3.8 billion only at present. It accounts for around 10% of the total capital (liability and equity) in 2004/05. Water supply and sewerage services are one of the processing industries, so huge capital investment is indispensable to manage the business soundly.

S3.4.3 Human Resource Development

There is no central coordinating role at policy level dealing with HRD. This has been devolved to the respective CE's and CO's to manage within their areas of responsibility.

Programmes for building staff capacity should be aimed at developing technical competencies, process competencies and managerial competencies to ensure efficient operation of all aspects of the business. Currently, apart from a variety of basic skills training courses, skills are developed by means of on-the-job training. Responsibility for training rests with the Director (Training) within the DMD (P&D) Department. However, resources are limited and most training is conducted on-the-job.

Currently KW&SB do not conduct conventional staff performance appraisals. 'Job descriptions' are not widely used and therefore, key tasks and priorities and how these are measured are not always clearly understood. A system for sharing corporate objectives has not been developed and therefore it is not clear how departmental or functional objectives are set and measured to ensure that these contribute to wider corporate goals. A system for sharing departmental objectives has not been developed and therefore it is not clear how individual's objectives contribute to wider departmental objectives.

KW&SB do not have a system in place for formally setting or communicating corporate, departmental or personal performance targets/key performance indicators and performance measures are not formally set or monitored. The current system of 'rewards and recognition' (terms and conditions) does not relate to performance and therefore good performance goes largely 'unrecognised' and poor performance goes largely 'un-checked'.

No or little feedback is given to individuals regarding their performance; consequently, training or future development needs are not formally discussed, agreed or documented.

Currently, KW&SB do not have a formal policy on career development or a career development and progression planning process, although criteria is well established for promotions and job transfers. Career development/progression is generally based on the following criteria:

- Length of service
- Age
- Experience
- Job history
- Past performance
- Seniority
- Educational background/qualifications

The above criteria is generally accepted by most despite the fact that such an approach does little to motivate those with potential for a more rapid career progression path. The current approach stifles initiative and motivation as good performance on its own does not lead to better terms and conditions or promotional prospects.

The ultimate aim of a career development programme is to enhance the future performance of the organisation itself through the development and advancement of its employees. It is recommended that individuals take responsibility for their own careers, by introduction of a training and development framework designed to allow all grades and disciplines equal opportunity for advancement.

Introducing a 'new' approach to career development and succession planning would require that KW&SB to give careful consideration to a number of factors, including the following:

- The need for a shift in culture and management willingness to change the current approach to career development and criteria for promotions
- The need to introduce a company policy and philosophy on employee development and career progression that is well communicated and understood by all
- The need to introduce personal training and career development plans for all individuals aspiring to gain new skills and experience or enhance existing skills and knowledge
- The need to introduce a transparent system of performance evaluation that rewards good performance
- The need to introduce a performance management system that leads to career and promotional prospects based on ability and good performance, experience, knowledge, attitude, initiative etc, rather than on seniority or length of service alone
- The need to train and develop managers to help manage their own careers and the careers of their subordinates

S3.5 IDENTIFICATION OF MAJOR PROBLEMS

S3.5.1 Water Supply System

Most of the urgent problems identified by the JICA Study are related to the water distribution system. In contrast, there seem to be fewer and less urgent problems in the bulk water supply system. Although the present water treatment capacity is insufficient and therefore a large volume of raw water is still being supplied without treatment, the addition of new water treatment capacity is not considered as being a high priority at present given the poor conditions of the existing distribution network. The overall picture is that there are many more urgent problems in the water distribution system than in the bulk water supply system.

The overall picture is that there are many more urgent problems in the water distribution system than in the bulk water supply system.

These problems are closely related to each other and are often mutually reinforcing. They can broadly be categorized as follows:

- Poor conditions of the existing water distribution system
- Lack of KW&SB’s autonomy in the day-to-day operation and management of the services
- KW&SB’s weak financial capacity
- Absence of measured supplies and volumetric charging system (imposition of ‘Water Tax’)

Table S35.1.1 provides the symptoms and consequences of these problems.

Table S35.1.1 Major Problems Identified by JICA Study

Major Problems	Symptoms	Consequences
Poor conditions of water distribution system	▫ Intermittent water supply ▫ High level of leakage ▫ Low system pressure ▫ Contamination ▫ Inequitable distribution	▫ Customers' distrust in KW&SB and the services it provides ▫ Reluctance to pay for the services ▫ Insufficient revenues
Lack of autonomy	▫ High level of receivables ▫ Tanker supplies ▫ Illegal connections ▫ Low tariffs	▫ Insufficient revenues ▫ Low morale of KW&SB staff
Weak financial capacity	▫ Delay in capital replacement ▫ Delay in system expansion ▫ Poor current maintenance ▫ Poor working environments (offices & equipment) ▫ Reliance on Government funding (OPEX and CAPEX)	▫ Deteriorating services ▫ Deteriorating assets ▫ Low morale of KW&SB staff ▫ Political interference
Absence of measured supplies and volumetric charging system	▫ Absence of system input metreing and retail supply metreing ▫ No incentives for efficient use of water ▫ No boundary of responsibilities for maintenance of service connections between KW&SB and its customers ▫ No means to estimate leakage and non-revenue water ▫ Negates the issue of illegal connections (retail users)	▫ No control of water supply system ▫ Misuse and wastage of water ▫ 'Leakage', 'non-revenue water' and 'illegal connections' being indefinable

Major problems of Water Supply System:

- **Poor conditions of water distribution system**
- **Lack of autonomy**
- **Weak financial capacity**
- **Absence of measured supplies and volumetric charging system**

Our assessment indicated that these problems have either directly or indirectly emanated from the KW&SB's financial constraints. **Figure S35.1.1** illustrates the vicious circle of the KW&SB's operations. It shows how KW&SB's financial constraints keep intensifying and thereby deteriorating the quality of the service. It is also because of its financial constraints that KW&SB have to rely on government subsidies to sustain its operations, which in turn makes KW&SB quite vulnerable to political interference in the day-to-day management and operation of its services.

These problems have either directly or indirectly emanated from the KW&SB's financial constraints.

A substantial improvement to water service quality will be required to break this vicious circle. It is the considered opinion of this JICA Study team that a substantial improvement to water service quality can be achieved by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. This view is shared by ADB in its Draft Karachi Sustainable Mega City Water & Wastewater Roadmap, May 2007.

A substantial improvement to water service quality will be required to break this vicious circle.

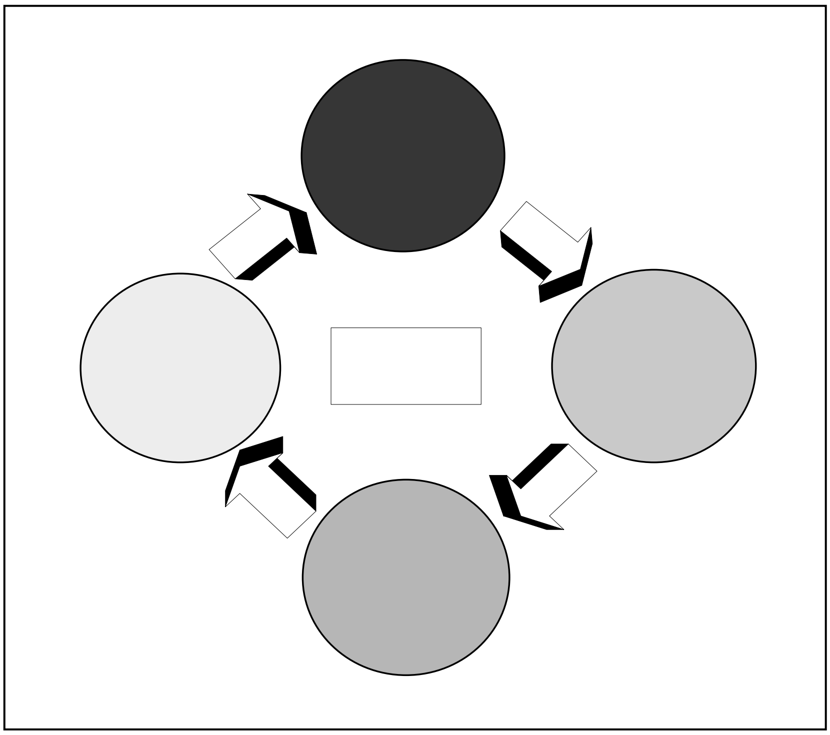


Figure S35.1.1 Vicious Circle of KW&SB Operation

S3.5.2 Sewerage System

Major problems about sewerage system are identified as follows.

<u>Absence of comprehensive master plan</u>

The master plan for sewerage implementation was once prepared in 1988, but the plan itself was not comprehensive and hence not pursued in the later stage. It is needed to prepare comprehensive master plan for sewerage implementation in line with the city planning, to implement sewerage facilities based on it and to revise the plan on regular basis taking social and physical changes into account.

<u>Limited budget allocation for sewerage facilities</u>

Since the tariff collected in water supply and sewerage sector is very limited, the budget allocated for sewerage sector is limited, too. With the limited budget, it is almost impossible to operate and maintain existing sewerage facilities so as they function as planned and to extend or newly construct sewerage facilities to meet the future requirements.

<u>Improper operation and maintenance of sewerage facilities</u>

Mainly due to the limited budget and personnel allocated for operation and maintenance of sewerage facilities, existing facilities are not operated properly. Improper maintenance might lead to earlier aging of facilities and non-compliance with the effluent quality standard.

<u>Insufficient sewerage facilities</u>

As described above, existing sewerage facilities for sewage collection and its treatment are far from sufficient in quantity to serve the large population of Karachi City. Additional sewage collection system including branch sewers, trunk sewers and pumping stations need to be constructed to improve living environment of the citizen. In the same manner, existing sewage treatment plants need to be extended and new plant(s) has to be implemented to treat all the generated sewage to improve water qualities of public water bodies, especially of Arabian Sea.

Insufficient information on facilities

Sewers, pumping stations and sewage treatment plants consist of civil structures, mechanical and electrical equipment. For efficient and effective operation and maintenance of these facilities, it is needed to equip their as-built drawings, list and specifications on site. However, site surveys by the JICA Study Team found that there was little information on these items, especially about sewers except for Lyari interceptor.

Insufficient record of operation and maintenance works

In the same manner, little information in written form is available on the performance of pumping and treatment facilities such as flow rates, operation hours, water qualities, facility failures and repairs and so forth.

Absence of operation and maintenance manual

Manuals for operation and maintenance of sewerage facilities (O/M) are not available. It is very difficult to operate and maintain sewerage facilities in a proper way without O/M manuals.

S4 MASTER PLAN

S4.1 WATER DEMAND FORECAST

S4.1.1 Population

(1) Past Trend of Population Growth

Karachi City conducted population censuses in 1961, 1972, 1981 and 1998. **Table S41.1.1** shows past population and actual annual population growth rates of Karachi City.

Table S41.1.1 Past Population and Annual Population Growth Rate

	1961	1972	1981	1998
Population (×1000)	1,912.6	3,498.6	5,395.4	11,335
Annual Growth Rate		5.5%	4.8%	4.5%

Note: 1) 1961, 1972 and 1981: Karachi Development Plan 2000, June 1991
2) 1998: Adjusted by Karachi Strategic Development Plan 2020 (August 2007) based on 1998 census data of 9.96 million.

(2) Future Population

For the population projection, Karachi Strategic Development Plan 2020 (KSDP – 2020) issued in August 2007 projected future population as shown in **Table S41.1.2** and **Figure S41.1.1**. The JICA Study adopted the population projection made by KSDP – 2020 as agreed by the Steering Committee held on 2nd October 2006. The future population and land use plan for the preparation of the water supply & sewerage master plan is based on KSDP - 2020.

Table S41.1.2 Future Population of Karachi

	1998	2005	2010	2015	2020	2025
Population (×1000) *	11,335	15,120	18,529	22,594	27,550	32,506
Growth Rate		4.20%	4.15%	4.05%	4.05%	3.36%

*: 1) 1998 to 2020: Projected by KSDP - 2020 (August 2007)
2) 2025: Projected by JICA Study

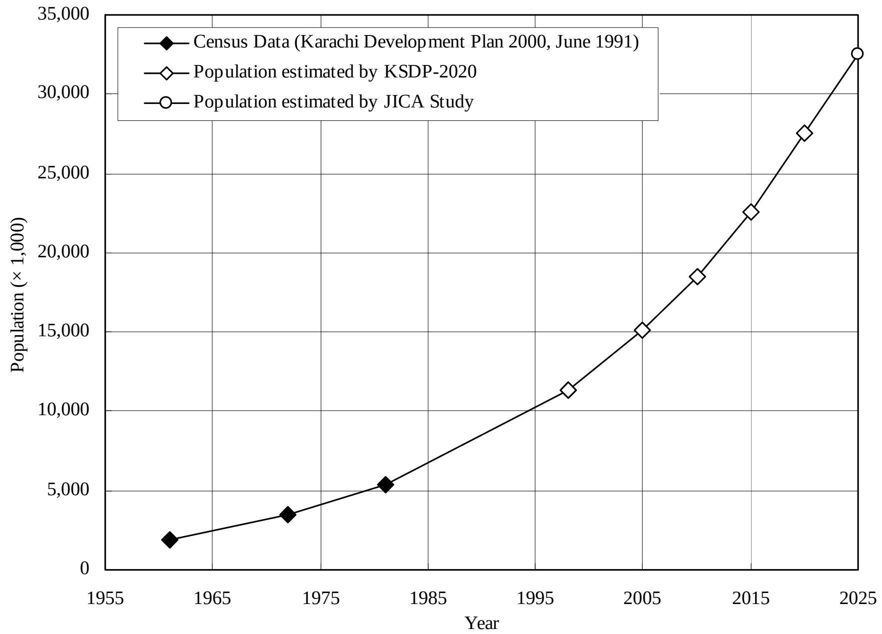


Figure S41.1.1 Population of Karachi

S4.1.2 Water Demand

(1) Basis of the Future Water Demand Forecast

1) Per Capita Bulk Water Demand

Present water supply system of Karachi City has a bulk (raw) water supply capacity of 600 mgd as shown in **Table S41.2.1**. This figure does not include the bulk supply of bulk water from Gujjo Headworks to Pakistan Steel Mills and Port Qasim Authority which have their own bulk water transmission facilities (canals and pumping stations) and filtration plants. As of the end of year 2006, the KW&SB actually supplies bulk water of about 630 mgd, which exceeds the capacity of 600 mgd.

Table S41.2.1 Bulk Water Supply Capacity

Bulk Water System	Capacity	Actual Supply
GK System	280 mgd	300 mgd
Haleji System	20 mgd	30 mgd
K-II System	100 mgd	120 mgd
K-III System	100 mgd	100 mgd
Dumlottee Wells	20 mgd	0 mgd
Hub System	80 mgd	80 mgd
Total	600 mgd	630 mgd

source: KW&SB

Therefore, per capita bulk water demand in 2006 can be calculated by dividing actual supply amount of 630 mgd by the population in 2006 of 15.8 million as follows:

$$\frac{\text{630 mgd}}{\text{15.8 million}} = \text{39.9 gallon/capita/day (181.3 lpcd)}$$

At present the KW&SB supplies bulk water of about 40 gallon per capita per day (gpcd) or 181 litres per capita per day (lpcd) for Karachi Water Supply System. JICA study proposed that 40 gpcd be also adopted for bulk water demand for the year 2025. Although the bulk water demand of 40 gpcd in 2025 is the same as the present demand, domestic per capita water consumption will increase because of the reduction of technical losses (UFW) and the water-saving efforts of non-domestic consumers.

2) Service Ratio

Considering the socio-economic survey conducted in Karachi Strategic Development Plan 2020 (Socio Economic Survey Report – 2005, Karachi City Profile, V-1.0/January 25, 2006) and our survey which was conducted mainly at Katchi Abadis during basic study period in 2006, JICA study has adopted 90% as the current average service ratio in Karachi in 2005. Considering the average groundwater withdrawal of about 30 mgd (Feasibility Study to explore Groundwater Sources in Karachi District, KW&SB, 2004), only 5 % to 10 % of population can access to groundwater other than the KW&SB water. As a result about 90 % of population is using the KW&SB water, because there is no alternative bulk source except the KW&SB water and groundwater. The service ratio is assumed to increase gradually from the current 90% to 100% by 2015.

3) Non-Domestic Water Consumption

Non-domestic water consumption accounts for about 40% of the total water consumption in Karachi. In future, however, this proportion is expected to decrease gradually to about 35% in 2025 as a result of water conservation efforts such as recycling and reuse of wastewater and introduction of desalination system exercised by large industrial and commercial consumers.

4) Technical Water Losses (UFW)

The current UFW in the transmission and distribution systems from filtration plants to customers was reported to be 25% to 35% of water supply capacity. It is assumed that through the implementation of the Distribution Network Improvements (DNI) during the next 20 years, UFW will be reduced to 15 % by 2025.

(2) Future Water Demand

For the water supply master plan, service ratio, non-domestic consumption ratio and technical water loss (UFW) are targeted as shown in **Table S41.2.2**.

Table S41.2.2 Target of Future Service ratio, Non-domestic Consumption Ratio and Water Loss (UFW) Ratio

Year	2005	2010	2015	2020	2025
Service Ratio	90.0%	95.0%	100.0%	100.0%	100.0%
Non-domestic Consumption Ratio	40.0%	39.6%	38.3%	36.8%	34.8%
Technical Loss (UFW)	35.0%	33.0%	28.5%	21.5%	15.0%

Based on **Table S41.2.2**, the future water demand is calculated as shown in **Table S41.2.3** and **Figure S41.2.1**.

Table S41.2.3 Future Water Demand

		unit	2005	2010	2015	2020	2025
a	Population	× million	15.120	18.529	22.594	27.550	32.506
b	Per Capita Bulk Water Demand	gpcd	40.0	40.0	40.0	40.0	40.0
c	Bulk Water Demand: a × b	mgd	604.8	741.1	903.8	1,102.0	1,300.3
d	Bulk Water Loss	%	10.0%	10.0%	10.0%	10.0%	10.0%
e	Water Demand: c / (1+d)	mgd	549.8	673.8	821.6	1,001.8	1,182.0
f	Water Loss (UFW)	%	35.0%	33.0%	28.5%	21.5%	15.0%
g	Total Supply to Customers: e × (1-f)	mgd	357.4	451.4	587.4	786.4	1,004.7
h	Ratio of Domestic Consumption	%	60.0%	60.4%	61.7%	63.2%	65.2%
i	Domestic Consumption: g × h	mgd	214.4	272.6	362.3	497.3	655.3
j	Non-domestic Consumption: g × (1-h)	mgd	143.0	178.8	225.1	289.1	349.5
k	Service Ratio	%	90.0%	95.0%	100%	100%	100%
l	Served Population: a × k	× million	13.608	17.602	22.594	27.550	32.506
m	Per Capita Consumption: i / l	lpcd	71.6	70.4	72.9	82.1	91.6

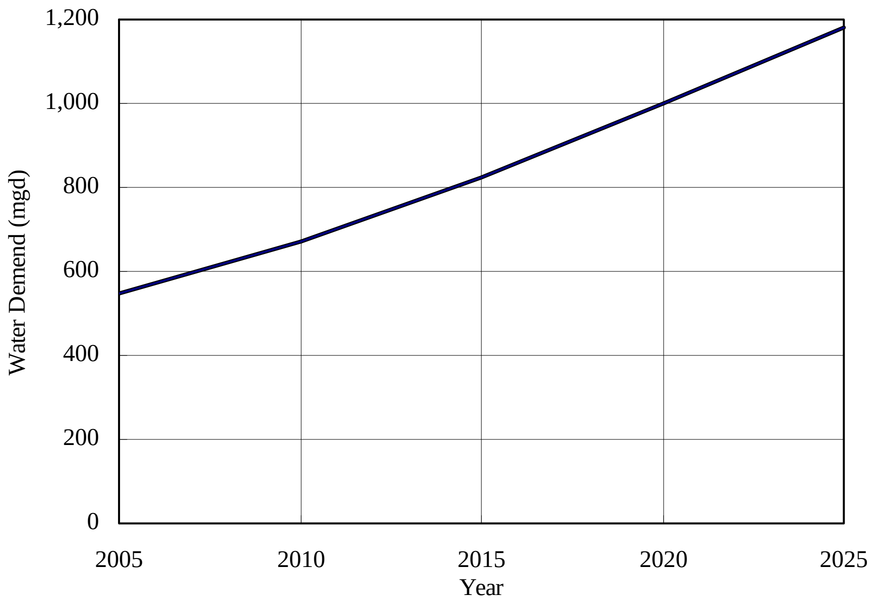


Figure S41.2.1 Future Water Demand

S4.2 WATER SUPPLY MASTER PLAN

S4.2.1 Planning Assumptions

This section discusses the planning assumptions, based upon which our master plan for water supply system in Karachi has been formulated.

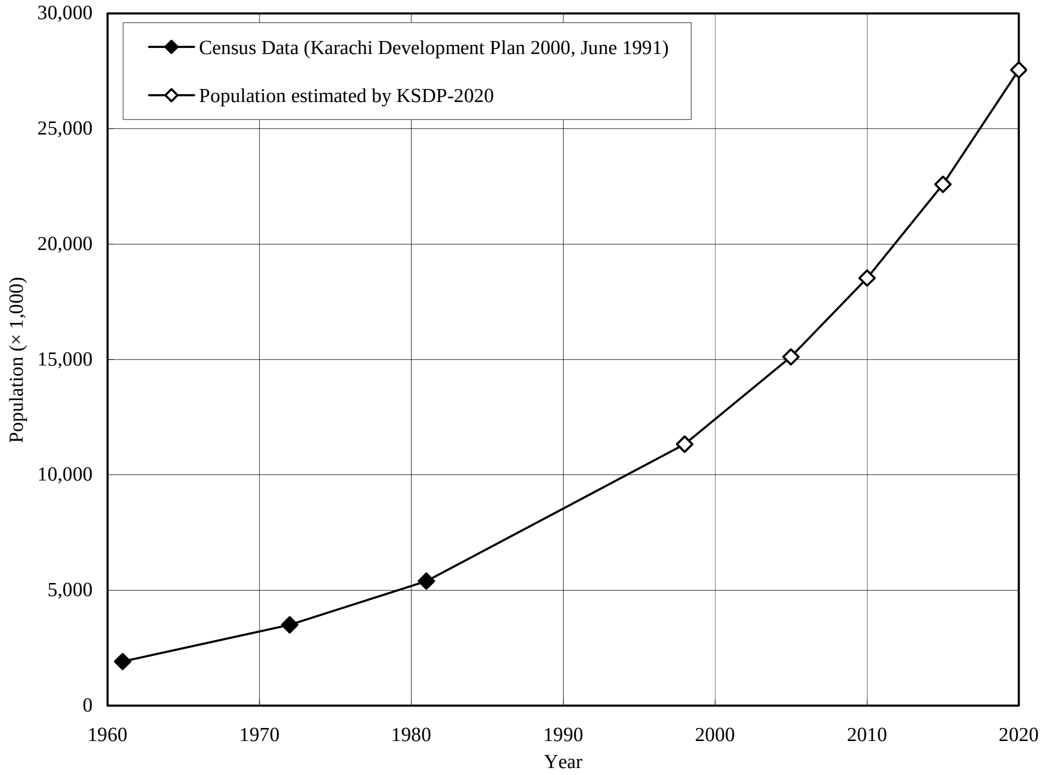
(1) Population and Development Patterns

In August 2007, CDGK issued the final report on Karachi Strategic Development Plan 2020 (Final Report, August 2007). This report indicated that the total population of Karachi was 15.2 million in 2005 and it would increase to 27.5 million in 2020. The report also predicted that more than 45% of the projected population increase during the 15 years from 2005 to 2020 would occur in the three towns located on the outskirts of the Karachi City, namely Keamari, Gadap and Bin Qasim whereas the balance 55% in the remaining 15 towns. This was based on the perception that during the next 15 years significant developments would take place on the outskirts of the city in particular in the southern part of Gadap Town. **Figure S42.1.1** shows the population projections made by the Karachi Strategic Development Plan 2020 (Final Report, August 2007). **Figure S42.1.2** illustrates the future land use envisaged by the same plan.

Karachi's total population was 15.2 million in 2005 and it would increase to 27.5 million in 2020.

We believe that the Karachi Strategic Development Plan 2020 (KSDP-2020), once it is approved and authenticated by higher authorities, will serve as a guiding principle, based on which all infrastructure development schemes for all public service sectors, such as water supply, sewerage, solid waste disposal, electricity, gas, telecommunication and roads will be developed. For this reason, we decided to develop a water supply and sewerage master plan for Karachi based on the population projections, future land use patterns and other basic data provided in the KSDP-2020 (Final Report, August 2007).

It has been projected that 45% of the population increase during the 15 years from 2005 to 2020 would occur in the three towns located on the outskirts of the Karachi City, namely Keamari, Gadap and Bin Qasim while the balance 55% in the remaining 15 towns.



Year	1981	1998	2005	2010	2015	2020
Population (1,000)	5,395.4	11,335	15,120	18,529	22,594	27,550
Average Annual Growth Rate (%)		4.46%	4.20%	4.15%	4.05%	4.05%

Figure S42.1.1 Population Projection by KSDP-2020 (Final Report - August 2007)

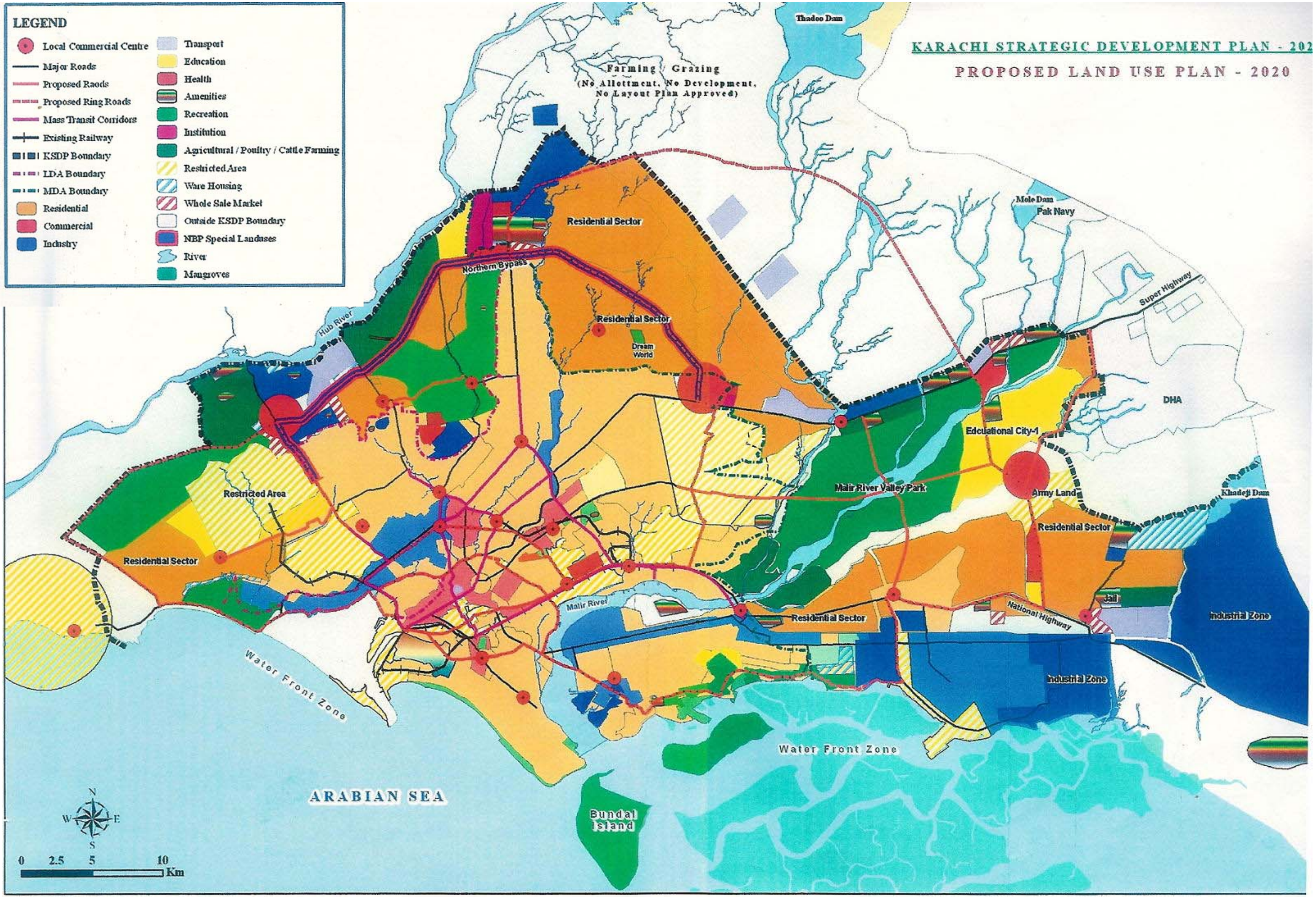


Figure S42.1.2 Land Use Plan Proposed by KSDP- 2020 (Final Report - August 2007)

(2) Water Sources

Despite the significant population increase envisaged by the KSDP-2020 (Final Report-August 2007), there has been no definite plan for increasing the capacity of water sources to meet the increasing water demand. In this respect, the KSDP-2020 has proposed the use of several modern technologies to increase the water supply capacity. They include the construction of sea water desalination plans, reuse of effluents from sewage treatment plants for recharging groundwater aquifers, and the development of dual water supply systems and dual sewerage systems. However, most of these technologies are not considered financially viable both at present and in the foreseeable future.

In the light of the immense size of the water demand in the city, there is no doubt that Indus River will continue to remain as the only viable water source for Karachi in the foreseeable future. This view was first indicated by the 1985 water supply master plan study for Karachi conducted by Sir M. MacDonald and Partners (principal consultant) and Associated Consulting Engineers (local associated consultant). The study made a review of all potential water sources in the Karachi region, which included the Indus River and other surface water and groundwater sources, seawater desalination, and the indirect reuse of treated sewage effluents for the recharge of aquifers and substitution of existing non-potable uses. As a result, the study indicated that the Indus River and desalination are the only two sources that could technically meet a large water demand in Karachi. The study also indicated that the cost of desalination for the foreseeable future was prohibitive and that desalination should therefore be considered as a last resort. The study then concluded that the Indus River was the only viable water source for Karachi.

This view was endorsed by a special committee formulated by GOS in 2002. The committee comprised representatives from the Planning and Development Department of GOS, Irrigation and Power Department of GOS, and Karachi Water & Sewerage Board (KW&SB), prepared a report on long term water supply plan for Karachi up to the year 2025, and submitted the report to the Central Development Working Party (CDWP) on November 14, 2002, which was evaluating the PC-I of the scheme "Assured Water Supply for Karachi – upgrading Kinjhar Lake System" at that time. In summary, the report provided the following major findings and recommendations.

(Findings)

- Existing allocation of 1,200 cusecs from Indus would be fully utilized in 2005 with completion of the 100 mgd K-III project. The population of Karachi was ever growing and additional requirement up to year 2025 was estimated to be another 1,200 cusecs thus the total requirement would be 2,400 cusecs.
- The present scheme of assured water supply for Karachi be treated as Phase-I to cater short-term Assured Water Supply for Karachi City up to year 2005. The Phase-II of this scheme would be required for long-term requirement of water supply to Karachi to cater requirements beyond 2005 and up to 2025.

(Recommendations)

- For growing water demand of Karachi the allocation for Karachi up to Vision 2025 may be increased by another 1,200 cusecs raising the total allocation to 2,400 cusecs by the Government under a national cause without affecting supply of water quota of the Thatta District for agriculture purposes. Once additional allocation was allowed then a 2-stage study programme for expansion of system would have to be initiated.
- Stage-I: Study by the Irrigation and Power Department of GOS for increasing capacity in the system from the KB Feeder Upper up to the Kinjhar Lake without affecting the stability of the Kotri Barrage.
- Stage-II: Feasibility study by KW&SB in consultation with the Irrigation and Power Department of GOS from the Kinjhar Lake to Karachi determining the most

economically viable, technically feasible and secure route.

Based on the committee's recommendations, CDGK requested the GOP to grant an additional quota of 1,200 cusecs (650 mgd) from the Indus River to meet the future water demand of the Karachi City. Furthermore, KW&SB since October 2005 has been conducting the K-IV Study, the main objective of which is to recommend on the most economical and technically viable route for conveying additional 1,200 cusecs of Indus water from the Kinjhar Lake to Karachi. The study examined several alternative routes and recommended the most economical route as a result of the comparison of capital and annual operating costs to be required for each alternative. Further, the study also identified the sites for construction of three water treatment plants each having an ultimate treatment capacity of 260 mgd, 260 mgd and 130 mgd. **Figure S42.1.3** shows the locations of the raw water conveyance route and three water treatment plants proposed by the study. In January 2008, the President Pervez Musharaff while presiding at the 'foundation stone unveiling ceremony' of the 'Corridor Project' at Governor's House assured the Federal Government's supports towards the implementation of the K-IV Project.

In developing a water supply master plan for Karachi, the JICA Study assumed that Karachi would be granted an additional quota of 1,200 cusecs from the Indus River and a total of 2,400 cusecs of Indus River water would be made available at the Kinjhar Lake for abstraction by KW&SB. This is based on our strong belief that if this additional quota is not granted, then there will be no such a large population increase or significant developments as have been envisaged by the KSDP-2020 (Final Report-August 2007).

Karachi would be granted an additional quota of 1,200 cusecs from the Indus River and a total of 2,400 cusecs of Indus River water would be made available at the Kinjhar Lake for abstraction by KW&SB. If this additional quota is not granted, then there will be no such a large population increase or significant developments as have been envisaged by the KSDP-2020 (Final Report - January 2007).

The Department of Irrigation and Power of GOS is currently responsible for the operation and maintenance of the Kotri Barrage, KB Feeder Upper and Kinjhar Lake while KW&SB's responsibility for the operation and maintenance of the bulk water supply system starts from the KG Canal that withdraws the impounded water of the Kinjhar Lake. It is likely that this demarcation of responsibilities will remain unchanged in future and as such it is assumed that any infrastructure development required for enabling KW&SB to withdraw additional 1,200 cusecs from the Kinjhar Lake would be planned, designed and implemented by GOS and that GOS would also be responsible for the operation and maintenance of such additional infrastructure. Instead, it is assumed that KW&SB would pay GOS a raw water charge at the rate of Rs.0.5 per 1,000 gallons (Rs.0.11 per m^3) to compensate GOS for part of the costs incurred with respect to the construction, operation and maintenance of such infrastructure.

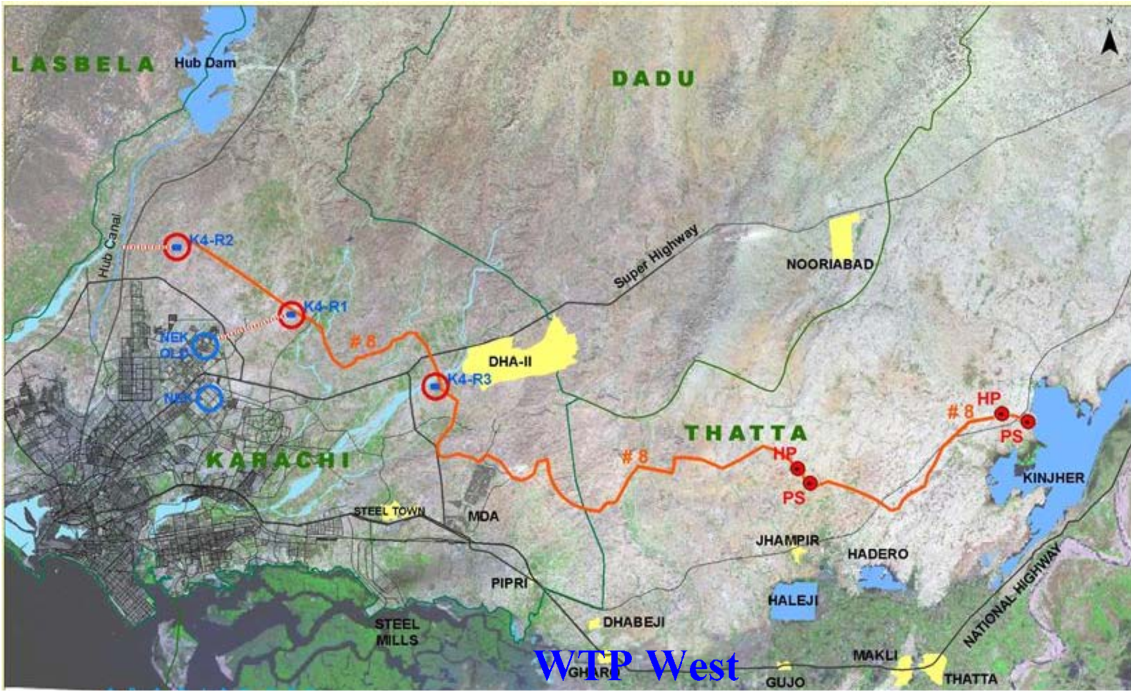


Figure S42.1.3 K-IV Project (Source: K-IV Project Executive Summary, OSMANI May 2007)

S4.2.2 Basic Policies, Goals and Strategies

WTP Central

This section discusses the following basic policies adopted for the formulation of the water supply master plan.

- Demand Management Approaches
- Separation of Bulk and Retail Supplies
- Zone-wise Management of Retail Supply
- Implementation of DNI on a Financially Sustainable Basis

WTP East

<u>Basic Policies Adopted for the Formulation of the Water Supply Master Plan</u>
(1) Demand Management Approaches
(2) Separation of Bulk and Retail Supplies
(3) Zone-wise Management of Retail Supply
(4) Implementation of DNI on a Financially Sustainable Basis

(1) Demand Management Approaches

KSDP-2020 estimated that Karachi had a total population of 15.2 million in 2005 and also projected that the total population would increase to 27.5 million in 2020. It is envisaged from this projection that the Karachi's total population could reach 32.0 million in 2025, which is almost double of the present total population. On the other hand, the possible increase in the capacity of water sources over the same period is estimated to be only 1,200 cusecs (650 mgd) as discussed in **Section S4.2.1**, which is less than the capacity of existing water sources i.e.720 mgd. These observations suggest that Karachi will continuously be subjected to severe water constraints over the planning horizon of 2025.

Our observations suggest that Karachi will continuously be subjected to severe water constraints over the planning horizon of 2025.

Karachi is located in the arid region where annual precipitation is as small as less than 200 mm. There is no prospective surface or underground water source available within or in the vicinity of the city which can be developed in a large scale to cater for the enormous water demand of the mega city. It is therefore extremely important to ensure that **'Demand Management Approaches'** are implemented in order to provide both general public and business entities with strong incentives to voluntarily restrict their water consumption within truly essential purposes. There should be a consensus reached by all stakeholders that making future water supply development plans based on unconstrained water demands is not a proper approach in the case of Karachi.

There should be a consensus reached by all stakeholders that making future water supply development plans based on unconstrained water demands is not a proper approach in the case of Karachi.

The central part of the demand management approaches will be the introduction of measured supplies with a volumetric charging system whereby all retail and bulk customers will be charged based on their actual consumption. This will be further reinforced by the introduction of a new water tariff structure which will provide both domestic and non-domestic customers with strong incentives for efficient use of water. The tariffs will be structured to differentiate essential water needs from non-essential water needs. Low tariffs would be applied to essential water needs while those who consume beyond essential needs should be severely penalized. Minimizing leakage, wastage and illegal connections will also constitute the core part of the demand management approaches.

(1) Demand Management

Goals

All consumers in the city including government and business entities are being highly conscious about water conservation and voluntarily restrict their consumption within truly essential purposes.

Strategies

- ❑ **Introduction of measured supplies with a volumetric charging system whereby all retail and bulk customers will be charged based on the actual consumption**
- ❑ **Introduction of a new water tariff structure which will provide both domestic and non-domestic customers with strong incentives for efficient use of water**
- ❑ **Implementation of efficient metre reading, billing and collection**
- ❑ **Minimizing leakage, wastage and illegal connections**
- ❑ **Implementation of mass media campaigns for enhancing consumers' awareness on water conservation**
- ❑ **Mandatory use of water-saving equipment and devices in newly constructed houses and buildings such as low-volume toilets, low-flow showerheads, water faucets with flow restrictors or aerators.**
- ❑ **Subsidizing large-scale commercial and industrial users part of their investment costs for water conservation including internal recycling of used water.**

(2) Separation of Bulk and Retail Supplies

KW&SB is currently supplying water to the entire Karachi District plus two union councils in the Thatta District of the Sindh Province. In the near future, KW&SB is also expected to supply treated water to the Lasbela District of the Balochistan Province. This demonstrates that KW&SB is playing a role of the regional bulk water supplier.

Under the Pakistani constitution, water is a provincial subject. However, GOP also performs a number of functions and responsibilities in the water sector, mostly relating to inter-provincial matters. The water supply to Balochistan under the K-III project is a good example of this. Because of the inclusion of the supply to Balochistan, the K-III project was given a status of an inter-provincial project and the entire project cost was subsidized by GOP. Both GOP and GOS have legitimate roles in shaping of policies and strategies for the water and sanitation sector in the region. It is obvious that the bulk water supplies to the Thatta and Lasbela Districts are the consequence of these policies and strategies. However, it should be noted that these policies and strategies often conflict with sound business and commercial principles.

Development of a new bulk water supply scheme to bring water from the Indus River to Karachi requires a large-scale investment which would simply exceed the financial capability of the service provider. Thus, part of the investment cost would have to be subsidized either by GOP or GOS. The reality is that in the past the entire capital costs required for the development of the bulk water supply system were subsidized either by GOP or GOS. The cost required for operation and maintenance of the bulk water supply system is also significantly large because of the long distances covered by the system. All these considerations lead to a conclusion that managing the bulk water supply system on a full cost recovery basis would not be feasible - at least within the planning horizon of 2025. On the contrary, retail water supply in Karachi can be managed on a full cost recovery basis with sound business and commercial principles. This is why we recommend the separation of bulk and retail supplies. **Figure S42.2.1** demonstrates the basic concept of the proposed separation.

Managing the bulk water supply system on a full cost recovery basis would not be feasible – at least within the planning horizon of 2025. On the contrary, retail water supply in Karachi can be managed on a full cost recovery basis with sound business and commercial principles. This is why we recommend that in the long run bulk and retail supplies should be managed and operated by different organizations.

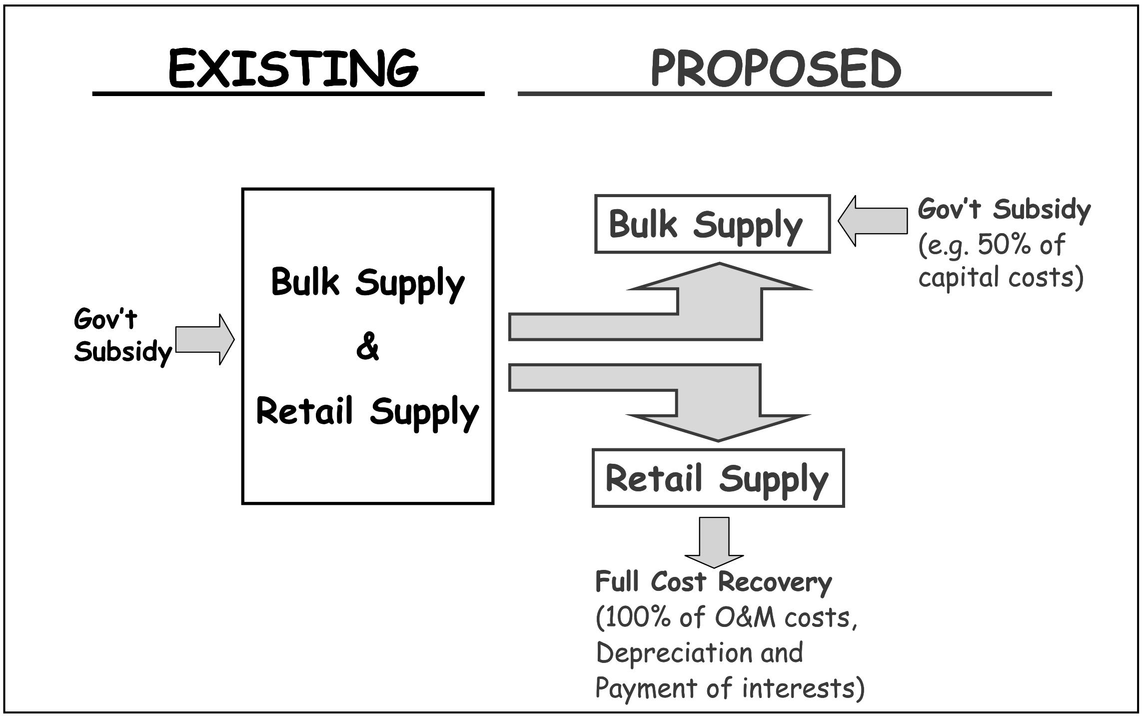


Figure S42.2.1 Separation of Bulk and Retail Supplies

The ultimate objective of the proposed separation is to enable the retail supplier to provide customer-focused, efficient water supply and sewerage services on a financially sustainable basis. This requires the insulation of the retail supplier from external interference in the micromanagement aspects of its operation, including the employment of staff, disciplining workers for poor performance, offering rewards and promotions based on good performance, handling of payment defaulters and illegal/unauthorized connections, recovery of arrears, etc. Experience indicates that as long as retail suppliers are dependent on government subsidies they will remain vulnerable to political interference in the day-to-day management of the services and in the technical execution of projects.

The ultimate objective of the proposed separation is to enable the retail supplier to provide customer-focused, efficient water supply and sewerage services to its customers.

This requires the insulation of the retail supplier from external interference in the micromanagement aspects of its operation.

Experience indicates that as long as retail suppliers are dependent on government subsidies, they will remain vulnerable to political interference in the day-to-day management of services and in the technical execution of projects.

(2) Separation of Bulk and Retail Supplies

Goals

An institutional framework is in place whereby a competent retail supplier (or suppliers) can provide water supply and sewerage services on a full cost recovery basis with sound business and commercial principles.

Strategies

- ❑ **All stakeholders agree to the separation of the bulk and retail supplies.**
- ❑ **Conduct a separate study to identify necessary changes to existing laws, ordinances and regulations and draft detailed legal provisions to put the separation into effect.**
- ❑ **Propose such changes for approval of legislators.**

(3) Zone-wise Management of Retail Supply

KW&SB has divided the entire Karachi City into five distribution zones, namely Zone I, Zone II-A, Zone II-B, Zone III-A and Zone III-B. This division was made for administrative purposes only, and from the hydraulic point of view each zone is not completely separated from others. **Figure S42.2.2** shows the locations of the existing five distribution zones. Zone I straddles the Malir River, and so do Zone II-A and Zone II-B the Lyari River. Zone III-A straddles both rivers. Retail service in each distribution zone is managed by a Zonal Chief Engineer. However, bulk customers in the zone such as cantonments, DHA, PSM, PQA and industries do not fall under his responsibility; they fall under the responsibility of the bulk transmission department. The same department is also responsible for operation and maintenance of water trunk mains that are passing through these distribution zones.

KSDP-2020 (Final Report-August 2007) proposed that the water and wastewater services in Karachi should be managed and operated by each town. This however would not be a feasible option at least in the foreseeable future because of (a) the complexity of the existing water distribution system in which one water trunk main is supplying a number of towns whereas many towns are supplied by more than one water trunk main, and (b) the significant economic disparities between towns, making it difficult for some towns (such as Orangi, Baldia and Lyari) to cross-subsidize tariffs from the rich to the poor because of their weak revenue bases.

We propose that Karachi should be divided into three distinct hydraulic zones each separated from others by two major rivers in Karachi i.e. Malir and Lyari Rivers. The rationale is that there is only a limited number of exiting water mains and sewer pipes that have been laid across these rivers and they can easily be located for installation of isolation valves or bulk flow metres. Further, separation of hydraulic zones by rivers would allow for more prudent approaches for planning of the sewerage system than by the administrative boundaries of the towns. **Figure S42.2.3** shows the locations of the proposed three hydraulic zones.

Karachi should be divided into three distinct hydraulic zones by the two major rivers in Karachi i.e. Malir and Lyari Rivers.

The size of the city is too large for a single retail entity to manage and operate water supply and sewerage services efficiently. It is therefore recommended that water supply and sewerage services in each hydraulic zone be managed and operated by an independent organization. Each organization will be responsible for operation and management of water supply and sewerage services within its own hydraulic zone, including the operation and maintenance of water trunk mains, leakage and NRW reduction, collection of tariffs, employment of staff and dealing with customer complaints. It will purchase treated water in bulk from the bulk supplier at the immediate downstream of filtration plants, service reservoirs, or pumping stations as the case may be, and distribute it through water trunk mains into various towns located within its hydraulic zone. The organization will also be accountable for collection, transportation and proper treatment of sewage generated in its hydraulic zone. Its revenue base would include not only retail consumers but also bulk consumers such as cantonments, DHA, and other industrial, commercial and governmental entities within the zone. Tariffs would be different from one zone to another reflecting the actual revenue requirements of each zone, provided that they should be subjected to the prior approval of an independent regulatory body.

The size of the city is too large for a single retail entity to manage and operate water supply and sewerage services efficiently. It is therefore recommended that water supply and sewerage services in each hydraulic zone should be managed and operated by an independent organization.

The advantages of having zone-wise management will be as follows:

- Each organization will be held directly accountable for the quality of the services it provides including the levels of leakage and NRW occurring in its zone
- Water supply and sewerage services can be managed and operated on a competitive basis in that each organization's performance will be evaluated on the basis of common performance indicators (PIs)
- Increase the ease with which equitable distribution can be attained
- Increase the ease with which both technical and non-technical losses can be monitored and reduced. Each zone will be further divided into a number of leakage/NRW control districts, which can be hydraulically isolated whenever necessary to monitor or control leakage and NRW.
- Increase the ease with which customer focused approaches can be implemented. For example, the time required to respond to customers' problems/complaints can be shortened.

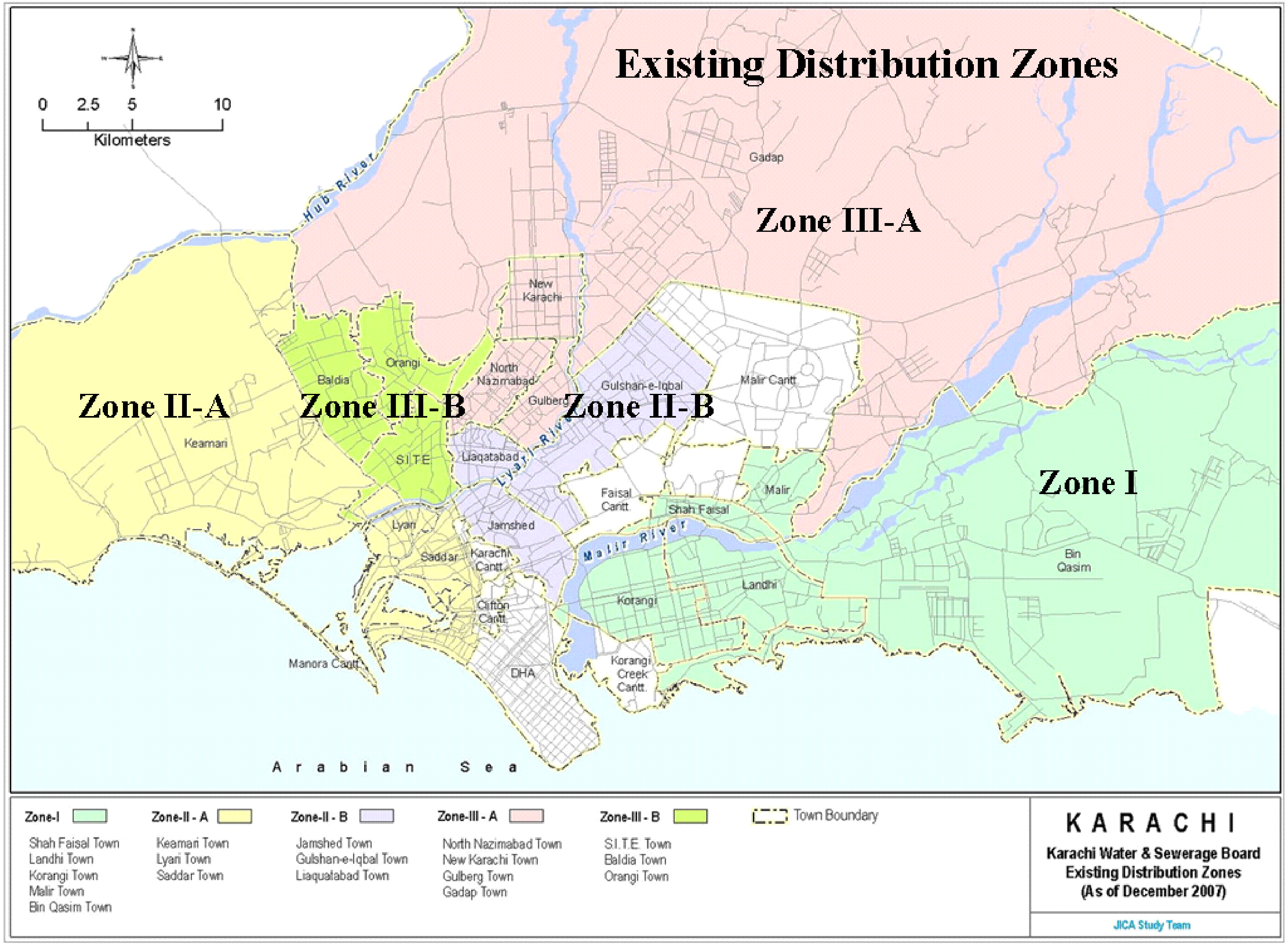


Figure S42.2.2 Existing Distribution Zones

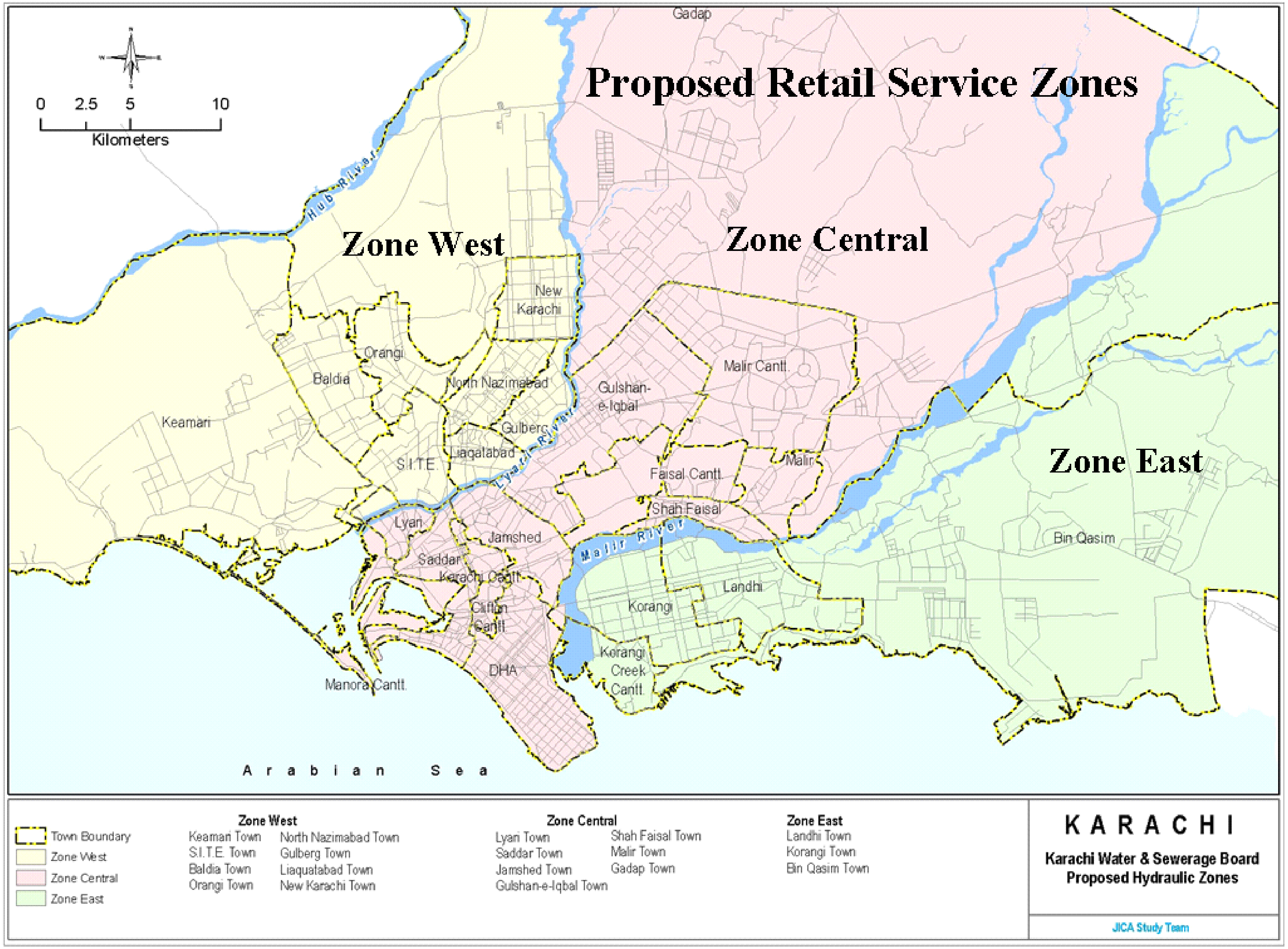


Figure S42.2.3 Proposed Hydraulic Zones

(3) Zone-wise Management of Retail Supply

Goals

Retail entities provide efficient water supply and sewerage services to its customers on a competitive basis and with accountability. This relates not only to the quantity and quality of water supplied but also to the improved efficiency in revenue collection, system maintenance, and response to customer problems/complaints.

Strategies

- ❑ **All stakeholders agree to the zone-wise management of water supply and sewerage services.**
- ❑ **Conduct a separate study to identify necessary changes to existing laws, ordinances and regulations and draft detailed legal provisions to put the proposed zone-wise management into effect.**
- ❑ **Propose such changes for approval of legislators.**

(4) Implementation of DNI on a Financially Sustainable Basis

Assessment of the existing water supply conditions in **Section S3.5.1** revealed that:

- While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high;
- The overall picture is that there are many more urgent problems in the water distribution system than in the bulk water supply system;
- In the light of the poor water supply situation, many residents in Karachi have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges;
- Many problems have either directly or indirectly emanated from the KW&SB's financial constraints; and
- A substantial improvement to water service quality is the only way to break the 'vicious circle' as depicted in **Figure S35.1.1**.

It is the considered opinion of this JICA Study team that a substantial improvement to water service quality can be achieved by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. This view is shared by ADB in its Draft Karachi Sustainable Mega City Water & Wastewater Roadmap, May 2007.

It is only if customers are satisfied with the quality of the service they receive that they find themselves willing to pay for the service. The water awareness survey conducted as part of the JICA study indicated that many households were willing to pay higher charges for a reliable supply of good quality water. With regard to the actual supply of water, the clear targets for the improved quality of the service can be summarized as follows:

- satisfy the customers' water demands so that they no longer need to utilize secondary sources (such as shallow wells and tanker supplies)
- water should be of a potable standard (this would make filtering and boiling of water unnecessary) and be aesthetically pleasing
- water should be supplied at an adequate pressure (this would make the use of suction/booster pumps and roof-top storage tanks unnecessary)
- water should be available on a 24-hour continuous basis to keep the supply system always full of water and under pressure to avoid both contamination and excessive air entrainment (this would make the use of ground-level water reservoirs unnecessary)

These improvements can only be attained through the implementation of distribution network improvements (DNI). The existing water distribution net work comprises about 4,850 km of pipelines of which about 65% is asbestos cement pipes and 26% cast iron. Much of the system is old and in very poor condition. Many pipelines in the system have already been undersized and deteriorated, and the current levels of leakage and non-revenue water are unacceptably high. DNI will embrace the rehabilitation of water trunk mains and distribution network and the refurbishment of service connections including installation of revenue metres. Where necessary, it will also include improvements to the existing sewerage system. Since DNI would require huge investments and more than 10 years of timeframe to complete it across all areas of Karachi, it can only be implemented on an area-by-area basis in a progressive way. In the short to medium term, the costs associated with DNI will have to be recovered from the tariffs charged to customers. This is necessary to implement DNI on a financially sustainable basis.

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In the short to medium term, the costs associated with DNI will have to be recovered from the tariffs charged to customers. This is necessary to implement DNI on a financially sustainable basis.

It is therefore recommended that customers in areas where DNI has already been completed (and receiving an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis) would pay a water charge that is some multiple of the current level of water charges, whereas customers in areas where DNI has not been completed (and continuously receiving the current level of service with intermittent supply) would continue to pay the current level of water charges. This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

Customers in areas where DNI has already been completed would pay a water charge that is some multiple of the current level of water charges. On the other hand, customers in areas where DNI has not been completed would continue to pay the current level of water charges.

This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

The current level of sewerage service charge is well below the level that would be necessary to ensure cost recovery in the medium and longer term, i.e. including the costs of building or extending the sewer network. With the introduction of a measured water supply, the current approach, whereby the charge for sewerage service is a proportion (25%) of the charge for clean water supply, will have the effect of linking the sewerage charge directly to the volume of clean water supplied. As such it will be in line with international practice. However, the 25% premium for sewerage service is certainly not sufficient to cover the costs of operating and maintaining the sewer network and sewage treatment plants. We suggest that this should be increased to 50% of the charge for clean water supply once the quality of sewerage service has been improved. The evidence from the water awareness survey mentioned above suggested that the priority need of the public with respect to the sewerage service is the smooth, uninterrupted removal of sullage and excreta from their home and their vicinity. For this reason, we recommend that DNI should also include improvements to the existing sewage system wherever it is found necessary. Meanwhile, customers in areas where the sewage system has already been improved through DNI would pay a sewerage service charge that is 50% of the charge for the improved service level of clean water supply which, as has been stated above, is already some multiple of the current level of water charges. In contrast, customers in areas where the sewage system has not been improved would continue to pay the current level of sewerage service charge, which is 25% of the charge for clean water supply.

DNI should include improvements to the existing sewage system wherever it is found necessary.

Meanwhile, customers in areas where the sewage system has already been improved through DNI would pay a sewerage service charge that is 50% of the charge for the improved service level of clean water supply, which is already some multiple of the current level of water charges. In contrast, customers in areas where the sewerage system has not been improved would continue to pay the current level of sewerage service charge, which is 25% of the charge for clean water supply.

Examination of the financial statements of KW&SB for recent years shows an extremely worrying trend as regards its short term financial positions. Over recent years, KW&SB has continuously been operating in deficit. The annual deficit ranges from Rs.2,000 to 2,700 million (US$33.3 to 45.0 million) as shown in **Table S42.2.1** below. **Figure S42.2.4** illustrates these deficits as compared with annual revenues. At the end of the fiscal year 2004/05, the accumulated deficit totalled to Rs. 10,435 million (US$173.9 million). These deficits have eventually been subsidised by GOP and GOS.

Table S42.2.1 Accumulated Deficit of KW&SB Rs.million

Fiscal Year	2000/01	2001/02	2002/03	2003/04	2004/05
Profit/Loss of the Fiscal Year	-820.70	-2,029.65	-2,693.09	-2,536.39	-2,358.71
Accumulated Surplus/Deficit at start of Fiscal Year	3.00	-817.70	-2,847.36	-5,540.44	-8,076.83
Accumulated Surplus/Deficit at end of Fiscal Year	-817.70	-2,847.36	-5,540.44	-8,076.83	-10,435.54

Source: Profit and Loss Statements, KW&SB

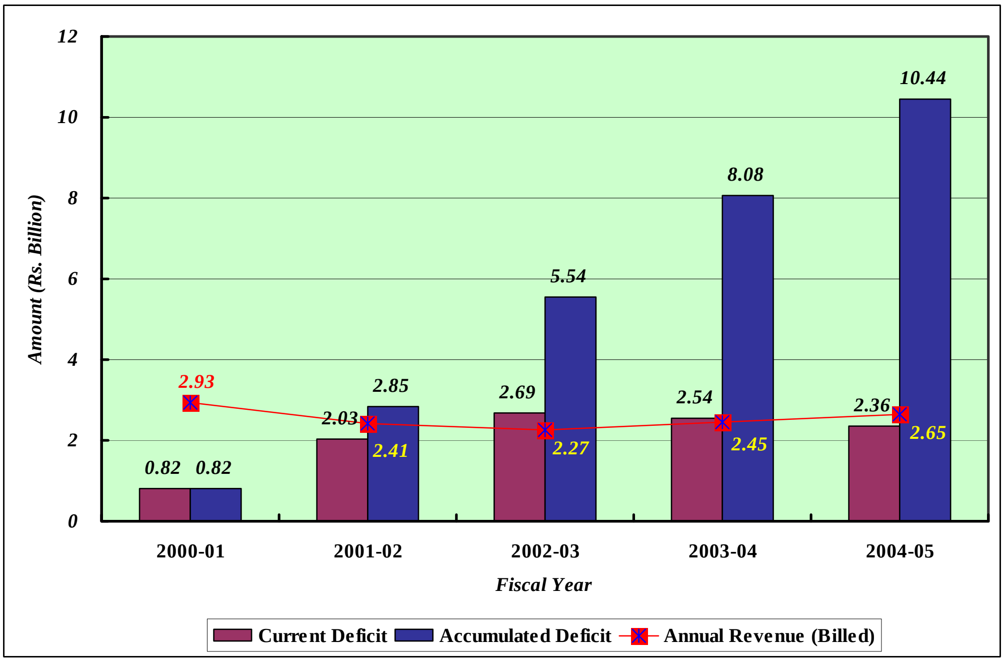


Figure S42.2.4 Revenues and Deficits of KW&SB

This demonstrates that KW&SB is not financially capable of taking new loans for implementation of DNI. DNI will involve not only physical improvement works; it will also include improvements to many institutional aspects, such as the introduction of a dual pricing system, elimination of illegal and unauthorised connections, and the strict enforcement of laws on payment defaulters. As such, it is very likely that the implementation of DNI would face severe political interference if it is financed by Government subsidies. It is therefore necessary to create a new institutional framework, whereby DNI can be implemented on a loan financing basis without any Government subsidies.

(4) Implementation of DNI on a Financially Sustainable Basis

Goals

In the short to medium term, retail entities will generate the revenues sufficient to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis).

Strategies

- **Implement DNI on an area-by-area basis in a progressive way.**
- **Introduce a dual pricing structure in that customers in areas where DNI has already been completed (customers receiving an improved level of service) would pay a water charge that is some multiple of the current level of water charges.**
- **Include improvements to the sewerage system in the scope of DNI.**
- **Increase the level of sewerage service charge to 50% of the charge for clean water supply in areas where an improvement to the sewerage system has already been made.**
- **Create a new institutional framework whereby DNI can be implemented on a loan financing basis without any Government subsidies.**

S4.2.3 System Development Plan

To meet the increasing water demand in Karachi, the water supply capacity of the filtration plants will be expanded in three stages. Under the Stage I the capacity will be expanded by 130 mgd to meet the water demand in year 2016 (the target year of stage I). The Stage II will also increase the total capacity by 260 mgd to satisfy the projected water demand in year 2021 (the target year of stage II). The Stage III will increase the supply capacity by 260 mgd to a total of 1,270 mgd which will be able to cater for the water demand up to year 2025 (the target year of stage III and also the master plan). The stage-wise expansion of the water supply capacity is shown in **Figure S42.3.1**.

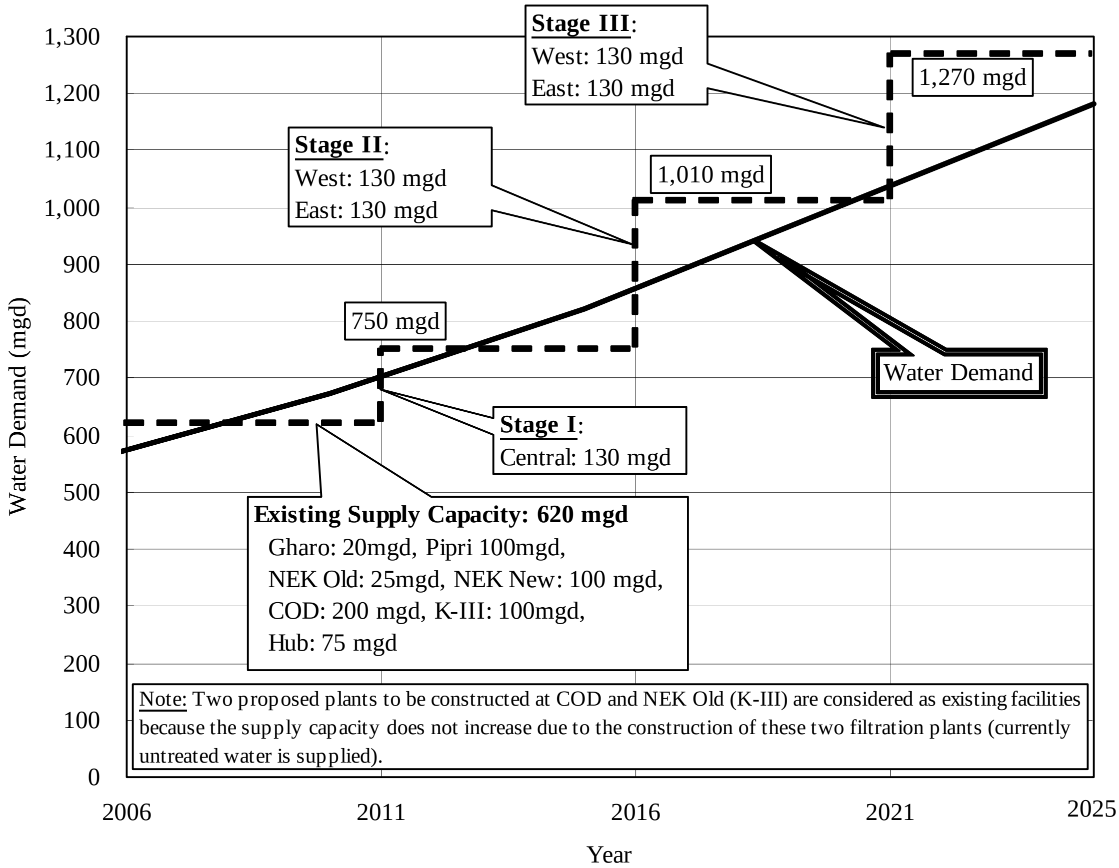


Figure S42.3.1 Stage-wise Development Plan for the Target Year of 2025

S4.2.4 Proposed Water Supply System

The water supply master plan covers 18 towns, DHA and Cantonments in Karachi City. The master plan was developed based on the planning assumptions, policies and strategies discussed in **Sections S4.2.1** and **S4.2.2**. The plan is conceived to deliver substantial improvements to the existing water distribution system while also increasing the water supply capacity and providing new water transmission and distribution infrastructure.

The water supply master plan will enable the KW&SB to meet future water demand and provide continuous and equitable water supply for its customers by 2025. In order to improve the quality of the water supply service, priority was given in the water supply master plan to the implementation of the Distribution Network Improvement (DNI) which includes the replacement of the existing distribution network mains and service connection pipes, and installation of water meters at all service connections.

As a result of our study on the institutional reform of the water supply and sewerage sector it is proposed that the retail supply should be separated from the bulk supply. In addition, considering the magnitude of the future water supply system and topographical features of Karachi City, the same study also recommends the zone-wise management of the retail supply in that water supply area will be divided into 3 zones (Zone West, Zone Central and Zone East) by two main rivers flowing through Karachi City, namely Lyari River and Malir River and each zone will be managed and operated by an independent organization or by a different business unit of the same organization.

Water supply plan for each zone was formulated based on the following policies:

- eliminating the use of several existing bulk pumping stations and a large number of small size distribution pumping stations for energy cost saving,
- supplying water to customers by gravity as much as possible, and
- keeping minimum dynamic water pressure of 10 m in distribution network system.

Tables S42.4.1 and **S42.4.2** present a summary of improvement works included in the master plan for the Karachi Water Supply System. **Table S42.4.1** shows the components for bulk water supply system by stages and **Table S42.4.2** shows the components of retail water supply system by zones. **Figure S42.4.1** depicts the proposed Karachi Water Supply System in 2025.

Table S42.4.1 Components of Bulk Water Supply System

Facility		Proposed				Rehabilitation / Replacement
	Stage	Stage I	Stage II	Stage III	Total	
	Target Year	2016	2021	2025		
	Construction	2009-2011	2014-2016	2019-2021		
Bulk Water Canal/Conduit		260 mgd	260 mgd	260 mgd	780 mgd	620 mgd
Bulk Pumping Station		2 P/Ss: 3.9MW, 7.1 MW	2 P/Ss: 7.8MW, 14.2 MW	2 P/Ss: 7.8MW, 14.2 MW	6 P/Ss	15 P/Ss
Filtration Plant		3 F/Ps: 315 mgd	2 F/Ps: 260 mgd	2 F/Ps: 260 mgd	5 F/Ps: 835 mgd	6 F/Ps: 435 mgd
		K-III: 100 COD: 85 K-IV(C): 130	K-IV(W): 130 K-IV(E): 130	K-IV(W): 130 K-IV(E): 130	K-III: 100 COD: 85 K-IV(W): 260 K-IV(C): 130 K-IV(E): 260	Gharo: 20 Pipri: 100 COD: 115 NEK Old: 25 NEK New: 100 Hub: 75
Transmission Pumping Station		3 P/Ss (2 P/Ss)	2 nos. (4 P/Ss)	2 nos. (6 P/Ss)	7 P/Ss	2 P/Ss
Transmission Main		32 km	53 km	44 km	129 km	17 km
Distribution Reservoir		2 nos. (7 nos.)	4 nos. (2 nos.)	2 nos. (6 nos.)	8 nos.	6 nos. (8 nos.)
Distribution Pumping Station		-	-	3 P/Ss	3 P/Ss	-

Note: Numbers in parenthesis are only expansion of capacity.

Table S42.4.2 Components of Retail Water Supply System

Facility		Proposed				Rehabilitation/ Replacement			
	Zone	West	Central	East	Total	West	Central	East	Total
Trunk Distribution Main (km)		406	364	152	922	273	259	153	685
Distribution Network Main (km)		2,539	3,152	2,349	8,041	3,751	4,208	1,220	9,179
	by DNI	-	-	-	-	2,578	3,069	681	6,329
	by other than DNI	-	-	-	-	1,173	1,139	539	2,850
Service Connection (×1,000)		454	564	420	1,438	1,119	900	378	2,398
	by DNI	-	-	-		553	784	283	1,620
	by other than DNI	-	-	-		566	116	95	778

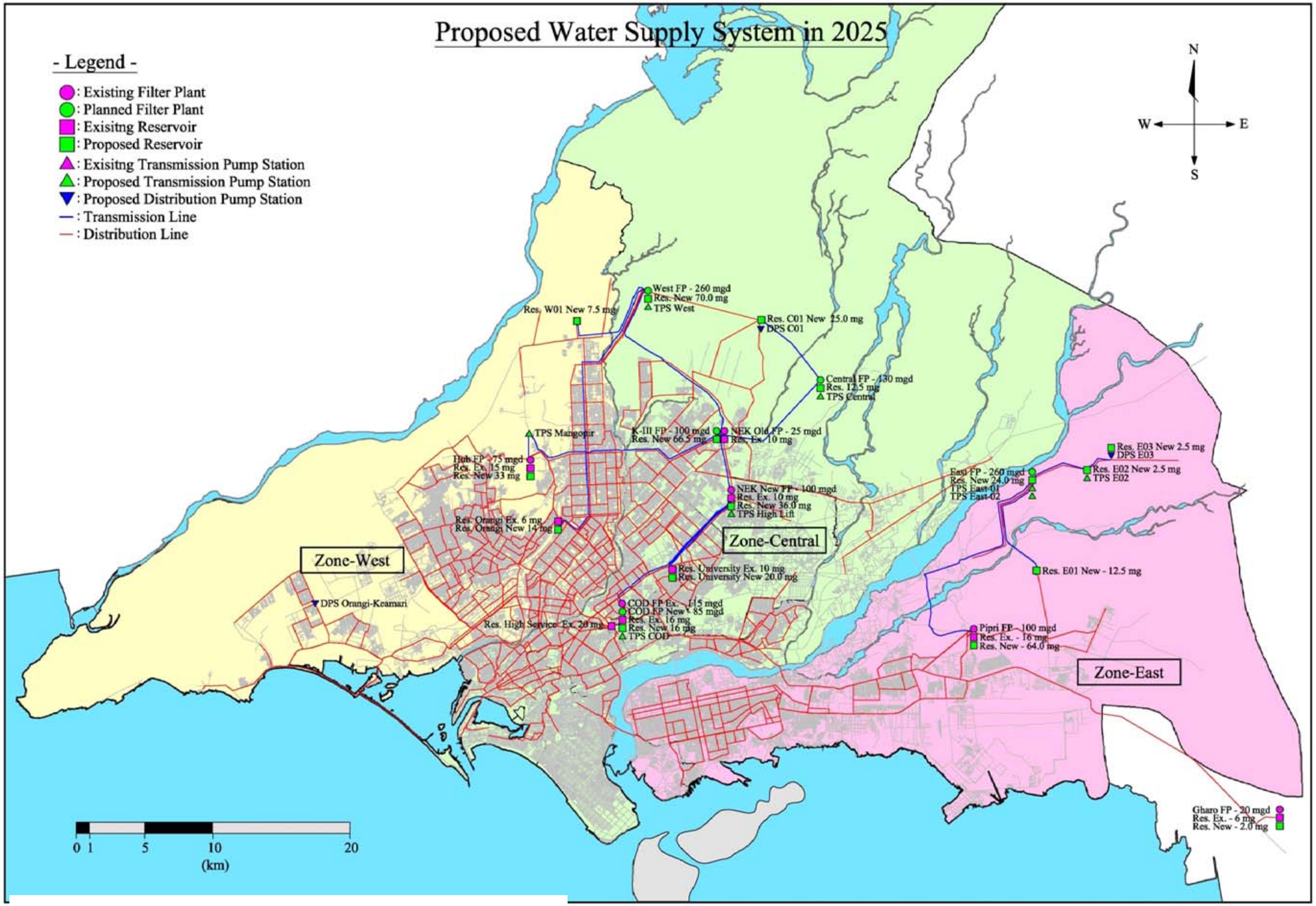


Figure S42.4.1 Proposed Water Supply System in 2025

S4.3 SEWERAGE MASTER PLAN

Sewerage system consists of sewage collection and its treatment. Sewage collection contributes to improved living environment by getting rid of generated sewage from living environment and sewage treatment to improved water qualities in public water bodies by treating collected sewage to permissible level. Specifically, the influent of BOD concentration of 600 mg/l is treated to the effluent of BOD concentration of 80 mg/l, and about 87% of BOD is removed, which improves the water quality of public water bodies. Hence, sewerage system is inevitable for better living and water environment. **Table S43.1.1** shows effluent standard for any wastewater flowing into sewage treatment plants and for any wastewater being discharged to public water bodies. For wastewaters including industrial ones being discharged to sewage treatment plants have to comply with the effluent standard shown in the table. Sindh Government is supposed to monitor water qualities of industrial wastewaters flowing into sewage treatment plants.

Table S43.1.1 Environmental Quality Standard (NEQS)

Parameter	Unit	Standards	
		Into Inland Water	Into sewage treatment plant
BOD (5 days at 20 degrees C)	mg/l	80	250
COD_{Cr}	mg/l	150	400
Total Suspended Solids	mg/l	200	400
Faecal Coliforms	MPN/100ml	Not applicable	Not applicable

Source: PEPC (Pakistan Environmental Protection Council)

S4.3.1 Fundamentals

The fundamentals in preparing sewerage master plan are as follows.

- To make full use of existing facilities by their rehabilitation and extension.
- To promptly get rid of generated sewage from living environment.
- To treat collected sewage to meet NEQS (National Environmental Quality Standard) with the effluent BOD of less than 80 mg/l.

Target year of Master Plan is 2025 when the population will be 32.5 million people with the generated sewage of 693 mgd (3.15 million m^3/d). The population in inner 15 towns will be 25.6 million people while that in outer three towns will be 6.9 million people. The sewage generation will be 552 mgd (2.51 million m^3/d) in inner 15 towns and that in outer three towns 141 mgd (0.64 m^3/d).

The Master Plan deals with inner 15 towns because necessary information such as road planning and site availability for sewage treatment plants is not sufficient. Further, EIRR of sewerage projects including and excluding outer three towns based on rough cost estimate revealed that the former is 3.8% and the latter 6.7%, respectively.

Appropriate treatment process will be selected taking into account required effluent qualities as well as full use of existing facilities.

Among three existing sewage treatment plants, TP-1 and TP-2 adopt high rate trickling filter process, while TP-3 adopts stabilization pond system consisting of anaerobic and facultative ponds. The same processes will be adopted for respective plants in MP but some pretreatment might be required for high rate trickling filter process due to the high estimated influent BOD of 600 mg/l.

Influent BOD for the existing three sewage treatment plants is designed to be either 385 or 365 mg/l, while the actual ones are observed to be in the range between 300 and 370 mg/l which is nearly the same as design value. In the Master Plan preparation, BOD loading per capita per day was calculated to be 50 g/capita/d applying influent BOD concentration and per capita sewage generation of 123 to 145 lpcd. BOD concentration of non domestic wastewater is supposed to be 250 mg/l complying with NEQS. Influent BOD concentration in the Master Plan is calculated to be 600 mg/l as follows by dividing total BOD loading contained in the influent by the whole sewage generation in 2025. (Refer to **Tables 81.2.5** and **81.2.8** in the Main Report.)

BOD Loading (Domestic): 50 g/capita-day × 25,581,942 person = 1,279,000 kg/d
BOD Loading (Non-domestic): 250 mg/l × 826,264 m^3/d = 207,000 kg/d
Total BOD Loading: 1,486,000 kg/d
Sewage amount: 2,508,000 m^3/d
BOD concentration: 1,486,000 kg/d / 2,508,000 m^3/d= 592 mg/l ≒ 600mg/l

Table S43.1.2 summarizes influent and effluent BOD concentrations of these processes.

Table S43.1.2 Influent/Effluent BOD of Each Process

Name of process	Influent BOD to the process (mg/l)	Effluent BOD from the process (mg/l)	BOD removal efficiency at the process (%)
UASB	600	300	50
High rate trickling filter	300	80	74
Anaerobic pond	600	300	50
Facultative pond	300	80	74

At present, sludges are dewatered at sludge drying bed at three existing treatment plants. The same will be adopted at extended and new plant(s) as much as possible within site area availability. If the condition is not met, mechanical dewatering will be partly introduced.

S4.3.2 Alternative Study

Table S43.2.1 compares three alternatives from various viewpoints. Alternative 1 shown in **Figure S43.2.1** is arranged so that no additional sewage treatment plant is required except for TP-4 and energy saving processes such as trickling filter process and waste stabilization pond process are adopted.

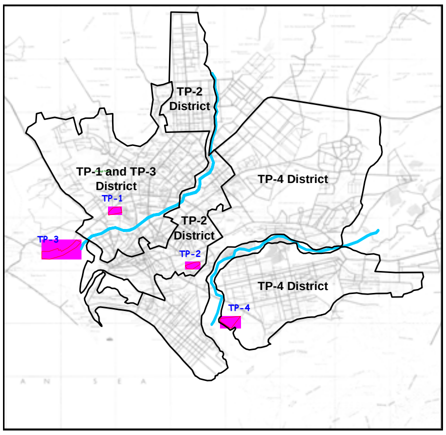


Figure S43.2.1 Schematic of Alt. 1

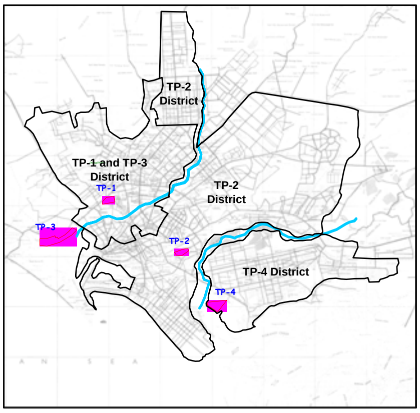


Figure S43.2.2 Schematic of Alt. 2

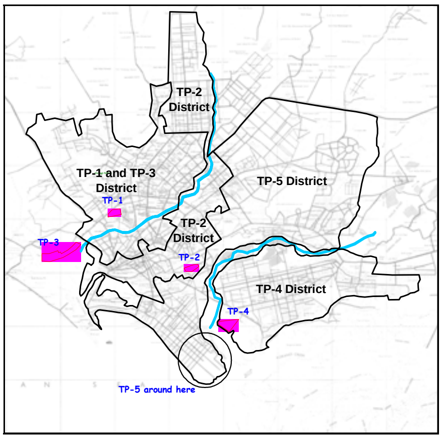


Figure S43.2.3 Schematic of Alt. 3

Alternatives 2 and 3 shown in **Figures S43.2.2** and **S43.2.3**, respectively, are both modified Alternative 1 and the difference between these two is how to divert the flow exceeding TP-2 capacity to other sewer districts.

In Alternative 2, excessive flow is treated at TP-2 by adopting activated sludge process. On the other hand, alternative 3 diverts some flow to new TP-5 whose site is located in DHA area where the land acquisition for the treatment plant is expected to be considerably difficult. Comparing these three alternatives, it is judged that the Alternative 1 is the most viable one from technical, financial and environmental viewpoints.

Table S43.2.1 Comparison of Three Alternatives

	Alternative 1 (Recommended)	Alternative 2	Alternative 3
Layout of Sewer District	TP-1/3 District: Southern part of right bank side of Lyari River and part of the area of between two rivers TP-2 District: Northern part of right bank side of Lyari River and western part of the area between two rivers TP-4 District: Northeastern and southern parts of the right bank side of Malir River and left bank side of Malir River	TP-1/3 District: Same as Alternative 1 TP-2 District: Northern part of right bank side of Lyari River and most of the area between two rivers TP-4 District: Left bank side of Malir River	TP-1/3 District: Same as Alternative 1 TP-2 District: Same as Alternative 1 TP-4 District: Same as Alternative 2 TP-5: Northeastern and southern parts of the area between two rivers
Treatment Process And Capacity	TP-1: UASB+HRTF, 110 mgd (500,000m^3/d) TP-2: UASB+HRTF, 108 mgd (490,000m^3/d) TP-3: AP+FP, 54 mgd (245,000 m^3/d) TP-4: UASB+HRTF, 284 mgd (1,290,000m^3/d)	TP-1: UASB+HRTF, 110 mgd (500,000m^3/d) TP-2: UASB+ASP, 273 mgd (1,240,000m^3/d) TP-3: AP+FP, 54 mgd (245,000 m^3/d) TP-4: UASB+HRTF, 119 mgd (540,000m^3/d)	TP-1: UASB+HRTF, 110 mgd (500,000m^3/d) TP-2: UASB+HRTF, 108 mgd (490,000m^3/d) TP-3: AP+FP, 54 mgd (245,000 m^3/d) TP-4: UASB+HRTF, 119 mgd (540,000m^3/d) TP-5: UASB+HRTF, 167 mgd (750,000m^3/d)
Technical Evaluation	Malir Interceptor (right bank side) has to cross Malir River. Less energy consuming processes are applied.	Malir Interceptor (right bank side) does not cross Malir River but it has to be connected to TP-2 by pump. TP-2 adopts activated sludge process that requires high energy consumption and skilled operators.	Addition of TP-5 prevents TP-2 from receiving larger flow which result in the adoption of activated sludge process. Malir Interceptor (right bank side) does not cross Malir River.
Social/Environmental Evaluation	No additional land acquisition for sewage treatment plants is required.	No additional land for sewage treatment plants is required. Adoption of activated sludge process for TP-2 might cause sewage flooding at power failure.	Additional land is needed for TP-5 site within DHA area.
Economic Evaluation based on construction and O&M costs for 30 years	NPV: Rs. 61,500 million Its total construction and O/M costs are nearly the same as those of Alternative 3. Hence, its NPV is nearly the same as that of Alternative 3.	NPV: Rs. 69,500 million Its NPV is the highest among three alternatives mainly due to high construction and O&M costs for activated sludge process.	NPV: Rs. 61,600 million Its total construction and O/M costs are nearly the same as those of Alternative 1. Hence, its NPV is nearly the same as that of Alternative 1.
Conclusion	The Alternative is viable judging from technical, economic and environmental viewpoints and is recommended.	The Alternative is not viable from technical, economic and environmental viewpoints.	Its NPV is nearly the same as that of Alternative 1, but the Alternative is not viable since the land acquisition for TP-5 site will hinder the smooth implementation of the project.

S4.3.3 Master Plan

In the target year of 2025, all the areas in inner 15 towns will be sewered, either through rehabilitation of existing sewers or construction of new sewers where no sewer is available at present. Relevant small pumping stations will be implemented, too.

Existing Lyari Interceptor will be extended to New Karachi to convey the sewage generated there down to TP-3. Two new interceptors at the both bank sides of Malir River will be implemented to collect the sewage generated in the upstream area between Lyari and Malir Rivers and in the whole left bank side area of Malir River and to convey it to TP-4.

Three new pumping stations of Gulberg, Bin Qasim and Karachi Port will be constructed to convey the collected sewage to TP-2 (Gulberg) and TP-4 (Bin Qasim and Karachi Port), respectively.

TPs-1 and 2 will be extended to treat the estimated amount of sewage, while TP-3 will have the same capacity as it is because it has no extra site for extension. **Table S43.3.1** summarizes the features of three sewer districts with four sewage treatment plants and **Figure S43.3.1** shows general plan of sewer districts.

Table S43.3.1 Features of Sewer Districts

	TP-1	**TP-3**	**TP-2**	**TP-4**
District are (km^2)	145.3		100.4	340.2
Population (persons)	8,849,000		5,013,000	11,720,000
Length of branch and sub-main sewers (km)	3,365		2,164	5,336
Length of trunk sewers (km)	44.9		51.3	125.8
Number of main PS	2 (Jamila and Chakiwara)		2 (Gulber and Clifton)	3 (Korangi, Bin Qasim and Karachi Port)
Location of TP	SITE Town	Keamari Town	Jamshed Town	Korangi Town
TP site area (ha)	49	221	49	168
Owner of land	KW&SB	KW&SB	KW&SB	CDGK
Design sewage flow (m^3/d)	494,400	241,900	482,000	1,289,000
Capacity (m^3/d) (number of trains)	500,000 (6)	245,000 (6)	490,000 (8)	1,290,000 (16)
Influent BOD (mg/l)	600	600	600	600
Effluent BOD (mg/l)	80	80	80	80
Sewage treatment process	UASB + HRTF	WSP (AP + FP)	UASB + HRTF	UASB + HRTF
Sludge treatment process	GT + MD	DB	GT + MD	GT + DB/MD (DB: 26%, MD: 74%)

Note: UASB for Upflow Anaerobic Sludge Blanket, HRTF for Jigh Rate Trickling Filter, AP for Anaerobic Pond, FP for Facultative Pond, GT for Gravity Thickenere, DB for Drying Bed and MD for Mechanical Dewatering

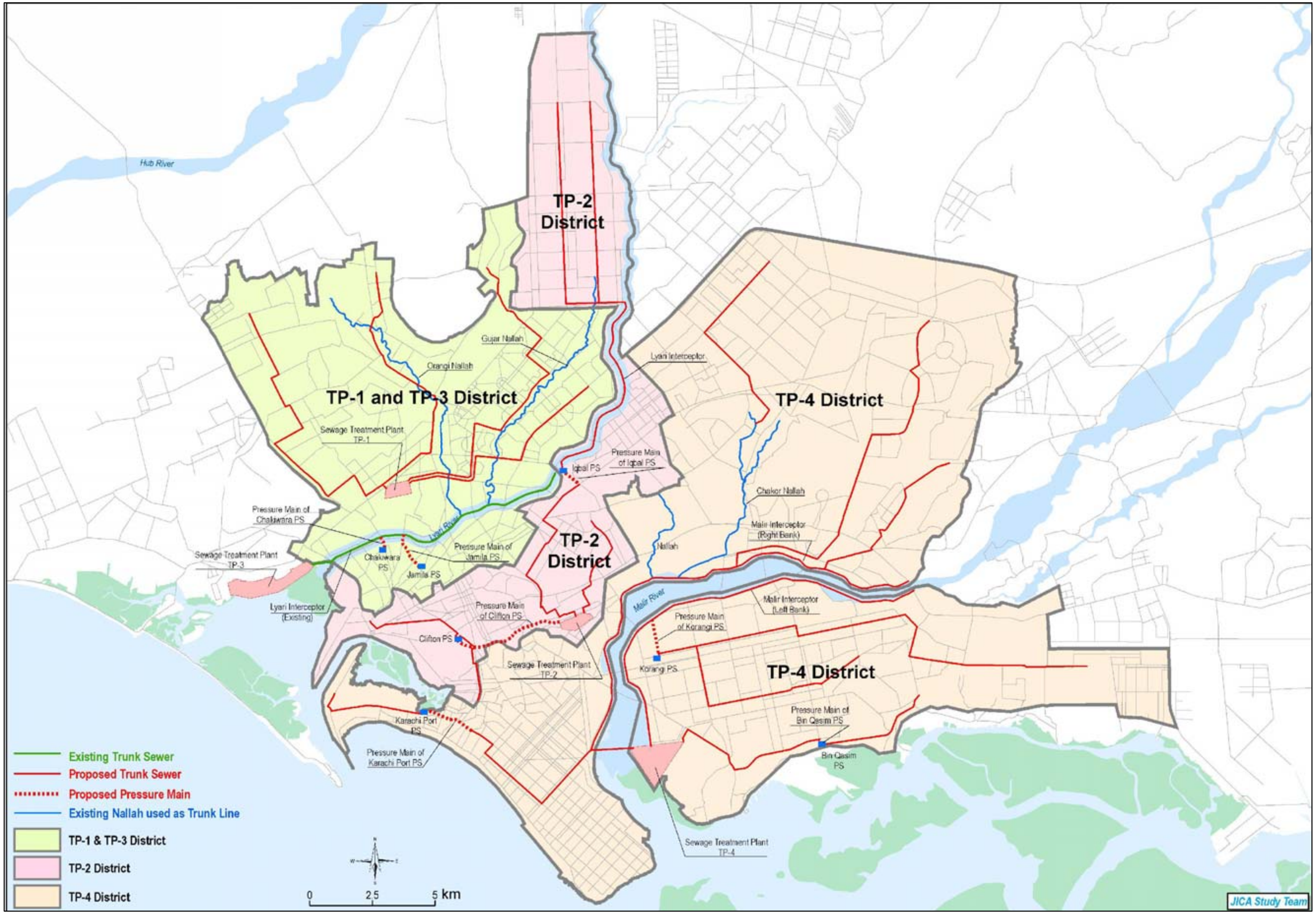


Figure S43.3.1 General Plan of Sewer Districts

S4.4 IMPROVEMENT OF MANAGEMENT SYSTEM

S4.4.1 Institutional Reforms Suggested by JICA Study

In the past, large capital investment works were implemented mostly for the purpose of developing large bulk supply schemes to bring water from distant water sources to Karachi. This has created a huge backlog of replacement, reinforcement and extension in the water distribution system. As a result, many water distribution pipes in the system have already been undersized and deteriorated, and the current levels of leakage and non-revenue water in the distribution system are unacceptably high. In most parts of the urban areas, residents are obliged to spend money on ground-level water reservoirs, suction/booster pumps, roof-top storage tanks, and water filters, and even then water must be boiled prior to drinking. While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high. Many households are compelled to use secondary sources of water such as shallow wells or tanker supplies just to meet their basic needs. In the light of the poor water supply situation, many residents in Karachi have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges.

It is only if customers are satisfied with the quality of the service they receive that they find themselves willing to pay for the service. The water awareness survey conducted as part of the JICA study indicated that many households were willing to pay higher charges for a reliable supply of good quality water. With regard to the actual supply of water, the clear targets for the improved quality of the service can be summarized as follows:

- satisfy the customers' water demands so that they no longer need to utilize secondary sources (such as shallow wells and tanker supplies)
- water should be of a potable standard (this would make filtering and boiling of water unnecessary) and be aesthetically pleasing
- water should be supplied at an adequate pressure (this would make the use of suction/booster pumps and roof-top storage tanks unnecessary)
- water should be available on a 24-hour continuous basis to keep the supply system always full of water and under pressure to avoid both contamination and excessive air entrainment (this would make the use of ground-level water reservoirs unnecessary)

These improvements can only be attained through the implementation of distribution network improvements (DNI). DNI will embrace the rehabilitation of water trunk mains and distribution network and the refurbishment of service connections including installation of revenue metres. Where necessary, it will also include improvements to the existing sewerage system. Since DNI would require huge investments and more than 10 years to complete it across all areas of Karachi, it can only be implemented on an area-by-area basis in a progressive way. In the short to medium term, the costs associated with DNI will have to be recovered from the tariffs charged to customers. It is therefore recommended that customers in areas where DNI has already been completed (and receiving an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis) would pay a water charge that is some multiple of the current level of water charges, whereas customers in areas where DNI has not been completed (and continuously receiving the current level of service with intermittent supply) would continue to pay the current level of water charges. This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby to implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

KW&SB has suffered severely from political interference. On the other hand, local governments such as GOS, CDGK, TMAs, and UCs have legitimate roles in the shaping of policies for water and sanitation sector in the region, including the adjustment of tariffs. The source of the problem is that KW&SB has been expected to act both as the local governments' agent in developing and delivering these policies and as the operator of services with managerial and technical functions. This promotes a culture of interference in the day-to-day management of services and in the technical execution of projects. To address this problem it is proposed that policy and representative functions should be separated from the operation of services. It is obvious that any new institutional arrangements have to provide the service operator with a much greater degree of insulation from political interference.

Any attempt to implement institutional reforms is likely to fail if it is not accompanied by a discernible improvement in the quality of the service (through implementation of DNI). Similarly, DNI will not be able to produce satisfactory results if it is implemented within the existing institutional framework (without institutional reforms). Thus, institutional reform and DNI (improvements in service quality) are the two inseparably intertwined elements that will need to be implemented simultaneously. Implementing only one of theses two is likely to fail.

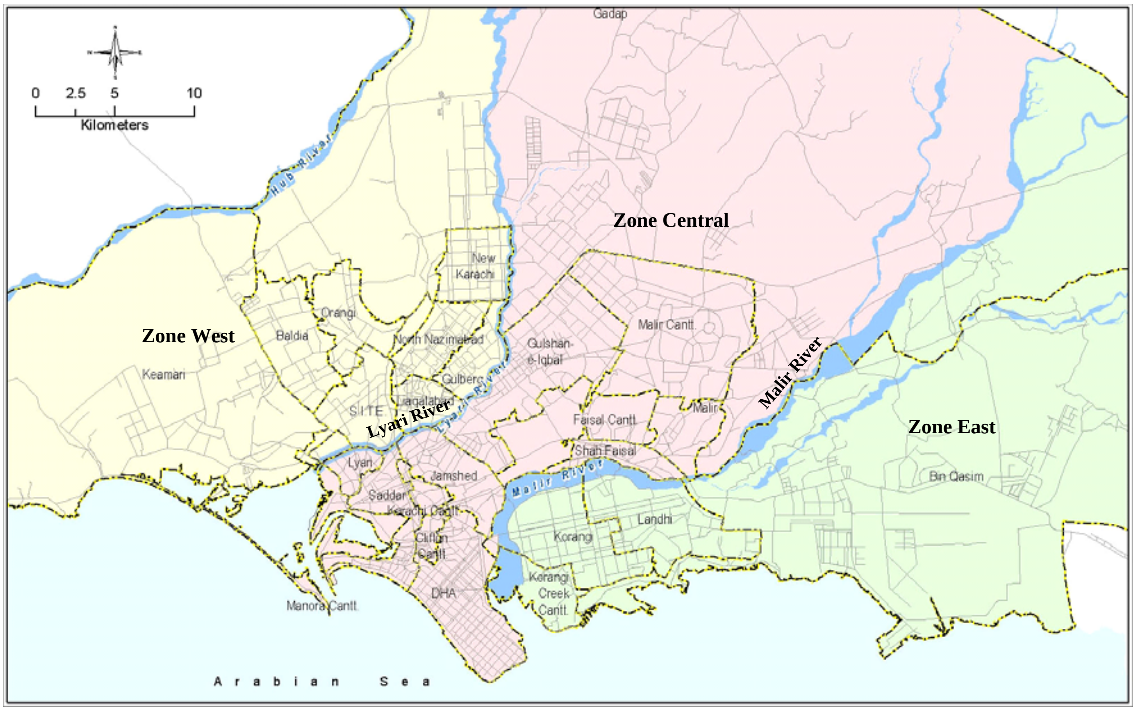


Figure S44.1.1 Three Independent Retail Service Zones

JICA Study proposes that the Karachi city be divided into three independent retail service zones by the Lyari and Malir Rivers (see **Figure S44.1.1**), and that in the long run the responsibilities for providing retail services (water supply and sewerage services) should gradually be transferred from KW&SB to 'corporatised' retail entities on a zone-by-zone basis as shown in **Figure S44.1.2**. The first stage of this reform process will take place in Zone West in early 2011 whilst at this point in time KW&SB will still retain responsibilities for bulk supply from the Kinjhar Lake to Karachi and for operation of retail services within Zone Central and Zone East. The Zone West retail entity will make improvements to the retail services within the Zone West through implementation of DNI in the zone.

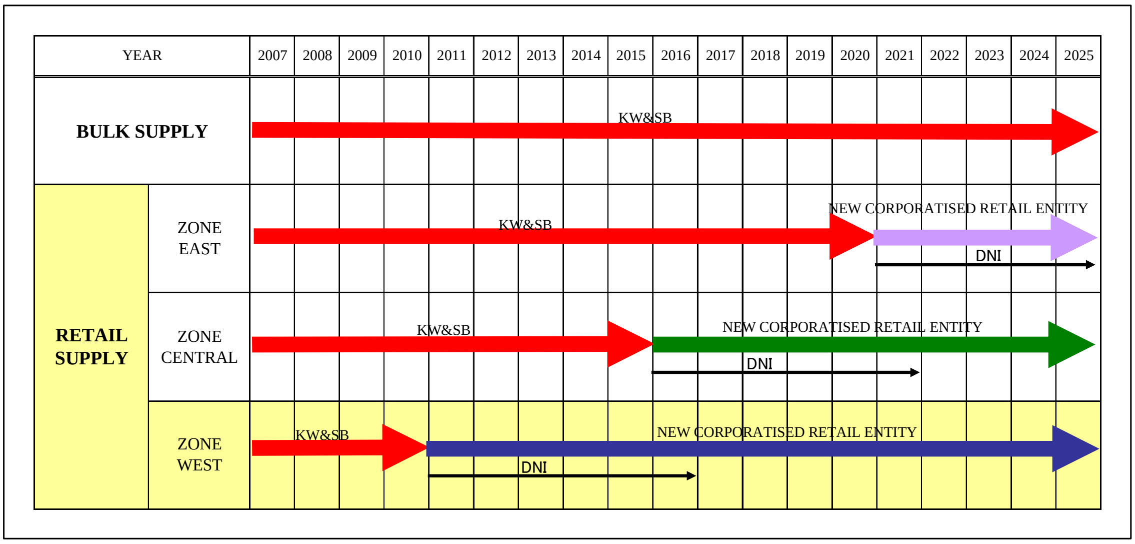


Figure S44.1.2 Transfer of Responsibility for Retail Services

Being an independent corporatised organisation, the Zone West retail entity would be able to perform free from civil service rules and develop its own rules and work ethics for how it does business. They will include rules for hiring and firing workers, adjusting wage structures, adopting performance-related payments and disciplining workers for poor performance or offering rewards and promotions based on good performance.

The Zone West retail entity would be established as a ‘Public Limited Company (PLC)’ under the provisions of the Companies Ordinance 1984. The PLC will purchase treated water from KW&SB in bulk and distribute it to all retail and bulk customers (both residential and non-residential) within Zone West. They will also be accountable for collection, transportation and treatment of sewage generated in Zone West. The PLC would take responsibility for all financial and technical aspects of the operation and management of water supply and sewerage services within Zone West including the collection of tariffs, employment of staff, dealing with customer complaints, etc. The scope of retail service that will be managed by the new service provider is broadly described as follows:

(i) Purchase bulk treated water from KW&SB and distribute it to all residential and non-residential customers in Zone West including bulk customers such as industries, governmental institutions/organizations, cantonments, commercial entities (hotels, restaurants, hospitals, etc.) currently on a bulk supply arrangement with KW&SB

(ii) Collect sewage generated in Zone West (and also sewage transferred by KW&SB from outside Zone West) and ensure that sewage is properly treated before being discharged into natural water bodies.

(iii) Operate and maintain water supply and sewerage system within Zone West, which among others include the following infrastructure.

(Water Supply)

- Water Trunk Mains
- Trunk Distribution Mains
- Distribution Network Mains
- Booster Pumping Stations
- Service Connections

(Sewerage)

- Service Connections
- Sewage Collection Network
- Trunk Sewers and Interceptors

- Sewage Pumping Stations
- Sewage Treatment Plants

(iv) Make extensions and improvements to the existing water supply and sewerage system in Zone West

(v) Collect water supply and sewerage charges from customers to recover the reasonable costs of providing services that are prudently and efficiently incurred

(vi) Enhance public hygiene and the preservation of the environment by supplying safe water that complies with the recommendations of the WHO Guidelines for Drinking Water and by ensuring that sewage is treated properly to such an extent that effluents from treatment plants comply with the requirements of the NEQS.

It is suggested that the majority of the PLC's shares would initially be held by CDGK and TMA's that fall within Zone West. As such, the reform is in line with the on-going process of "Devolution". Other stakeholders in Zone West such as large industries, cantonments, organizations representing civil society, private companies and a trust representing the interests of the company's employees would gradually be included as part of the shareholders as the financial performance of the PLC improves in future.

The objective of the PLC would be to undertake the operation of water supply and sewerage services in Zone West in accordance with high commercial and professional standards and without external interference in the day-to-day management of the services. There would be no political representation on the Board of the PLC and the articles of association and shareholders' agreement would specify that members of the Board should be selected on the basis of their commercial, professional, managerial and/or technical qualifications and experience.

JICA Study proposes that an independent Regulatory Board (RB) should be formed for economic and technical regulation of water supply and sewerage services in Zone West (see **Figure S44.1.3**). The RB should have the obligation to ensure that the new retail entity in Zone West is able to recover the reasonable financial and economic costs of providing water supply and sewerage services in Zone West. For this purpose, it will define a formula for setting tariffs that reflect the reasonable costs of providing the services to ensure that expenditures are prudently and efficiently incurred. It will also ensure that the formula is properly applied and implemented. The GOS and other local governments will have the power to intervene to limit tariff increases for reasons of regional policy but will be required to compensate the retail entity in such cases. The RB would be responsible for ensuring that the poor and lower income groups are protected from any unacceptable distributional impacts of tariff increases that might fall on them. Where services are provided free of charge the retail entity must be compensated by the relevant local body responsible for social welfare services. The Zone West retail entity would pay a regulatory charge from out of its gross water supply and sewerage revenues to cover the costs of the Regulatory Board.

The RB would monitor the performance of the Zone West retail entity against the prescribed service standards and will also act as 'Ombudsman' in dealing with customer complaints and related issues of customer service. It would also be responsible for setting out and enforcing 'Water Supply and Sewerage Services Regulations' which define clearly the statutory rights and obligations of both the Zone West retail entity and its customers in delivering and receiving the services.

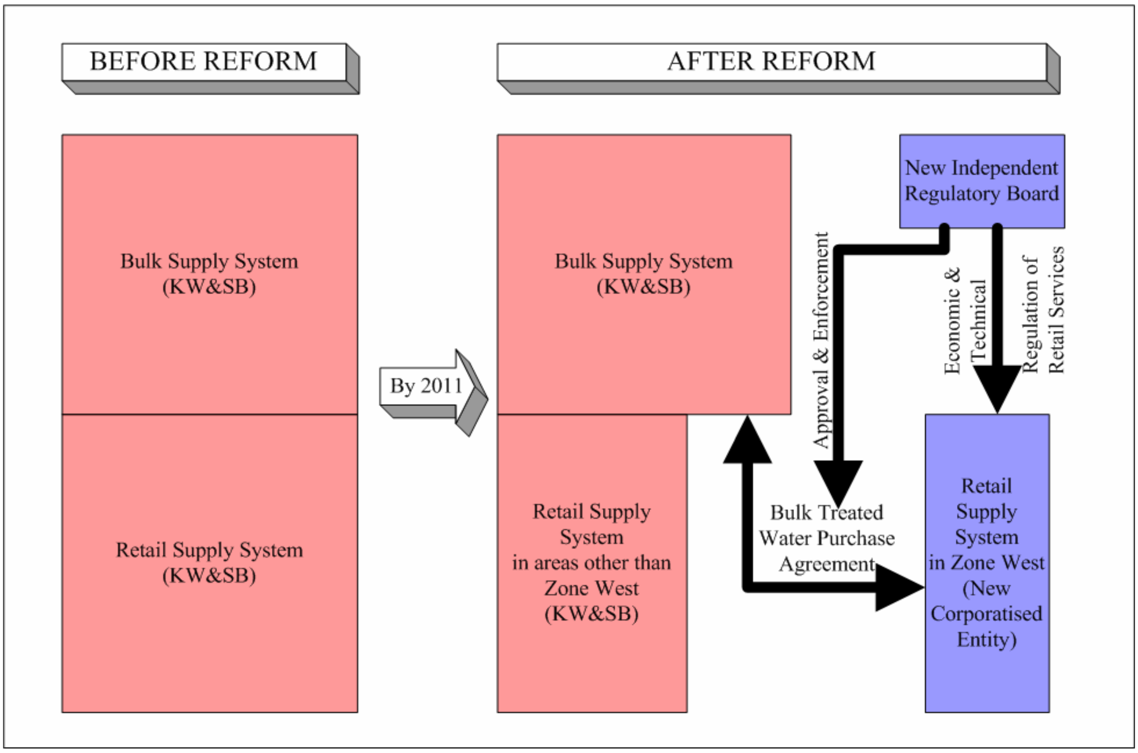


Figure S44.1.3 Institutional Reform Suggested by JICA Study

It should be noted that the 'JICA Study Team' are primarily concerned with the identification of possible reform options and therefore has sought to provide an outline of suggested reforms in principle at this stage. It is expected that detailed studies related to the suggested reforms will be carried out jointly by the Water and Sanitation Program (WSP) and the ADB assisted 'Karachi Mega City Sustainable Development Program (KMCSDP)'.

In order to put this reform (corporatisation) into effect, separate studies will need to be conducted:

- To draft amendments to relevant laws, ordinances and/or regulations that are necessary to enable KW&SB to relinquish responsibility for provision of retail services (water supply and sewerage) in Zone West
- To draft articles of association and shareholders agreement of the Zone West retail entity
- To develop a tariff structure which would be applied in areas where DNI has already been completed, and which, while providing adequate protection for the poor and a strong incentive for efficient use of water, ensure that the Zone West retail entity is able to recover the reasonable costs of providing the services including debt service on loans borrowed for financing DNI.
- To establish a mechanism for the transfer of KW&SB's employees currently engaged in provision of retail services in Zone West to the Zone West retail entity, including transfer of employees' pension rights, severance funds, etc.
- To establish a mechanism to determine the condition of retail assets and for the valuation and transfer of retail assets to the Zone West retail entity
- To establish a mechanism for dealing with the liabilities and receivables associated with the retail assets and customer base transferred to the Zone West retail entity
- To establish an independent Regulatory Board for economic and technical regulation of the water supply and sewerage services
- To draft 'Bulk Treated Water Purchase Agreement' between KW&SB and the Zone

West retail entity

It is expected that the reform process would be put into effect through the 'Reform Committees' that have already been established under WSP's initiatives, which would take responsibility for ensuring the progressive implementation of reforms in close coordination with the Local Support Unit (LSU)-CDGK of the ADB assisted KMCSDP.

S4.4.2 Improvement of Financial Management System

KW&SB will need to develop further financial management and control skills and expertise to manage the organisation on sound commercial principles. Accordingly, KW&SB will need to develop business planning practices as well as new, sound accounting and budgeting procedures and formats to ensure effective financial management, control and sustainability. This will include the need for sound computerised financial application software and computer systems; a 'Financial Information System' (FIS). Where financial staff are placed at operational sites or 'town offices', systems will need to be 'networked' to ensure access to and security of finances and financial information. KW&SB will need to invest in this as well as other systems to improve financial as well as operational performance. Taking SSGC as an example, they have invested heavily in "ORACLE Enterprise Resource Planning"; a systems suite that integrates application across all business processes including finance, human resources, operations, project planning, etc.

An asset revaluation exercise will also have to be undertaken to establish a complete list and value of current assets for effective planning and depreciation. Based on the above, it is likely that intensive staff training will be required to raise the level of financial management and control throughout all levels of the organization, including technical, field and accounting staff.

In future KW&SB's FIS will need to be capable of providing managers with timely and vital financial information relevant to their responsibilities within the organisation. Relevant financial reports and key performance indicators will need to be measured and tracked to provide internal information as well as satisfy external reporting needs.

One of the major purpose of compiling the financial statements; Balance Sheet, Income Statement, and Cash Flow Statement, is to assess the financial condition of KW&SB. More emphasis should be placed on financial performance through the analysis of financial indicators. These are calculated from the information contained within the financial statements and are designed to show the relationship between various components of the entity's financial statements. KW&SB will need to focus on performance measurement in this way in order to measure financial performance and to enable comparison with other organisations (benchmarking).

S4.4.3 Reduction of Non-revenue Water

In the absence of system-input metreing and retail supply metreing the UFW percentage can only be a reasonable estimate. This report uses a reasonable estimate of 35% for UFW.

The water distribution network comprises about 4,850 km of pipelines of which about 65% is asbestos cement pipes and 26% cast iron. Much of the system is old and in very poor condition. KW&SB regulate supplies to sub-zones by opening and closing feeder valves from the trunk mains and regulating the hours of operation of distribution pumping stations. Almost all "retail" (un-metreed) consumers (consumers other than bulk metreed supplies) are subjected to intermittent water supply. There is no overall specific strategy, plan or department to deal with leakage; this task falls to the SEs of the 18 towns, under the direction of the appropriate Zone CE.

Substantial water losses and leakage occur due to the following:

- An aging network lacking maintenance and repair

- No planned leakage control system
- Poor workmanship and materials used for pipe and joint repairs. It is said that lack of funds prevents the purchase of spare pipe, repair collars etc. The current practice of using rubber tubing and cement rendered plastic for repairs has become the accepted norm of KW&SB.
- Poor workmanship and materials for connections carried out by the consumer (rarely the declared registered plumber) which are largely unsupervised by KW&SB staff
- Household water systems comprising ground and overhead tanks and an electric pump usually directly connected to the distribution pipe cause large losses due to leakage and overflows which go unchecked because there is no volume charge

It is the considered opinion of this JICA Study Team that a substantial improvement to water service quality can be achieved by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. This view is shared by ADB in its Draft Karachi Sustainable Mega City Water & Wastewater Roadmap, May 2007.

It is also interesting to note that about 85% of households interviewed in the Water Awareness Survey support the introduction of domestic water meters. For the implementation of DNI's, efficient systems need to be developed for the reduction of non-revenue water including the reduction of physical water losses (UFW) which together with other initiatives will reduce overall NRW, these include:

- Proper repair to leakage points using appropriate materials and developing a skilled labour force and/or replacing pipes that are beyond repair
- Proper installation of new connections, water meters, accurate metre reading, calibration, repair and replacement of metres
- Water loss monitoring, identification of leaks and repair
- An accurate customer database and an efficient and effective billing and collection system
- A Consumers Service Centre for information as well as complaint resolution
- Elimination of illegal and unauthorised connections
- Efficient water use

In addition Regulations need to be modernised and extended, particularly in view of the intended metreing of retail consumers, to cover:

- Ownership of service connection pipe and responsibility for metre maintenance
- Materials & workmanship for service connections (including pipe tapping)
- Location and installation of water meters
- Metre reading, disconnection policy, metre repair and testing
- Procedures for KW&SB inspection & approval of new service connections
- KW&SB rights to oblige consumers not to waste water

A significant increase in the availability of water could be achieved by replacing and refurbishing the distribution network, resulting in cost effective use of existing bulk water. Universal metreing, efficient and effective billing would rationalise water usage, so too would reduce the number of illegal connections.

Timescales for the short term, medium term and long term goals for the reduction of NRW are given in the following **Figure S44.3.1**.

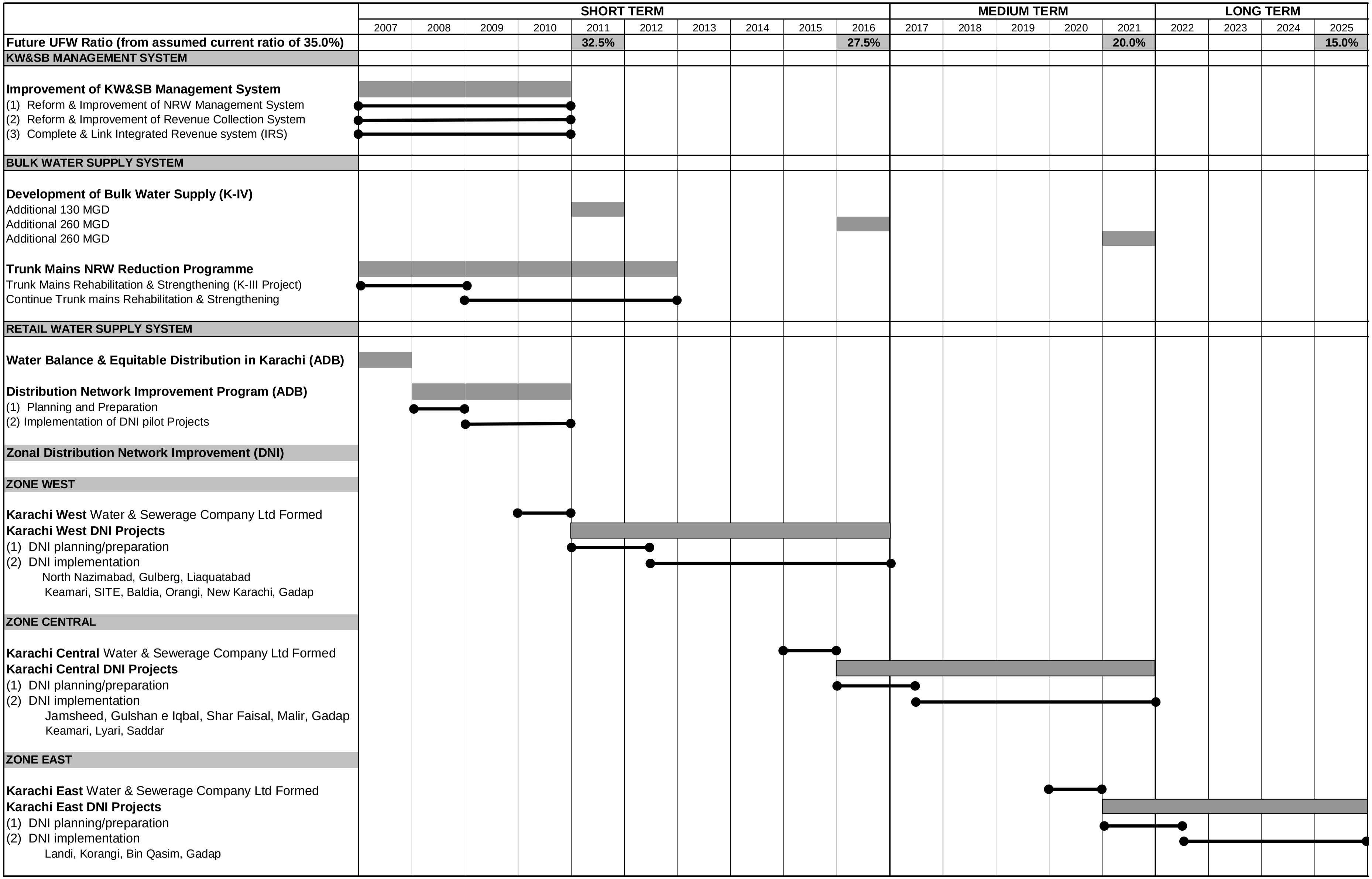


Figure S44.3.1 Timescales for Reduction of NRW

S4.4.4 Improvement of Revenue Collection System

The key to a successful water & sewerage service provider is to have the capacity to manage an efficient revenue collection system. Without adequate financial resources, water & sewerage service providers have little chance of sustaining proper operation and maintenance and expand for the future. In the case of KW&SB it has had major problems in its revenue collection system with poor revenue recovery and mounting arrears.

It had been hoped that a combination of monthly billing introduced for "retail" consumers in July 2006 with the inclusion in the bill of 5% of arrears and the imposition of a 10% surcharge on unpaid amounts would lead to a rapid improvement in the collection rate. Although there were some early gains when the monthly billing system was introduced there has been no significant improvement. However the reason for non-payment of bills is not simply a matter of introducing a computerised monthly billing system. The system of bill delivery to the consumers does not work efficiently, the level of service is so poor that consumers see no reason to pay, and disconnection of supply and other punishments have proved unworkable.

In June 2006 KW&SB awarded a 5 year contract to Millennium Systems & Consultants (Pvt) Ltd. (MSCL) for the printing of bills and other services at a cost of Rs 4 per bill comprising:

- Printing of Consumers monthly Bills for both retail and bulk
- Develop & Implement application software for billing related complaints management
- Develop & Implement application software for billing related MIS
- Data Entry of changes in billing Database
- Correlate KW&SB Billing Database with Citibank
- Establish a Billing Complaints Centre at premises provided by KW&SB
- Establish a Software Development Centre for developing application software for KW&SB

The MSCL facility is located in the recently refurbished Revenue Secretariat in the KW&SB office complex at 9th mile Karsaz, Shara-e-Faisal which also houses the newly established Consumers Service Centre (CSC), the CRO and his supporting departments, and the Bulk Transmission departments concerned with billing & collection of bulk metreed supplies. MSCL have a staff of 26 including 10 for the two shift telephone complaints centre currently open from 0900 hrs to 2200 hrs.

Bills are produced monthly for about 1 million retail (domestic un-metreed) consumers and about 5,000 bulk metreed consumers. The bills are for water, sewerage, conservancy and fire and include 5% of the arrears for payment each month with a surcharge of 10% for non-payment. Monthly bills are printed at a separate facility, boxed for collection by KW&SB staff for distribution from the KW&SB Town offices. Bulk consumer bills are delivered by the metre readers, retails bills are delivered by revenue staff at the town offices. There is known to be a problem with bill delivery due to confusion over addresses and lack of personnel.

The payment system is very high-tech and includes payment through mobile 'phones, credit cards and cheques but also caters for the 65% of population who don't have bank accounts with cash payments at banks or conveniently located NADRA kiosks. The aim was to increase the number of registered retail consumers to 1.2 million by the end of the first year of operation (June 2007), but this has not materialised.

Payment may be made through 550 branches of 9 banks, all payments being consolidated daily through Citibank who pass the information on to MSCL on CD with about a 2 day time lag. In November 2006, KW&SB signed an accord with NADRA for payment of bills through their system of Kiosks. Currently this service is available at 66 kiosks and will be extended to all 178

UCs in the future. All bills include the sum of Rs 8 to cover the bank charges.

Improvement of the management system for billing & revenue collection is a vital and urgent task. Recent interventions appear to have had limited success in terms of improved revenue collection. Despite changes to the management of the bulk supply the payment of bills and revenue collection remains unacceptably low. The split to 5 administrative zones does not show any significant change to the revenue stream. KW&SB would be well advised to urgently add the following to its internal reforms:

- Review and revise the bill delivery system
- Update the Register of Consumers

With the introduction of the latest technology and data management (IRS-MIS) KW&SB must not miss the opportunity to train its own revenue staff for strengthening of its management capacity. Strengthening is also required for the new CSCs requiring both IT skills training and training for dealing with complaint management.

S4.4.5 Establishment of Sustainable Data Management

A Geographic Information System (GIS) is generally defined as a computer based technology used to collect, store, manipulate, analyse and display geographically referenced data. GIS links spatial data to non-spatial attribute data. One of the main strengths of GIS is the capability to overlay information in different thematic layers, revealing complex spatial relationships between physical, social, and economic variables.

GIS has wide applicability in a municipality, utility, or government agencies. In developed countries, water and wastewater utilities are increasingly adopting GIS to perform day-to-day operations, maintenance, data management and customer service. Utilities can also use GIS for demand analysis, facility expansion planning, and network design based on hydraulic modelling and infrastructure management. KW&SB should develop its own GIS system according to their requirements.

Considering the existing problems in the water supply and sewerage facility operation and maintenance in Karachi, GIS applications for asset/facility management is the most important and basic requirements of the GIS development for KW&SB. GIS-based asset/facility management will increase the efficiency in renewal, expansion and disposal of the facilities as well as operation and maintenance.

JICA Study Team adopted GIS-based facility mapping using high resolution Quick Bird satellite imageries (0.6m resolution) for build-up areas and SPOT imageries (2.5m resolution) for surrounding rural areas; based on which accurate maps of existing major facilities for the planning of future facility improvements were prepared.

JICA Study Team has already carried out the GIS-based facility mapping in the following steps using 'ESRI's ArcGIS' software.

1) Evaluation of required base map
2) Acquisition of high resolution satellite imageries
3) Image processing and geo-referencing of the satellite imageries to use them as the foundation of base map
4) Digitisation of basic topographic futures such as roads and rivers from the satellite imageries as part of the base map.
5) Collection of existing facility maps and drawings from KW&SB's offices.
6) Scanning of the collected maps and drawings
7) Digitisation of the scanned maps and drawings into GIS layers

8) Rectification of the digitised information with the help of KW&SB's engineers using the satellite imageries.

By November 2007, the JICA Study team have completed digitisation and rectification processes on the following information and infrastructure.

- topographic information such as roads, rivers, canals, railways
- administrative boundaries of CDGK, 18 TMAs and 178 UCs
- the entire Bulk Water Supply System from the Kinjhar Lake to Karachi
- 405 km trunk distribution pipes
- 643 km distribution mains 10 inches and larger in diametre
- 325 km trunk sewers 18 inches and larger in diametre
- water distribution pumping stations
- sewage treatment plants and pumping stations

The facility maps created using the GIS software have been used by the JICA Study team for the analysis of existing systems and the planning of future development as well as for the presentations of the Master Plan.

Establishment of GIS department within KW&SB has been discussed with KW&SB. One of the concerns is the sustainability of the GIS system after completion of the JICA Study. Since September 2007, JICA Study team have been providing on-the-job training for 2 officials nominated by KW&SB. These officials have been seconded to the JICA Study Team on a full time basis and have been working on the digitisation of small diametre distribution mains on a town-by-town basis under the guidance of the JICA Study team. They will be able to continue the work even after completion of the JICA Study. In the meantime, the JICA Study team have suggested that KW&SB should establish a 'GIS Department' and develop its GIS system on a stage-by-stage basis corresponding to the changes in the actual needs. The stage-by-stage development is proposed to avoid over-investments in early stages.

It is recommended that initially KW&SB should use the GIS system only for producing facility maps. The management of the GIS system requires the continuous updates of facility data. In order to maintain the sustainability of the GIS system, it is also recommended that KW&SB should not contract out the management of the GIS system to local consultants.

The least-required resources for Initial Stage of the GIS Development within KW&SB are shown in **Table S44.5.1**.

Table S44.5.1 Human Resources, Software, Hardware Required for Initial Stage

Category	Items	Number	Required Experience, Specifications, etc.
Human Resources	GIS Manager	1	experience with GIS development planning, facility management, image processing, etc.
	GIS Operator	2	experience with geo-referencing and digitisation, etc.
	Office Assistant/System Technician	1	management of appointments with engineers, maintenance of the system, etc.
Hardware	High Performance PC	1	for image processing, etc. (3.2GHz dual core processor, 4GB RAM, Two SCSI HDs of 146GB, Graphic Card of 256MB)
	Middle Performance PC	2	for Digitisation, etc. (2.8GHz CPU, 1.5GB RAM, SATA HD of 200GB, Graphic Card of 256MB)
	Low Performance PC	1	for distraction work, etc.
	Colour Printer	1	A3 size ink jet
Software	ESRI ArcInfo	1	for geo-referencing and spatial analysis, etc.
	ESRI ArcView	2	for digitisation, inquiring and printing
	ERDAS Imagine	1	for image processing
	Standard Software	4	MS Windows, MS Office, Norton Anti Virus

S4.4.6 Improvement of Customer Services

KW&SB do not have a clear customer mandate describing the levels of services to be provided and the responsibilities of customers to pay bills, settle arrears and to comply with regulations with respect to illegal connections, tampering with supplies, etc. KW&SB does not conduct regular customer surveys to ensure that all customers who receive a supply are registered on the billing database. Whilst there is evidence of illegal connections and 'stealing' of water on a large scale, audits are not systematically conducted. Opinion surveys are not used to improve service shortfalls.

KW&SB does not have a 'Customer Service Strategy' or service policy in place. Consequently, customer service practices and standards vary within and across Regions and are highly dependent on local management attitudes towards customer service provision. KW&SB will therefore need to consider introduction of a strategy that clearly details the organisation's strategic intent with regard to customer services. This should state short and long term service aspirations and service standards to be applied across the customer base.

Based on the recent drive to improve revenue collection it is evident that KW&SB have recognised the paramount importance that good customer service practices has on the success of the organisation. Control of the revenue stream is vital to long-term financial sustainability and proper, responsible control of revenue through accurate metreing and billing followed by responsive collection will ensure that KW&SB's financial position is sufficiently healthy to sustain growth and investment in future. In addition, timely response to customer service inquiries and requests (as well as complaints handling) is essential in building public confidence and support of the utility's management.

KW&SB will need to adopt a focused, pro-active approach to complaints handling. To ensure that procedures are followed, timescales are met, and that standards of response are satisfactory, responsibility for complaint management should be assigned to dedicated teams who are trained to handle, track, progress chase, and monitor complaints. All complaints should be recorded and coded as such to allow accurate information to be produced about the volume and nature of complaints received, and about response times to resolve them. This information should be used for the purposes of monitoring performance against the agreed standards and also for identifying trends in complaint volumes/types.

With the view of improving awareness and company image, KW&SB could also consider a regular programme of “open houses”, ‘road shows’, talks and presentations to the general public, community groups and businesses. Additionally as part of KW&SB’s website strategy, customers should be able to obtain basic billing and operational information, for example, a guide to rates, what to do if you spot a leak, advice on saving water, etc.

KW&SB will want to maximise the use of customer feedback and consult with customers about current and future standards of service. In this way KW&SB would be able to monitor actual performance, measure the effectiveness of any changes implemented, and anticipate future requirements. In addition, consulting with customers will help KW&SB to establish a direct relationship with customers and to demonstrate that customers’ opinions are valued. Not all customers have the same level of expectations and requirements. Customer surveys will help KW&SB to identify and prioritise the elements and levels of service required by different customer types.

S4.4.7 Human Resource Development

Like other government establishments, KW&SB are bound by various civil service rules and regulation ‘imposed’ from time to time. This has influenced the current civil service ‘values and behaviours’ and is largely the cause of low morale and lack of motivation and enthusiasm prevalent throughout the organisation. Many employees have long service with KW&SB, turnover of staff has been negligible (apart from retirement) and recruitment has effectively been put on hold for the past few years. The practice of promoting staff based almost entirely on seniority rather than on ‘ability to do the job’ does little to encourage the development of sustainable policies and processes for improved performance. At the same time valuable experience and knowledge is being lost as routines are not in place to capture and transfer knowledge.

The current policy of internal transfers and promotions from within the organisation and no external recruitment (until most recently, whereby graduate engineers are currently being recruited) despite some obvious skill gaps is becoming more and more evident, not least due to the need to introduce new systems and technologies etc. to improve business, commercial and operational performance.

KW&SB do not have a formal training policy or documentation regarding the training and development needs of individuals or KW&SB as a whole. However, both internal and external training is provided as funds allow. It is recommended that all training in future is based on individual and departmental development needs and should be targeted and prioritised, rather than be made available to those who have time to attend.

The quality and success of training imparted is not measured or monitored. We recommend introduction of a system that measures the effectiveness of training delivered and the effects of training on the trainee’s performance. Currently, KW&SB do not have a formal policy on career development or a career development and progression planning process, although criteria is well established for promotions and job transfers.

KW&SB do not have a system in place for formally setting or communicating corporate, departmental or personal performance targets/key performance indicators and performance measures are not formally set or monitored. ‘Job descriptions’ are not widely used and therefore, key tasks and priorities and how these are measured are not always clearly understood. For KW&SB to be a successful service organisation, employees must know what is expected of them and to have the opportunity to learn new skills to improve their contribution to the ‘Business’. A system for sharing corporate objectives has not been developed and therefore, it is not clear how departmental or functional objectives are set and measured to ensure that these contribute to wider corporate goals. Similarly a system for sharing departmental objectives has not been developed and therefore it is not clear how individual's objectives contribute to wider departmental objectives.

The current system of 'rewards and recognition' (terms and conditions) does not relate to performance and therefore good performance goes largely 'unrecognised' and poor performance goes largely 'un-checked'. No or little feedback is given to individuals regarding their performance; consequently, training or future development needs are not formally discussed, agreed or documented.

S4.5 PRELIMINARY COST ESTIMATES AND IMPLEMENTATION SCHEDULES

S4.5.1 CONDITION OF COST ESTIMATE

(1) Construction Cost

The capital costs of the proposed water supply and sewerage projects were estimated based on the data and information provided in the following documents using the conditions and assumptions shown in **Table S45.1.1**.

a) JBIC-financed Karachi Water Supply Improvement Project – Contract Documents
b) K-III Project – Contract Documents
c) Tameer-e-Karachi Project – Trunk Mains Installation Contracts
d) K-IV Project, Greater Karachi Water Supply Scheme, Executive Summary May 2007
e) Greater Karachi Sewerage (S-III) Project – PC-1 Documents
f) Schedule of Rate, Government of Sindh, October 1, 2004
g) Catalogue prices of manufacturers and suppliers

Table S45.1.1 Conditions and Assumptions Used for Estimate

(a)	Base Cost	Current price in 2007
(b)	Engineering Fees	7.5% of (a)
(c)	Physical Contingency	5% of [(a) + (b) + land acquisition cost]
(d)	Price Contingency	1.5% of (c) for F/C component, 6.0% of (c) for L/C component
(e)	Project Administration	1.5% of (d)

(2) Operation and Maintenance Cost

Operation costs comprise personnel costs, electricity costs, diesel fuel costs, chemical costs, sludge disposal costs (sewerage) and other. These costs were estimated based on the total pumping capacity in case of a pumping station and the total treatment capacity in case of a water treatment plant or a sewage treatment plant. Maintenance costs of mechanical and electrical equipments of pumping stations, water treatment plants and sewage treatment plants were calculated based on their construction costs. Maintenance costs of sewers were presumed to depend on the length.

S4.5.2 Cost Estimates

(1) Initial Cost

A summary of the Initial costs for the water supply components and sewerage components are presented in **Table S45.2.1**.and **S45.2.2** respectively. Overall total basic cost (TBC) and total project cost (TPC) including both water supply and sewerage projects are as follow.

Overall TBC: Rs. 319,347 Million
Overall TPC: Rs. 519,894 Million

(2) Operation and Maintenance Cost

A summary of the operation and maintenance cost for the water supply components and sewerage are presented in **Table S45.2.3** and **S45.2.4** respectively

Table S45.2.1 Cost Estimate for Water Supply Components (Million Rs.)

		Total	Breakdown	
			F/C	L/C
(A)	Bulk Water Supply		60%	40%
		72,641	43,362	29,279
(B)	Zone West		72%	28%
		52,653	37,691	14,962
(C)	Zone Central		71%	29%
		58,527	41,803	16,724
(D)	Zone East		71%	29%
		30,252	21,541	8,711
Total Base Cost (TBC)			67%	33%
		214,073	144,397	69,676
(E)	Engineering Fees		70%	30%
		16,055	11,238	4,816
(F)	Land Acquisition		0%	100%
		1,547	0	1,547
(G)	Physical Contingency		67%	33%
		11,583	7,781	3,802
Sub-total (TBC+E+F+G)			67%	33%
		243,257	163,416	79,841
(H)	Price Contingency		30%	70%
		80,792	24,052	56,740
Sub-total (TBC+E+F+G+H)			58%	42%
		324,049	187,468	136,581
(I)	Project Administration		0%	100%
		4,861	0	4,861
Total Project Cost (TPC)			57%	43%
		328,910	187,468	141,441

Table S45.2.2 Cost Estimate for Sewerage Components (Million Rs.)

		Total	Breakdown	
			F/C	L/C
(A) Zone West				
	TP-1 and TP-3 District		44%	56%
		24,002	10,532	13,470
	TP-2 District		21%	79%
		4,122	871	3,251
	Sub Total		41%	59%
		28,124	11,403	16,721
(B) Zone Central				
	TP-1 and TP-3 District		44%	56%
		2,563	1,117	1,446
	TP-2 District		52%	48%
		19,101	9,911	9,190
	TP-4 District		23%	77%
		14,861	3,395	11,466
	Sub Total		39%	61%
		36,525	14,423	22,102
(C) Zone East				
	TP-4 District		50%	50%
		40,625	20,147	20,478
	Sub Total		50%	50%
		40,625	20,147	20,478
Total Base Cost (TBC)			44%	56%
		105,274	45,973	59,301
(D)	Engineering Fees		70%	30%
		7,896	5,527	2,369
(E)	Land Acquisition		0%	100%
		18	0	18
(F)	Physical Contingency		45%	55%
		5,660	2,575	3,085
Sub-total (TBC+D+E+F)		0	45%	55%
		118,848	54,075	64,773
(G)	Price Contingency		14%	86%
		69,313	9,477	59,836
Sub-total (TBC+D+E+F+G)			34%	66%
		188,161	63,552	124,609
(H)	Project Administration		0%	100%
		2,823	0	2,823
Total Project Cost (TPC)			33%	67%
		190,984	63,552	127,432

Table S45.2.3 Operation and Maintenance Cost of Water Supply Component

(Million Rs./year)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Bulk Water Supply System (Common)																		
Operation Cost	991	991	991	991	1,437	1,503	1,503	1,503	1,503	2,070	2,211	2,351	2,492	2,524	2,777	2,918	3,059	3,200
Maintenance Cost	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Total	999	999	999	999	1,445	1,511	1,511	1,511	1,511	2,078	2,219	2,360	2,500	2,532	2,785	2,926	3,067	3,208
Bulk Water Supply System (Zone West)																		
Operation Cost	73	73	73	73	73	73	73	73	73	196	197	199	201	203	330	340	350	360
Maintenance Cost	4	4	4	4	8	8	8	8	8	21	21	21	21	21	35	35	35	35
Total	78	78	78	78	81	81	81	81	81	217	218	220	222	224	365	375	385	395
Bulk Water Supply System (Zone Central)																		
Operation Cost	310	310	310	310	627	646	665	683	702	706	711	715	720	724	739	750	761	772
Maintenance Cost	14	14	14	14	41	41	41	41	41	60	60	60	60	60	79	79	79	79
Total	324	324	324	324	668	687	705	724	742	766	770	775	779	784	817	828	839	850
Bulk Water Supply System (Zone East)																		
Operation Cost	354	355	355	355	355	355	355	355	355	481	486	492	497	503	636	646	655	665
Maintenance Cost	8	8	8	8	8	8	8	8	8	16	16	16	16	16	23	23	23	23
Total	362	364	364	364	364	364	364	364	364	497	502	508	513	519	660	669	679	688
Total																		
Operation Cost	1,727	1,729	1,729	1,729	2,493	2,578	2,596	2,615	2,633	3,452	3,605	3,758	3,911	3,954	4,483	4,654	4,825	4,996
Maintenance Cost	35	35	35	35	65	65	65	65	65	105	105	105	105	105	145	145	145	145
Total	1,762	1,764	1,764	1,764	2,557	2,643	2,661	2,680	2,698	3,557	3,710	3,862	4,015	4,058	4,627	4,799	4,970	5,141

Table S45.2.4 Operation and Maintenance Cost of Sewerage Components

(Million Rs./year)

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Zone West																			
TP-1 and TP-3 District	Operation Cost	9	9	9	9	9	9	32	74	78	145	152	160	179	186	198	209	222	233
	Maintenance Cost	14	14	14	14	14	14	28	51	53	92	95	98	102	105	112	117	127	133
	Sub Total	24	24	24	24	24	24	61	125	131	237	247	258	281	291	309	326	349	366
TP-2 District	Operation Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maintenance Cost	0	0	0	0	2	2	7	12	12	17	17	17	17	19	22	24	26	29
	Sub Total	0	0	0	0	2	2	7	12	12	17	17	17	17	19	22	24	26	29
Sub Total	Operation Cost	9	9	9	9	9	9	32	74	78	145	152	160	179	186	198	209	222	233
	Maintenance Cost	14	14	14	14	16	16	35	63	66	109	112	114	119	124	134	141	154	161
	Sub Total	24	24	24	24	26	26	67	136	144	254	264	274	298	311	331	350	375	395
Zone Central																			
TP-1 and TP-3 District	Operation Cost	7	7	7	7	8	8	12	12	13	13	14	14	15	15	16	16	17	17
	Maintenance Cost	1	1	1	1	1	1	5	7	8	12	12	13	14	14	15	16	17	18
	Sub Total	8	9	9	9	9	9	16	20	20	25	26	27	28	29	31	32	34	35
TP-2 District	Operation Cost	0	0	0	0	0	0	0	0	0	0	0	0	156	182	202	221	241	261
	Maintenance Cost	0	0	0	0	0	0	0	0	0	0	0	0	44	53	57	65	69	76
	Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	201	235	259	286	309	338
TP-4 District	Operation Cost	0	0	0	0	0	0	0	0	0	0	0	7	8	9	10	10	11	12
	Maintenance Cost	0	0	0	0	13	14	16	17	18	27	36	45	53	62	74	85	96	106
	Sub Total	0	0	0	0	13	14	16	17	18	27	36	51	61	71	84	95	107	118
Sub Total	Operation Cost	7	7	7	7	8	8	12	12	13	13	14	21	179	206	227	248	269	290
	Maintenance Cost	1	1	1	1	14	16	20	25	26	39	48	57	111	129	146	166	181	201
	Sub Total	8	9	9	9	22	24	32	37	39	52	62	78	290	335	373	414	450	491
Zone East																			
TP-4 District	Operation Cost	0	0	0	0	59	64	68	73	77	112	155	201	260	306	363	427	495	553
	Maintenance Cost	0	0	0	0	20	26	27	28	29	45	56	67	85	96	109	127	145	158
	Sub Total	0	0	0	0	78	90	95	100	106	157	211	268	344	402	472	554	639	712
Sub Total	Operation Cost	0	0	0	0	59	64	68	73	77	112	155	201	260	306	363	427	495	553
	Maintenance Cost	0	0	0	0	20	26	27	28	29	45	56	67	85	96	109	127	145	158
	Sub Total	0	0	0	0	78	90	95	100	106	157	211	268	344	402	472	554	639	712
Total																			
Total	Operation Cost	16	17	17	17	76	81	113	158	167	269	321	381	618	699	788	884	985	1,077
	Maintenance Cost	16	16	16	16	50	58	82	115	121	193	216	239	315	349	388	433	480	520
	Sub Total	32	32	32	33	126	139	194	274	288	462	537	620	932	1,048	1,176	1,318	1,464	1,597

S4.5.3 IMPLEMENTATION / DISBURSEMENT SCHEDULE

(1) General

Proposed water supply and sewerage projects are implemented during the period between 2008 and 2025. These projects are allocated as follows. The whole implementation is divided into three stages, namely, Stage I (Target year: 2016), Stage II (Target Year: 2021) and Stage III (Target Year: 2025).

(2) Schedule of Water Supply Projects

A summary of implementation schedule of the water supply component is shown in **Table S45.3.1.**

(3) Schedule of Sewerage Projects

A summary of implementation schedule of the sewerage component is shown in **Table S45.3.2**.

Table S45.3.1 Implementation Schedule of Water Supply Projects

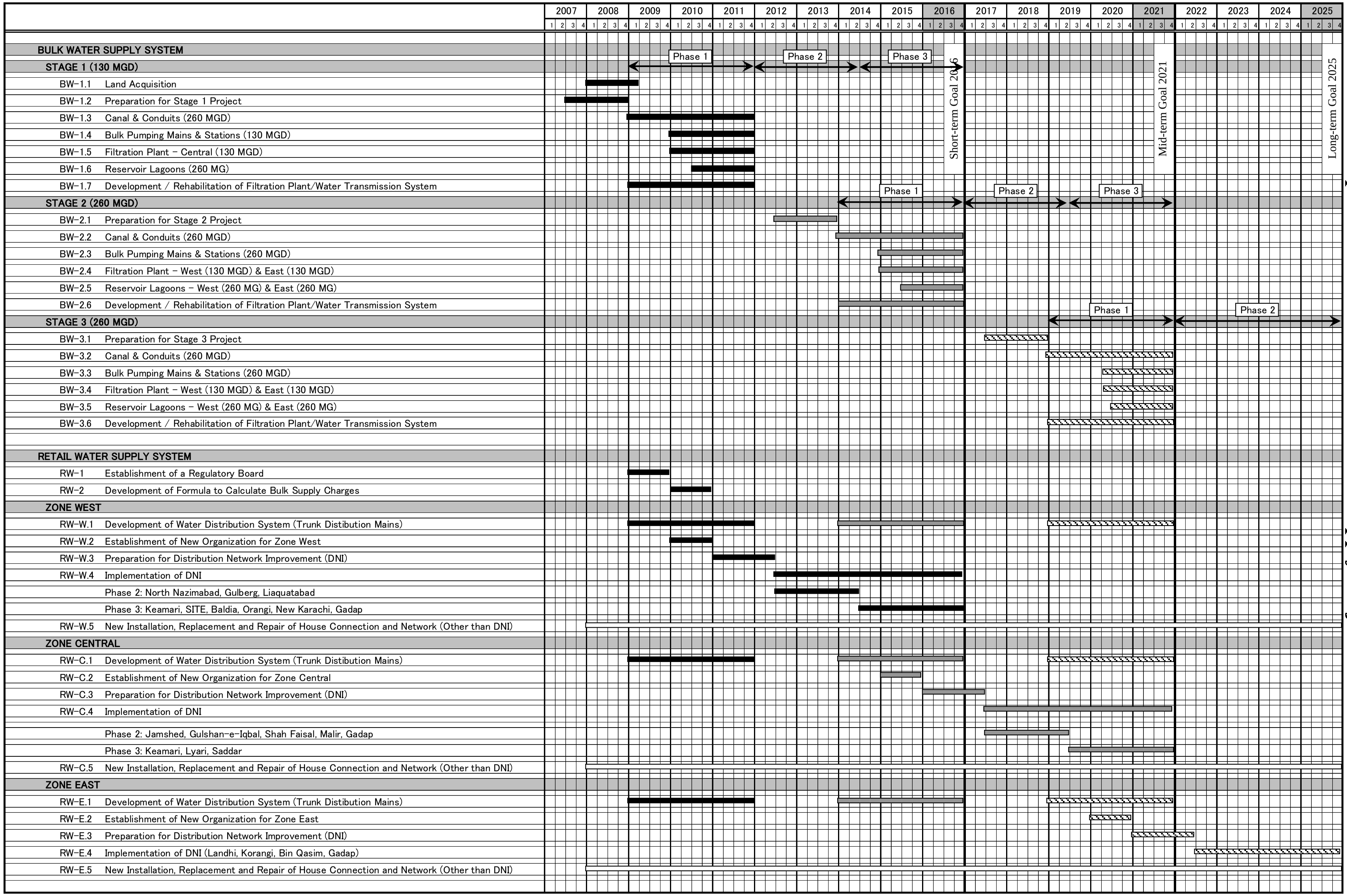


Table S45.3.2 Implementation Schedule of Sewerage Projects

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
SEWERAGE COMPONENTS																				
ZONE WEST																				
TP-1 AND TP-3 DISTRICT																				
A-1	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump						■	■	■											
	New Branch Sewer / Small Pump						■	■	■	■	■	■	■	■	■	■	■	■	■	■
A-2	Trunk Sewer																			
	New Trunk Sewer (North Nazimabad, Gulberg and Liaquatabad)						■	■	■											
	Other New Trunk Sewer									■	■	■	■	■						
	New Effluent Discharging Channel of TP-1									■	■									
A-3 (1)	Sewage Treatment Plant TP-1																			
	Rehabilitation of Existing Facility						■	■	■											
	Extension of Facility									■	■		■	■	■	■	■	■		
A-3 (2)	Sewage Treatment Plant TP-3																			
	Rehabilitation of Existing Facility						■	■	■											
	Extension of Main Pump														■	■				
TP-2 DISTRICT																				
A-4	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump									■	■									
	New Branch Sewer / Small Pump						■	■	■	■	■	■	■	■	■	■	■	■	■	■
A-5	Trunk Sewer																			
	Extension of Lyari Interceptor		■	■	■	■														
	Other New Trunk Sewer									■	■						■	■	■	
ZONE CENTRAL																				
TP-1 AND TP-3 DISTRICT																				
B-1	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump											■	■	■						
	New Branch Sewer / Small Pump						■	■	■	■	■	■	■	■	■	■	■	■	■	■
B-2	Trunk Sewer																			
	New Trunk Sewer											■	■	■						
B-3	Pumping Station																			
	Rehabilitation of Jamila Pumping Station											■	■							
	Rehabilitation of Chakiwara Pumping Station											■	■							
TP-2 DISTRICT																				
B-4	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump											■	■	■						
	New Branch Sewer / Small Pump						■	■	■	■	■	■	■	■	■	■	■	■	■	■
B-5	Trunk Sewer																			
	New Trunk Sewer											■	■	■	■	■				
	New Effluent Discharging Channel of TP-2											■	■							
B-6	Pumping Station																			
	Gulberg Pumping Station (New)											■	■		■	■				
	Rehabilitation of Clifton Pumping Station											■	■		■	■				
B-7	Sewage Treatment Plant TP-2																			
	Rehabilitation of Existing Facility											■	■	■						
	Extension of Facility											■	■	■	■	■	■	■		
TP-4 DISTRICT																				
B-8	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump											■	■	■	■	■				
	New Branch Sewer / Small Pump						■	■	■	■	■	■	■	■	■	■	■	■	■	■
B-9	Trunk Sewer																			
	Malir Interceptor (Right Bank)		■	■	■	■														
	Other New Trunk Sewer											■	■	■	■	■				
B-10	Pumping Station																			
	Karachi Port Pumping Station (New)											■	■							
ZONE EAST																				
TP-4 DISTRICT																				
C-1	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																■	■	■	■
	New Branch Sewer / Small Pump						■	■	■	■	■	■	■	■	■	■	■	■	■	■
C-2	Trunk Sewer																			
	Malir Interceptor (Left Bank)		■	■	■	■														
	Other New Trunk Sewer											■	■	■			■	■	■	
C-3	Pumping Station																			
	Rehabilitation of Korangi Pumping Station											■	■							
	Bin Qasim Pumping Station (New)																■	■		
C-4	Sewage Treatment Plant TP-4																			
	Construction / Extension of Facility		■	■	■	■				■	■	■	■	■	■	■	■	■	■	

S4.6 EVALUATION OF MASTER PLAN AND SELECTION OF PRIORITY PROJECTS

S4.6.1 Environmental and Social Evaluation of Master Plan

(1) Water Supply System

From environmental and social point of view, the water supply system will improve the living condition, public health, standard of living and contribute to encouraging economic growth. However, the implementation of the Master Plan may cause the environmental and social impacts summarised below, thus the mitigation measures should be taken during both construction and operational stages.

- The land acquisition will be needed for the proposed facilities of distribution reservoirs and pumping stations. The sites for eight distribution reservoirs and three pumping stations were carefully selected and they were planned to be constructed at arid or vacant land. Hence, non-spontaneous resettlement will not occur. KW&SB should acquire the necessary land by strictly complying with the Land Acquisition Act 1894 and National Resettlement Policy to compensate for lost private properties.
- The construction of pipelines such as transmission & distribution mains will cause the serious traffic disturbance within the Karachi City. To mitigate this impact, the schedule of installation of pipelines should be informed in advance, traffic should be controlled and relief road should be proposed.
- The areas that are provided with no water supply or low quality service are watered by tankers operated and managed by Rangers. As the water supply service area will be expanded by Master Plan, it will affect the sales by tankers of Rangers. However, as the water supply facilities will be constructed step by step till 2025, the demand for tankers water supply will not decrease immediately. KW&SB have to consult with them on this matter.

Overall, implementation of proposed water supply system in Master Plan is necessary as water is inevitable for human life. Some impacts will be expected by construction and operation of these facilities but these impacts can be avoided / minimised by taking appropriate mitigation measures and proper operation and maintenance of facilities.

(2) Sewerage System

From environmental and social point of view, the sewerage system will improve the living condition, public health, standard of living, water quality of water bodies such as rivers and sea, and contribute to encouraging economic growth. However, the implementation of the Master Plan may cause the environmental and social impacts summarised below, thus the mitigation measures should be taken during both construction and operational stages.

- The land acquisition will be needed for the proposed facilities of pumping stations and TP-4. The land for TP-4 is already acquired by CDGK and no impact will be expected. Resettlement can be avoidable by carefully selecting the location of pumping stations but their land acquisition is inevitable. KW&SB should acquire the necessary land by strictly complying with the Land Acquisition Act 1894 and National Resettlement Policy to compensate for lost private properties.
- The construction of sewers such as pressure mains and trunk sewers will cause the serious traffic disturbance within the Karachi City. To mitigate this impact, their installation schedule should be informed in advance, traffic should be controlled and relief road should be proposed.
- As a result of sewage treatment, the treated sewage and sludge will be generated. As long as effluent meets the Pakistan's standards, it will not affect the water quality of

receiving water bodies. Rather, it will improve water qualities there. The sludge from the existing TPs is used as soil conditioner and this will be applied to proposed TP-4. If the sludge will be disposed of, it should be done in environmentally sound manner at appropriate location.

- TPs will generally emit odour unless they are properly operated, and odour comes from the sludge handling system such as sludge drying beds. It is the most effective mitigation measure for TPs to be operated and maintained properly. The sludge drying bed should be located away from the residential area as far as possible. It is recommended to set buffer zone to mitigate the impact.

Overall, implementation of proposed sewerage system in Master Plan is necessary since sewage collection and its treatment is inevitable for human life. Some impacts will be expected by construction and operation of these facilities but these impacts can be avoided / minimised by taking appropriate mitigation measures and proper operation and maintenance of facilities.

(3) EIA Requirement at F/S Stage

The EIA report submission is required with the documents of PC-1 which is the application documents for approval of project implementation to ECNEC (Executive Committee of the National Economic Council). The EIA report is not required at the F/S stage. The environmental and social considerations at EIA level will be conducted in F/S stage to assess the impact which may be expected by the implementation of priority project, to propose the mitigation measures and monitoring plan. The report will include the requirements of Pakistan EIA and will be the basis of the EIA report which will be prepared at the time of submitting PC-1 documents by KW&SB.

S4.6.2 Economic Evaluation of Master Plan

(1) Objectives

In the national economy, there are various economic sectors, such as agriculture, industry, transportation, infrastructure, etc. Even in one sector, there are also various sub-sectors. Infrastructure structure sector, for instance, includes water, sewerage, waste-disposal, electric power, city gas, telecommunication, etc. The projects of these sub-sectors have proposed to produce their products and services for the people through utilising human resources, natural resources, artificial resources, etc. In these projects, economic evaluation proposes the most optimal plan in the fields of resources' utilisation from the viewpoint of national economy.

(2) Criteria and Assumptions

In the economic evaluation in this study, the following criteria and assumptions are applied for estimation of economic value and judgement of the proposed projects.

1) Standard conversion factor: 0.88
2) Price level: the end of January 2007
3) Foreign exchange rate: Rs.60.77 per US$1.00; JP¥121.68 per US$1.00; and JP¥2.00 per Rs.
4) Social discount rate: 12% per annum
5) Distribution of benefit accruing from public health improvement:
   - Water supply 50%
   - Sewerage 20%
   - Waste-disposal 30%
6) Evaluation period: 30 years after the completion of the construction work (2008– 2055)

(3) Water Supply Project

1) Economic Benefit

The tangible economic benefits adopted in this water supply evaluation study are listed up as follows.

a) Benefits from saving costs of domestic water source procurement
b) Benefits from public health improvement
   - Saving of household medical expenditures
   - Saving of medical treatment expenses medical institutions
   - Decrease of absence from work due to illness
c) Benefit from saving costs through improvement of non-domestic water supply system
d) Reduction of O&M expenses in the existing water supply system
e) Negative benefits
   - Removal of existing useless distribution pipes
   - Residual value of existing domestic water supply system in residences
   - Residual value of existing well water supply system in non-domestic user's facilities

The economic tangible benefits mentioned above were quantified on the basis of data and information presented by people and agencies concerned. The total economic benefit was estimated as follows. The total benefit was estimated Rs.75 billion in the target year 2025, although it was negative Rs.3.4 billion in the beginning year 2012 because of large negative benefit. The economic benefits are summarized in **Table S46.2.1**.

Table S46.2.1 Economic Benefits of Water Supply Project (Unit: Rs. Billion)

Benefit Item	2012	2016	2021	2025
1. Domestic Saving Costs	4.81	19.62	44.11	65.19
2. Public Health Improvement	0.92	3.59	7.13	9.65
3. Non-domestic Saving Costs	0.35	1.39	2.92	4.01
4. Reduction of O&M Costs	0.09	0.36	0.78	1.12
5. Negative benefits	-9.59	-6.75	-4.05	-5.32
Total	-3.42	18.20	50.88	74.64

2) Economic Costs

The estimated costs of the proposed project in market prices were converted into economic value applying the standard conversion factor to local cost portion. The economic costs were summarized as follows.

a) Capital investment cost: the total cost by the target year 2025 was calculated at Rs.237 billion in economic value, against the estimated costs of Rs.329 billion in market prices.
b) O&M cost: the O&M cost is annually disbursed for the economic life of the proposed project. The O&M cost starts in 2012, just the beginning year of the distribution network improvement and continues to the end of evaluation in 2055.
c) Replacement cost: The electrical and mechanical equipment is considered that its economic life is 15 years in general. This equipment has to be replaced in every 15 years within the evaluation period consecutively during the evaluation period.

3) Economic Evaluation

The evaluation indices were 15.7% of EIRR, Rs.52.0 billion of NPV and 1.39 of B/C. Then, the project is viable from the economic point of view, because its EIRR was higher than the social discount rate, 12%.

(4) Sewerage Project

1) Economic Benefit

The tangible economic benefits adopted in this sewerage evaluation study are listed up as follows. The economic benefits are summarized in **Table S46.2.2**.

1) Willingness-to-Pay (WtP) of beneficiaries for improved environment
   - Quantified as 1% of household income of beneficiaries in service areas
2) Benefits from public health improvement
   - Saving of household medical expenditures
   - Saving of medical treatment expenses medical institutions
   - Decrease of absence from work due to illness
3) Benefits of saving costs owing to elimination of septic tank management
4) Benefit from environment improved for non-domestic sewage generators
   - Assumed as the same benefit unit value as residents' WtP
5) Reduction of O&M expenses for existing sewerage system
6) Negative benefits
   - Elimination of unnecessary septic tanks
   - Removal of existing useless sewer pipes

Table S46.2.2 Economic Benefit of Sewerage Project (Unit: Rs. Billion)

Benefit Item	2012	2016	2021	2025
1. WtP of residents	0.57	1.59	3.99	6.54
2. Public Health Improvement	0.27	0.77	2.46	3.76
3. Elimination of septic	0.06	0.16	0.50	0.77
4. Effects of non-domestic users	0.28	0.52	1.93	3.21
5. Reduction of O&M Costs	0.02	0.08	0.50	1.10
6. Negative benefits	-0.01	-0.07	-0.14	-0.18
Total	1.19	3.05	9.24	15.22

2) Economic Costs

The estimated costs of the proposed project in market prices were converted into economic value applying the standard conversion factor to local cost portion. The economic costs were summarized as follows.

a) Capital investment cost: the total cost by the target year 2025 was calculated at Rs.203 billion in economic value, against the estimated costs of Rs.381 billion in market value.
b) O&M cost: the O&M cost is annually disbursed for the economic life of the proposed project. The O&M cost starts from the beginning of 2008, when TP3 functions for its service areas. Following that, TP4 starts its service in 2011. TP1 is rehabilitated until 2014, and stats its services in 2015. Finally, sewerage system starts to cover the outer three towns in 2017. These O&M costs continue to the end of evaluation in 2055.
c) Replacement cost: the electrical and mechanical equipment is considered that its economic life is 15 year in general. This equipment has to be replaced in every 15 years within the evaluation period consecutively during the evaluation period.

3) Economic Evaluation

The evaluation indices were 3.8% of EIRR, minus Rs.30.2 billion of NPV and 0.56 of B/C. Then, the project is not viable from the economic point of view, because its EIRR was much lower than the social discount rate, 12%.

4) Economic Evaluation of Sewerage System Excluding Outer Three Towns

One of the reasons of the negative viability above was considered as lower cost performance of the outer three towns in the said sewerage system. Thus, a scheme of the sewerage system excluding the outer three towns is evaluated under the same conditions and assumptions.

The evaluation indices were 6.8% of EIRR, minus Rs.14.5 billion of NPV and 0.69 of B/C. Then, this sewerage scheme is also not viable from the economic point of view. Since this EIRR becomes higher than that of the original scheme, its economic prospect may be more improved than the original case. The EIRR, however, be still lower than 12%, so the implementation of the project would be difficult from the viewpoint of economic viability, unless the planning policy is radically accepted by beneficiaries.

(5) Integrated Project

It is said that the water supply and sewerage service are inseparably related to each other for improvement of living environment. It is a known fact that KW&SB has managed these systems together for long time. Hence, the projects of water supply and sewerage systems are evaluated in combination with these systems, as integrated project. Since two alternative plans were proposed in the sewerage system, two cases of the integrated project are analysed from the economic viewpoint. They are named as (i) the project covering entire areas of Karachi City (Case 1) and (ii) the project excluding the outer three towns (Case 2).

1) Evaluation of Integrated Project (Case 1)

The evaluation indices were 13.3% of EIRR, Rs.21.4 billion of NPV and 1.11 of B/C. Then, the Case 1 project is viable from the economic point of view, although its EIRR was slightly higher than the social discount rate, owing to the good economic efficiency of the water supply system.

2) Evaluation of Integrated Project (Case 2)

The evaluation indices were 14.2% of EIRR, Rs. 37.1 billion of NPV and 1.20 of B/C. Then, the Case 2 is also considered as viable from the economic point of view, because its EIRR considerably exceeds the social discount rate of 12%. This result suggests that the integrated project of Case 2 would be more feasible than Case 1.

S4.6.3 Selection of Priority Projects

(1) Identification of Priority Projects

The existing water distribution network has many problems which combined have resulted in the current low quality of the service in Karachi. Many residents have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges. As a result, KW&SB faces a very low level of revenue collection and severe financial constraints. It is expected that Distribution Network Improvements (DNI) will be able to address those problems efficiently and effectively and thereby substantially improve the current situation. It is also expected that, with the introduction of a ‘dual pricing structure’ as discussed in **Section S4.2.2**, it will be possible to implement DNI on a financially sustainable basis while minimizing negative social impacts and potential wastage and misuse of water by residents at the same time. All these considerations led to a conclusion that DNI should be selected as the ‘Priority Project’ and given a high priority for implementation.

DNI will embrace the rehabilitation of water trunk mains, trunk distribution mains and distribution network mains, and the refurbishment of service connections including installation of retail supply metres. Where necessary, it will also include improvements to the existing sewerage system. In addition, DNI will also have efficient systems with regard to:

- Developing/maintaining GIS-based accurate customer/asset databases
- Metre reading;
- Metre installation/replacement/repair/calibration;
- Billing based on metre reading;

- Bill collection;
- Receiving customer complaints and feedback and responding accordingly;
- Install new service connections;
- Minimizing leakage and wastage;
- Removing/regularizing illegal/unauthorized connections;
- Increasing awareness on water conservation;
- Record keeping and data collection; and
- Liaison with other utility service authorities.

(2) Location of Priority Projects

Given the immense size of the city and the current poor conditions of the existing distribution network, it would require huge investments and more than 10 years of timeframe to complete DNI across all urban areas of Karachi. DNI therefore can only be implemented on an area-by-area basis in a progressive way. With respect to the institutional reform, the JICA Study proposes that Karachi should be divided into three independent retail service zones by the Lyari and Malir Rivers (see **Figure S44.1.1**), and that in the long run the responsibilities for providing retail services (water supply and sewerage services) should gradually be transferred from KW&SB to 'corporatised' retail entities on a zone-by-zone basis as shown in **Figure S44.1.2**. It is also suggested that the first stage of this reform process will take place in Zone West in early 2011, and that the new Zone West retail entity will implement DNI in Zone West.

Zone West encompasses a number of Towns. They are New Karachi, North Nazimabad, Gulberg, Liaquatabad, S.I.T.E., Orangi, Baldia, Keamari and Gadap. With the exception of Keamari and Gadap, other towns are fully developed urban areas. The JICA Study selected three towns, namely North Nazimabad, Gulberg and Liaquatabad, as the 'priority towns' where DNI should be implemented on a priority basis. This selection was made based on the following criteria.

a) Towns where a stable supply can be maintained

One of the key objectives of DNI is to provide a 24-hour continuous supply at an adequate pressure. The results of our water distribution analysis for Zone West have suggested that Orangi, Baldia and S.I.T.E. should be supplied from the Hub Filtration Plant, while Gadap, New Karachi, North Nazimabad, Gulberg and Liaquatabad from the NEK Old Filtration Plant and Keamari from COD Filtration Plant. The analysis also indicated that a sufficient head is available between the NEK Old Filtration Plant and the three towns, namely North Nazimabad, Gulberg and Liaquatabad, and that water from the filtration plant can therefore gravitate across all areas of these three towns at an adequate pressure. Gadap and New Karachi were excluded from the 'priority towns' because of their relatively high altitudes. It is recommended that DNI in these two towns should be delayed until completion of a new K-IV water filtration plant (130 mgd) which is proposed to be constructed at a higher elevation to the north of the NEK Old.

A new 100 mgd water filtration plant is proposed to be constructed at the NEK Old under the first tranche of the ADB's US$ 800 million loan. This will increase the total filtration capacity of the plant to 125 mgd which is sufficient to meet the total water demand of the five towns, namely Gadap, New Karachi, North Nazimabad, Gulberg and Liaquatabad until 2016. It was judged from the foregoing assessments that the 'priority towns' would be able to receive a stable supply once DNI is completed in these towns.

b) Towns where 'Ability to Pay' of residents is high

The residents of the three 'priority towns' have a relatively high 'ability to pay' as compared with the residents of other towns in Zone West. As such, it is expected that they would agree to pay a water charge that is some multiple of the current level of water charges once they receive an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis. This is necessary: (a) to generate the revenues in the short or medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

Figure S46.3.1 shows the location of the three 'priority towns'. **Table S46.3.1** provides some basic features of these towns. The total population in the three towns was approximately 2.4 million in 2005 which was equivalent to 15.8% of the total municipal population in Karachi (15.2 million) or 38% of the total population in Zone West (6.4 million) in the same year.

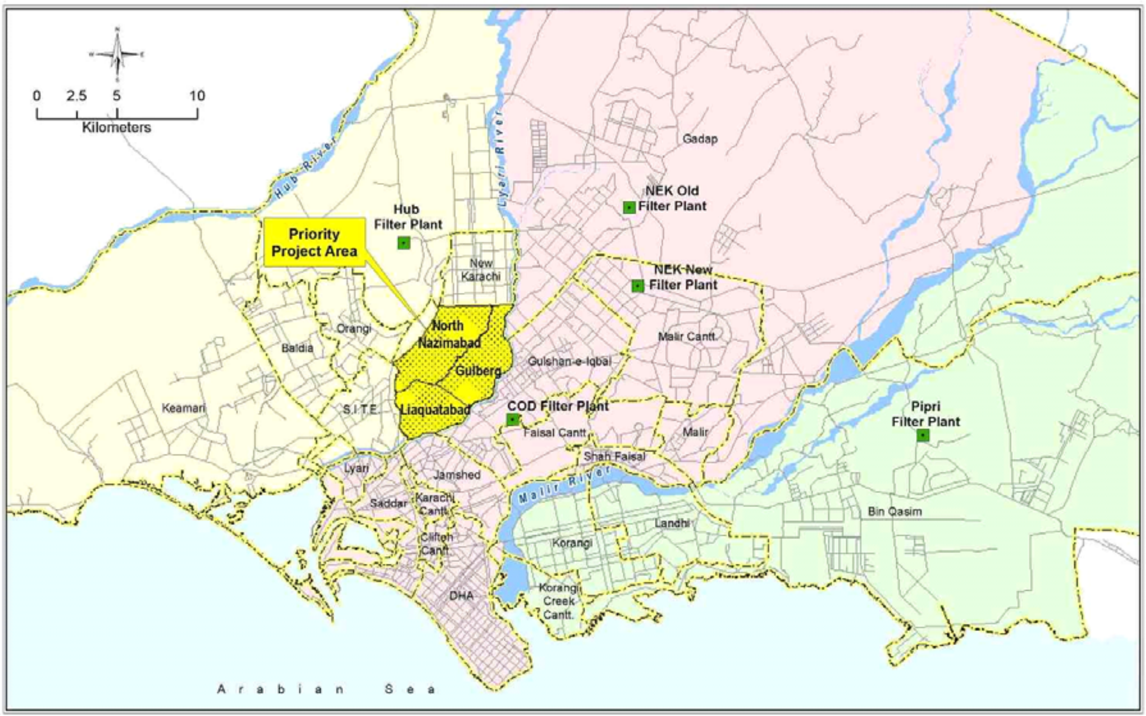


Figure S46.3.1 Location of Three 'Priority Towns'

Table S46.3.1 Basic Features of Three 'Priority Towns'

Town	Area		Population				
	acre*	km^2	2005*	2010	2015	2020*	2025
North Nazimabad	4,127	17	753,423	815,407	889,328	979,450	1,069,572
Gulberg	3,417	14	688,581	745,229	812,788	895,154	977,520
Liaquatabad	2,685	11	985,577	999,095	1,015,211	1,034,860	1,054,509
Total	10,229	42	2,427,581	2,561,741	2,719,342	2,911,484	3,103,626

Source: Figures with *- Karachi Strategic Development Plan 2020 (Final Report, August 2007); other figures-JICA Study Team

S5 FEASIBILITY STUDY

S5.1 SCOPE OF PRIORITY PROJECTS

S5.1.1 Water Supply Project

Distribution Network Improvement (DNI) for the three towns in Zone West (i.e. North Nazimabad, Gulberg and Liaquatabad) was selected as the priority project of water supply in this JICA Study from technical, economical, financial and institutional points of view as described in the previous chapter. The scale of the water supply priority project was set based on the overall schedule of DNI for the whole Karachi City prepared in the stage of Master Plan, water demand, supply capacity and bulk water availability related to K-IV project. The selected priority project includes not only DNI for the three towns but also components for stably and safely conveying filtered water from NEK Old Filtration Plant (F/P) to these three towns as shown in **Figure S51.1.1** and described below:

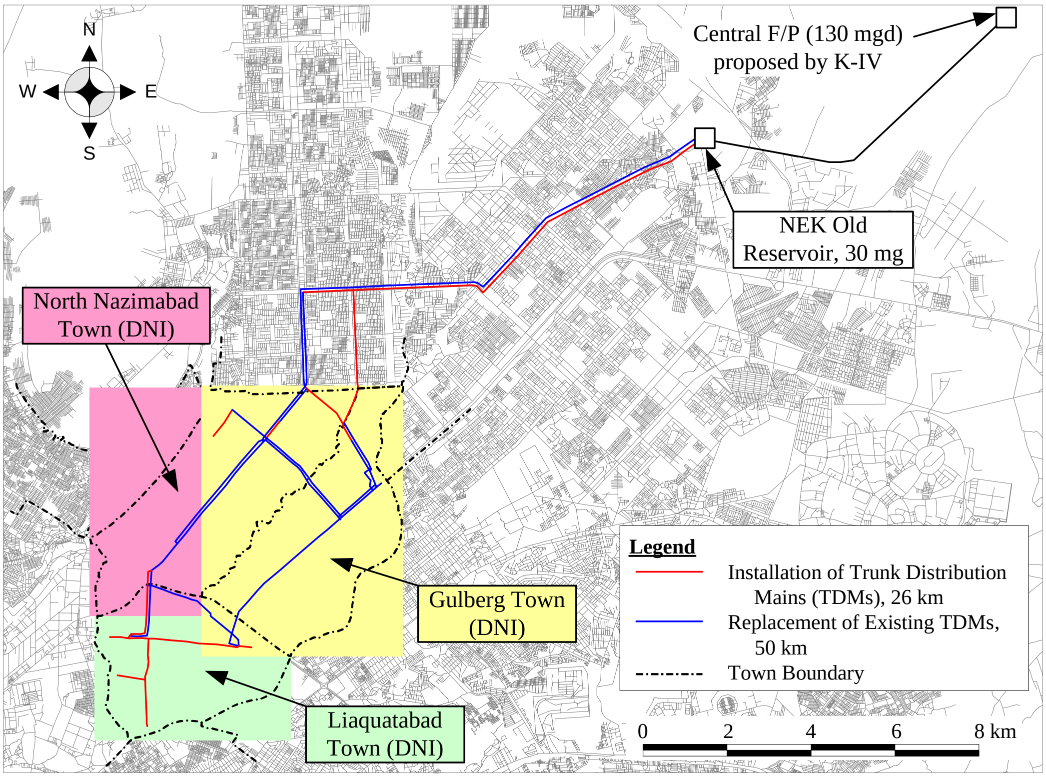


Figure S51.1.1 Components of the Water Supply Priority Project

- Replacement of all the existing distribution network mains in the three towns (about 1,000 km in total length)
- Rehabilitation/replacement of all the existing service pipes branched from the distribution network mains in the three towns (about 230,000 connections in total)
- Installation of individual flow metres at all the existing service connections in the three towns (about 230,000 connections in total)

- Replacement of about 50 km of essential existing trunk distribution mains for supplying water to the three towns (blue lines in **Figure S51.1.1**)
- Installation of about 26 km of new trunk distribution mains (red lines in **Figure S51.1.1**)
- Installation of 17 district flow metres
- Expansion of the existing NEK Old Reservoir (30 mg)

In addition to the above components, it is a precondition for the implementation of the priority project to complete the first phase of K-IV project by the year 2011 successfully. KW&SB should also rehabilitate or replace the existing trunk distribution mains other than those included in the priority project. KW&SB should also execute leakage control before, during and after the DNI in the priority project.

S5.1.2 Sewerage Projects

Sewerage projects selected as priority projects include the collection and treatment of sewage generated in three target towns of North Nazimabad, Gulberg and Liaquatabad where DNI will be implemented as priority projects for water supply. The implementation of DNI will inevitably increase sewage generation, which in turn requires the rehabilitation and extension of sewerage facilities there.

These three towns are already sewered to the extent of 90%, but some rehabilitation works of aged sewers are needed and additional sewers have to be constructed to collect all the generated sewage. Collected sewage flows into either TP-1 or TP-3.

As a whole, sewerage projects targeted in the Feasibility Study include;

- Rehabilitation of branch sewers
- Rehabilitation of two sewage treatment plants of TP-1 and TP-3
- New installation of branch sewers to collect all the generated sewage in the target year
- New installation of sub-main and trunk sewers

Table S51.2.1 shows the major components of the sewerage priority projects and **Figure S51.2.1** shows the location of priority projects.

Table S51.2.1 Major Components of Sewerage Priority Projects

	Name	Dimension/Specification	Quantity	Remarks
Sewers	Branch sewers Sub-main sewers Trunk sewers	10” 12” to 36” Larger than 42”	269 km 43 km 11 km	To rehabilitate or newly install To newly install To newly install
TP-1	Inlet pumps Primary settling tanks Trickling filter Final settling tanks Connecting pipes	0.52 m^3/s/unit 42 m diametre 41.4 m diametre 42 m diametre -	7 units 4 units 8 units 4 units 1 (LS)	Capacity: 110,000 m^3/d Process: high rate trickling filter Only mechanical and associated electrical equipment Connecting inlet works, primary settling tanks, trickling filters and final settling tanks for sewage. Connecting primary/final settling tanks and sludge handling facilities for sludge.
TP-3	Secondary pumps	Vertical centrifugal type 0.83 m^3/s/unit	18 units	Capacity: 245,000 m^3/d Process: stabilization pond

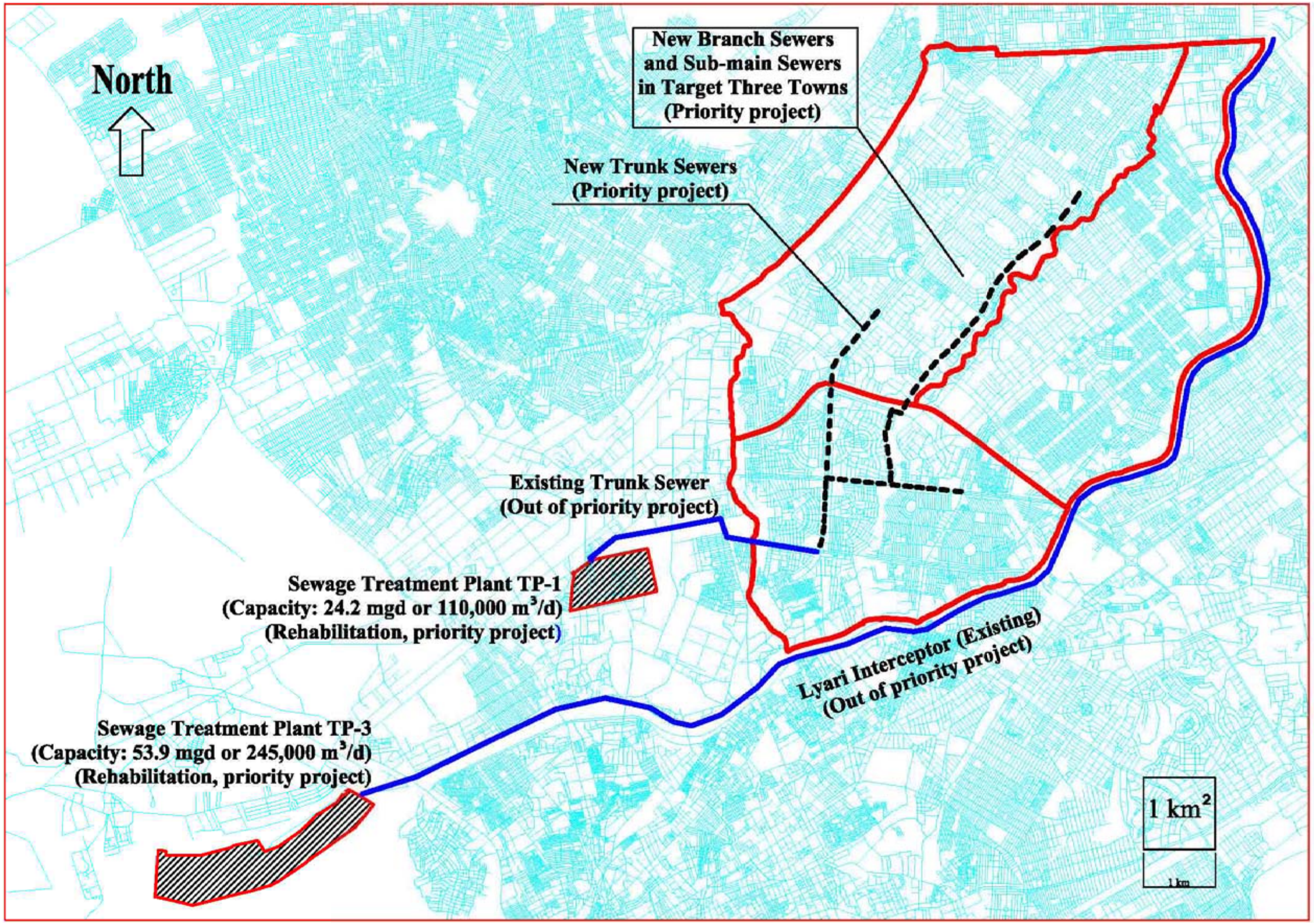


Figure S51.2.1 Location of Priority Projects

S5.2 INSTITUTIONAL DEVELOPMENT

S5.2.1 Establishment of A 'Corporatised' Retail Entity in Zone West

With respect to the institutional reform, the JICA Study suggests that the Karachi city should be divided into three independent retail service zones by the Lyari and Malir Rivers (see **Figure S44.1.1**), and that in the long run the responsibilities for providing retail services (water supply and sewerage services) should gradually be transferred from KW&SB to 'corporatised' retail entities on a zone-by-zone basis as shown in **Figure S44.1.2**. The first stage of this reform process will take place in Zone West in early 2011. The Zone West retail entity will make improvements to the retail services (water supply and sewerage) within the Zone West through implementation of the Distribution Network Improvements (DNI) in the zone. Zone West embraces all of the three 'priority towns' selected in **Section S4.6.3** for implementation of DNI on a priority basis. As such, it is envisaged that DNI in these 'priority towns' will be implemented by the new Zone West retail entity.

The Zone West retail entity would be established as a 'Public Limited Company (PLC)' under the provisions of the Companies Ordinance 1984. The PLC will purchase treated water from KW&SB in bulk and distribute it to retail customers (both residential and non-residential) within Zone West. They will also be accountable for collection, transportation and treatment of sewage generated in Zone West. The PLC would take responsibility for all financial and technical aspects of the operation and management of water supply and sewerage services within Zone West including the collection of tariffs, employment of staff, dealing with customer complaints, etc. The objective of the PLC would be to undertake the operation of water supply and sewerage services in Zone West in accordance with high commercial and professional standards and without external interference in the day-to-day management of the services. There would be no political representation on the Board of the PLC and the articles of association and shareholders' agreement would specify that members of the Board should be selected on the basis of their commercial, professional, managerial and/or technical qualifications and experience.

S5.2.2 Establishment of An Independent Regulatory Board

JICA Study proposes that an independent Regulatory Board (RB) should be formed for economic and technical regulation of water supply and sewerage services in Zone West (see **Figure S44.1.3**). The RB should have the obligation to ensure that the new retail entity in Zone West is able to recover the reasonable financial and economic costs of providing water supply and sewerage services in Zone West. The RB would monitor the performance of the Zone West retail entity against the prescribed service standards and will also act as 'Ombudsman' in dealing with customer complaints and related issues of customer service. It would also be responsible for setting out and enforcing 'Water Supply and Sewerage Services Regulations' which define clearly the statutory rights and obligations of both the Zone West retail entity and its customers in delivering and receiving the services.

S5.2.3 Way Forward

It should be noted that the 'JICA Study Team' are primarily concerned with the identification of possible reform options and therefore has sought to provide an outline of suggested reforms in principle at this stage. It is expected that detailed studies related to the suggested reforms will be carried out by the Water and Sanitation Program (WSP) and the ADB assisted 'Karachi Mega City Sustainable Development Program (KMCSDP)'.

In order to put the institutional reforms suggested by the JICA Study into effect, separate studies will need to be conducted:

- To draft amendments to relevant laws, ordinances and/or regulations that are necessary to enable KW&SB to relinquish responsibility for provision of retail

services (water supply and sewerage) in Zone West
- To draft articles of association and shareholders agreement of the Zone West retail entity
- To develop a tariff structure which would be applied in areas where DNI has already been completed, and which, while providing adequate protection for the poor and a strong incentive for efficient use of water, ensure that the Zone West retail entity is able to recover the reasonable costs of providing the services including debt service on loans borrowed for financing DNI.
- To establish a mechanism for the transfer of KW&SB's employees currently engaged in provision of retail services in Zone West to the Zone West retail entity, including transfer of employees' pension rights, severance funds, etc.
- To establish a mechanism to determine the condition of retail assets and for the valuation and transfer of retail assets to the Zone West retail entity
- To establish a mechanism for dealing with the liabilities and receivables associated with the retail assets and customer base transferred to the Zone West retail entity
- To establish an independent Regulatory Board for economic and technical regulation of the water supply and sewerage services
- To draft 'Bulk Treated Water Purchase Agreement' between KW&SB and the Zone West retail entity

It is expected that the reform process would be put into effect through the 'Reform Committees' that have already been established under WSP's initiatives, which would take responsibility for ensuring the progressive implementation of reforms in close coordination with the Local Support Unit (LSU)-CDGK of the ADB assisted KMCSDP.

It is envisaged that the preparatory stage for DNI in Zone West will start from early 2011 and it will be followed by the actual implementation of DNI from mid-2012. It is likely that this timing will coincide with the availability of additional water (130 mgd) from the K-IV Project. In order to achieve these goals, the following actions as a minimum will need to be put into effect between now and mid-2012.

- KW&SB relinquish their responsibility for retail services within Zone West
- A new Public Limited Company (PLC) which provides retail services in Zone West is established
- An independent Regulatory Board is established
- KW&SB's employees, assets, debts, receivables associated with Zone West are transferred to the new PLC
- A 'Bulk Treated Water Purchase Agreement' between KW&SB and the new PLC is established and enforced
- A 'Raw Sewage Transfer Agreement' between KW&SB and the new PLC is established and enforced
- The new PLC develops business strategies for efficient operations and service delivery
- Employees of the new PLC are well trained, developed and motivated to deliver improved performance in O&M, revenue collection and customer services
- The new PLC raises funds for implementation of DNI
- The new PLC establishes a specialist unit (PIU) dedicated to implementation of DNI

Timeframes in which each of these actions will need to be put into effect are given in **Figure S52.3.1**.

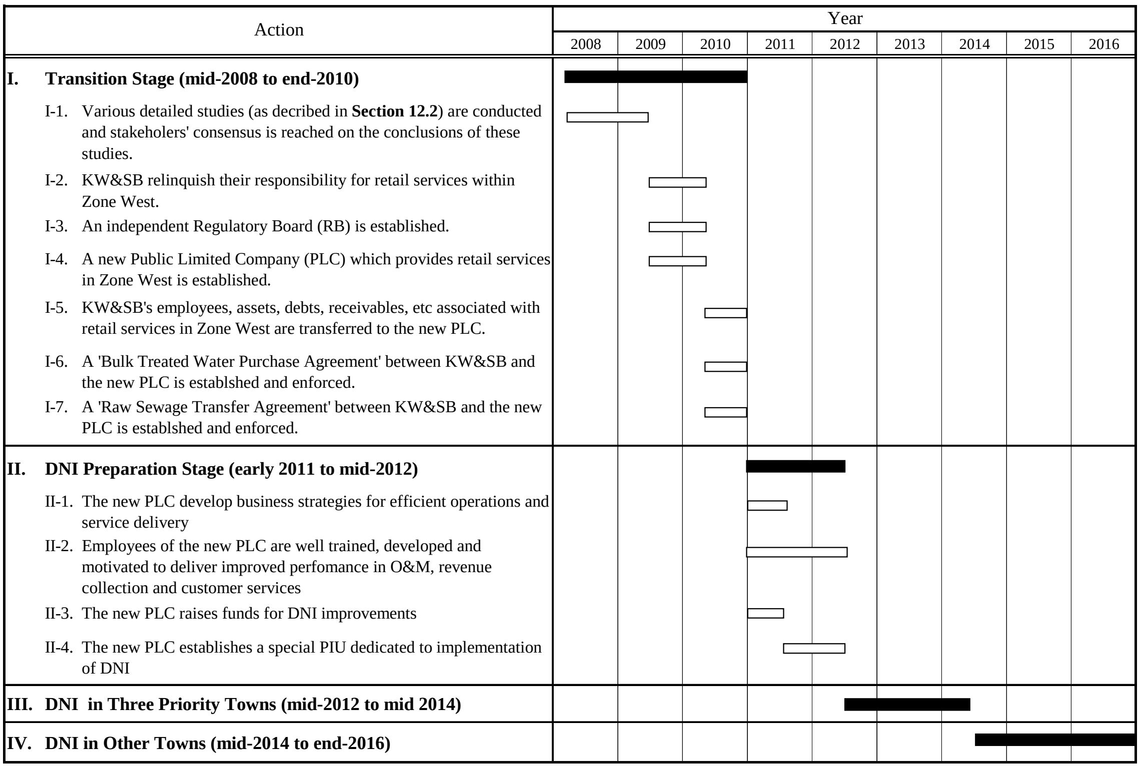


Figure S52.3.1 Institutional Reform Roadmap for Zone West

S5.3 PLANS FOR OPERATION AND MAINTENANCE OF PRIORITY PROJECTS

S5.3.1 Water Supply Projects

(1) Maintenance of Distribution Network

After completion of DNI, the distribution network will be maintained by leakage/NRW reduction survey teams. With the use of a portable flow metre, they will measure the minimum night flow (MNF) in small District Metreing Areas (DMAs) with a view to reducing leakage assuming that MNF represents the magnitude of leakage occurring within the DMA.

Each survey team will consist of one engineer, one technical assistant and three workers, and will be equipped with one portable ultrasonic flow metre, one leak detector, two listening rods, one metal pipe locator, one metal detector, and three pressure recorders.

On average, one survey team would be able to cover about 8 km length of distribution mains per week or 32 km per month. It is estimated that after completion of DNI the total length of distribution network mains in one town will be approximately 370 km. Thus, if covered by two teams, it will take about six months (370 / 64 = 5.8) to complete the survey in one town. This will ensure that each and every distribution main in the town will be subject to the survey once in every six months, which is more or less in line with international practices. Ultimately, two survey teams will need to be established for each town or six teams for the three 'Priority Towns'. The number of survey teams can be increased gradually corresponding to the progress of DNI.

In the past, leakage/NRW reduction surveys were not conducted by KW&SB. As such, extensive training will need to be provided to staff who take on leakage/NRW reduction surveys. They will require the training on how to isolate a DMA from the rest of the distribution network, how to measure the minimum night flow in the DMA, and how to use ultrasonic flow metres, leakage detectors, pressure recorders and other survey equipment. To this end, it is recommended that the retail entity should request the Japan International Cooperation Agency (JICA) for its technical assistance through implementing a 'Technical Cooperation Project (TCP)'. TCP would be able to offer a comprehensive package of technical assistance to support the self-help efforts of the retail entity, which would include (a) the dispatch of leakage/NRW reduction experts from Japan to provide technical supports, (b) training of relevant local staff in Japan or in other countries, and (c) the supply of necessary equipment on a grant basis.

(2) Metre Reading/Billing

After implementation of DNI, the distribution network and customer base will be managed by the Zone West retail entity. It is predicted that the number of service connections in Zone West at the start of DNI (2011) will be approximately 600,000 and in the three 'Priority Towns' there will be approximately 217,000 connections.

DNI will be operated on the basis of 100% metreing of bulk and retail customers and therefore will require the installation of revenue metres to every service connection. As household metreing will be a new concept for Karachi (currently KW&SB do not metre households), extensive training will be provided to transferred staff from KW&SB to the retail entity, in the use of modern billing and metre reading techniques including the hardware, software and technologies employed. Metres will be read on a monthly basis to maximise revenues and cash flows.

Based on the number of service connections in the three 'Priority Towns', it is expected that approximately 100 qualified and trained metre readers will be required ultimately. This is based on the assumption that each metre reader will be capable of reading approximately 100 metres per day on each of the 22 working days per month which is line with international standards with use of modern metres and electronic 'hand held devices'. The number of metre readers can be increased gradually corresponding to the actual progress of DNI. The 'hand held device' will be linked locally at the town office for downloading metre reading routes to the device from the billing system and for uploading metre readings back to the billing system to update customer accounts. The hardware and software for modern hand held devices as well as proprietary billing/data management systems such as CIS are readily available on the market. Necessary training can be provided by the manufactures of these hardware and software and therefore it should be included as part of the procurement contract.

The hand held devices will deploy modern technology capable of 'local bill presentment' which means that the metre reader will be able to print the bill after reading the metre and present this to the customer at the time of reading. This will minimise the chance of frauds by metre readers and will also eliminate the need for centralised bill printing and bill delivery, thus reducing operating costs and the time for the customer to pay the bill. The use of modern technology such as this (instead of the traditional manual methods) will be prerequisite to processing as many as 10,000 (100 metre readers × 100 metres per metre reader per day) metre readings and consumer bills per day.

(3) Metre Repair/Testing

It is expected that good quality domestic metres will be purchased and installed that will comply with international standards to ensure a long service life. Metres will be the property of the retail entity who rent them out to customers. The retail entity will recover the cost of the metre through tariffs in the long run. Whilst the unit price will be higher than cheaper metres available locally, good quality metres would be expected to last trouble-free between 5-10 years in service and therefore the overall life-cycle cost will be lower.

On this basis it is expected that household metres would be replaced periodically (every 5-10 years and will be determined by field experience over time) and as such it is envisaged that it will not be cost effective for the retail entity to operate a metre repair workshop. Instead, it is suggested that a service contract will be let to a specialist contractor certified by the metre manufacturer for repair of household metres.

The retail entity will invest in and deploy portable metre test equipment (that will be certified and regularly calibrated for accuracy) to test household metres (0.5 to 2 in) where customers complain of irregularities. The retail entity will also need to invest in a metre test bench to conduct the regular calibration of the test equipment. The test metre is taken to site and installed in series with the existing metre to test the revenue metre's recording accuracy. It is estimated that approximately 200 sets of such portable metre test equipment (60 sets for 0.5 in, 50 sets for 0.75 in, 30 sets each for 1.0, 1.5 and 2.0 in) will be required for each town ultimately, but this number can be increased gradually corresponding to the actual progress of DNI.

Bulk metres (3 to 24 in) are limited in number at present, but are expected to increase substantially in future since they will be installed at all multi-storey condominiums and apartment buildings in the three 'Priority Towns' during the implementation of DNI. As such it is recommended that the retail entity will invest in bulk metre (3 to 24 in) calibration equipment and facilities (similar to that provided at COD filtration plant) in order to check and confirm bulk metre recording accuracy at the request of bulk customers. Bulk metres will also be the property of the retail entity who rent them out to customers. The retail entity will recover the cost of the bulk metres through tariffs in the long run. It is suggested that a service contract will be let for repair of malfunctioning bulk metres. This is a specialist job and therefore the service contract will be let to the metre manufacturer or a specialist contractor certified by the metre manufacturer. It is also suggested that the retail entity should maintain a stockpile of approximately 50 standby bulk metres which consist of 10 metres each for 3 and 4 in, 8 metres each for 6, 8 and 12 in, 4 metres for 15 in, and 2 metres for 24 in. These bulk metres will be used to replace customer metres while they are being calibrated or repaired.

S5.3.2 Sewerage Projects

O&M activities and improvement plans for the sewerage facilities are designed to fit in with the priority projects identified during the Feasibility phase; namely the rehabilitation of branch sewers, installation of branch and trunk sewers, to collect generated sewage as well as rehabilitation of two associated treatment plants of TP-1 and TP-3. The priority will be to operate and maintain sewerage facilities to ensure efficient sewage collection and its treatment, safe effluent discharge and sludge disposal that complies with environmental standards.

After implementation of DNI, the sewers, the pumping stations and the sewage treatment plants associated with Zone West will be managed by the Zone West retail entity. The retail entity will therefore be responsible for the O&M of TP-1, TP-3 and related facilities.

Modern O&M methods employed by the Zone West retail entity will include mainly:

- - Asset management plans and the recording of asset information
- - O&M manuals that clearly state the parametres, procedures, schedules and responsibilities for effective operation of collection and treatment systems
- - 'Planned preventative maintenance' practices

It is estimated that the length of sewers in the three towns will be approximately 1,018km in 2016. Maintenance of sewers includes three major tasks of regular inspection, cleaning and repairs. Maintenance manuals will be used to document procedures for the maintenance of sewers and will be used for training purposes. This will ensure the deployment of standard

operating procedures and practices throughout the sewers located within three towns.
Regular maintenance of sewers or every five years at least will include the need to periodically remove deposits, grit and debris. For larger diametre sewers, it will be necessary to use mechanised sewer cleaning equipment including high pressure cleaning vehicle and sludge vacuum vehicle. For smaller diametre size sewers, on the other hand, manual cleaning equipment will be deployed extensively such as rodding and swabbing tools.

Operation and maintenance manuals will be used to document procedures for plant operation and maintenance and will be used for training purposes. This will ensure the deployment of standard operating procedures and practices at each plant.

Running maintenance includes regular inspection, oiling and greasing of plant and equipment. The TP's will be operated on a 24-7 basis and all facilities will be subject to daily and periodic inspection of concrete structures, mechanical and electrical equipment.

Concrete structures include inlet pumping station, grit chambers, primary settling tanks, trickling filters and final settling tanks. Mechanical and electrical equipment include pumps, screens, rakes, grit collectors, scrapers of primary and final settling tanks and sprayers of trickling filters.

Treatment control parametres will be monitored as a minimum such as flow rate, water level at treatment facilities, water qualities including pH, BOD and SS at the inlet and the outlet of the plant, and sludge layer at the bottom of anaerobic and facultative ponds.

Sewage treatment plants constantly generate grit, screenings and sludges removed during sewage treatment. Such solid wastes shall be removed from the TP's and properly disposed of or reused.

S5.4 PRELIMINARY COST ESTIMATES AND IMPLEMENTATION SCHEDULES & PLANS

S5.4.1 Preliminary Cost Estimates

(1) Construction Cost

Table S54.1.1 shows the construction cost for the priority projects. The cost for water supply project is Rs.12,452 million and that for sewerage projects is Rs.3,976 million. The total cost for the priority projects is Rs.16,428 million.

(2) Operation and Maintenance Cost

Table S54.1.2 shows the operation and maintenance cost for the priority projects in 2016. The O&M cost for water supply project is Rs.864 million and that for sewerage project is Rs.90 million. The total cost for the priority projects is Rs. 954million.

Table S54.1.1 Construction Cost

Component	Construction Cost (Rs. Million)	
Water Supply Project		
Direct Construction Cost	9,166.8	
Reservoir		490.9
Trunk Distribution Main		4,606.0
Flow Meter		46.1
Distribution Network Main		2,988.3
House Connection		1,035.5
Engineering Fee	687.5	
Land Acquisition	3.7	
Physical Contingency	492.9	
Price Contingency	1,916.8	
Project Administration	184.0	
Sub-total	12,451.7	
Sewerage Project		
Direct Construction Cost	2,649.6	
Rehabilitation of TP-1		337.3
Rehabilitation of TP-3		198.7
Branch Sewer and Trunk sewer		2,113.6
Engineering Fee	198.7	
Land Acquisition	-	
Physical Contingency	142.4	
Price Contingency	927.0	
Project Administration	58.8	
Sub-total	3,976.5	
Total	16,428.2	

Table S54.1.2 Operation and Maintenance Cost

Component	O&M Cost (Rs. Million/year)		
Water Supply Project			
Purchased Water Fee	643.8		
Trunk distribution main	92.1		
Distribution Network Main	59.8		
House connection	68.5		
Sub-total	864.2		
Sewerage Project			
Sewage Treatment Plant TP-1	42.5		
Operation Cost		41.1	
Personnel			13.8
Electricity			16.1
Diesel			4.2
Polymer			0
Sludge Disposal			4.2
Laboratory and other			2.8
Maintenance Cost		1.4	
Sewage Treatment Plant TP-3	37.8		
Operation Cost		36.9	
Personnel			9.6
Electricity			18.8
Diesel			4.2
Polymer			0
Sludge Disposal			1.7
Laboratory and other			2.6
Maintenance Cost		0.9	
Branch and Trunk Sewer	9.7		
Operation Cost		0.0	
Maintenance Cost (Cleaning)		9.7	
Sub-total	90.0		
Total	954.2		

S5.4.2 Implementation Schedule

(1) Water Supply System

As engineering services, detail design will begin in 2012 followed by construction supervision which will be finalized in mid 2014. Reservoir, trunk distribution main, distribution network main, house connection will begin to be constructed simultaneously along with the installation of flow metres and water meters.

(2) Sewerage System

As engineering services, detail design will begin in 2012 followed by construction supervision which will be finalized in mid 2014. Rehabilitation of two sewage treatment plants of TP-1 and TP-3, installation of branch and trunk sewers will begin simultaneously and end in mid 2014.

S5.4.3 Financing Plans

The Zone West retail entity will need to raise funds for the implementation of the Priority Projects. The total project cost of the Priority Projects is estimated at Rs. 16.4 billion as shown in **Table S54.3.1**.

Table S54.3.1 Summary of Priority Project Cost

Items	Rs. (million)	US$ (million)
Base Costs	11,817	194.4
Water Supply	9,162	150.8
Sewerage	2,650	43.6
Other Costs	4,612	75.9
Engineering Fee	886	14.6
Land Acquisition	4	0.1
Physical Contingency	635	10.4
Price Contingency	2,844	46.8
Project Administration	243	4.0
Total Project Cost	16,429	270.3

It is assumed that about 80% of the total project cost would be financed by external sources of funds while the remaining 20% by the internal sources of funds of the Zone West retail entity. There are two prospective external sources of fund which would possibly be used for financing the implementation of the Priority Project. They are ADB and JBIC loans.

(1) ADB Loan

The Asian Development Bank (ADB) fielded an appraisal mission to Pakistan from 21 - 25 January 2008 to conduct loan appraisal of the Karachi Mega City Sustainable Development Program (KMCSDP). The Government of Pakistan (GOP) has requested ADB to provide financing through a 'Multitranche Finance Facility (MFF)' for US$ 800 million over 8 years, for selected infrastructure investments and associated public sector reform and institutional development initiatives in Karachi.

The Investment Program under KMCSDP will comprise the following parts:

Part A: Institutional Reform, Implementation Support and Capacity Development.
Part B: Water Supply and Wastewater Management.
Part C: Urban Transport.
Part D: Katchi Abadi Improvement and Low-income Housing.

An MFF of up to US$ 800 million equivalent will provide loans for (i) up to an aggregate of US$ 710 million equivalent from ADB's ordinary capital resources (OCR) under ADB's London interbank offered rate (LIBOR)-based lending facility, and (ii) up to US$ 90 million equivalent in Special Drawing Rights from ADB's Special Fund Resources.

Financing from OCR resources will be subject to interest to be determined in accordance with ADB's LIBOR based lending facility, and commitment charge of 0.75% per annum and other terms and conditions. The Special Funds resources will have a 32-year term including a grace period of 8 years, and with an interest rate of 1.0% per annum during the grace period and 1.5% per annum thereafter.

The borrower of the loan will be GOP. All loans from OCR and the Special Funds will be onlent by GOP to the Government of Sindh (GOS) at the same terms and conditions as those of the ADB loans to the GOP. GOS will bear the foreign exchange risk for all loans. The Finance Department of the GOS will be the Executing Agency (EA).

It is currently expected that about 46% of the US$ 800 million loan (US$ 368 million) will be allocated for Part B: Water Supply and Wastewater Management. Although US$ 93 million has already been allocated for Part B in the first PFR, a large portion of the balance US$ 275 million can be allocated in the subsequent tranches for financing the implementation of the Priority Projects.

(2) JBIC Loan

In the past, JBIC provided a Japanese Yen Loan (L/A No.PK-P40 dated November 22, 1994) for the implementation of the 'Karachi Water Supply Improvement Project'. The JBIC loan amounted to JPY 10.3 billion was a general untied loan carrying 2.6% interest rate and 30 years repayment period including 10 years of grace period.

JBIC loan for the main components of the Priority Projects would be a general untied loan carrying an interest rate of 1.2% with 30 years repayment period including 10 years of grace period. For consulting services, the interest rate will be minimal (0.01%) and the repayment, grace period and conditions for procurement will be the same as those for main components.

JBIC loan would be able to cover almost the entire project cost shown in **Table S54.3.1** except for the costs associated with land acquisition and project administration.

S5.4.4 Plans for Construction

Plans for construction are prepared based on the implementation schedule. Construction materials are procured according to plan for procurement of equipment/material. In order to obtain high quality outcome of the construction works, plans for construction will include routine quality control, schedule control and safety management. Vibration, noise, liquid and solid wastes that are expected to be generated during the construction works have to be minimized, which will be incorporated in the plans for construction.

As-built drawings are to be prepared at the time of construction completion for concrete structures, water supply pipes, sewers, mechanical and electrical equipment and to be used for operation and maintenance purposes at the later stage.

The following items will be taken into account in the preparation of the plans for construction.

<u>Reservoir</u>: The soil bearing capacity of its base has to be verified by plate bearing test. The reservoir functions to store potable water and no water leakage should occur.

<u>Trunk distribution main</u>: Pipe material is steel and the accuracy of joint welding is very important. The possibility of electric corrosion occurrence has to be checked and anticorrosion measures need to be taken if necessary.

Distribution network main: Plans for construction need to be prepared mitigating traffic jams and protecting pedestrians. Many asbestos cement pipes are used for existing distribution network main. Asbestos dust can be carcinogens and asbestos cement pipes should be left as they are underground for safety reasons.

House connection: It is important to employ the contractors with sufficient expertise in house connection works including water meter setting to minimize water leakage.

Sewage treatment plants of TP-1 and TP-3: Plans for construction have to be prepared by minimizing interrupted operation, since these two plants in operation are to be rehabilitated. TP-3 is close to the sea and salt erosion free paint will be used for mechanical equipment.

Trunk and branch sewers: Sheet piles and other soil retaining apparatus will be adopted for larger diametre pipe and deeper excavation. Replacement of sewers is planned with smooth flow diversion and abandoned sewers are left underground as they are.

S5.4.5 Plans for Procurement of Equipment/Materials

(1) Water Supply System

Concrete, reinforcing steel bars, steel/polyethylene pipes and flow metres can be procured domestically while valves and water meters have to be imported.

(2) Sewerage System

Electrical and mechanical equipment, concrete pipes, concrete and reinforcing steel bars can be procured domestically while cast iron pipes, valves, pumps have to be imported.

S5.5 ENVIRONMENTAL IMPACT ASSESSMENT

The regulation concerning the EIA of Pakistan requires EIA Study to water supply and sewerage projects with the project cost of Rs. 25 million or more, and the project cost of the priority project is Rs. 16,428 million. Therefore, the EIA Study concerning the priority project was carried out, and the findings of the EIA Study are described as below.

The components of the priority project are the following items:

- Expansion of reservoir (NEK Old reservoir) for water supply system;
- Distribution network improvement for water supply system;
- Collection and conveyance network improvement for sewerage system, and
- Rehabilitation of sewage treatment plants (TP-1 and PT-3).

The expected positive impacts of the priority project include:

- Realization of the living condition which has possibility to access safe water during all day;
- Possibility to collect all of generated sewage and to treat appropriately, and expectation of the health, sanitary and environmental improvement as the result;
- Enhanced employment opportunities particularly in the construction stage. Furthermore, promotion of the regional economy by improvement of the living environment of the overall project area is expected.

Based on the findings of the EIA Study, the following items should be considered as mitigation measures for project implementation.

<u>Land acquisition for extension of reservoir (NEK Old)</u>
The site (land owner is the Sindh Province) which adjoins the east side of the existing reservoir is not used for other project and there is sufficient area as the construction site for the extension of reservoir (NEK Old Reservoir). If this site is determined as a proposed site, it is expected that adverse impacts of land acquisition are very small.

<u>Construction of water distribution network and sewer collection network</u>
The main adverse impacts in the construction phase of water distribution network and sewer collection network are effects of the economic activity, traffic situation, public health condition, air pollution, noise and vibration.
Especially, when appropriate measures are not performed, it is expected that serious traffic disturbance will occur. However, these are short-term impacts, and these can be reduced by appropriate construction site management including an announcement and traffic control.

<u>Impact on the tanker water service by implementation of the Distribution Network Improvement</u>
The Distribution Network Improvement in the priority project area will be completed by 2014. Consequently, it is predicted that the tanker water service will become unnecessary in the project area and its business will end. However, the water supply facilities in the Karachi city will be constructed step by step till 2025, the demand for tanker water supply will not decrease immediately. Therefore, it is expected that adverse impacts on the tanker water service are not significant.

<u>Water pollution and offensive odour from sewage treatment plants (TP-1 and TP-3)</u>
According to the sewerage system planning, if the treatment plants are properly operated and maintained, the effluent will meet the effluent water quality standards and no significant adverse impacts may be expected. Similarly, it is expected that when proper operation and maintenance is performed, odour emission can be controlled.

Impact due to disruption of operation of the water supply facilities and the sewage treatment plants (power cut and electrical accident)
A power failure can be compensated for the installation of power generator. The social infrastructure improvement concerning electricity progresses in the future, and it is expected that power failure will less frequently occur. Furthermore, the adverse Impacts can be controlled to the minimum by preparation of the spare electrical & mechanical equipment, operation manual for emergency, and training to the operation staff for the emergency situation.
As a conclusion, though the above adverse impacts can be considered on the implementation of the priority project, all the adverse impacts are controlled to the minimum by taking the common measures.

In addition, the project owner should establish monitoring system to assess the quality of the neighbouring environment after the commissioning of the project. An environmental monitoring programme is important as it provides useful information and helps to:

- Verify the predictions on environmental impacts presented in this study,
- Assist in detecting the development of any unwanted environmental situation, and thus, provides opportunities for adopting appropriate control measures.

The Environmental Monitoring Programmes are summarized in **Table S55.1.1**.

Table S55.1.1 The Environmental Monitoring Programme

Object	Monitoring Point	Parametres
Water Supply System		
Raw water and distributed water	NEK Old reservoir	Basic items for water supply: Escherichia Coli, Turbidity and etc. Hazardous substance: According to the WHO Guideline
Tap water	House connections	Water pressure, pH, Turbidity, Escherichia Coli and etc.
Sewerage System		
Influent and treated effluent	TP-1 and TP-3	Basic parametres: Temp., pH, SS, BOD, COD, Nitrogen and etc. Hazardous substance: According to the effluent Standards.
Sludge characteristics		Hazardous substance and etc.
Air quality		Ammonia, Methyl Mercaptan, Hydrogen Sulphide, and etc.

S5.6 EVALUATION OF PRIORITY PROJECTS

S5.6.1 Economic and Financial Evaluation and Economic Impacts

(1) Objectives

The priority project was evaluated from the economic and financial points of view. The economic evaluation was conducted in the same manner as described in **Section S4.6.2**. In the financial evaluation, the priority project was examined with a view to identify the levels of water supply and sewerage charges that would have to be applied in order to make the project financially viable. This was done using certain indices, such as financial internal rate of return (FIRR), net present value (NPV) and benefit-cost ratio (B/C). Finally, the financial conditions/arrangements which would ensure the financially sustainability of the Zone West retail entity were studied through financial simulation analyses.

(2) Economic Evaluation

At first, economic evaluation of the priority project was conducted for water supply and sewerage projects separately. Then, both projects were combined and evaluated as one scheme as was the case for the master plan.

1) Water Supply Project

The economic tangible benefits of the priority project were quantified based on the same data and information as used for the evaluation of the master plan. The structure of benefits is the same as discussed in **Section S4.6.2**. It is expected that the benefits will emerge immediately after completion of the distribution network improvement (DNI) in the project area, i.e. from the latter half of the year 2012. The total economic benefit was estimated at Rs.8.1 billion in the matured year 2015.

In the economic evaluation, the total economic cost was estimated as the sum of three cost components: (a) DNI in the priority project area; (b) costs associated with the use of existing water supply facilities in the project area which were assumed as being sunk costs; and (c) costs associated with the bulk water supply to project area, including the costs of reservoirs and transmission pipelines. In addition, operation and maintenance costs of relevant facilities and replacement costs of electrical and mechanical equipment were also included as part of the economic cost.

The economic evaluation of the water supply project revealed 23.5% of EIRR, Rs.17.9 billion of NPV and 2.35 of B/C. The project was found to be quite viable from the economic point of view, since its EIRR is much higher than the social discount rate i.e.12%. One reason for this is that the project area has already been fully urbanised and as such the intended benefits of the project are expected to emerge immediately after completion of DNI. Another reason is that most of the residents of the project area belong to a relatively high income group and spend a large amount of indirect costs associated with the use of piped water from KW&SB system. The sensitivity test of the economic evaluation suggested no risk in terms of economic viability of the priority project.

2) Sewerage Project

The economic tangible benefits of the priority project were quantified based on the same data and information as used for the economic evaluation of the master plan. It is expected that the benefits would emerge just after the rehabilitation project of the treatment plants in the second half of the year 2014. The matured benefit was estimated at Rs.1,246 million in 2015.

Sewers have already been installed in most of the project area. It is therefore proposed that only 20% of the existing sewers would be rehabilitated under the priority project. It is also proposed that major mechanical and electrical equipment at the existing sewage treatment plants would be rehabilitated under the project. The residual values of existing sewers and sewage treatment plants were included in the project cost as sunk cost. In addition, O&M and replacement costs were also included in the project cost.

The economic evaluation of the sewerage project indicated 20.3% of EIRR, Rs.2.1 billion of NPV and 1.82 of B/C. The project was considered to be quite viable from the economic point of view, since its EIRR is significantly higher than the social discount rate i.e.12%. The sensitivity test of the economic evaluation suggested no risk in terms of economic viability of the priority project.

3) Integrated Project

The water supply and sewerage projects were combined as one project and subjected to economic evaluation. The results indicated 23.0% of EIRR, minus Rs.18.1 billion of NPV and 2.29 of B/C. Thus, the integrated project was also found to be quite viable from the economic point of view.

(3) Financial Evaluation

The following indices were used for financial evaluation of the priority projects: financial internal rate of return (FIRR); net present value (NPV) and B/C (benefit-cost ratio). The financial benefits would be derived from water sales to consumers, that is, the revenue of water sales. The financial viability of the project was judged by comparing the FIRR of the project with a likely interest rate of foreign loans used to finance the project. According to the latest information available from agencies concerned and major foreign donors, the likely interest rate falls somewhere between 7% and 9% per annum (8% is applied in this evaluation as medium rate) including the charges for averting the risks associated with foreign exchange rates.

1) Water Supply Project

The current water supply charge for metreed supply is Rs.44/1000 gallon (Rs.9.7/m^3) for domestic use and Rs.73/1000 gallon (Rs.16.1/m^3) for non-domestic use. The revenue derived from the priority project was calculated as the product of (a) the volume of water supplied to consumers and (2) water tariff. It was found that the FIRR of the project would be negative if the present levels of tariffs were applied, but it would increase to 8% if tariffs were increased to Rs.128/1000 gallon (Rs.28/m^3) for domestic use and Rs.212/1000 gallon (Rs.47/m^3) for non-domestic use.

2) Sewerage Project

The current sewerage charge is 25% of water charge. It was found that the FIRR of the project was also found to be negative if the current level of sewerage charge was applied, but it would increase to 8% if the charge was increased to 50% of water charge.

3) Economic Impacts

An average water and sewerage service charge paid by the residents of the priority project area is estimated at Rs.290/month per household (5,300 gallon/month times Rs.44/1000 gallon plus 25% of surcharge). This accounts for 1.9% of the average household income (Rs.15,600/month) in the priority project area. However, the charge would increase to Rs.1,014/month per household if the increased tariffs as discussed above are applied; it would account for 6.5% of the household income, exceeding the level of affordability-to-pay suggested by World Bank (5%).

(4) Financial Management of Zone West Retail Entity

The financial sustainability of the Zone West retail entity was examined through a financial simulation analysis based on the schemes proposed in the master plan and priority projects, and by adopting the following assumptions.

1) Prices and escalation

- Domestic water	Rs.88/1000 gallon (2 times of current price)
- Non-domestic water	Rs.146/1000 gallon (2 times of current price)
- Sewerage Service	40% of water charge
- Price escalation	10% per 3 years

2) Procurement of financial sources for capital investment

- Equity	Rs.14 billion (25% of total investment)	
- Transferred Assets	Rs.12 billion of existing facilities in Zone West as of 2008	
	Rs.18 billion of facilities constructed between ’08 and ‘11	
- Foreign Loans	Rs.45 billion (80% of capital investment)	
	Repayment period: 30 years	Grace period:10 years
	Interest rate: 8%	Other charges 1%

3) Bulk treated water from KW&SB: Rs.23/1000 gallon

4) Stock dividend for share holders
   10% (when net profit after tax exceeds 10% of the total equity)

5) Income tax — 35% of profit of the year

The simulation results are shown as ‘Base Case’ in **Figure S56.1.1**. In this case, the retail entity would only be able to make profits in 2020 for the first time after 9 years of its operation; accumulated deficits would not be able to be eliminated until 2031.

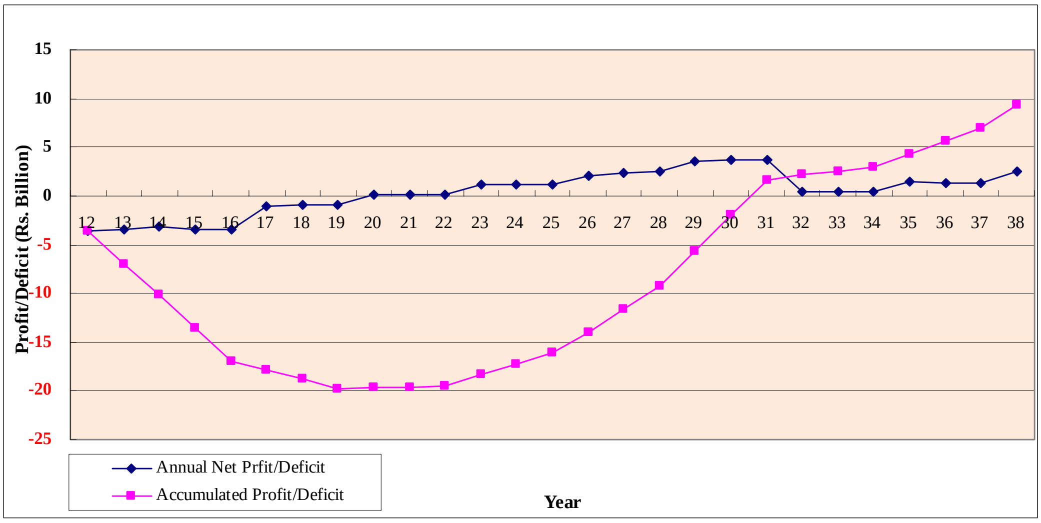
Then, the following changes were made to the assumptions adopted in 'Base Case' and another simulation analysis was conducted.

1) Bulk treated water from KW&SB is Rs.15/1000 gallon for the initial 5 years of operation and thereafter Rs.25/1000 gallon;
2) Interest rate of foreign loans is 4% per annum.

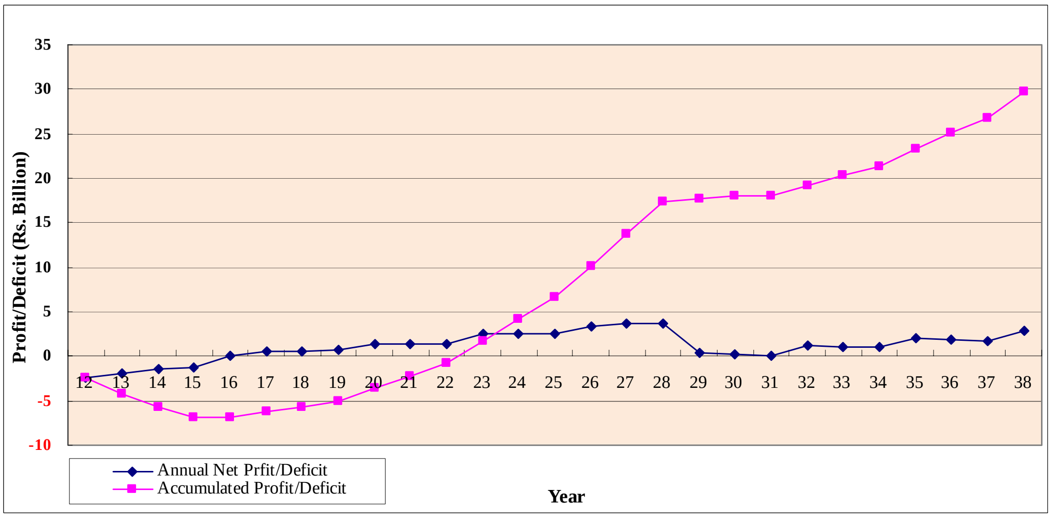
The results of this simulation analysis are shown as 'Case 1' in **Figure S56.1.1**. It was indicated in this case that the retail entity would be able to make profits in 2016; accumulated deficits would be able to be eliminated in 2023.

Finally, a simulation analysis was conducted for 'Case 2' shown in **Figure S56.1.1**. It was assumed in this case that the water supply and sewerage prices would be escalated at a rate of 15% per 3 years. Other assumptions are similar to those used for 'Case 1'. The results of this 'Case 2' analysis indicated that the retail entity would be able to eliminate accumulated deficits in 2020. It is considered that this 'Case 2' would ensure the financial sustainability of the Zone West retail entity.

Base Case



Case 1



Case 2

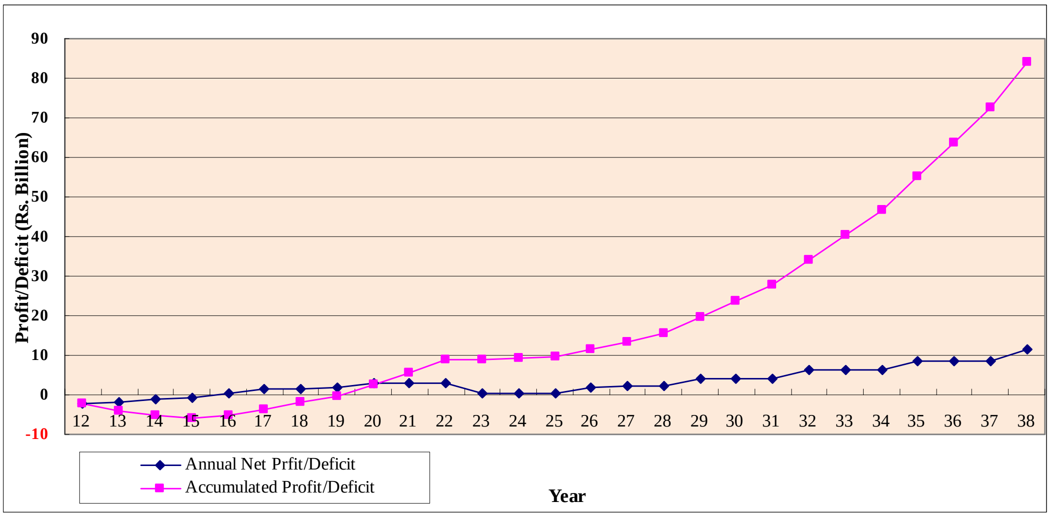


Figure S56.1.1 Results of financial Simulation

S5.6.2 Evaluation of Environmental and Social Impacts

Components of the priority project are classified into two categories; one is water supply system with expansion of reservoir and distribution network improvement (DNI), and the other is sewerage system with improvement of sewage collection network and replacement of electrical equipment in TP-1 and TP-3 sewage treatment plants (STPs). Implementation of these components will bring about the following benefits and positive impacts.

<u>Water supply system</u>

- DNI enables access to safety water and sufficient amount of water on 7-24 basis.
- Improvement of the rate of leakage is expected.
- Introduction of a metre-charge system, and it is expected to lead the improvement in users' water-saving awareness.
- By improving water supply service and reducing individual compulsory associated fees concerning water use, enhanced in the charge collection rate is expected.
- Financial improvement in the management of water and sewerage services is expected by improvement in the charge collection rate.

<u>Sewerage system</u>

- Improved sewage collection will collect all the sewage in the priority project area and convey it to STPs.
- By replacement of equipment in STPs, proper sewage treatment is possible, and the water quality of the treated effluent will be possible to meet the effluent water quality standards.
- Consequently, reduction of the discharged pollution load to the public water bodies and water quality improvement in the public water bodies are expected.

According to the findings of the EIA Study, there are some adverse impacts that require mitigation measures in the priority project implementation. Main adverse impacts are following items:

- Adverse impacts on the land acquisition by the extension of reservoir
- Adverse impacts on the construction for improvement of water distribution network and sewage collection network
- Adverse impacts on the water environment by the increase in the amount of sewage
- Adverse impacts from sewage treatment plants
- Adverse impacts on the tanker water supply business

As a conclusion, though the above adverse impacts may be expected, all the adverse impacts are controlled to the minimum by taking appropriate measures. In addition, not only the above-mentioned benefits and positive impacts by implementation of the priority project, but improvement of the local economy and sanitary conditions as multiplied effects are also expected.

S5.6.3 Evaluation of Technical Feasibility

(1) Water Supply Project

1) Evaluation

The project includes the installation/replacement of pipelines and the expansion of a reservoir as its major construction components. Since KW&SB has enough experiences in constructing pipelines and reservoirs, required knowledge and skills to implement the project are already available within KW&SB. In conclusion, no major technical constraints are envisaged during and after the implementation of the water supply priority project, as long as the new corporatised entity, which will be established in Zone West, inherits the experiences, knowledge and skills of KW&SB efficiently.

2) Recommendations

a. Confirmation of Optimum Facility Designs in the Stage of Detailed Design

The preliminary design of distribution network was undertaken during the feasibility study of this JICA Study to identify potential pipe alignments and to propose a possible distribution network system for the three towns. The results of the preliminary design was used to estimate the project costs for conducting economic and financial analyses and to provide basic information on the project for KW&SB and international donors. However, the preliminary design of distribution network is not suitable for the reference during the implementation of pipe construction works, as matter of off course, in terms of accuracy and details. Therefore, the detail design of distribution network including more accurate hydraulic analysis should be prepared, before implementing the project, based on detailed topographic and line surveys and geotechnical investigations.

b. Implementation of K-IV Projects without Delay

KW&SB are implementing the first phase of K-IV project at present. The project includes the construction of 260 mgd bulk water supply system from Kinjhar Lake to Karachi and the construction of 130 mgd filtration plant at the central part of Gadap Town. KW&SB should execute the first phase of K-IV project without any delay or suspension.

c. Coordination during DNI

It is important to cooperate with concerned authorities when installing pipes and related facilities by cutting, excavating, refilling and restoring paved roads.

d. Equitable Water Supply

It is necessary for equitable water supply to take records of district and sub-district flow metres and water consumption of each customer and to control the flow entering into each water supply block.

e. Update of GIS Database

KW&SB or the new corporatrised entity of Zone West should update and add pipeline information, on a day to day basis before, during and after DNI, to the GIS database of water supply network system which was established during the JICA Study and handed over to the newly established GIS Department of KW&SB.

(2) Sewerage Project

Priority project of sewerage targets three towns of North Nazimabad, Gulberg and Liaquatabad. These three towns are also the target of water supply project in which DNI is implemented. The implementation of DNI will bring about constant water supply which will inevitably increase sewage generation. Increased sewage has to be collected and treated as required.

Priority projects of sewerage will collect the increased amount of sewage generated in these three towns through new installation of branch sewers in currently unsewered areas and rehabilitation of existing sewers. One of the principal roles of sewage works to promptly collect generated sewage can be played by installation and/or rehabilitation of sewers while making full use of existing facilities.

Another principal role of sewage works is to treat collected sewage at the required level. Increased sewage will be collected and conveyed either to TP-1 or to TP3 where the collected sewage will be treated with the effluent BOD of less than 80 mg/l as stipulated in NEQS. Priority project also includes the rehabilitation of these two treatment plants to restore their original function.
The new installation and rehabilitation of sewerage facilities in these three towns and two sewage treatment plants do not apply any sophisticated treatment processes or construction methods. Operation and maintenance of implemented/rehabilitated facilities can be done by currently available techniques.

From above mentioned discussions, it is judged that the priority project proposed here is technically feasible.

S5.6.4 Overall Evaluation and Recommendations

(1) Overall Evaluation

It is anticipated that the Priority Project would, through implementation of distribution network improvement (DNI), make a substantial improvement to water supply and sewerage services in the three towns located in the western part of Karachi, namely North Nazimabad, Gulberg and Liaquatabad. The total population in these three towns is approximately 2.5 million at present. Almost the entire area covered by these three towns have already been urbanised with the current average population density of the area being as high as 580 persons per hectare. As such, the Priority Project is considered to be a highly cost-effective investment, in which intended benefits of the project could emerge immediately upon completion of DNI.

The primary objective of DNI is to provide a 24 hour continuous supply on a regular basis with an adequate pressure. It is expected that once DNI has been completed, it would substantially reduce the indirect costs associated with the use of piped water in Karachi. They would include the costs for providing ground-level water reservoirs, suction/booster pumps, roof-top storage tanks and water filters, as well as electricity charges for pumping and fuel costs for boiling water prior to drinking. Many households who are compelled to use expensive tanker supplies would also be able to reduce their expenditure on water considerably.

Currently, low and negative pressures in the distribution system exposes the system to contamination from polluted ground water and there is a sever danger to public health. In addition, many households are obliged to use poor quality subsoil water from shallow wells. The expense of not having an adequate supply of potable water is compounded by the inevitable medical bills resulting from the treatment of water-borne diseases (typhoid, cholera, and hepatitis are common) and the loss of income due to sick time. It is expected that once DNI has been completed, the distribution system would be kept always full of water and under pressure, and as such the chances of contamination would be drastically reduced, and so would be the risks of infection with water-borne diseases, spending on medical bills, and loss of time due to sick time.

It is expected that the Priority Project would considerably reduce the potential health risks associated with the repair, replacement, and demolition of existing asbestos cement pipes in the distribution system. For many years, asbestos cement pipes have been used for water mains in Karachi. As a result, they now constitute about 65% of existing water mains in the distribution system. Most of them have already been deteriorated and undersized, and despite the low system pressure the level of leakage in the distribution system is unacceptably high. It is anticipated that leakage and the incidence of pipe bursts would significantly increase when the system pressure is raised by completion of DNI. This would require all or part of the existing asbestos cement pipe network to be removed or disposed. However, asbestos, in an air borne condition, is a hazardous material. Asbestos cement pipe is non-friable in its intact state but is likely to become friable upon removal, demolition and/or disposal. Once it becomes friable, it will require special safety measures and procedures for handling, containerizing, transporting and disposal, which would also be very costly. It is therefore planned that DNI will develop an entirely new distribution network while leaving the existing distribution network intact. Upon completion of DNI, the new distribution network will replace the existing one completely. The completion of DNI will therefore make the use of the existing distribution network totally unnecessary, and as such it is expected that no repair, demolition, or replacement work of existing asbestos cement pipes would become necessary in future. It is suggested that existing asbestos cement pipes should continue to remain underground and maintain their non-friable state.

It is anticipated that the Priority Project would greatly enhance the efficient and effective use of water resources. DNI would bring about a substantial improvement to water service quality by significantly reducing leakage and other water losses and introducing metered supplies with a volumetric tariff to all consumers. Introduction of a volumetric charging system would provide a strong incentive for the efficient use of water when it is accompanied by block tariff pricing with increased charges for consumption beyond essential use. This is necessary to prevent the households in areas where DNI has been completed from wasting/misusing water. The tariff structure should differentiate essential use from non-essential use. Low tariffs should be applied to the level of essential use while significantly high tariffs should be applied to the level of consumption that is considered non-essential. This would provide a strong incentive for the efficient use of water and also enable the cross-subsidization of water tariffs from the rich to the poor.

(2) Recommendations

It is recommended that DNI should use good quality pipe materials which comply with internationally accepted standards and competent contractors who would be able to execute pipe laying works in an orderly and disciplined manner. Despite the higher level of initial costs required, this would ensure the quality of constructed pipelines and the smooth execution of pipe laying works. Enforcement of stringent quality control would be required throughout the construction stage, in particular with respect to the pressure and leakage tests of pipelines. It is suggested that the Zone West retail entity should establish a special Project Implementation Unit dedicated to the implementation of DNI and to employ a foreign consultant/s who have had similar experience in other large cities in the past to manage the unit.

It is recommended that the cost for providing service connections should be included as part of the total project cost and recovered in the long run through water tariffs. This is necessary to ensure that proper materials and workmanship are used for construction of service connections and to minimize the chances of leakage in service connections in the future. This also applies to water meters. Meters should be the property of the Zone West retail entity who rent them out to customers. This is necessary to maintain the quality of water meters and to minimize the types of water meters used in the distribution system for ease of maintenance. It is recommended that a regulatory board to be established as part of the proposed institutional reform should be responsible for setting out and enforcing ‘Water Supply and Sewerage Services Regulations’ which clearly define the statutory rights and obligations of both the Zone West retail entity and its customers in delivering and receiving the services. The regulations should clearly define that although meters are the property of the Zone West retail entity, the responsibility for maintenance of meters invariably remains with customers.

It is recommended that bulk meters should be installed at all existing high-rise condominiums and apartment buildings. This is because of the difficulty of installing individual household meters in those buildings. However, in the absence of individual water meters, it is necessary to develop a special charging mechanism which will effectively prevent the tenants of the buildings from wasting/misusing water. Meanwhile, it is strongly suggested that individual water meters should be installed from the outset at all new high-rise condominiums and apartment buildings in the future.

With respect to the actual implementation of DNI, considerable attention should be drawn to the fact that approximately 65% of existing water distribution mains in Karachi are asbestos cement pipes. It is recommended that contractors should be made fully aware of this prior to the submission of tenders and they should be instructed not to cut, damage or demolish any pipes which are not picked up (registered) by metal detectors. Other utility service operators should also be informed about the danger and the Zone West retail entity should try to provide them with as much information on the existing distribution system as possible. In addition, both contractors and utility service operators should be informed about the procedures that should be followed by them when they accidentally or unknowingly disturbed existing asbestos cement pipes and thereby causing them to become friable.

There are not so many Katchi Abadies in North Nazimabad, Gulberg and Liaquatabad Towns. Nonetheless, where services must be provided free of charge the Zone West retail entity should be compensated by the relevant local body responsible for social welfare services. Although it is necessary to ensure that residents of Katchi Abadies will receive water for their essential use, it should not be realized at the expense of the Zone West retail entity.

DNI will involve not only physical improvement works; it will also include improvements to many institutional aspects, such as the introduction of a dual pricing system, elimination of illegal and unauthorised connections, and the strict enforcement of laws on payment defaulters. As such, it is very likely that the implementation of DNI would face severe political interference if it is financed by Government subsidies. It is therefore necessary to create a new institutional framework, whereby DNI can be implemented on a loan financing basis without any Government subsidies. We have provided in this report an outline of suggested reforms in principle at this stage, which would be necessary to create such a new institutional framework. It is expected that detailed studies related to the suggested reforms will be carried out under the assistance of ADB and WSP. It is also expected that the reform process would be put into effect through the two Reform Committees (one at provincial level and the other at CDGK level) that have already been established under WSP’s initiatives, which would take responsibility for ensuring the progressive implementation of reforms in close coordination with the Local Support Unit of the ADB assisted Karachi Mega City Sustainable Development Program.

Understanding and corporation of the public are indispensable for the smooth and effective execution of DNI. It is therefore recommended that the Zone West retail entity should endeavour to inform the public in advance about the objectives, targets and components of DNI through mass media such as newspapers, TV and radio. Since DNI is expected to take many years to complete across all areas of Karachi, it could only be implemented on an area-by-area basis. This creates the situation where some neighbourhoods enjoy an improved level of service whereas other neighbourhoods continue to suffer from the current poor level of services. This, although being unfavourable from the viewpoint of social justice and equity, is an unavoidable unless and until DNI has been completed across all areas of Karachi. It would therefore be absolutely necessary for the Zone West retail entity to inform the public about this and ask for their understanding. It would also be important for the retail entity to maintain close coordination with NGOs, CBOs, CCBs, UCs, TMAs, traffic police and other utility service operators.

It is recommended that customers in areas where DNI has already been completed (and receiving an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis) would pay a water charge that is some multiple of the current level of water charges, whereas customers in areas where DNI has not been completed (and continuously receiving the current level of service with intermittent supply) would continue to pay the current level of water charges. This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods. We consider that the introduction and enforcement of the dual pricing structure is a prerequisite for the successful implementation of DNI.

It is suggested that the KW&SB's assets relating to the water supply and sewerage system in Zone West would be transferred to CDGK initially and then from CDGK to the Zone West retail entity. CDGK would have an initial shareholding of less than 30% of the voting shares but would, in addition, hold convertible preference shares reflecting the value of the assets transferred from CDGK to the Zone West retail entity. Provisions would be made for converting these shares to voting share after the retail entity's first 5 years of operation. This would allow CDGK the option to ensure that the Zone West retail entity remains under public control after its first 5 years of operation.

All staff transferred from KW&SB to the Zone West retail entity would be on probation for a period of 12 months and would be paid in accordance with their existing contracts of employment. At the end of this period the retail entity will offer new terms and conditions of employment to those staff that it wishes to retain as employees of the retail entity. Staff who do not wish to accept this offer or are not offered continued employment would become the employees of KW&SB and would be eligible for immediate voluntary redundancy.

Because of the extremely poor conditions of the existing distribution network, huge investments would be required to make a substantial improvement to the service quality. Hence, it is likely that the Zone West retail entity's expenses would increase more rapidly than its revenues during the first 5 years of its existence. This implies that special arrangements would have to be made to finance the operating losses that the Zone West retail entity is likely to make during its first 5 years of operation.

CHAPTER 1

INTRODUCTION

1 INTRODUCTION

1.1 BACKGROUND

1.1.1 Formulation of JICA Study

Karachi is the capital of the province of Sindh and the largest city in Pakistan with a total present population of approximately 16 million. It is playing pivotal roles in the nation's economic and industrial activities. However, due mainly to the significantly large population growth rates (4 to 5% per annum) the city has experienced over the last three decades, the augmentation of the water supply system including water source, bulk conveyance system and distribution network has consistently lagged behind the fast growing water demand of the city. The consequence is the rationing of supply currently experienced in most areas of the city in that water is supplied only once in every two or three days and for the duration of two to three hours at a time. People are obliged to spend money on ground-level tanks, booster pumps, roof-top storage tanks and water filters and even then all water must be boiled prior to drinking. Many households are compelled to use secondary sources of water such as shallow wells or tanker supplies (costing in excess of US$ 1.50/ m^3) just to meet their basic needs.

The existing sewerage system of which service coverage is said to be 30% at present has also a number of problems. They include low sewage flows received at existing sewage treatment plants resulting from the inadequate provisions of sewer trunk mains and the malfunctioning of pumping facilities, deterioration of water quality in rivers and canals, and clogging of waterways caused by damping of massive rubbish.

In Karachi, a master plan for the water supply system was prepared in 1985 and that for the wastewater management system in 1988. In the past, however, only a few projects were actually implemented in line with the recommendations of these master plans mainly because of the financial constraints. After the elapse of almost two decades since preparation of these master plans, situations surrounding the city have changed so significantly that the development plans proposed by these master plans have largely become obsolete or greatly deviated from the actual needs of the city. This eventually lead to the formulation of a broad consensus in Pakistan that these master plans should be reviewed and revised for the future development of water supply and sewerage systems as well as for the optimization of the water services management.

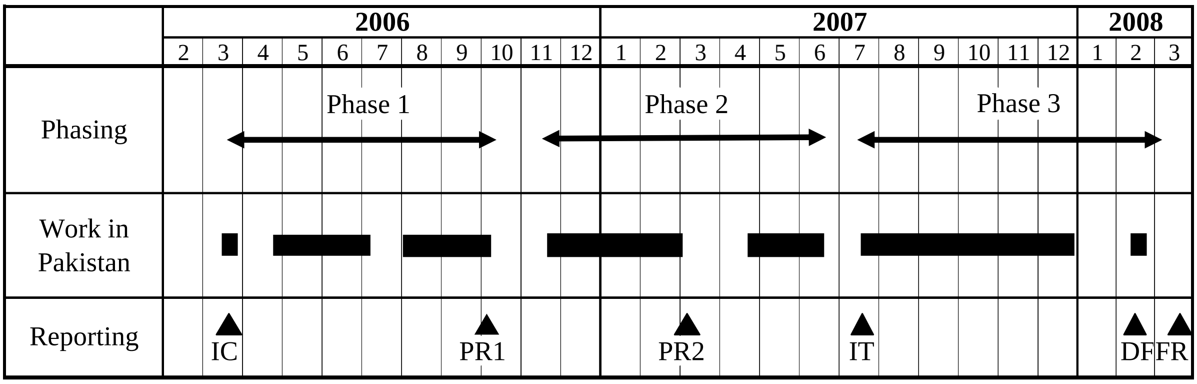
Against the background mentioned above, the Government of Pakistan officially requested the Government of Japan to conduct a master plan study to formulate a phased development plan of water supply and sewerage system for Karachi up to the year 2025.

In response to the request of the Government of Pakistan, the Government of Japan through the Japan International Cooperation Agency (hereinafter referred to as 'JICA') dispatched a preparatory study team to Pakistan in July 2005 and the "Scope of Work for the Study on Water Supply and Sewerage System in Karachi in the Islamic Republic of Pakistan (hereinafter referred to as the 'Scope of Work' or 'S/W')" was agreed upon on 13 July 2005 between JICA on one part and the City District Government Karachi (hereinafter referred to as "CDGK") and the Karachi Water and Sewerage Board (hereinafter referred to as 'KW&SB') on the other part. The agreed S/W and the minutes of the meeting which discussed the S/W are attached as **Appendixes A11.1** and **A11.2**.

1.1.2 Implementation Schedule of JICA Study

It was originally agreed that the Study would be implemented in the following three phases over a total period of approximately two years as shown in **Figure 11.2.1**.

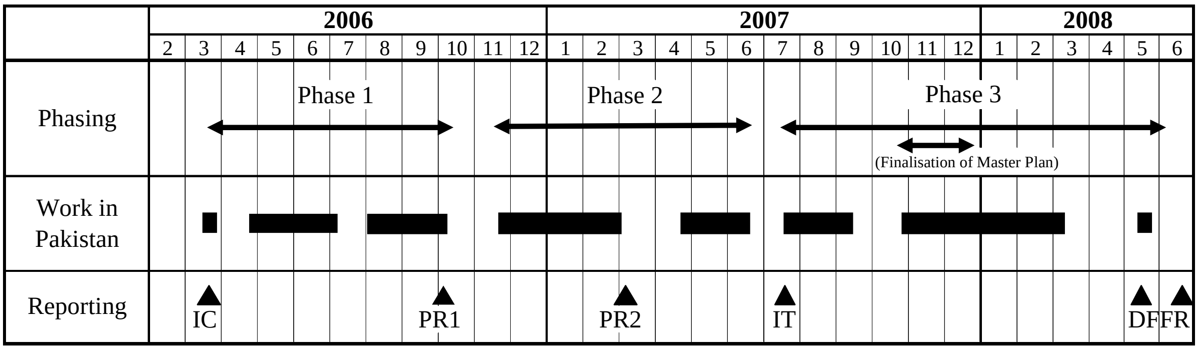
Phase 1: Basic Study (March 2006 to October 2006)
Phase 2: Master Plan (November 2006 to June 2007)
Phase 3: Feasibility Study (July 2007 through March 2008)



IC : Inception Report
PR1 : Progress Report No.1
PR2 : Progress Report No.2
IT : Interim Report
DF : Draft Final Report
FR : Final Report

Figure 11.2.1 Original Implementation Schedule of JICA Study

However, due to the additional work required for the finalization of the water supply and sewerage master plan as described in **Section 1.4**, the Study period was extended for approximately 3 months until June 2008. **Figure 11.2.2** shows the final implementation schedule, according to which the JICA Study was actually carried out.



IC : Inception Report
PR1 : Progress Report No.1
PR2 : Progress Report No.2
IT : Interim Report
DF : Draft Final Report
FR : Final Report

Figure 11.2.2 Final Implementation Schedule of JICA Study

1.2 PHASE 1: BASIC STUDY

In March 2006, the JICA study team visited Pakistan for two weeks for presentation and discussion of the Inception Report on the Study. At a meeting held in Karachi on March 14, 2006 at the Committee Room of the Planning and Development (P&D) Department of the Government of Sindh, the JICA study team presented the Inception Report and it was accepted without any modification. The meeting was chaired by the Additional Chief Secretary (Dev), P&D Department of the Government of Sindh. The minutes of the meeting are attached as **Appendix A12.1** to this report. In the meantime, the Government of Sindh through its letter No.SO (C-I)/SGA&CD/4-23/2006 dated March 30, 2006 notified the constitution of the Steering Committee (SC) for the Study, which consists of a chairman and nine members as follows.

1.	The Additional Chief Secretary, Planning & Development Department, Government of Sindh	: Chairman
2.	The City District Nazim, City District Government Karachi	: Member
3.	The Secretary, Local Government, Katchi Abadies & Spatial Development Department, Government of Sindh Karachi	: Member
4.	The District Coordination Officer, City District Government Karachi	: Member
5.	The Chief – Foreign Aid Planning & Development Department, Government of Sindh, Karachi	: Member
6.	The Special Secretary, Planning & Development Department, Government of Sindh Karachi	: Member
7.	The Managing Director & EDO (Water & Sanitation) CDGK, Karachi Water & Sewerage Board	: Member
8.	The EDO Master Plan Group of Offices, City District Government Karachi	: Member
9.	The Chief Engineer (Projects), Karachi Water & Sewerage Board	: Member
10.	The Chief (PP&H), P&D Department, Government of Sindh Karachi	: Member

The JICA study team returned to Pakistan in late April 2006 to undertake the rest of the "Phase 1: Basic Study", which comprised the following study components.

- Review of water supply and sewerage master plans prepared in the past
- Assessment of existing water sources
- Assessment of existing water supply, sewerage and drainage facilities
- Evaluation of water quality
- Review of existing land use
- Assessment of existing laws, policies and administration systems related to water supply, sewerage and drainage services
- Assessment of KW&SB's institutional and managerial capacity
- Study on environmental and social considerations
- Review and analysis of relevant studies and projects
- Evaluation of existing water supply, sewerage and drainage conditions and identification of major problems
- Identification of quick impact programmes

In undertaking these studies, the JICA study team collected and analyzed various data and information related to the Study, including study reports prepared in the past. It was then followed by the field inspections of key water supply and sewerage infrastructure located in and out of Karachi as well as by intensive discussions with officials of the KW&SB and other government agencies concerned. Further, in order to obtain accurate information on the actual conditions of the existing water supply and sewerage services in Karachi, the JICA study team also conducted the following field survey works.

- Water Quality Sampling and Analysis Survey in which water samples were taken and analyzed two times - one in the dry season and the other in the wet season.
- For water supply : 29 samples (raw water, treated water and water in the distribution system) at each season
- For sewerage: 7 samples (effluent discharging point, Lyari River, Malir River, domestic and commercial wastewaters) at each season
- Leakage Surveys at two locations – one in Landhi Town and the other in Gadap Town
- Water Consumption and Public Perception Survey which covered a total of 1,200 households in Karachi

The JICA study team organized and convened a workshop on June 27, 2006 in Karachi, in which all the Superintendent Engineers (SEs) of KW&SB were invited to participate to express their views and opinions on various problems of the existing water supply and sewerage services. The JICA study team also assisted KW&SB in organizing and convening the first stakeholders meeting in Karachi on September 7, 2006, which complied with the procedures required under the 'JICA Guidelines for Environmental and Social Considerations'.

In late September 2006, the JICA study team prepared the Progress Report No.1 compiling the outcome of the Phase 1: 'Basic Study'. The report consisted of two separate volumes, namely, Volume I: Main Report and Volume II: Appendices. It was presented to the Steering Committee at a meeting held in Karachi on October 2, 2006 and was accepted in principle. The minutes of the meeting of this Steering Committee are attached as **Appendix A12.2**.

1.3 PHASE 2: MASTER PLAN

The JICA study team started the Phase 2: 'Master Plan' in late November 2006, which, among others, included the following study components.

- Water demand forecast
- Forecast of future quality and quantity of sewage
- Formulation of basic planning framework, policies, goals and strategies
- Equitable water distribution
- Bulk water sources and conveyance system
- Reduction of energy costs
- Formulation of facility development plans
- Strengthening of KW&SB's management capacity
- Preliminary cost estimates
- Formulation of phased implementation programmes
- Evaluation of Master Plan and selection of priority projects

In the development of the institutional aspects of the Master Plan, the JICA study team convened the 'Human Resources Management and Development' workshop on February 6, 2007 in Karachi. The workshop provided a forum where senior KW&SB managers could express their ideas and concerns in an open and honest environment with the idea of transforming KW&SB into a customer focused efficient and financially sustainable professional organization. 40 senior managers mostly from non-engineering departments were invited of which 26 attended.

In late February 2007, the JICA study team produced the Progress Report No.2 which presented the progress of Phase 2: 'Master Plan Study' made up to mid February 2007. The report was presented to the Steering Committee at the meeting held in Karachi on February 28, 2007. The minutes of the meeting of this Steering Committee are attached as **Appendix A13.1**. As agreed at this meeting, follow-up meetings between KW&SB and JICA study team took place on March 1, 2007 and March 2, 2007 to discuss and resolve issues raised by KW&SB regarding the contents of the Progress Report No.2. The minutes of these follow-up meetings are attached as **Appendix A13.2**. At the meeting held on March 1, 2007, KW&SB provided the JICA study team with a questionnaire regarding the Progress Report No.2. JICA study team prepared and e-mailed KW&SB its replies to the questionnaire on April 15, 2007. The KW&SB's questionnaire and JICA study team's replies including e-mails exchanged between the two in this respect are attached as **Appendix A13.3**.

The issues described in Items 16 and 17 of the minutes of the February 28, 2007 meeting with the Steering Committee were discussed further at the meetings of JICA study team and the JICA delegation from Japan and Islamabad with (1) the Managing Director of KW&SB on May 7, 2007 and (2) the Additional Chief Secretary (Dev) of the Government of Sindh on May 8, 2007;

the following decisions were made by consensus of all those who participated in these meetings.

- The Secretary of the Steering Committee would distribute Progress Report No.2 (which KW&SB received from the JICA study team on February 24, 2007) to each member of the Steering Committee without further delay with (a) the minutes of the February 28, 2007 Steering Committee meeting, (b) the KW&SB's questionnaire delivered to the JICA study team on March 1, 2007, and (c) JICA study team's replies to the KW&SB's questionnaire attached to the report.
- It was therefore not necessary to convene the meeting of the Steering Committee referred to in the last sentence of Item 17 of the minutes of the February 28, 2007 Steering Committee meeting.

The minutes of the May 7, 2007 and May 8, 2007 meetings are attached as **Appendix A13.4** and **Appendix A13.5** respectively. Based on the decisions made at these meetings, the JICA study team submitted three letters to KW&SB. The first letter provided JICA study team's comments on the minutes of the February 28, 2008 Steering Committee. It informed the decisions made at the May 7, 2007 and May 8, 2007 meetings that neither the revision/ resubmission of Progress Report No.2 nor another meeting of the Steering Committee to review Progress Report No.2 was necessary. The second letter concerned about the minutes of the follow-up meetings held on March 1, 2007 and March 2, 2007. It enclosed the "Notes of the Meetings" prepared by the JICA study team, which represented their understanding of what was discussed and agreed at these meetings. The third letter pertained to the issues raised by KW&SB during the March 1, 2007 and March 2, 2007 follow-up meetings for consideration by the JICA Headquarters in Japan. It contained a document detailing the points raised by KW&SB for JICA's consideration with confirmation of JICA's response. Copies of these three letters are attached as **Appendix A13.6**, **Appendix A13.7** and **Appendix A13.8** respectively.

In accordance with the decisions made at the May 7, 2007 and May 8, 2007 meetings, the Secretary of the Steering Committee officially distributed Progress Report No.2 (Main Report & Appendixes) to the Chairman and members of the Steering Committee on May 25, 2007. The minutes of the February 28, 2007 Steering Committee Meeting along with the KW&SB's questionnaires on the report and the JICA study team's replies to those questionnaires were enclosed in the report. A copy of the letter sent to the Chairman and members of the Steering Committee in this regard is attached as **Appendix A13.9**.

1.4 PHASE 3: FEASIBILITY STUDY

In early August 2007, the JICA Study team issued the Interim Report. The report consisted of Volume I: 'Main Report' and Volume II: 'Appendices' and presented the outcome of Phase 2: 'Master Plan Study', which included water supply and sewerage master plan along with phased implementation schedules and preliminary cost estimates. The report also provided recommendations on the 'Priority Project' which would be subjected to feasibility studies in the Phase 3: 'Feasibility Study' stage of the JICA Study. At a meeting held in Karachi on August 8, 2007, the report was presented to the Chairman and members of Steering Committee including the City Nazim. JICA Study team informed the Steering Committee that the water supply and sewerage master plan shown in the report had been developed based on the town-wise population projections, land use plans and other basic data provided in the Karachi Strategic Development Plan 2020 (CV-3) that was prepared by CDGK and officially submitted to the Embassy of Japan in Islamabad in January 2007. The City Nazim then informed the Committee that the CV-3 of the Karachi Strategic Development Plan 2020 was still a draft version and its final version containing revised town-wise population projections that were significantly different from that of the CV-3 version would be issued very shortly. Also, he insisted that the water supply and sewerage master plan should be developed based on the revised town-wise population projections provided in the final version of the Karachi Strategic Development Plan 2020. His view was supported by the Chairman and other members of the Steering Committee. On the following day, August 9, 2007, this issue was again discussed and the following consensus was reached among the parties concerned.

- CDGK would submit the final report of the KSDP-2020 to the Embassy of Japan and JICA Pakistan Office in Islamabad on August 15, 2007, which would be accompanied by a letter signed by the City Nazim certifying that the report was the final report of the KSDP-2020 while also requesting JICA to revise the water supply and sewerage master plan provided in the Interim Report so that the plan would become consistent with the town-wise population projections, land use plans and other basic data provided in the final report of the KSDP-2020
- The JICA Headquarters in Tokyo would review the request for the revision of the master plan and inform GOP, GOS, CDGK and KW&SB in writing within one month after the receipt of the report from CDGK its decision on whether it was possible to revise the master plan according to the request

The above consensus was subsequently documented in the form of Minutes of Understanding which were signed by the parties concerned on August 9, 2007. The minutes of the August 8, 2007 Steering Committee meeting and the Minutes of Understanding dated August 9, 2007 are attached as **Appendix A14.1**.

In line with the Minutes of Understanding dated August 9, 2007, the EDO Master Plan of CDGK with his letter Ref No. CDGK-MPGO/KSDP-2020/JICA/93 dated August 15, 2007 (See **Appendix A14.2**) provided JICA with a copy of the final report of the Karachi Strategic Development Plan 2020. Subsequently, the following two letters were exchanged between the JICA /Embassy of Japan and the City Nazim.

- JICA's letter Ref No. JICA/10-03007/Admn/2007 dated October 3, 2007 addressed to the City Nazim (See **Appendix A14.3**)
- City Nazim's letter Ref No. City/Nazim/Secy/2262/2007 dated October 4, 2007 addressed to the Embassy of Japan, Islamabad (See **Appendix A14.4**)

Finally, JICA through its letter Ref No. JICA/10-25008/Admn/2007 dated October 25, 2007 (See **Appendix A14.5**) informed the City Nazim of its decision that it would undertake additional work to revise the water supply and sewerage master plan provided in the Interim Report so that the plan would become consistent with the town-wise population projections, land use plans and other basic data provided in the final report of the Karachi Strategic Development Plan 2020. Since this revision work required an extension of the JICA Study period stated in the Scope of Work (S/W) dated July 13, 2005, Minutes of Meeting were prepared for the modification of the S/W and signed by the parties concerned on November 14, 2007. These Minutes of Meeting are attached as **Appendix A14.6**.

CHAPTER 2

OBJECTIVES OF THE STUDY AND STUDY AREA

2 OBJECTIVES OF THE STUDY AND STUDY AREA

2.1 OBJECTIVES OF THE STUDY

It was agreed in the S/W dated 13 July 2005 that the "Study on Water Supply and Sewerage System in Karachi in the Islamic Republic of Pakistan (hereinafter referred to as the 'Study')" would be conducted by a team of the consultants appointed by JICA (hereinafter referred to as the 'JICA Study team') with the main objectives of (a) formulating a master plan for development of the water supply and sewerage systems in Karachi up to the target year of 2025, (b) conducting a feasibility study on the priority projects selected in the master plan, and (c) pursuing technical transfer to Pakistani counterpart personnel in the course of the Study. KW&SB, the organization currently responsible for the provision of water and sewerage services in Karachi, was the counterpart agency to the JICA Study team. KW&SB also acted as a coordinating body in relation with other governmental and non-governmental organizations concerned for the smooth implementation of the Study.

2.2 STUDY AREA

The Study area covers the entire administrative area of the City District Government Karachi (CDGK) plus other areas administered by various agencies such as the Government of Pakistan, Government of Sindh, 6 Cantonment Boards, Defence Housing Authority, Port Qasim Authority, Karachi Port Trust, Pakistan Railways, Sindh Industrial Trade Estate, Lyari Development Authority, Malir Development Authority and Cooperative Housing Societies. In addition, it also covers areas outside the CDGK's administrative boundaries where water sources and bulk water transmission facilities currently exist or planned for future development.

The CDGK's administrative area occupies an area of 2,787 km^2. It is administratively divided into 18 Towns which are further sub-divided into 178 Union Councils (UCs). **Table 22.1.1** provides the names and areas of the 18 Towns and the number of UCs included in each Town.

Table 22.1.1 18 Towns and 178 Union Councils

Sr No	Town	Area			No. of Union
		Acres[1)]	km^2	%	Councils[2)]
1	Keamari	106,217	429.84	15.4%	8
2	SITE	6,286	25.44	0.9%	9
3	Baldia	7,217	29.21	1.0%	8
4	Orangi	5,803	23.48	0.8%	13
5	Lyari	1,977	8.00	0.3%	11
6	Saddar	5,967	24.15	0.9%	11
7	Jamshed	5,790	23.43	0.8%	13
8	Gulshan-E-Iqbal	13,260	53.66	1.9%	13
9	Shahfaisal	2,901	11.74	0.4%	7
10	Landhi	9,670	39.13	1.4%	12
11	Korangi	10,247	41.47	1.5%	9
12	North Nazimabad	4,127	16.70	0.6%	10
13	North Karachi	5,058	20.47	0.7%	13
14	Gulberg	3,417	13.83	0.5%	8
15	Liaqatabad	2,685	10.87	0.4%	11
16	Malir	4,395	17.78	0.6%	7
17	Bin Qasim	137,961	558.31	20.0%	7
18	Gadap	355,798	1,439.86	51.7%	8
Total		688,776	2,787.37	100.0%	178

Source: 1) KSDP-2020, Page 43; 2) JICA Fact Finding & Recommendation Study on Water Supply and Sewerage System in Karachi - Final Report March 2005, Table 2.1, Page 2-2

2.3 DESCRIPTION OF THE STUDY AREA

2.3.1 Natural Conditions

(1) Topography

Karachi is located in the south of Sindh, on the coast of the Arabian Sea. It covers an area of approximately 3,600 km^2, comprised largely of flat or rolling plains, with hills on the western and northern boundaries of the urban sprawl. The city represents quite a variety of habitats such as the sea coast, islands, sand dunes, swamps, semi arid regions, cultivated fields, dry stream beds, sandy plains, hillocks. Classified according to physiographic features, Karachi City District can be divided into three broad categories:

- Hilly Region (Mountain Highland)
- Alluvial Plain (Piedmont Plain)
- Coastal Areas (Valley Floor)

The metropolitan area is divided by two non-perennial river streams namely Lyari and Malir Rivers. The Malir River flows from the east towards the south and centre, and the Lyari River flows from north to the south west. Gujjar and Orangi are the two main tributaries of the Lyari River while Thaddo and Chakalo are the main tributaries of the Malir River. The dry weather flow of both rivers carries urban sewage that is ultimately drained in the Arabian Sea.

Among the various physiographic features, low flat-topped parallel hills devoid of vegetation, interspersed with widespread plains and dry riverbeds are the main topographic characteristics of the city. The greatest height of the region is 250 ft that gradually decreases to 5 ft above mean sea level along the coastline. The Karachi Harbour is a sheltered bay to the south-west of the city, protected from storms by the Sandspit Beach, the Manora Island and the Oyster Rocks. The Arabian Sea beach lines the southern coastline of Karachi. Dense mangroves and creeks of the Indus delta can be found towards the south east side of the city. Towards the west and the north is Cape Monze, an area marked with projecting sea cliffs and rocky sandstone promontories.

(2) Geology and Geomorphology

The present geological setup of the city is largely composed of sandstone, shales of Nari, Gaj and Mancher formation ranges from Oligocene to recent. The area comprises hills, valleys and the coast as the physical features. Rocks are deposited under shallow marine to deltaic condition. On the basis of the water bearing properties, the lithostraitigraphic units can be classified as consolidated and un-consolidated sediments. The area extends in the north to south east direction, sloping towards the Arabian Sea. The area between valley floor and mountain highland is covered by sub-recent deposits generally sloping towards the drainage system of the four river basins. Physiographical classification of the area establishes three separate landforms, namely mountain highland, piedmont plain and the valley floor. According to the geological classification, the rocks of the entire region of Karachi and its suburbs, upper valleys of Lyari and Malir rivers are almost exclusively of the tertiary system that belongs to the most recent geological period. The lower reach of the Lyari basin constitutes post-tertiary alluvial subsoil while the upper reach constitutes boulders and conglomerate. Malir River basin consists of alluvial deposits of boulders, gravels sand and clay. Mole and Khadeji streams form the uppermost tributaries of the Malir River. The thickness of the bed gradually increases downstream.

(3) Climate

Located on the coast, Karachi tends to have a relatively moderate climate with high humidity. The weather is hot and swelters during May-June with an average maximum temperature of about 34 °C. The winters are relatively mild and with an average minimum temperature of about 13 °C. For greater part of the year, the relative humidity around Karachi is high. The average relative humidity is at a minimum in the months of December to March while it is at a maximum during the monsoon months of July to September. **Table 23.1.1** presents typical climatological conditions in Karachi. The annual average rainfall is 203 mm which classifies the region as 'arid'. The rainfall is brought about mostly by the northwesterly monsoon during the period June to September.

Table 23.1.1 Typical Climatological Conditions in Karachi

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Temp. (°C)	Min.	12.8	14.4	19.4	22.8	26.1	27.8	27.2	26.1	25.0	22.2	17.8	13.9
	Max	25.0	26.1	29.4	32.2	33.9	33.9	32.8	31.1	31.1	32.8	30.6	26.7
Precipitation (mm)	Max	69	51	56	131	60	183	392	428	252	69	41	66
	Ave	13	10	8	3	3	18	84	41	13	2	3	5
	Max/ 24 hr	41	28	43	104	30	183	201	137	206	13	23	46
Average Relative Humidity (%)		54	61	58	75	78	78	81	82	80	70	59	55

Source: Karachi Airport (1947 – 1990)

Strong coastal winds are also the characteristic feature of the region. The wind direction during the southwest monsoon period is dominantly from the northeast and north. Wind intensity at the time when the southwest monsoon sets in is much dependent upon the low air pressure system prevailing over the sub-continent.

2.3.2 Socio-Economic Conditions

(1) Population

In terms of the number of population, Karachi is one of the ten largest cities in the world. The population of Karachi is estimated at 15.1 million in 2005 and 27.5 million in 2020 under the Karachi Strategic Development Plan 2020 (August 2007). The increase in population is putting heavy pressures on the physical, infrastructural, financial and institutional systems of the city.

A large segment of Karachi's population, roughly 40%, is afflicted with poverty. The living conditions of the deprived section and its economic wellbeing are therefore a major concern, as these impact the environment and growth potential of the city.

Karachi's population is diversified in terms of ethnicity and economic conditions. Apart from in-migrants from Pakistan's provinces, a large number of migrants from Afghanistan, Bangladesh and other South Asian countries have settled in the city.

With an average monthly household income of Rs. 15,000 (US$250), there is considerable variation in income distribution. Roughly 75% of the households fall in the category of poor and low income groups and 25% constitute the middle and high income groups.

In Pakistan, a nation-wide census is conducted once in every ten years. The last census was carried out in 1998 and it reported that Karachi's population was 9,960,000 at that time. On the grounds that the 1998 census undercounted Katchi abadi residents and migrants, the KSDP-2020 (August 2007) corrected this baseline population as 11,335,000 and then projected that the population would increase to 15.12 million by 2005 by applying the average annual population growth rate of 4.2% which comprises 3.5% of natural growth rate and 0.7% of social growth rate. The next census is scheduled for 2008.

(2) Land Use and Urban Planning

a) Land Use

The Karachi City District is spread across an area of approximately 3,600 km^2. A large portion of this area consists of vacant land including the area dedicated to the Kirther National Park. The KSDP-2020 (August 2007) indicated that Karachi has now an urbanised area of approximately 527 km^2 which comprises various types of land uses as shown in **Table 23.2.1**.

Table 23.2.1 Existing Land Use in Urbanised Area

Land Use	Urbanised Area 2006		
	Acres	km^2	%
Formal Residential	35,206	142.5	27.0%
Informal Residential	10,558	42.7	8.1%
Goth (Villages = Residential)	2,043	8.3	1.6%
Commercial	2,921	11.8	2.2%
Health	685	2.8	0.5%
Educational	3,320	13.4	2.6%
Government	3,036	12.3	2.3%
Other Institutional	1,218	4.9	0.9%
Industries	9,285	37.6	7.1%
Cottage Industries	28	0.1	0.0%
Transport	723	2.9	0.6%
Warehouses	563	2.3	0.4%
Mining	166	0.7	0.1%
Vacant Land	9,541	38.6	7.3%
Open Space	13,439	54.4	10.3%
Agriculture	7,296	29.5	5.6%
Water	2,392	9.7	1.8%
Road Space	23,089	93.4	17.7%
Other Land Uses	4,660	18.9	3.6%
Total	130,169	526.8	100.0%

Source: KSDP-2020 (August 2007), Annexure-I, 3. Existing Land Use and Housing

It should be noted that vacant land accounts for only 7% of all land and housing is the biggest user of land (with about 37% of the total), while roads and open spaces are also significant. Most of the developed areas are concentrated in the inner ring towns of Saddar, Jamshed, Lyari, Liaquatabad, Gulshan-e-Iqbal and Gulberg. These towns contain the most diverse mix of land uses and include most of the governmental and regional-scale industrial and commercial activities.

The KSDP-2020 (August 2007) stated that with mounting pressures exerted by the population growth over the last two decades, the following two basic trends in land use have recently been observed.

- Commercial growth has taken place along major arterials.
- While most residential neighbourhoods have acquired one or two storey structures, significant densification has taken places through construction of upper floors and subdivisions of large plots. In many old and new areas, apartment buildings, 5-6 storeys high, have replaced the low-density bungalow type housing.

b) Urban Planning

The key urban master planning exercises carried out for Karachi City are briefly described as follows:

(i) The Greater Karachi Resettlement Plan

In 1958, Ayub Khan (the then military ruler of the country) took a number of decisions that affected Karachi and its relationship with the rest of Pakistan. Ayub decided to shift the capital to Islamabad. He also decided that the refugees should leave the city and the working classes, migrating into the city from the other areas of Pakistan should also be discouraged from living within the city centre. To achieve these ends he hired a Greek planner, Doxiades, to prepare what is known as the 'Greater Karachi Resettlement Plan' (GKRP). The plan consisted of developing two satellite towns, Landhi-Korangi to the east and New Karachi to the north of the city. These satellite towns were to be about 25 km from the city centre. Industrial estates were developed as part of the satellite town plans and industrialists were offered incentives to invest here. At the same time, core houses were developed to house the refugee population and other squatter settlement residents. It was assumed that these people, who were being forcibly moved to these locations, would find employment here. However, that did not happen as industrialization was slow to develop and the owners of the new core houses refused to pay their installments which were to finance the continuation of the housing process. Consequently, by 1964, the program was abandoned.

(ii) The Karachi Master Plan 1974-85

The failure of the GKRP forced the governments in the mid to late 1960s to seek alternative solutions to the housing and infrastructure problems of the city. The government of Pakistan in 1968, asked for UNDP assistance for preparing a master plan for the city of Karachi. The resulting Karachi Master Plan 1975-85 was a landmark in the planning history of Karachi. It made plans for a rational road network; housing, consisting of site-and-services and the upgrading of katchi abadis; bulk water supply; transport terminals and warehousing; land management; bypasses to the city; mass transit and ecological issues. In the plan period, only the road networks were built and these too in a sub-standard manner. However, they eased and rationalized movement between different areas of the city. Most of the plan components could not be implemented, nor could the institutional arrangements be made that were envisaged by the plan for the management of the city. Legal cover was not given to the plan either.

(iii) The Karachi Development Plan 2000

On the expiry of the 1974-85 Karachi Master Plan period work on the Karachi Development Plan 2000 was begun by the KDA with UNDP assistance. The plan document was completed in 1990. Essentially the plan consisted of a computer model that would monitor developments in Karachi so that investments could be directed appropriately. It also contained important recommendations for planning and a related institutional set-up which included the setting up of an independent Karachi Division Physical Planning Agency (KDPPA) supported by a steering committee and an implementation board. Building control in this agreement was to be subservient to the KDPPA. However, the monitoring and related planning exercise could not be carried out without a constant supply of data for which no system was proposed by the plan. This and other related factors rendered the entire set-up created for the Karachi Development Plan 2000 ineffective. In addition, the plan was never given legal cover as its Steering Committee could not meet to approve it.

(iv) Karachi Strategic Development Plan 2020 (KSDP-2020)

A project for the formulation of a Master Plan 2020 for Karachi City is presently being carried out within the Master Plan Group of Offices (MPGO) of the City District Government Karachi (CDGK). It is undertaken under the Tameer-e-Karachi Program to set out a strategic framework and overall development direction and future pattern of the city over the next 13 years up to 2020. The final report of the KSDP-2020 was issued in

August 2007.

(3) Health

Karachi has a variety of medical facilities. It has all sorts of hospitals, clinics and dispensaries, both in the public and private sectors. However, a vast majority of the population also get treatment from medical practitioners, both qualified and unqualified and by hakims (traditional doctors using herbal medicines). Most of these doctors operate from small, one room clinics and have no proper diagnostic facilities. There is no record of the number of such clinics. However, they greatly outnumber public sector health facilities. Since public sector facilities remain highly centralized in a few locations, they become largely inaccessible to population of most city sectors. This provided the stage to the private sector to establish clinics and hospitals in the residential neighborhoods.

Although the access to public sector hospitals is unrestricted and is also non-discriminatory, treatment and hospitalization facilities are lacking so that there is considerable pressure on the present resources. Major deficiencies exist in both the quantity and quality of these public sector health care facilities. The current system has 33 hospitals, 271 health centres and 152 dispensaries. It includes an estimated 15,000 beds, of which 9,000 are in the tertiary and teaching hospitals and the remaining 6,000 dispersed among the primary and secondary facilities.

In contrast, private hospitals provide better facilities and better service but restrict access on account of affordability. The private sector health care system has 356 hospitals (of which 145 are large), 391 maternity homes, 2,347 dispensaries and about 6,600 beds.

(4) Education

According to a survey conducted by the Applied Economic Research Centre (AERC) in 1987, the literacy rate in Karachi was 76% in planned areas and 49% in unplanned areas. The Government of Sindh, the federal government, the City Government and the private sector are the main providers of education in Karachi. However, owing to the inadequacy of the government run educational facilities, such facilities have been supplemented in a very significant way by the private sector.

The KSDP-2020 (August 2007) indicated that approximately 75% of all children in need of basic education are enrolled in primary schools, while about 60-65% receives education at the secondary level. As for the quality of education, public sector institutions lag behind the private sector. However, the public education is much more affordable than the private education.

The Pakistan Social & Living Measurement Survey of 2004-05 showed a 72% literacy rate for the urban areas of Sindh. The rate was 80% for men and 62% for women. The overall literacy rate for urban areas in Pakistan was 71%. A socio-economic survey conducted as part of the KSDP-2020 study in 2005 showed a similar literacy rate of 71% for the city of Karachi.

Social indicators representing the whole of Karachi may be misleading since there are major differences between the social indicators for the city’s planned areas and katchi abadis. There are also major differences in social indicators among low-income settlements themselves.

(5) Economy

Karachi is the financial capital of Pakistan; it accounts for the lion's share of GDP and revenue. In February 2007, World Bank has termed Karachi as the most business-friendly city in Pakistan. KSDP-2020 (August 2007) describes the Karachi’s economy as follows:

(Start Quote from KSDP-2020) Karachi, benefiting from its status as the country's principal port, and its capital until 1959 has emerged as the main industrial and commercial centre. Until the 1970s, the city's industrial expansion was driven by traditional industries such as food processing, textiles and garments, but in the 1980s a number of modern chemical, electronic and automotive industries began to make an increasingly important contribution to industrial growth. During this period, Karachi became the main attractor for foreign direct investment in manufacturing in Pakistan and its industrial structure was diversified through the establishment of large manufacturing units in the chemical, petroleum and metallurgical industries. However, owing to a deteriorating law and order situation resulting in production shutdowns and payment of extortion to various agencies, the increase in the cost of production through higher energy costs, power outages resulting in loss of output, the last 20 years have witnessed the physical shifting of small enterprises to the Punjab (the origin of most of the small-scale manufacturers) and medium-scale enterprises to Dubai (because of a secure location and employer-friendly labour laws), there has been a continuous decline in manufacturing activity. Despite these setbacks, Karachi has witnessed a substantial increase in the trade and services sectors. The financial services sector has seen the induction of a large number of international banks, the emergence of exchange companies, and a boom in the stock market.

As the largest city and the transportation, trade and financial gateway to the outside world, Karachi's economic fate is closely ties to that of the nation. Karachi's considerable presence can be portrayed best by showing the city's central role in various sectors of national economic activity:

- 40% of financial activity
- 30% of manufacturing, and 40% of large-scale manufacturing
- 50% of bank deposits
- 20% of federal tax revenue, 40% of Sindh's provincial revenues, and 62% of income tax collected
- 95% of foreign trade passes through Karachi's two ports and its airport

It is estimated that the city generates about 20% of the national output, creates more than 30% of value added in manufacturing, and accounts for 25% of national tax revenues. More importantly, the city provides jobs for a large population – 40% of national employment in large-scale manufacturing is based in Karachi. Karachi's economic underpinnings include industries in seven major concentrations namely the Sindh, Korangi and Landhi Industrial Estates, Federal 'B' Area, North Karachi, the Export Processing Zone, and Port Qasim.

One of the Karachi's key comparative advantages is the low cost of labour. The low wage work force lives primarily in Katchi Abadis (squatter settlements) that run along water ways and on government owned land in pockets throughout the urbanised area. Many poor people work near where they live, which reduces commuting costs and helps keep wages low. Inflation in Karachi is the lowest among all of the large cities (population in excess of 500,000) in Pakistan with the exclusion of Faisalabad. *(End Quote from KSDP-2020)*

(6) Government

The City of Karachi Municipal Act was promulgated in 1933. Initially the Municipal Corporation comprised the mayor, the deputy mayor and 57 councillors. The Karachi Municipal Corporation was changed to a Metropolitan Corporation in 1976. The administrative area of Karachi was a second-level subdivision known as Karachi Division, which was subdivided into five districts: Karachi Central, Karachi East, Karachi South, Karachi West and Malir. In 2000, the Government of Pakistan designed a new devolution plan of financial resources and responsibilities. This plan abolished the earlier second-level division and merged the five districts of Karachi into a Karachi District. When the devolution plan was implemented in 2001, this district officially became a City District, with the City District

Government of Karachi handling its government. Karachi now has a three-tier federated system formed by:

- The City District Government (CDGK)
    - Town Municipal Administrations (TMAs)
        - Union Council Administrations (UCAs)

The City-District of Karachi is divided into 18 towns governed by elected town municipal administrations (TMAs) responsible for infrastructure and spatial planning, development facilitation, and municipal services (water, sanitation, solid waste, repairing roads, parks, street lights, and traffic engineering), with some functions being retained by the CDG.K.

The towns are sub-divided into 178 localities governed by elected union councils (UC's), which are the core element of the local government system. Each UC is a body of 13 directly elected members including a Nazim (mayor) and a Naib Nazim (deputy mayor). The UC Nazim heads the union administration and is responsible for facilitating the CDG to plan and execute municipal services, as well as for informing higher authorities about public concerns and complaints.

The City Council comprises 255 elected councillors which consist of 178 UC Nazims, 59 representatives of women, 9 representatives of workers, and 9 representatives of minority groups.

CHAPTER 3

EXISTING WATER SUPPLY AND SEWERAGE SYSTEMS

3 EXISTING WATER SUPPLY AND SEWERAGE SYSTEMS

3.1 EXISTING WATER SUPPLY AND SEWERAGE MASTER PLANS

3.1.1 1985 Water Supply Master Plan

(1) Background

In 1985 when the Karachi Development Authority (KDA) prepared a water supply master plan for Karachi, the total population of metropolitan Karachi was 6.7 million and about 6.0 million people received treated water either directly through connections to the system or indirectly from tankers and standposts; the remainder of the people in the city obtained water from other sources such as private wells, ponds and water courses. On average, KW&SB provided 323 mgd (1,469,000 m^3/d) of potable water each day, which originated from the supply sources shown in **Table 31.1.1**.

Table 31.1.1 Water Supply Sources in 1985

Source	Capacity	
	mgd	m^3/d
Groundwater abstracted from the Malir basin at Dumlottee	4	18,000
Surface water taken form the Indus river through Kinjhar Lake, the Jam Branch canal and Haleji Lake	230	1,046,000
Surface water impounded by the Hub dam	89	405,000
Total	323	1,469,000

The Phase IV Project of the Greater Karachi Bulk Water Supply (GKBWS) Scheme was under implementation at that time and it was expected that the completion of the project would provide an additional 50 mgd (230,000 m^3/d) of water from the Indus River giving the total resource availability of 373 mgd (1,700,000 m^3/d) by mid 1987. However, treatment of this additional supply was not included in the Phase IV project.

In 1985, the KDA awarded a consultancy service contract for preparation of a master plan for the future expansion of the water supply system to Sir M. MacDonald and Partners (principal consultant) and Associated Consulting Engineers (ACE Ltd – local associated consultant). The study comprised three parts with the following objectives.

Part I
An evaluation of alternative means to supply 240 mgd (1,090,000 m^3/d) of additional water from the Indus River and identify the preferred system for conveyance of the water to Karachi.

Part II
To study alternative sources of water to augment the supplies by an additional 300 mgd (1,360,000 m^3/d) and to identify the preferred system for conveyance of the water to Karachi. Also to determine the sufficiency of 300 mgd.

Part III
To prepare preliminary designs, estimates and a phased programme for the works identified in Part I.

The contract agreement for the study was signed on 24 January 1985 with completion of the study scheduled for:

Part I and Part II: Feasibility Studies – 24 September 1985
Part III: Preliminary Designs – 24 June 1986

(2) Water Demand

The study forecasted that the population of Karachi would be 14.347 millions in the year 2000 and 30.91 millions in 2025. The average growth was projected at 5.48% from 1981 to 2000 and 3.04% from 2000 to 2005. Projection of water demand included domestic, commercial and non-domestic demand and was made assuming a full pressure supply in the future; losses and unaccounted consumption were allowed at 40% in 1985 reducing to 25% in 1995 and thereafter following the development of a proposed planned approach to leakage detection and repair. On the basis of these projections, the master plan estimated water demands to the year 2025 as shown in **Table 31.1.2**.

Table 31.1.2 Projected Water Demands

Year	Average Day Demand		Peak Day Demand	
	mgd	m^3/d	mgd	m^3/d
1985	371.9	1,691,000	437.49	1,988,000
1990	492.3	2,238,000	578.6	2,630,000
1995	614.2	2,792,000	721.2	3,278,000
2000	820.0	3,728,000	962.9	4,377,000
2010	1,338.6	6,086,000	1,571.7	7,144,000
2025	2,451.7	11,146,000	2,878.7	13,085,000

As a result, equivalent per capita demands for the period, based on average day figures were estimated to increase from 252 litres (55 gallons) in 1985 to 260 litres (57 gallons) in 2000 and to 368 litres (81 gallons) in 2025.

Based on the above water demand projections and the supply capacity of 373 mgd to be available upon completion of the Phase IV Project in mid 1987, the study concluded that:

1) The completion of the Part I Project (240 mgd or 1,090,000 m^3/d) would increase the total supply capacity to 613 mgd (2,787,000 m^3/d) which would be able to satisfy the average day demand up to 1995.
2) The supply increment of 300 mgd (1,360,000 m^3/d) originally suggested for the Part II Project was clearly insufficient to meet the future demand and consequently Part II Project should be reframed as:

    Part II a – 300 mgd (1,360,000 m^3/d)
    Part II b – 300 mgd (1,360,000 m^3/d)

(3) Water Resources

The 1985 master plan study made a review of all potential water sources in the Karachi region, which included the Indus River and other surface water and groundwater sources, desalination of sea water, and the indirect reuse of treated sewage effluents for substitution of existing non-potable uses and recharge of aquifers. As a result, the study concluded that only the Indus River and desalination could supply very large quantities of water needed for Karachi; the cost of desalination for the foreseeable future was prohibitive and only if technological advances were made to considerably reduce the costs of energy would it likely to become attractive for Karachi. Alternative surface water sources were found to have very small potential yields and in all cases the likely cost of development would exceed that for the Indus River. The review identified the Lasbela plain in the Porali river basin as the most promising groundwater source in the region. However, this source is located in Balochistan and was already proposed as a source of water for local irrigation development. The other groundwater sources in the region were found to be of relatively small magnitude with the total potential yield of all the groundwater sources within 100 km of Karachi being as insignificant as 4 mgd (18,000 m^3/d). For these reasons, the study concluded that Indus River was the only viable water supply source for Karachi. At the same time, it also recommended that the following long-term requirement of Karachi should be made known to the Government so that it might be taken into account in the apportionment of Indus water between various users.

1) From 1997 to the year 2025 the basic need for Karachi would be a supply gradually increasing to 3,700 cusecs (9,050,000 m^3/d), this would be required at Kotri during the period November to June, in the form of guaranteed releases from upstream storage.
2) The above flow would be augmented by additional withdrawals when the river is in flood (June to October), which would be regulated through Kinjhar lake to provide Karachi with a total of 10,480,000 m^3/d in rabi and 12,050,000 m^3/d in kharif.

(4) Part I Project

The cost of the Part I Project to bring 240 mgd of Indus water to Karachi was estimated to be Rs 6,518 million at end 1985 price levels, which was equivalent to US$ 407 million at an exchange rate of US$1 = Rs 16.00. After allowing for inflation the anticipated total project cost increased to Rs. 8,233 million (US$ 515 million). Assuming that the construction of the Part I Scheme would be completed over the four years from 1988 to 1991, the estimated project costs implied an annual expenditure of Rs 1,630 million as compared with the then on-going Phase IV project of GKWBS (Rs 140 million/year) and the KW&SB's actual annual expenditure for the fiscal year 1983-84 (Rs 307 million for operating, distribution and administration plus some loan and other charges). Further, the annual O&M cost of the Part I Project when running at full capacity was estimated to be Rs 236 million at end 1985 price levels.

Financial viability of the proposed Part I Scheme was examined based on the estimated capital and recurrent costs of the scheme and the financial targets set by the World Bank for the Phase IV Project of GKBWS, which required water tariffs to recover the following expenditures.

- O&M costs
- 30% of its investment needs
- debt service charges (on 70% of its investment needs)

Based on the results of the above financial examination, KDA, KW&SB and the World Bank finally concluded that a full Part I scheme (240 mgd) costing Rs 8,233 million (US$ 515 million) was not financially viable. An analysis of alternatives showed that a scheme to supply 200 mgd (900,000 m^3/d) to be constructed in equal phases of 100 mgd (450,000 m^3/d) would match the budget ceiling. **Table 31.1.3** shows a revised scope of the Phase 1 of Part I (100 mgd) Project. The total project cost for the Phase 1 of Part I Project including physical and price contingencies was estimated to be Rs 3,641 million (US$ 227 million). The project would transmit 100 mgd of Indus water from Gujjo to NEK for treatment. In addition, it also included the construction of the following facilities at Pepri to treat additional water to be available upon completion of the Phase IV Project.

- a raw water pumping station that abstracts water from the GKBWS conduit
- a 40 mgd water purification plant
- a 500m-long, 1,000mm-dia raw water supply main which connects the pumping station to the water purification plant

Table 31.1.3 Scope of Phase 1 of Part I (100 mgd) Project

Item		Description	
		Capacity	Remarks
Canal	Gujjo to Gharo	100 mgd	20 km long
Conduit	Gharo to Dhabeji	100 mgd	9.8 km long
Dhabeji P/ST		100 mgd	
Pumping Mains	Dhabeji P/ST to High Point	100 mgd	2 lines × 1,500mm dia. × 4.6 km long
Conduit	High Point to Pipri	100 mgd	3.3 × 3.3 m, 27.7 km long
Pipri P/ST		40 mgd	
Pumping Main	Pipri P/ST to Pipri T/W	40 mgd	1,000 mm dia. × 500 m long
Pipri T/W		40 mgd	
Conduit	Pipri to N.E.K.	100 mgd	3.3 × 3.3 m, 25.2 km long
N.E.K P/ST(1)	Low Lift to T/W	100 mgd	
N.E.K T/W		100 mgd	
N.E.K P/ST(2)	High Lift to University Reservoir	70 mgd	
Pumping Mains	N.E.K. T/W to University Reservoir	70 mgd	2 lines × 1,400 mm dia. × 9.0 km long
Gravity Main	N.E.K. T/W to COD Hills T/W	50 mgd	1,800 mm dia. × 13.0 km long
Distribution Mains	Additional Primary Mains		1,200 to 2,100 mm dia. × 22.5 km long
Storage Reservoirs	Additional Volume	10 mg	

(5) Conclusions

Figure 31.1.1 illustrates the water demands projected by the 1985 master plan study and the system expansion plans proposed by the study to meet the projected water demands. It shows how significantly the master plan overestimated future water demands. It was mainly because of the large population growth rates and high per capita water demands adopted in the study.

The 1985 master plan study projected that the total population of Karachi (6.72 million in 1985) would increase to 9.01 million in 1990, 11.67 million in 1995, 14.35 million in 2000, 20.37 million in 2010 and to 30.91 million in 2025. However, the census conducted in 1998 reported that the total population of Karachi was only 9.8 million in the same year.

The study projected that the gross per capita average day demand would increase from 252 litres (55 gallons) in 1985 to 260 litres (57 gallons) in 2000, 299 litres (66 gallons) in 2010 and to 368 litres (81 gallons) in 2025. Subtracting from there leakage and other water losses that were assumed to be 40% in 1985 and 25% in 1995 and thereafter, and also non-domestic water demands assumed to be 12% in 1985 and 13% in 1995 and thereafter, net per capita average day domestic water demand was projected at 161 litres in 2000, 185 litres in 2010 and 228 litres in 2025. Given the fact that approximately 40 to 50% of people in Karachi live in Katchi Abadis and that an average household in Karachi has more than five persons, the levels of these per capita demands are considered to be much larger than the essential water needs of average people in Karachi

As can be seen in **Figure 31.1.1**, the implementation of the proposed system expansion projects delayed significantly from the original schedule envisaged by the master plan. It should be noted that only Phase 1 (100 mgd) and Phase 2 (100 mgd) of Part I Project have actually been implemented until today. Today, they are respectively referred to as the “K-II” and “K-III” projects. The K-II Project was completed in 1998 with a reduced scope of work. The facilities originally proposed to be installed at Pepri for treatment of additional Indus water were excluded from the final scope of the K-II Project. K-III Project was just recently completed in May 2006.

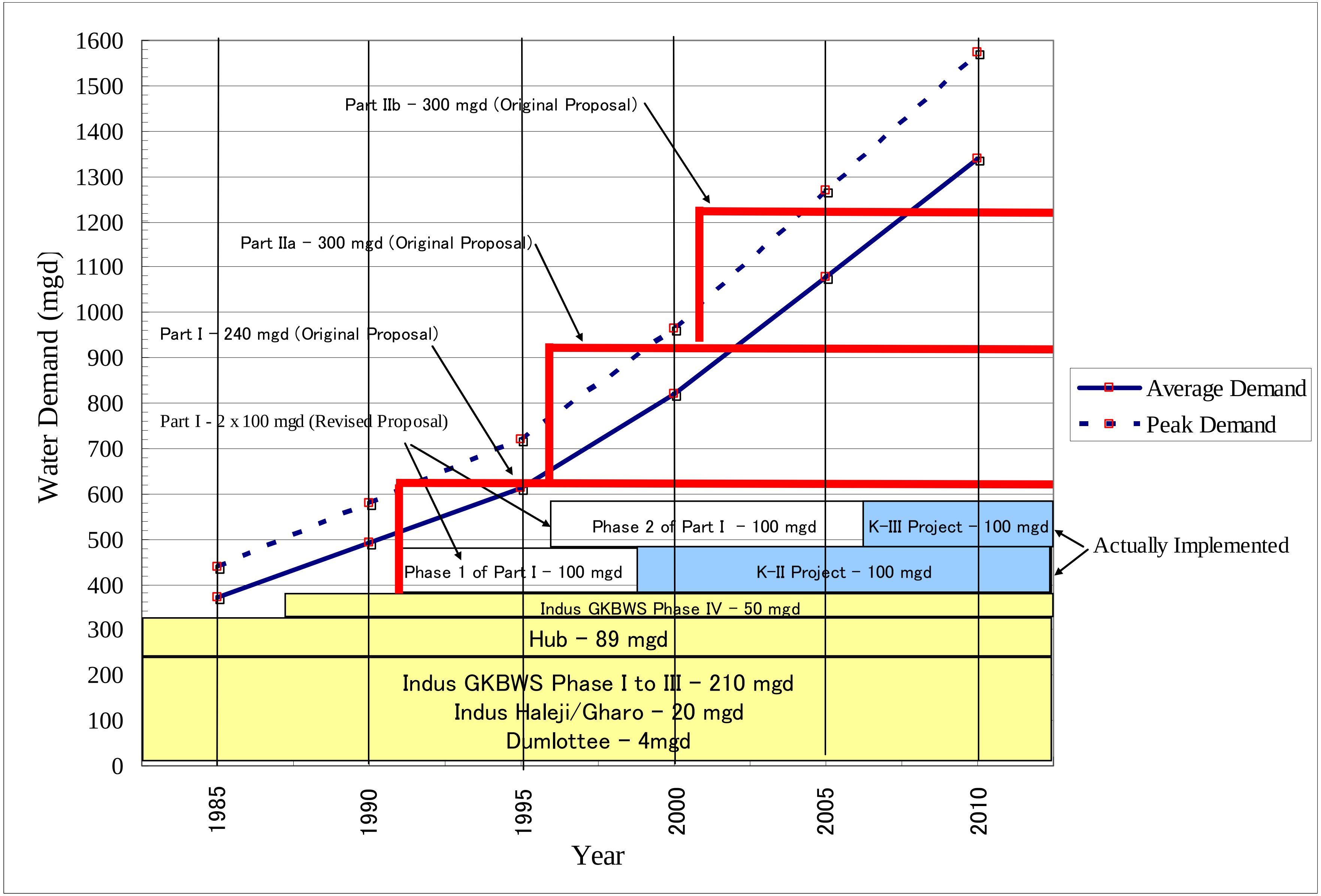


Figure 31.1.1 Water Demand Projection and Proposed System Expansion Projects

In summary, the 1985 water supply master plan study has the following characteristics.

- Rather than being a master plan study, it was a feasibility study conducted in a very short period of time (about 8 months)
- Proposed large-scale system expansion projects based on significantly large population growth rates and high per capita water demands
- Focused on the expansion of the existing bulk water supply system to bring additional water from the Indus River to Karachi (supply driven approach) while placing little emphasis on the improvement of the existing water distribution networks to reduce water losses and to enhance equitable water distribution and water conservation (demand driven approach)
- Did not address the institutional capacity strengthening of the water service provider, which is vital to ensure the financial viability and smooth implementation of the system expansion projects proposed by the study

3.1.2 1988 Sewerage Master Plan

(1) 1988 Master Plan

Karachi Water and Sewerage Board (KW&SB) prepared "Feasibility Study for Preparation of Sewerage and Waste Water Disposal Project in Karachi" in 1988. The Study is one and only comprehensive study on sewerage in Karachi to date and is regarded as Master Plan. Though the Master Plan describes that the city area is divided into 11 sewer districts, only three sewage treatment plants of TP-3, TP-4 and Baldia are planned in detail in addition to two existing sewage treatment plants (TPs) of TP-1 and TP-2 at the time of the Master Plan preparation.

a. Outline of Sewer Districts and TPs

Referring to the drawings of 1988 Master Plan (Volume VI Drawings), proposed sewer districts and TPs are outlined in **Tables 31.2.1** and **31.2.2**, respectively.

Table 31.2.1 Outline of Sewer Districts

Name of TP and its location	Conditions	Drainage area	Remarks
TP-1 Right bank of lower Lyari River	Existing and in operation	Part of left bank side included	Constructed in 1960s and rehabilitated in 1995
TP-2 Right bank of lower Malir River	Existing and in operation	Left bank side of Malir River and its left bank side (central part of the city, port area, cantonment and the area near airport)	Constructed in 1960s and rehabilitated in 1995
TP-3 or Mauripur TP Right mouth of Lyari River	Planned in MP Existing and in operation since 1998	Both right and left bank sides of Lyari River	Sewage exceeding capacities of TP-1 and TP-2 flows into TP-3 through Lyari Interceptor.
TP-4 Korangi TP	Planned in MP but not implemented yet. Pumping station and trunk sewers were financed by ADB and already constructed.	It was planned to divide the left bank area of Malir River into two parts and the sewage was to be treated either at TP-2 or at TP-4.	TP-4 has not been constructed because it was supposed to mainly treat industrial wastewater and hence was not agreed upon by the nearby residents. The site for TP-4 was owned by the government but was not coordinated among relevant agencies. Besides, the local NGOs did not admit its construction insisting that the construction be only locally funded.
TP-NK (North Karachi TP)	Constructed in 1993 but not operated	Drainage area of 1,200 ha. Hilly area of the northern part of city	The TP is not included in 10 TPs planned in MP. It was envisaged that the area would be covered by extended Lyari Interceptor and that the TP would be demolished in the future.
TP-5 （Baldia TP）	Planned but not implemented. Along Baldia Trunk Sewer	Baldia and Naval City area (residential area to be extended)	The location of TP is not identified. Pumping station was planned along the trunk sewer.
TP-6 （Taiser TP）	Just envisaged. Taiser area at northern part of the city of left bank side of upper Lyari River is targeted.	Residential area of left bank side of upper Lyari River.	Its location not identified. The effluent was to be discharged to Lyari River.
TP-7 (North-east Karachi)	Just envisaged	Middle part of left bank side of Lyari River Part of TP-1 service area to be diverted	To be located at the cross of Super highway extending towards northeast and Lyari River Satellite image shows vast are of housing development but little of which is inhabited. Illegal houses can be seen in undeveloped areas.
TP-8 Pipri TP	Just envisaged and its location unidentified.	Middle part of left bank side of Malir River	Near steel mill and might be near the cross of railway and Malir River
TP-9 Hawkes Bay TP	Just envisaged, western part of city Its location Unidentified	Far eastern area of city, along the seacoast	Future housing area along Hawkes Bay might be targeted.
TP-10 Halkani Town TP	Just envisaged Urbanized area Its location Unidentified	North-western part of city next to Orangi area	Halkani area North-eastern part of Orangi area. To be urbanized in future

In **Table 31.2.1**, the locations of the facilities of "envisaged" are not identified in the drawings of Master Plan. The information on sewer districts such as district areas and boundaries are not available, hence design flow rate and others cannot be verified.

Table 31.2.2 Capacities and Treatment Processes of Proposed 11 TPs

Name of TP	Capacity in 1993 Unit: mgd (Unit: m^3/day)	Capacity in 2003 Unit: mgd (Unit: m^3/day)	Treatment Process
TP-1 (existing at the time of the Master Plan preparation)	65 (300,000)	65 (300,000)	Trickling filter
TP-2 (existing at the time of the Master Plan preparation)	65 (300,000)	105 (480,000)	Trickling filter
TP-3 (Existing at present)	38 (170,000)	154 (700,000)	Anaerobic pond + Facultative pond
TP-4	48 (220,000)	37 (330,000)	Anaerobic pond + Facultative pond
TP-NK	5 (23,000)	5 (23,000)	No information available
TP-5 （Baldia TP）	3 (13,000)	12 (53,000)	Anaerobic pond + Facultative pond
TP-6 （Taiser TP）	- -	22 (100,000)	Facultative pond + Maturation pond
TP-7 (North-east Karachi)	No information available	No information available	No information available
TP-8 Pipri TP	No information available	No information available	No information available
TP-9 Hawkes Bay TP	No information available	No information available	No information available
TP-10 Halkani Town TP	No information available	No information available	No information available

b. Collection System

Details of respective sewer districts are described below.

<u>TP-1 Area (existing at the time of M/P preparation)</u>

Gulsman-e-Iqbar trunk sewer was planned to be implemented to collect the sewage generated at the left bank side of Lyari River and to connect to the right bank side of the river. However, the river crossing part has not been constructed and it is assumed that the collected sewage is discharged to the river with no treatment.

<u>TP-2 Area (existing at the time of M/P preparation)</u>

The sewage generated at the left bank side of Malir River had been pumped by Korangi pumping station to TP-2 at the other side of the river, but was stopped because pipes installed in the river were broken due to the flood in 1974. At present, the collected sewage is pumped and discharged to the river.

1988 Master Plan reports that the sewage generated at the left bank side of the river was supposed to be treated at TP-4, but the concept was not realized due to the several reasons shown in the above table. However, the plan itself is rated as appropriate.

<u>TP-3 (planned in M/P and began its operation in 1998)</u>

The sewage generated at SITE area is planned to introduce to the interceptor to be constructed at the right bank of Lyari River (box culvert of 2400 mm to 3500 mm) and then it will flow into TP-3.

No.48 Manhole is located at the confluence of Malir River and Orangi River. The sewage exceeding the capacity of TP-1 is planned to introduce to Lyari Interceptor. The first phase facility of the plan corresponds to the plant of 6 trains constructed in 1998. The second and third phase facilities are to be implemented at the western side of the existing plant.

TP-4 (planned)
It was planned to divert the sewage of the roght bank side of Malir River which was originally a part of TP-2 area. The plant has not been implemented due to the objection of the residents and to the insufficient coordination among agencies concerned. In addition, there was an objection to falling in foreign debt. At present, the collected sewage is discharged to Malir River through Korangi pumping station. The location of the plant is judged to be appropriate.

TP-5 (planned)
It was supposed to collect the sewage of Naval City and to treat the collected sewage at TP-5, but its location and other related information are not identified.

Other TPs
The locations of TPs of 6 through 10 are not shown in the available drawing.
Problems identified (referring to the plan and longitudinal sections of existing trunk sewers) are as follows.

c. Overall Evaluation of M/P

Trunk sewers were planned to enhance their capacities, but many of them were not implemented along main roads, at railway crossing and road crossing. As a result, much sewage does not reach treatment plants and is discharged to rivers. It is needed to connect existing sewers to sewage treatment plants by applying jacking methods or by implementing interceptors along rivers, which can avoid river crossing.
The 1988 Master Plan does not give clear blueprint about what sewerage facilities would be implemented in which order, which makes it difficult to trace and monitor how or to what extent the Master Plan has been implemented.
The facilities constructed based on the Master Plan were Lyari Interceptor and TP-3 only. TP-4 was not constructed mainly because there was no coordination with existing sewers and there were disputes on financial arrangement.

(2) Others

a. S-III

KW&SB also has a long-term sewerage development plan comprising three phases, namely S-I, S-II and S-III. The plan in each phase is summarized below.

S-I
S-I comprises the components of which the followings were implemented.

- Preparation of Master Plan for Wastewater Disposal and Sewerage Development 1988 – 2003 (1988 Master Plan)
- Upgrading of TPs-1 and 2

S-II
S-II comprises the components of which the followings were implemented.

- Construction of TP-3
- Construction of Lyari Interceptor
- Construction of Baldia trunk sewer
- Construction of secondary sewers in Baldia Town

Fate of S-I and S-II

While the components mentioned above were implemented, the following ones were left undone mainly due to the financial constraints.

- Construction of TPs at Korangi and other places
- Extension of Lyari Interceptor up to North Karachi
- Construction of trunk sewers

In spite of daily sewage generation of 400 mgd (1.8 million m^3/day), total capacity of existing three TPs is 151 mgd (0.7 million m^3/day). Furthermore, the amount of sewage actually flowing into three TPs is just 90 mgd (0.5 million m^3/day). If the K-III of supplying additional 100 mgd (450,000 m^3/day) is completed, the situations are expected to become worse. To solve these problems, S-III is planned in two stages.

S-III

S-III is divided into two stages. Stage-1 projects will be implemented in two phases shown below. Stage-2 projects have not been identified yet.

Phase-1

- Construction of interceptors on both sides of Malir River which convey the collected sewage to proposed TP-4 at Korangi.
- Connection of Chakora Nallah to Malir Interceptor
- Construction of interceptors along both sides of Nehr-e-Kahyyam to convey the sewage to Clifton pumping station and finally to TP-2.
- Connection of Manzoor Colony drain to Malir Interceptor
- Diversion of City Railway Nallah and Soldier Bazar Nallah to Clifton Pumping Station and then to TP-2.
- Construction of secondary interceptor to link Pitchard Nallah and Kalri Nallah finally connecting to TP-3.
- Extension of Layri Interceptor up to North Karachi
- Connection of Shershah Nallah, Gujro Nallah and Orangi Nallah to Lyari Interceptor
- Construction of TP-4 with the treatment capacity of 200 mgd (910,000 m^3/day).
- Extension of TPs-1, 2 and 3 with the total capacity of 300 mgd (1,360,000 m^3/day).

Phase-2

- Construction of more TPs to enhance treatment capacities
- Conversion of nallahs to interceptors and box culverts

PC-1, the documents to submit to the Government of Pakistan for its approval, for Stage-1 projects of S-III was approved in October 2007 by the Government of Pakistan. The implementation period for Stage-1 will be four years including the period for design works that is expected to commence in early 2008. The financial sources necessary to implement Stage-1 projects will be equally shared by central and provincial governments.

b. Common Effluent Treatment Plant (CETP)

Based on the discussion between Labour, Transport, Industries and Commerce Department, Government of Sindh, and KW&SB, the plan was formulated by Pakistan Industrial Development Corporation (PIDC) to construct four CETPs to treat both industrial and domestic wastewaters in four locations and to dispose of hazardous wastes at two locations as a part of Industrial Efficiency and Environmental Management (IEEM). Out of these CETPs and disposal sites, three CETPs will be located in Karachi, namely Landhi, Korangi and SITE, and one disposal site at Jam Chakro.

The CETPs will apply extended aeration system and produced sludges are to be conveyed and disposed of at hazardous waste disposal site. The effluent is to meet the effluent standard stipulated by National Environmental Quality Standards (NEQP).

Table 31.2.3 summarizes these three CETPs and related collection system. The construction costs include land acquisition costs and taxes.

Table 31.2.3 Outline of CETPs

Name of CETP	Landhi	Korangi	SITE
Location	Lalabel Colony	Korangi	Mauripur
Capacity mgd (m^3/day)	6.82 (31,000)	13.2 (60,000)	40.9 (186,000)
Site area acre (m^2)	16 (64,700)	20.6 (83,400)	34.1 (138,000)
Kind of industrial Wastewater Flow rate (m^3/day)	20 major textile units with 300 industrial units 28,700	370 textile units with 1500 industrial units and commercial wastewater 55,400	210 textile units with 2200 industrial units and commercial wastewater 173,400
Domestic wastewater (m^3/day)	1,900	4,000	12,000 (within industrial estate)
Treatment process	Chemical and biological Process	Chemical and biological Process	Chemical and biological Process
Sludge yield (m3/day) and its disposal	46 HWHF(Hazardous Waste Handling Facility) at Jam Chakro, Gaddop Town	73 HWHF(Hazardous Waste Handling Facility) at Jam Chakro, Gaddop Town	131 HWHF(Hazardous Waste Handling Facility) at Jam Chakro, Gaddop Town
Drainage Area (acre, (ha.)) and Population	1600 (650) 102,000	4,000 (1,600) 607,000	4,500 (1,820) 240,000
Influent quality (mg/l) BOD_5 COD TSS TDS	 700 1,400 500 3,200	 630 1,200 1,000 6,100	 400 1,100 600 5,300
Effluent quality (mg/l) BOD_5 COD TSS TDS	 80 150 200 3,200	 80 150 200 6,100	 80 150 200 5,300
Construction cost (Rs.mil) Sindh Government PSDP	1,020.3 166 854.3	1,559 86 1,473	2,826 184 2641
Annual O/M cost (Rs.mil/year)	218.9	439.6	916.2
Tariff (Rs. /m^3 for industry only)	25	25	16
Pipe material	RCC lined with PVC or epoxy resin	RCC lined with PVC or epoxy resin	RCC lined with PVC or epoxy resin
Revenue form industrial product (Rs.mil/day)	1,600	255	1,560
Period for construction (years)	3	3	3
Sewers Trunk (more than 30") Collection (less than 30")	 9.19 km 5.32 km	 10.8 km 22.2 km	 16.22 km 33.3 km
Remarks	CETP 0.6 km away from drainage area CETP site available	CETP 3.4 km away from drainage area CETP site available	CETP 3.2 km away from drainage area CETP site not available

3.2 WATER SOURCES

3.2.1 Existing Water Sources

(1) Indus River

The Indus River, the main source of water for Karachi, is severely constrained by dry season demand, but has abundant wet season discharges. Except during the summer flood season, very little water escapes to the sea. The quota for urban supplies in Karachi from the River Indus was first sanctioned on May 11, 1957, which allowed Karachi to take 450 cusecs (242 mgd or 1,100,000 m^3/d) from 16 October to 15 April (rabi) and 520 cusecs (280 mgd or 1,270,000 m^3/d) from 16 April to 15 October (kharif) from the tail of the system at Kotri, through storage in Kinjhar Lake. Later, a presidential decree in 1988 increased this quota to 1,200 cusecs (645 mgd or 2,940,000 m^3/d).

In March 1991, representatives of the four provinces held a series of meetings in Lahore and Karachi and agreed on the apportionment of the waters of the Indus River System as shown in **Table 32.1.1**.

Table 32.1.1 1991 Water Apportionment Accord

Province	Kharif		Rabi		Total	
	MAF	MCM	MAF	MCM	MAF	MCM
Punjab	37.07	45,725	18.87	23,276	55.94	69,001
Sindh*	33.94	41,865	14.82	18,280	48.76	60,145
N.W.F.P (a)	3.48	4,293	2.30	2,837	5.78	7,130
(b) Civil Canals**	1.80	2,220	1.20	1,480	3.00	3,700
Balochistan	2.85	3,515	1.02	1,258	3.87	4,773
Total	77.34	95,398	37.01	45,651	114.35	141,049
	1.80	2,220	1.20	1,480	3.00	3,700

* Including already sanctioned Urban and Industrial uses for Metropolitan Karachi
** Ungauged Civil Canals above the rim stations.
MAF: Million Acre Feet. MCM: Million Cubic Metre

Source: Water Apportionment Accord, 1991

Water from the Indus River is distributed over the Sindh Province through three barrage systems, namely, Guddu, Sukkur and Kotri. **Table 32.1.2** presents the allocation of the provincial quota to each of these three barrage systems. Urban and industrial water for Karachi is taken from the Kotri Barrage and discharged through the Kalri Baghar Feeder Upper (KB Feeder Upper) to Kinjhar Lake. Kotri Barrage is the lowest barrage on the River Indus. It was completed in 1955 to command a gross area of 1.34 Mha (13,400 km^2) mainly on the left (east) bank of the Indus, southeast of Hyderabad. The right (west) bank command of 310,000 ha (3,100 km^2) gross is supplied by a single canal, the KB Feeder which also supplies Karachi 150 km west-southwest of the off-take. The KB Feeder Upper has a design capacity at its head of 9,075 cusecs (22,300,000 m^3/d) and terminates at the head of Kinjhar Lake. This is also the offtake for the Right Bank Link Canal which, since it was opened in 1982, has enabled water from the KB Feeder Upper to be supplied directly to the KB Feeder Lower without passing through the lake. This allows unsettled silty water to be supplied to downstream irrigators and also serves to reduce sedimentation of the lake. Flow data of Indus River upstream of the Kotri Barrage from 1976 to 1984 including average and minimum flows and allocation of quota from the Kotri Barrage for each feeder canal are compiled in **Appendix A32.1**.

Table 32.1.2 Allocation of Provincial Quota in Sindh State

Month	Period	Barrage System (1,000 cusec)			
		Guddu	Sukkur	Kotri	Total
April	1	0.00	34.00	6.20	40.20
	2	0.20	34.30	6.80	41.30
	3	1.40	31.60	6.90	39.90
May	1	3.70	35.10	12.30	51.10
	2	6.50	39.50	15.70	61.70
	3	12.60	43.10	21.70	77.40
Jun	1	22.70	49.10	26.90	98.70
	2	31.10	56.00	32.60	119.70
	3	35.20	60.60	33.80	129.60
Jul	1	41.10	61.20	34.20	136.50
	2	36.20	57.10	29.80	123.10
	3	30.10	54.30	31.00	115.40
Aug	1	28.50	54.00	27.60	110.10
	2	27.80	54.40	28.40	110.60
	3	28.70	54.60	23.80	107.10
Sep	1	26.50	55.10	27.60	109.20
	2	26.80	57.50	25.10	109.40
	3	25.80	55.80	23.30	104.90
Oct	1	17.60	43.60	18.00	79.20
	2	10.20	37.80	14.50	62.50
	3	6.30	33.00	11.30	50.60
Nov	1	4.10	31.40	9.60	45.10
	2	3.50	31.40	7.50	42.40
	3	3.20	31.10	5.70	40.00
Dec	1	2.60	31.40	5.00	39.00
	2	1.99	31.80	4.70	38.49
	3	1.99	26.30	4.50	32.79
Jan	1	5.40	12.30	3.10	20.80
	2	10.40	5.40	8.60	24.40
	3	5.50	20.30	11.70	37.50
Feb	1	1.30	31.90	8.80	42.00
	2	1.70	31.10	4.90	37.70
	3	2.30	30.00	5.20	37.50
Mar	1	2.70	29.70	4.40	36.80
	2	3.40	29.40	4.20	37.00
	3	2.00	28.50	4.70	35.20

Source: Water Apportionment Accord, 1991, Annexure - II

Kinjhar Lake is a natural reservoir, the storage of which has been increased by constructing nearly 20 km of embankments having a maximum height of 9 m. The original design levels of the Kinjhar lake embankments are:

- top irrigation retention level	54.0 ft RL
- allowance for storm water storage	2.0 ft
- top storm retention level	56.0 ft RL
- freeboard	6.0 ft
- embankment top	60.0 ft RL

Because of excessive seepage through the southern part of this embankment, the top water level (TWL) of the lake was initially held at 51.6 ft RL, giving a maximum useable storage of 310,000 acft (377,000,000 m^3). The embankments were then raised and strengthened to increase the flood storage capacity and allow the normal retention level to rise to 54.0 ft RL whereby increase the useable storage to 390,000 acft (481,000,000 m^3). The surface area of the lake is about 30,000 acres (12,000 ha or 120 km^2). The lake has a catchment area of 910 km^2 which collects runoff from most of the area between the Baran Nai basin to the north and the Malir basin to the west. The Kinjhar catchment extends north of the Karachi-Hyderabad Superhighway and includes Kalu Khuhar.

Water leaves the lake through the KB Feeder Lower and the KG (Kinjhar - Gujjo) Canal. The latter was opened at the same time as the Right Bank Link Canal, to supply settled water directly to the intake at Gujjo. This replaced the previous arrangement whereby water destined for Karachi was released in the KB Feeder Lower and then conveyed through the irrigation system to Gujjo, which was found to be unfavourable due to the introduction of silty water through the Right Bank Link Canal.

The Indus River System Authority (IRSA) is being responsible for the implementation of the 1991 Water Apportionment Accord while Kotri Barrage, KB Feeder and Kinjhar Lake are being maintained by the Irrigation Department of the Government of Sindh. The existing quota for the KW&SB from the River Indus is 1,200 cusec (645 mgd or 2,940,000 m^3/d) and it has already been exhausted by the completion of the K-III Project in May 2006.

The existing quota for the KW&SB from the River Indus (1,200 cusecs or 645 mgd or 2,940,000 m^3/d) has already been exhausted by the completion of the K-III Project in May 2006.

At present, the KW&SB is supplying approximately 580 mgd (2,640,000 m^3/d) of Indus water to Karachi through various schemes shown in **Table 32.1.3**.

Table 32.1.3 Present Supply from Indus River

Raw Water Bulk Supply	Pakistan Steel Mill (PSM)	26 mgd
	Port Qasim Authority (PQA)	7 mgd
Gharo		28 mgd
GKBWS		480 mgd
Army Pump House		40 mgd
Total		581 mgd

Source: KW&SB

At present, KW&SB is supplying approximately 580 mgd (2,640,000 m^3/d) of Indus water to Karachi through various schemes.

(2) Hub Dam

The Hub Dam is a multi-purpose dam (municipal, industrial and irrigation purposes) constructed on the Hub River approximately 50 km to the north-west of Karachi City. The construction of the dam started in September 1963 and completed after 18 years in September 1981. The construction of the Lasbela Canal and Hub Main Canal was completed in September 1981 and September 1982 respectively. The catchment area of the dam extends across two provinces namely Sindh and Balochistan covering a total area of 3,410 sq miles (8,730 km^2). There has been an agreement between the two provinces that, at the Regulator located at the end of the Hub Main Canal, 63.3% of the total flow from the dam will be diverted to the Karachi Water Supply Canal (Sindh) while 36.7% to the Lasbela Canal (Balochistan).

The Hub Dam was completed in 1981 and first filled up in 1984. It was again filled up in 1989, 1992, 1994, 1995 and 2003. The last time the dam was filled up was August 2007. During the 8 years from 1995 to 2003, the dam was never filled up. As a result, the supply from the dam reduced to almost zero during the four years from July 1999 till June 2003. The dam has a design capacity of 717,000 acft (884, 000, 000 m^3) with the following operational properties.

Maximum Water Level	: 339 ft above the mean sea level
Lowest Water Level	: 276 ft above the mean sea level
Effective Water Depth	: 63 ft

Rationing of supply from the dam normally starts when the water level in the dam subsides to the level 285 ft above the mean sea level. On May 13, 2006 when the Study Team visited the dam, the water level was very low at 285.6 ft above the mean sea level. The life storage of the dam at that level was 41,436 acft (51,000,000 m^3), which is equivalent to only 5.8% of the design capacity of the dam, i.e. 717,000 acft (884,000,000 m^3).

In the past, a yield analysis of the Hub River was conducted based on the 18 years discharge data collected at the Bund Murad Khan gauging station. The outcome of the analysis have been compiled in the report, "Feasibility Study for Future Expansion of Karachi Water Supply System, Final Report Volume III Water Resources Appendices, December 1985". They are summarized in **Table 32.1.4**.

Table 32.1.4 Outcome of Hub River Yield Analysis

Level of Reliability (%)	Allowable Abstractions		
	Mm^3/yr	mgd	cusecs
95	124	75	138
87	173	104	193
80.8	238	143	266
80	246	148	275

Source: Feasibility Study for Future Expansion of Karachi Water Supply System, Final Report Volume III Water Resources Appendices, December 1985

The analysis indicated that at the 95% level of reliability the corresponding yield from the dam was 124,000,000 m^3 /yr (340,000 m^3/d or 75 mgd).

The yield analysis of the Hub River conducted in 1985 indicated that at the 95% level of reliability the corresponding yield from the dam was 75 mgd (340,000 m^3/d).

(3) Dumlottee Well Field

In the later half of the 19th century, water for Karachi was supplied from the Dumlottee Well Field, located on the banks of Malir River in the Dumlottee area about 30 km to the northeast of the city. The well field was first developed some 120 years ago under the British Municipal Commission. A number of large diametre shallow wells constructed in the Malir river alluvium provided about 8 mgd (36,340 m^3/d) of water to Karachi through a gravity conduit. For many years since then, the well field remained as the main source of supply for Karachi.

The capacity of the system was increased to 20 mgd in 1923 by adding some more wells, a 15 mgd gravity conduit and two 6 mgd reservoirs. However, the supply from this system has gradually decreased over time to 4 mgd by 1985, and to 1.5 mgd in 2002 and afterwards. At present, this system can produce merely 1.4 mgd of water during only a few months after the rainy season. The system is almost dry in the rest of the year. Excessive quarrying of sand from the river bed of Malir River combined with the extensive use of groundwater by farmers in the area is considered to be the main reason for the depletion of the well yield. The overall picture of the Dumlottee Well Field is that it is no longer an entirely reliable source of supply for Karachi.

The overall picture of the Dumlottee Well Field is that it is no longer an entirely reliable source of supply for Karachi.

The existing conduit from the Dumlottee Well Field was originally designed to convey 15 mgd of water by gravity to the Low Service Reservoir (LSR), Temple, Currie and Sydenham Reservoirs. It has an interconnection with the Greater Karachi Bulk Water Supply (GKBWS) system at their crossing point. At present, approximately 12 mgd of Indus water is diverted to the conduit from the GKBWS system by pumping from the 84 inch diametre trunk main that connects the end of the 280 mgd Tunnel to the NEK Old Pumping House. A 33 inch diametre trunk main which connects the conduit to one of the 84 inch diametre PRCC pipes installed at the end of the Siphon No.19 of the GKBWS system provides another interconnection between the two systems.

3.2.2 Future Development of Water Sources

It was agreed in the Minutes of Meeting on S/W of JICA Study signed on 13 July 2005 that the JICA Study would not embrace within its scope of work any new studies on the development of water sources, but it would examine existing relevant data and reports to explore the possibility of alternative resources including storage, desalination, reuse of wastewater and other options.

(1) Surface Water

The 1985 water supply master plan study conducted by Sir M. MacDonald and Partners (principal consultant) and Associated Consulting Engineers (local associated consultant) made a review of all potential water sources in the Karachi region, which included the Indus River and other surface water and groundwater sources, seawater desalination, and the indirect reuse of treated sewage effluents for the recharge of aquifers and substitution of existing non-potable uses. As a result, the study indicated that the Indus River and desalination are the only two sources that could technically meet a large water demand in Karachi. The study also indicated that the cost of desalination for the foreseeable future was prohibitive and that desalination should therefore be considered as a last resort. The study then concluded that the Indus River was the only viable water source for Karachi.

The 1985 water supply master plan study concluded that the Indus River was the only viable water source for Karachi.

The PC-I of the scheme “Assured Water Supply for Karachi – upgrading Kinjhar Lake System” was discussed at the Central Development Working Party (CDWP) meeting held on June 29, 2002. The main objective of the scheme was to ensure the availability of 1,200 cusecs of drinking water for Karachi from the Indus River (sanctioned by the President of Pakistan in 1988) to meet the requirement of the city up to 2005 while also satisfying the requirement of agricultural water in the Thatta and Hyderabad Districts. The CDWP while recommending the project to the Executive Committee of the National Economic Council (ECNEC) requested the GOS to prepare a long term plan for drinking water supply to Karachi which should include on-going and pipeline projects along with suggestions for long term funding arrangements. In response, GOS established an ad-hoc committee comprising of representatives from the Planning and Development Department of GOS, Irrigation and Power Department of GOS, and Karachi Water & Sewerage Board (KW&SB). The committee prepared a report on long term water supply plan for Karachi up to the year 2025 and submitted the report to the CDWP on November 14, 2002. In summary, the report provided the following major findings and recommendations.

(Findings)

- Existing allocation of 1,200 cusecs from Indus would be fully utilized in 2005 with completion of the 100 mgd K-III project. The population of Karachi was ever growing and additional requirement up to year 2025 was estimated to be another 1,200 cusecs thus the total requirement would be 2,400 cusecs.
- The present scheme of assured water supply for Karachi be treated as Phase-I to

cater short-term Assured Water Supply for Karachi City up to year 2005. The Phase-II of this scheme would be required for long-term requirement of water supply to Karachi to cater requirements beyond 2005 and up to 2025.

(Recommendations)

- For growing water demand of Karachi the allocation for Karachi up to Vision 2025 may be increased by another 1,200 cusecs raising the total allocation to 2,400 cusecs by the Government under a national cause without affecting supply of water quota of the Thatta District for agriculture purposes. Once additional allocation was allowed then a 2-stage study programme for expansion of system would have to be initiated.
- Stage-I: Study by the Irrigation and Power Department of GOS for increasing capacity in the system from the KB Feeder Upper up to the Kinjhar Lake without affecting the stability of the Kotri Barrage.
- Stage-II: Feasibility study by KW&SB in consultation with the Irrigation and Power Department of GOS from the Kinjhar Lake to Karachi determining the most economically viable, technically feasible and secure route.

In November 2002, the ad-hoc committee constituted by the Government of Sindh prepared a report on long term water supply plan for Karachi up to the year 2025. The committee concluded in the report that Karachi would need additional quota of 1,200 cusecs (total 2,400 cusecs) from the Indus River to meet the city's future water requirement up to the year 2025.

Based on the recommendations of the above committee, the KW&SB initiated a feasibility study titled 'Feasibility Study for Future Alternative Route of Bulk Water Supply and Long Term Expansion of Karachi Water Supply System from Kinjhar Lake – K-IV Project of Karachi Water and Sewerage Board' in December 2005. Details of this feasibility study are provided in **Section 4.4.2**.

Past operation records of the Hub dam indicate that the dam is not an entirely dependable water source. Many now observe that the dam could serve as a standby reservoir for the best. During the 8 years from 1995 to 2003, the dam was never filled up. The consequence was serious water shortages in areas where water was supposed to be supplied from the Hub dam. Those areas include the townships of Orangi, Baldia, SITE (both residential and industrial areas), Surjani, North Karachi and parts of Keamari Town. There is no real prospect of expanding this surface water source in the future.

There is no real prospect of expanding the Hub water source in the future.

Meanwhile, no studies examining the exploitability of local surface water sources have been conducted to date. Potential local surface sources would include the Thadoo, Mole and Khadeji Nallahs, and the reactivation of the Haleji Lake. Although the exploitability of these sources as a reliable source of water supply for Karachi appears to be very low, it would be worth conducting studies to examine the potentiality of these sources if accurate flow records covering at least 25 years in the past are available.

(2) Groundwater

The 1985 water supply master plan study made a review of all potential water resources in the Karachi region including groundwater. The review identified the Lasbela plain in the Porali river basin as the most promising groundwater source in the region. However, this source is located in Balochistan and was already proposed as a source of water for local irrigation development. The review also found that other groundwater sources in the region were of relatively small magnitude with the total potential yield of all the groundwater sources within

100 km of Karachi being as insignificant as 4 mgd (18,000 m^3/d).

In 2004, KW&SB conducted a study to explore the possibility of developing groundwater sources in the region as a source of water supply for Karachi. The study was titled "Feasibility Study to Explore Groundwater Source in Karachi District" and explored the availability of groundwater from the basins of Malir, Gadap, Lyari and Hub to supplement the existing supplies. This feasibility study was conducted by the consortium of M/s. Engineering Associates, Indusmens Corporation and Subzazar Agriculture Development (Pvt.) Ltd. The scope of the study included a) reconnaissance survey, b) resistivity survey, c) drilling of investigation boreholes, and d) construction of tube wells and piezometres.

a) Reconnaisance Survey
  - Inventory of private wells
  - Observation of selected wells
  - Chemical analysis of selected wells
  - Pumping test of selected wells

b) Resistivity Survey
  - 160 probes using Schelumberger - 4 electrode configuration

c) Drilling of Investigation Boreholes
  - Drilling of 30 investigation boreholes of 8 inch diametre up to a depth of 1200 feet for determining the underground strata and availability of potable water.

d) Construction of Tube Wells and Piezometres
  - Construction of 5 tube wells and 10 piezometres by reaming of test holes to 16 inch diametre and conversion into tube wells by providing casing pipes and strainers and development of tube well and pump test for these five tube wells.

After extensive surveys and analyses, this study concluded that since there was a little precipitation and a little groundwater recharge in Karachi, the sustainable yield of groundwater was already in balance with the existing pump discharge from about 1,000 existing wells and it was difficult to develop new wells. Prior to this study, no extensive groundwater investigations in the Karachi district had been conducted, except for some geological studies in and around Karachi that were undertaken by the Geological Survey of Pakistan. The conclusion of this study is quite similar to that of the 1985 water supply master plan and is further reinforced by the significant depletion of yield from the Dumlottee Well Field as discussed in **Section 3.2.1**.

Based on the foregoing, it is concluded in this JICA Study that the capacity of groundwater resources in Karachi is small that it can barely meet the present level of withdrawal. Under the circumstances, there is no realistic prospect of developing new groundwater resources which can be used to cater for the future water requirement of Karachi. It is rather recommended that more stringent controls should be put in place on the construction of new wells in order to maintain the current groundwater balance in the region. Over-pumping of groundwater may cause land subsidence and the lowering of groundwater tables, which is likely to result in the intrusion of seawater into aquifers and the further deterioration of groundwater quality in the region.

It is concluded in this JICA Study that there is no realistic prospect of developing new groundwater resources which can be used to cater for the future water requirement of Karachi.

(3) Desalination

The 1985 water supply master plan study assessed the possibility of seawater desalination as a means of meeting future water supply requirements. It reviewed the following basic processes available for seawater desalination.

- Distillation
- Reverse Osmosis
- Solar distillation
- Freezing

As a result, the study concluded that multi-stage flash (MSF) distillation was the only practical means to provide a large quantity of desalinated water. With regard to the other three processes, the study made the following assessments.

- Without energy recovery the costs of seawater reverse osmosis for large supplies would be very high and therefore the process was impractical to apply for the Karachi water supply;
- Solar distillation was only applicable for small supplies and therefore was irrelevant to the Karachi water supply; and
- Freezing of seawater as a means of desalination had been attempted but had not been technically successful.

The study also concluded that

- The cost of desalination for the foreseeable future was prohibitive and only if technological advances were made to considerably reduce the costs of energy then desalination could become an attractive option for Karachi.
- Given the very high capital and operating costs, desalination should be considered as a last resort.
- Since it was essential to use clean, unpolluted seawater the distiller would have to be located on the coast some distance from the city centre.
- Development of desalination plants to serve smaller, isolated consumers might be attractive, particularly where revenue from sales could cover costs; such consumers would include the Karachi Port Trust (KPT), Port Qasim Authority (PQA) and Pakistan Steel Mill (PSM).

The 1985 water supply master plan study concluded that the cost of desalination for the foreseeable future was prohibitive.

During the last two decades, there has been no remarkable technical breakthrough which could substantially reduce the capital and recurrent costs of seawater desalination. As such, the conclusion of the 1985 water supply master plan study is still effective at present. During the past five years, however, several agencies and authorities in the coastal region have tried to install seawater desalination plants to cope with water shortages in their areas of jurisdiction using the Private Sector Participation (PSP) modalities. However, due to the high price of desalinated water indicated by the private sector, contract negotiations on almost all of these schemes were either cancelled or suspended indefinitely. The only exception is the 3 mgd (13,500 m^3/d) MSF distillation plant currently under construction in the DHA Phase-VIII area under a BOT contract. The plant, upon its scheduled completion in April 2008, is expected to generate 94 MW of electricity with the use of natural gas while also producing 3 mgd of desalinated water at the same time. It has been agreed that the BOT contractor will operate the plant for a concession period of 20 years before handing it over to DHA, and that, during the concession period, the contractor will sell 80 MW of electricity to the Karachi Electricity Supply Corporation (KESC) and 3 mgd of desalinated water to the Clifton Cantonment Board (CCB) at the immediate exit of the plant. The price of water was set to be Rs 95/1,000 gallons at the base year which would be subjected to an automatic annual increase of 5% every year onward. The plant was initially planned to be fully operational in the first half of 2007 but it was still under construction in early November 2007 when the JICA Study team inspected the plant. **Table 32.2.1** presents a summary of various desalination schemes that emerged in the coastal region during the last five years.

Table 32.2.1 Summary of Desalination Schemes in Coastal Region

Organization	No. of Proposed Plants	Capacity (mgd)	Financing Scheme	Year of proposal	Desalination Process	Proposed Location	Status
Karachi Port Trust (KPT)	3	25	N/A	2002-2003	N/A	Keamari Groyne	Cancelled
		1	N/A	2004-2005	RO	Manora	Hold
		4	BOT	2004-2005	RO	Keamari Groyne	Pending
Port Qasim Authority (PQA)	1	25	BOO	2005-2006	N/A	East zone of Port Qasim	Pending
KW&SB/CDGK	1	25	BOO	2005	N/A	Behind PAF Korangi	Pending
Defense Housing Authority (DHA)	2	3	BOT	2006	MSF	Phase-VIII DHA	Construction in progress
		20	BOT	2006	MSF	N/A	Under consideration

N/A: Information Not Available; BOT: Build-Operate-Transfer; BOO: Build-Operate-Own; RO: Reverse Osmosis; MSF: Multi-stage Flash Distillation

Based on the foregoing, it is concluded in this JICA Study that seawater desalination will not be able to provide a viable solution for a mega city like Karachi in the foreseeable future unless there is a significant technical breakthrough substantially reducing the cost of desalinated water. Nonetheless, it would continue to remain as an option for a limited number of organizations and industries in the coastal region which can afford to pay the high cost of desalinated water in order to alleviate water shortages persisting in their areas of jurisdiction.

During the last two decades, there has been no remarkable technical breakthrough which could substantially reduce the capital and recurrent costs of seawater desalination. As such, the conclusion of the 1985 water supply master plan study is still effective at present, and it will continue to remain effective in the foreseeable future.

(4) Reuse of Treated Effluent

Reuse of treated effluent is practiced in TP-3 and Pakistan Steel Mill sewage treatment plant. In TP-3, one mgd (approximately 4,500 m^3/d) of effluent is pumped to nearby Pakistan Air Force (PAF) premise to water the plants there. Necessary costs for the implementation and operation of pumping and conveyance facilities are borne by PAF. No tariff is charged for obtaining treated effluent.

Pakistan Steel Mill has its own sewage treatment plant within its premise to treat domestic sewage generated in its company housing and part of pre-treated industrial wastewaters and to deliver the treated effluent to a nearby golf course and orchard.
The sewage treatment plant there began its operation in 1982. The plant is outlined below.

Site area: 46,000 m^2
Treatment capacity: 12,000 m^3/d
Construction cost: Rs.13 million
Design and construction: by M/S Lurgi (West Germany)
Treatment process: Activated sludge process consisting of pre-aeration, aeration and settling followed by thickening, sludge lagoon and natural drying
Sewage to treat: Domestic wastewater of around 100,000 people in Pakistan Steel Township and Gulshan Hadeed outside the factory, and of 15,000 employees working in the factory. Some portion of industrial wastewater also flows into the plant after pre-treatment.
Influent/Effluent qualities: SS 300/20 mg/l, BOD 180/25 mg/l, COD 200/120 mg/l

Treated effluent is used at a golf course and an orchard both within Pakistan Steel Mill premise.

- Golf course: around 2,200 m^3/d of effluent is supplied by pump. The charge is Rs. 15 per 1,000 gallons or Rs. 3.3/m^3.
- Orchard: It occupies 200 acres (81 ha.) of land. The charge is Rs.10,000 per acre of land per year or Rs. 24,700 per hectare per year.

No tariff is collected to operate and maintain the treatment plant, because it treats the sewage of company employees and their family members. The treatment cost is borne by Pakistan Steel Mill as a part of the factory operation cost.

Apart from treated effluent reuse, raw sewage is sprayed to grasses and trees at road dividers. CDGK's Works and Services Department waters grasses and trees in the city. The Department has installed a hydrant at Malir Nallah at Shara-e-Faisal from which substantial sewage is pumped to the tanker. The tanker sprays the pumped liquid to grasses and trees in the city. The necessary cost for watering is borne by the Department.

Other applications of raw sewage are found in some areas. One is Karsaz Golf Club where raw sewage application was being done from August 1986 through June 1992 at the charge of Rs.3 per 1,000 gallons (Rs.0.66 per cubic metre). The sewage was taken at a sewage pumping station and the golf club paid the amount to KW&SB. Later, the Club made its own arrangement to take the sewage from Malir trunk sewer free of charge. In DHA area, seven mgd of water is supplied to Clifton Cantonment Board on bulk basis. Out of generated sewage that is estimated to be five mgd, 0.1 mgd is used to water trees and grasses there.

There are several applications of raw sewage as well as treated effluent to trees and grasses. Raw sewage application on trees and grasses is not recommended from hygienic viewpoints, since it possibly is contaminated by pathogenic bacteria from its nature.

A study titled "Effluent Water Reuse for Karachi" is planned under Technical Assistance loan of Asian Development Bank. The outcome of the Study is expected to include the followings.

- Estimating the quantities, cost and potential revenues from water that could be made available for various municipal waste water re-uses such as agriculture and landscape irrigation, industrial recycling, groundwater recharges, recreational and environmental uses and non-potable urban uses etc. and developing options comparing these costs with the costs of abstracting additional water from the Indus River or with the cost of desalination.
- Preparation of strategic action plan for waste water reuse, detailed time bound costed action plan and institutional & operational mechanism.

Treated effluent can be used for various purposes as follows.

- Watering plants/grasses in parks and similar facilities
- Irrigation
- Agriculture
- Industrial use
- Groundwater recharge

In any case, a large scale reuse of treated effluent requires careful investigation whether the reuse is viable or not from technical, hygienic, financial and economic viewpoints, especially in case additional and/or advanced level treatment is needed. Trial application of treated effluent is recommended prior to its full application.

3.3 WATER SUPPLY AND SEWERAGE SYSTEMS

3.3.1 Water Supply System

(1) Bulk Water Supply System

1) General

The existing bulk water supply system for Karachi City shown in **Figure 33.1.1** has a capacity of 600 mgd as summarised in **Table 33.1.1**. Actually as of the end of year 2006, the KW&SB supplied bulk water of about 630 mgd beyond the capacity as shown in **Table 33.1.1**. However, it is noted that these figures may not be reliable because the KW&SB have never measured any flow rates of bulk water supply system.

Table 33.1.1 Bulk Water Supply Capacity

Bulk Water System	Rated Capacity	Actual Supply
GK System*	280 mgd	300 mgd
Haleji System	20 mgd	30 mgd
K-II System	100 mgd	120 mgd
K-III System	100 mgd	100 mgd
Dumlottee Wells	20 mgd	0 mgd
Hub System	80 mgd	80 mgd
Total	600 mgd	630 mgd

*: downstream of Fore Bay source: KW&SB

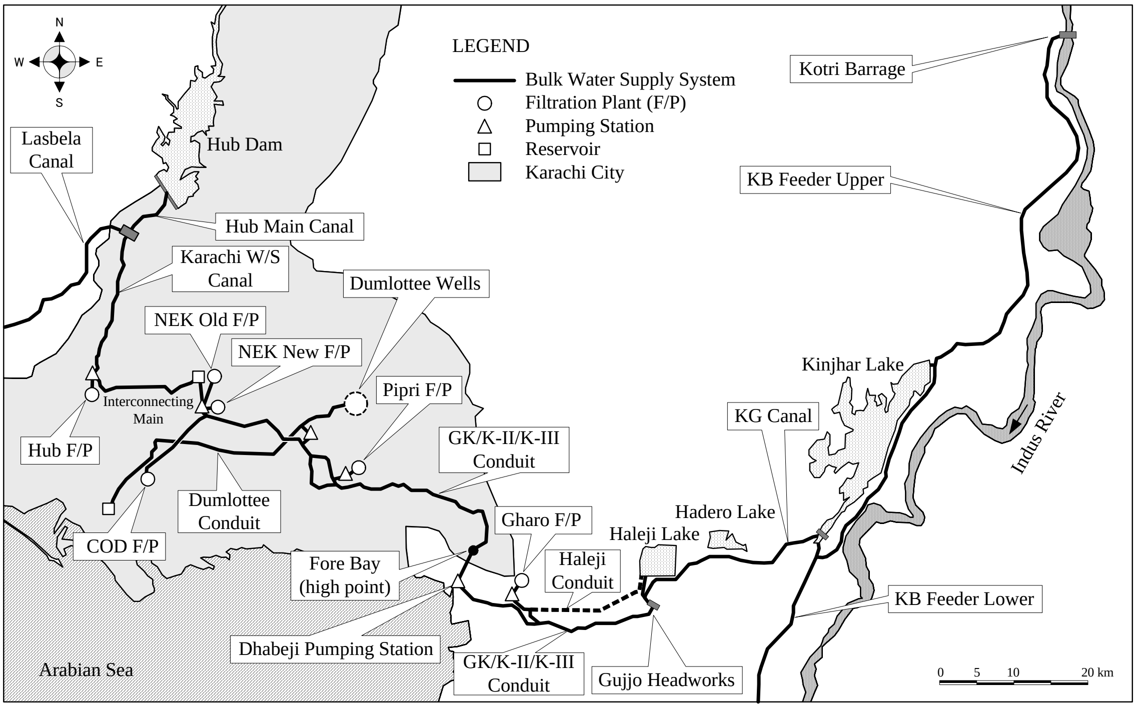


Figure 33.1.1 Existing Bulk Water Supply System

The existing bulk water supply system conveys water to Karachi from two main sources, namely, Indus River and Hub Dam.

2) Indus River System

Indus water is conveyed to Karachi through the following systems;

- Greater Karachi Bulk Water Supply (GKBWS) system
  (including GK Conduit, K-II Conduit and K-III Conduit),
- Haleji conduit, and
- Dumlottee conduit
  (originally the conduit is for conveying the groundwater from Dumlottee Wells).

a) Greater Karachi Bulk Water Supply (GKBWS) system

Since the lining works of the KG canal was completed in 1992, water from Kinjhar Lake has been conveyed to the Gujjo Headworks through the KG canal only. Before 1992, the Jam Branch canal was used to convey water from Kinjhar Lake to the Gujjo Headworks when KG canal was closed for maintenance and lining. At present, the Jam Branch canal is only used for emergencies. From the Gujjo Headwork water is further conveyed to Dhabeji pumping station through the RCC canal (315 mgd or 1,430,000 m^3/d) and the K-II/K-III canal (200 mgd or 910,000 m^3/d). The total conveyance capacity between Gujjo and the Dhabeji pumping station is 515 mgd (2,340,000 m^3/d) at present. The final section of the RCC canal to Dhabeji includes siphons and a 22-km long horseshoe-shape concrete conduit. The final section of the K-II/K-III canal for approximately 11 km in length is divided into two units of box culverts each sized 3.3 m by 3.3 m.

At Dhabeji, water is pumped over a distance of 4.5 km from the GK and K-II/K-III conduits to two units of receiving chambers located at a collection point (Forebay High Point) near the 200 feet contour through a number of pumping stations. Large diametre rising mains constructed in various development phases of the GKBWS system as shown in **Table 33.1.2** below. The details of the Dhabeji pumping stations are provided in **Table 33.1.2**.

Table 33.1.2 Dhabeji Pumping Stations and Rising Mains

<table>
<tr><th colspan="4">Pumping Stations</th><th colspan="3">Rising Mains</th><th rowspan="2">Receiving Chamber at Forebay High Point</th></tr>
<tr><th colspan="2">Name</th><th>Rated Capacity (mgd)</th><th>Running Capacity (mgd)</th><th>Material</th><th>Diametre (mm)</th><th>Number</th></tr>
<tr><td rowspan="4">K-I</td><td>Phase 1</td><td>70</td><td>48</td><td>PRCC</td><td>1,800</td><td>2</td><td rowspan="4">No.1</td></tr>
<tr><td>Phase 2</td><td>70</td><td>100</td><td>MS</td><td>1,800</td><td>1</td></tr>
<tr><td>Phase 3</td><td>70</td><td>100</td><td>MS</td><td>1,800</td><td>1</td></tr>
<tr><td>Phase 4</td><td>70</td><td>100</td><td>MS</td><td>1,800</td><td>1</td></tr>
<tr><td colspan="2">K-II</td><td>100</td><td>140</td><td>MS</td><td>1,500</td><td>2</td><td rowspan="2">No.2</td></tr>
<tr><td colspan="2">K-III</td><td>100</td><td>140</td><td>MS</td><td>1,800</td><td>2</td></tr>
</table>

PRCC: Pre-stressed Reinforced Cement Concrete; MS: Mild Steel
Source: KW&SB

From the receiving chamber No.1 at the Forebay High Point, water gravitates through a horseshoe-shape concrete conduit to the COD filtration plant located at COD Hills in the Gulshan-e-Iqbal town of Karachi. En route, the conduit supplies water to raw water pump houses at Pipri and NEK New, which pump the water to the Pipri and NEK Old water filtration plants respectively. From the receiving chamber No.2, water gravitates to Karachi through twin rectangular-shape box culverts each sized 3.3 m by 3.3 m. The K-II conduit supplies raw water to the water filtration plants located at Pipri and NEK New. The K-III conduit feeds raw water to the K-III New pumping station at NEK New, which then pump the water through twin 66-inch diametre MS rising mains to the 10 mg NEK Old reservoir. From this reservoir water is distributed by gravity to areas in the north and north-eastern parts of Karachi. An interconnecting main has been provided under the K-III Project between this reservoir and the Manghopir pumping station of the Hub Dam system, which makes it possible for the KW&SB to divert part of Indus water to the Hub filtration plant whenever it is necessary. The GKBWS system is illustrated in **Figure 33.1.2** including its actual flow rate as of the end of 2006.

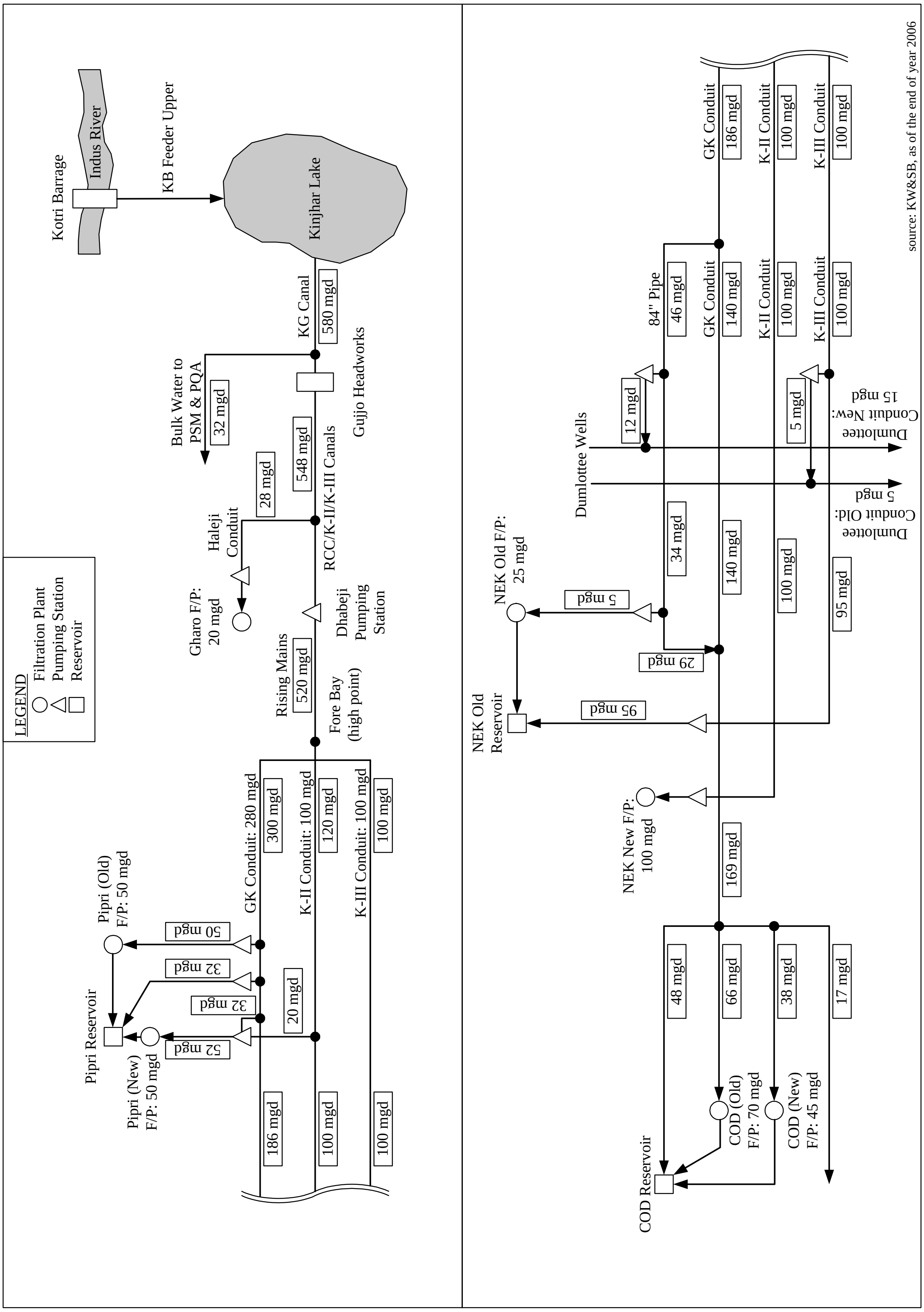


Figure 33.1.2 Existing Greater Karachi Bulk Water Supply System

b) Haleji conduit

Supplies were first obtained from Haleji Lake in the mid 1940s. The conduit which has a design capacity of 20 mgd (91,000 m^3/d) conveyed water from the lake to Gharo where it is pumped to the filter plant some 4 km along the route. Treated water is then conveyed, by gravity, to Karachi and the conduit terminates at the 9th Mile pumping station (20 mgd or 91,000 m^3/d).

Supplies are made from the conduit to Landhi, Pipri and Korangi residential and industrial areas in south-east Karachi and a connection from the Landhi/Pipri trunk main (supplied from the Pipri filtration plant) supplements supplies in the conduit. Since the Haleji reservoir has been abandoned as a regular source, supplies are made from the open (RCC) canal through a 72 inch diametre connection provided before Siphon No.1 near Gharo. The section of the conduit from this point to Haleji Lake is not used except for emergencies.

c) Dumlottee Conduit

The Dumlottee Conduit was originally constructed to convey groundwater from the Dumlottee Wells to the centre of the city. The Dumlottee Conduit crosses the 280 mgd (1,273,000 m^3/d) GK conduit system near the Malir River. At this point as shown in **Figure 33.1.3**, 17 mgd (77,000 m^3/d) of water is currently being pumped into the Dumlottee Conduit from the 84-inch diametre bulk water main which connects the end of the GK tunnel to the Old Pumping House and K-III Conduit which connects the NEK Old Reservoir through the K-III Pumping Station near NEK New F/P.

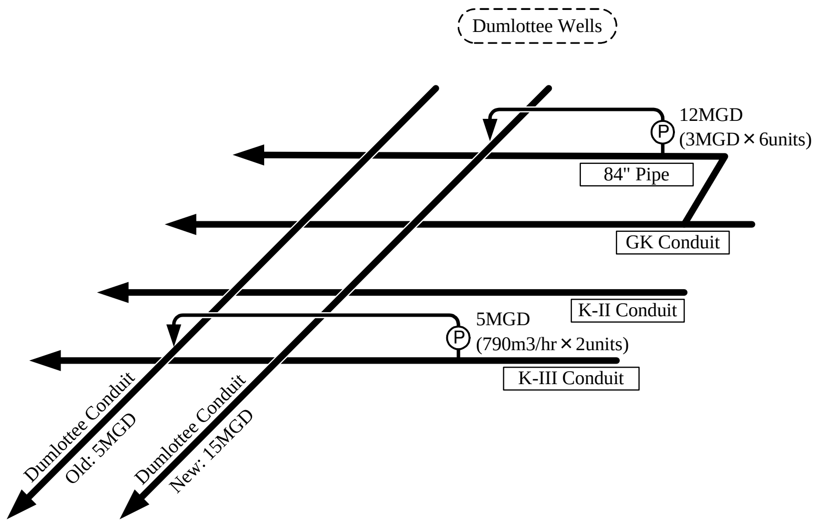


Figure 33.1.3 Flow Diagram at Dumlottee Pumping Station

Another interconnection with the GKBWS system is provided from Siphon No.19 to divert Indus water to the Dumlottee Conduit from the GK Conduit. At present, no water is produced from the Dumlottee Wells throughout the year, except for a few months immediately following the rainy season when approximately 1.4 mgd (6,300 m^3/d) of groundwater is produced from the well field. The Dumlottee conduit system feeds the Low Service reservoir and terminates at the Sydenham, Currie and Temple reservoirs near the centre of the city.

3) Hub Dam System

The catchment area of Hub dam extends across two provinces namely Sindh and Balochistan covering a total area of 3,410 8,730 km^2. There has been an agreement between the two provinces that, at the Regulator located at the end of the Hub Main Canal, 63.3% of the total flow will be diverted to the Karachi Water Supply Canal (Sindh) while 36.7% to the Lasbela Canal (Balochistan).

Both Hub Dam and the Hub Main Canal (about 8 km long) which connects the dam to the Regulator have been maintained by the WAPDA (Water and Power Development Authority). The Karachi Water Supply Canal which connects the Regulator to the Manghopir Pumping Station is currently maintained by the KW&SB, although it was also maintained by WAPDA until only a few years ago. The existing capacities of these canals are as follows:

Hub Main Canal	: 370 cusecs (905,000 m^3/d or 199 mgd)
Karachi Water Supply Canal	: 210 cusecs (514,000 m^3/d or 113 mgd)
Lasbela Canal	: 160 cusecs (391,000 m^3/d or 86 mgd)

The Karachi Water Supply Canal is a 23 kilometre-long open channel. It conveys water from the Regulator to the Manghopir pumping station by gravity. Twin 66-inch diametre MS rising mains, each 2.2 km long, connect this pumping station to the Hub filtration plant. Both Manghopir pumping station and Hub filtration plant were completed in 2005 under the Karachi Water Supply Improvement Project financed under a JBIC loan. From a reservoir located at the Hub filtration plant water is distributed to the townships of Orangi, Baldia, SITE (both residential and industrial areas), Surjani, North Karachi and parts of Keamari Town.

4) Bulk Pumping Stations and Water Filtration Plants

Present water supply system of Karachi City has a supply capacity of 560 mgd as shown in **Table 33.1.3**.

Table 33.1.3 Present Water Supply Capacity

Supplied from		Rated Capacity	Actual Supply
Gharo Filtration Plant		20 mgd	30 mgd
Pipri Filtration Plant	with Filtration	100 mgd	102 mgd
	without Filtration	-	32 mgd
Dumlottee Conduit (without Filtration)	from Wells	20 mgd	0 mgd
	from GK/K-III Systems	-	17 mgd
NEK Old Filtration Plant		25 mgd	5 mgd
NEK New Filtration Plant		100 mgd	100 mgd
COD Filtration Plant	with Filtration	115 mgd	104 mgd
	without Filtration	-	48 mgd
Hub Filtration Plant		80 mgd	80 mgd
Supply without Filtration (from K-III System)		100 mgd	95 mgd
Supply without Filtration (from GK System)		-	17 mgd
Total		560 mgd	630 mgd

source: KW&SB

Actually as of the end of year 2006, the KW&SB supply bulk water of about 630 mgd beyond the capacity as shown in **Table 33.1.3** (also see **Figure 33.1.2**). Out of 630 mgd, water of 209 mgd is supplied without filtration, which is equivalent to one third of actual supply amount of 630 mgd.

Table 33.1.4 provides the salient features of bulk pumping stations currently in service. There are a total of 10 water purification plants currently in operation with a total filtration capacity of 440 mgd. **Table 33.1.5** presents the salient features of those plants (see also **Appendix 33.1**).

Table 33.1.4 Bulk Pumping Stations in Service

Sr.No.	Name of Pumping Station	Name of the Town / UC No.	Year of Construction	Total Capacity (MGD)	Running Capacity (MGD)	Pumps & Motors							Generator		
						Total No. of Pumps	No, of Stand-By Pumps	Capacity of Each Pump (MGD)	Pump Head (ft)	Electric Motor (KW)	No. of Hours Operated per Day	Last Replacement (Year)	Existence	Capacity (MW)	Operative
1	Hub (Manghopir)	Gadap	1983	164	0	4	4	35	168	1050	-	-	Yes	3.5	No
						2	2	12	168	600	-	-			
2	Dhabeji (Phase-I)	Dhabeji	1959	120	48	5	3	24	210	Diesel+Gas	24	-	Yes	0.25	yes
3	Dhabeji (Phase-II)	Dhabeji	1971	125	100	5	1	25	210	1050	24	-	--	--	--
4	Dhabeji (Phase-III)	Dhabeji	1978	125	100	5	1	25	210	1050	24	-	--	--	--
5	Dhabeji (Phase-IV)	Dhabeji	1997	125	100	5	1	25	210	1050	24	-	Yes	4.52	No
6	K-II (Dhabeji)	Dhabeji	1998	175	140	5	1	35	210	1635	24	-	--	--	--
7	K-III (Dhabeji)	Dhabeji	2006	210	140	6	2	35	210	1635	24	-	--	--	--
8	Gharo (Old)	Thatta District	1943	37	23	3	1	5	170	Diesel	24	-	Yes	0.5	Yes
			1982			6	2	2.0	170	74.6	24	-			
			2002			2	1	5.0	170	149.1	24	-			
9	Gharo (New)	Thatta District	1953	40	21	2	1	10	170	Diesel	24	-	Yes	0.5	yes
			1997			5	2	2.0	170	93.2	24	-			
			2002			2	1	5.0	170	186.4	24	-			
10	Pipri (old)	Bin Qasim	1971	75	50	6	2	12.5	100	260	24	-	Yes	1.5	Yes
11	Pipri (Phase IV)	Bin Qasim	1994	50	37.5	4	1	12.5	56	132	24	-	Yes	1.25	Yes
12	Pipri (New)	Bin Qasim	2000	60.48	51.84	14	2	4.32	100	111.9	24	-	Yes	0.6	Yes
13	9th Mile	Gulshan-e-Iqbal	1988	13.2	6.6	4	2	3.3	200	149.1	24	-	-	-	-
14	LSR (Old)	Gulshan-e-Iqbal	1968	18	12	3	1	6.0	120	164	24	-	-	-	-
15	LSR (New)	Gulshan-e-Iqbal	1999	6.5	3.25	2	1	3.25	120	149.1	24	-	-	-	-
16	Ajmer Nagri	North Karachi	1999	46.53	33.84	11	3	4.23	150	149.1	24	-	-	-	-
17	Hub (New)	Gadap	2006	175	105	4	1	35	168	1350	24	-	-	-	-
	(Manghopir)					2	2	17.5	168	750	24	-			
18	T&C	Jamshed	1989	9	1.5	6	5	1.5	150	74.6	24	-	-	-	-
19	NEK (Old)	Gadap	1978	80	35	4	2	12.5	160	372.9	24	-	Yes	1.25	Yes
						6	4	5	160	111.9	24	-			
20	High Lift (at NEK New)	Gadap	1998	125	75	5	2	25	85	307.2	24	-	-	-	-
21	Low Lift (at NEK New)	Gadap	1998	175	105	5	2	35	40	232.7	24	-	-	-	-
22	K-III (at NEK New)	Gadap	2006	135	90	6	2	22.5	160	391.5	24	-	-	-	-
23	Dumlotte (Interconnection) To Old Dumlotee Conduit	Gadap	1971	16.8	11.2	6	2	2.8	40	22.4	24	-	Yes	1.35	Yes
			2006	10	5	2	1	5	40	37.3	24	-			
24	Board Office	North Nazimabad	2000	24	16	6	2	4	100	74.6	24	-	-	-	-
25	Kidney Hill	Gulshan-e-Iqbal	1982	15	5	3	2	5	200	164	12	-	-	-	-
26	Sakhi Hasan	North Nazimabad	1974	25.92	21.6	6	1	4.32	200	149.1	12	-	-	-	-

source: KW&SB

Table 33.1.5 Existing Water Filtration Plants

	Unit	Gharo		COD		Pipri			NEK Old	NEK New	Hub
		Plant 1	Plant 2	Plant 1	Plant 2	Plant 1	Plant 2	Plant 3			
Year of Construction		1943	1953	1962	1971	1971	1978	2006	1978	1998	2006
Rated Production Capacitty	mgd	10	10	70	45	25	25	50	25	100	80
	m^3/d	45,460	45,460	318,220	204,570	113,650	113,650	227,300	113,650	454,600	363,680
Inlet (Receiving) Chamber											
Number of Basin	nos.	2	1	1	1	1	1	-	2	1	1
Mixing Chamber											
Number of Basin	nos.	-	-	3	1	1	1	-	1	2	-
Type of Mixer	-	-	-	Flush Mixer	Weir	Flush Mixer	Weir	-	Flush Mixer	Weir	Weir
Flocculation & Sedimentation Basin											
Type of Basin	-	Rectangular Horizontal Flow	Circular Type	Center Feed Circular Type	Pulsation Type	Center Feed Circular Type	Pulsation Type	-	Center Feed Circular Type	-	-
Number of Basin	nos.	1 Floc. Basin 8 Sed. Basin	2 Floc. Basin 2 Sed. Basin	3	2	2	2	-	2	-	-
Size/Area		300 m^2	ϕ 21 m	ϕ 60 m	1,280 m^2	ϕ 43.5 m	710 m^2	-	ϕ 43.5 m	-	-
Surface Loading	$m^3/m^2/d$	19	65	45	80	42	80	-	42	-	-
Withdrawal of Sludge		Manual	Manual	Manual	Air-operated	Manual	Air-operated	-	Manual	-	-
Filter Bed											
Number of Bed	nos.	8	8	24	14	8	8	10	8	20	16
Filtration Area	m^2/bed	55	55	128	99	100	97.5	157	100	157	157
Filtration Rate	$m^3/m^2/d$	104	104	105	148	142	146	145	142	145	145
Type of Backwash	-	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water	Air Scour & Water
Number of Backwash Pump	nos.	1 air blowers 2 bw pumps	2 air blowers 2 bw pumps	2 air blowers 3 bw pumps	2 air blowers 3 bw pumps	3 air blowers 4 bw pumps		3 air blowers 3 bw pumps	2 air blowers 2 bw pumps	3 air blowers 3 bw pumps	3 air blowers 3 bw pumps
Clear Water Reservoir											
Volume	mg	6		10	6	10	6	-	10	10	15
Chemical Feeding Facilities											
Alum – Applied Chemical	-	Solid Alum	Solid Alum	Solid Alum	Solid Alum	Solid Alum	Solid Alum	Solid Alum	Solid Alum	Solid Alum	Solid Alum
Chlorine – Applied Chemical	-	Liquid Chlorine		Liquid Chlorine	Liquid Chlorine	Liquid Chlorine		Liquid Chlorine	Liquid Chlorine	Liquid Chlorine	Liquid Chlorine
Chlorine – Number of Chlorinator	nos.	1		4	4	2		3	7	3	3
Chlorine – Dosing Point	-	Post		Pre & Post	Pre & Post	Pre & Post	Pre & Post	Pre & Post	Pre & Post	Pre & Post	Pre & Post
Other Chemicals	-	-	-	-	-	-	-	Sulphuric Acid and Lime for pH control	-	Lime for pH control	Sulphuric Acid and Lime for pH control
Power Substation (not including for P/S)											
Transformer		300 KVA × 2 units		500 KVA × 2 units	500 KVA × 2 units	500 KVA × 2 units		750 KVA × 1 unit	630 KVA × 2 units	750 KVA × 1 unit	800 KVA × 1 unit
Generator		219 KVA × 2 units		630 KVA × 1 unit	-	-	-	-	660 KVA × 1 unit (out of order)	-	800 KVA × 1 unit

source: KW&SB

(2) Water Trunk Mains

Water trunk main system in Karachi City is managed by the Superintendent Engineer of Water Trunk Main who functions under the Chief Engineer of Bulk Transmission. The water trunk main system transmits water from the bulk water system such as filtration plants (F/Ps), pumping stations (PSs) and distribution reservoirs to supply area through the water distribution network system as schematically shown in **Figure 33.1.5** and summarized in **Table 33.1.7**. Major routes of the water trunk mains are shown in **Figure 33.1.6**.

The water trunk main system consists of approximately 400 km pipelines with diametres ranging from 12 in to 84 in as listed in **Table 33.1.6**. Main material of the water trunk mains is pre-stressed cement concrete (PRCC), which is about 80 % of the total length (**Figure 33.1.4**).

Table 33.1.6 Water Trunk Mains

Diametre		Length
inch	mm	(m)
12	300	5,720
15	375	4,266
18	450	36,106
24	600	72,268
32	800	27
33	825	77,235
36	900	15,311
40	1,000	2,644
42	1,050	2,631
48	1,200	88,113
54	1,350	39,667
64	1,600	6,112
66	1,650	30,960
72	1,800	13,693
84	2,100	10,409
Total		405,163

Source: KW&SB

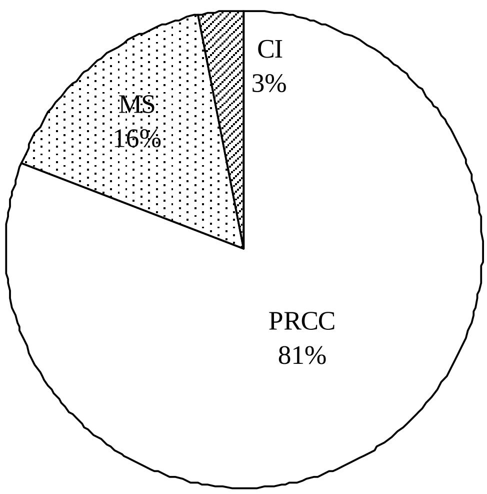


Figure 33.1.4 Proportions of Materials used for Water Trunk Mains

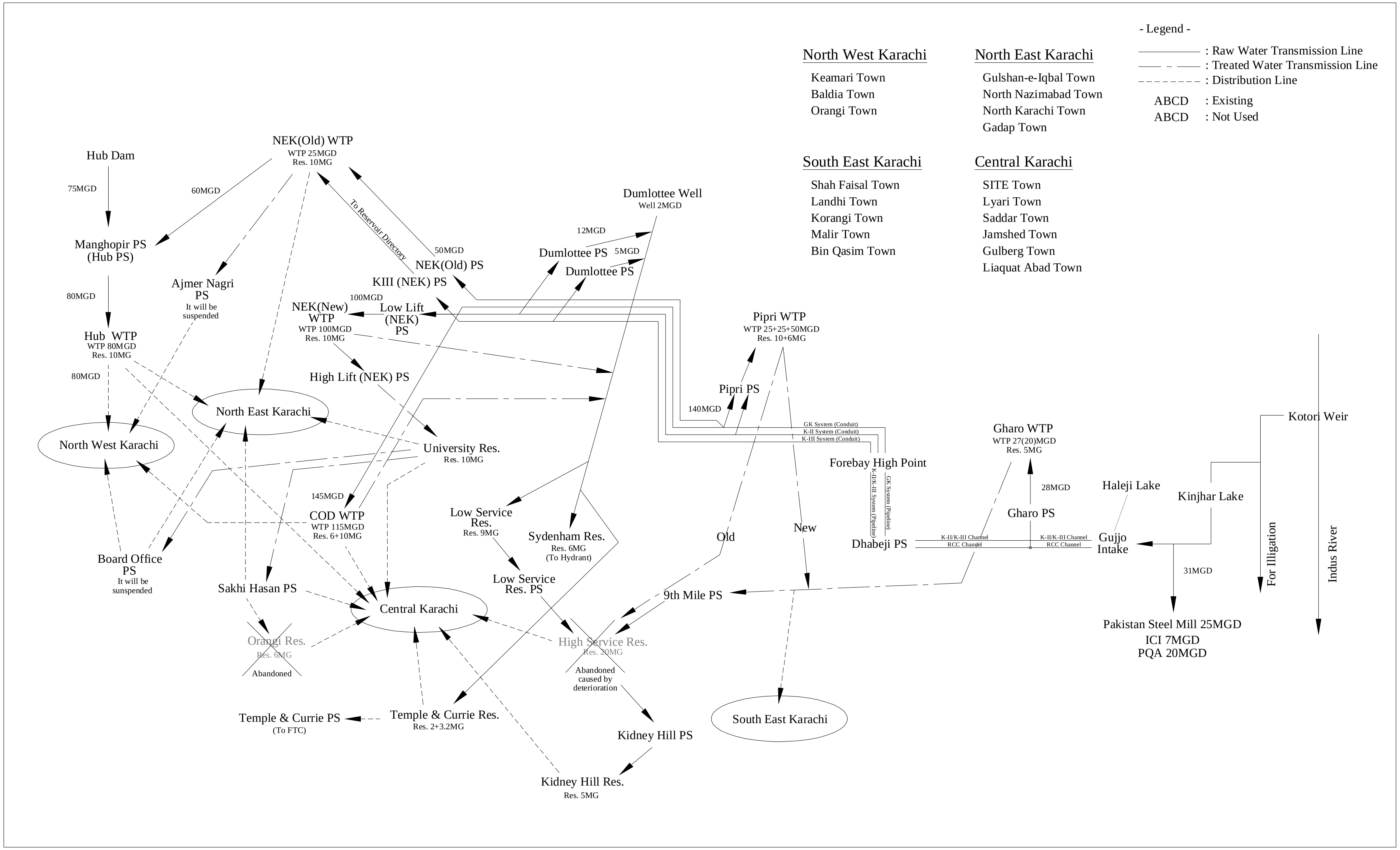


Figure 33.1.5 Water Transmission System

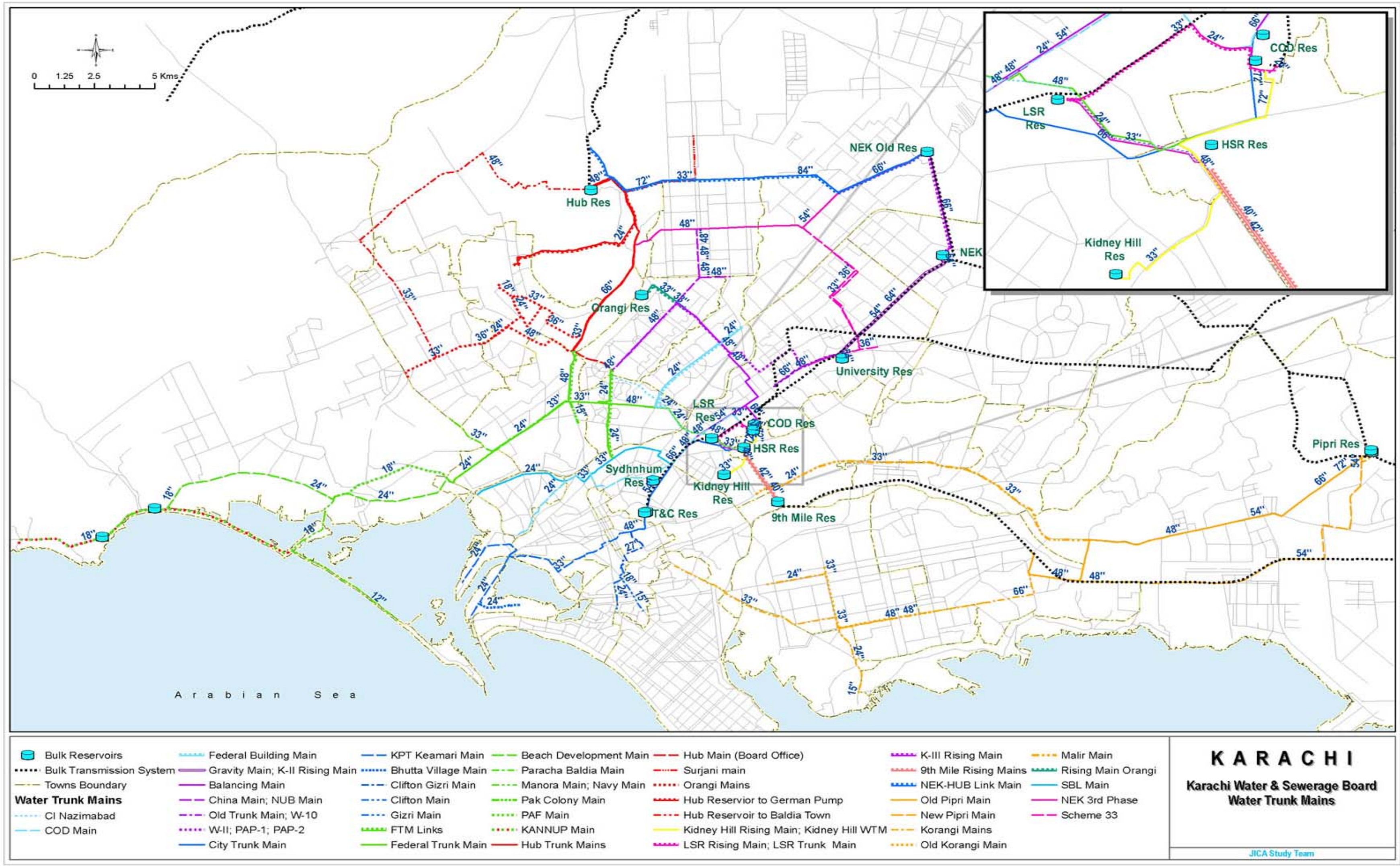


Figure 33.1.6 Route of Major Water Trunk Mains

Table 33.1.7 Supply Area from F/Ps, Reservoirs and Pumping Stations

WTPs	Reservoirs / PSs			Town supplied	Area
Gharo WTP (20 mgd)	9th Mile PS (6 mgd)	through abandoned H.S.R. Site		Jamshed	Central Karachi
Reservoir (5 mg)				Bin Qasim	South East Karachi
				Landhi	South East Karachi
				Korangi	South East Karachi
				Shah Faisal	South East Karachi
Pipri WTP (100 mgd)	through abandoned H.S.R. Site			Jamshed	Central Karachi
Reservoirs (16 mg)				Maril	South East Karachi
				Bin Qasim	South East Karachi
				Landhi	South East Karachi
				Korangi	South East Karachi
				Shah Faisal	South East Karachi
Dumlottee Wells (supplied through the Dumlottee Conduit)	L.S.R. (9 mg)	L.S.R. PS (9.3 mgd)	through abandoned H.S.R. Site	Jamshed	Central Karachi
	T & C Reservoir (5.2 mg)	T & C PS (3 mgd)		Shah Faisal	South East Karachi
				Lyari	Central Karachi
				Saddar	Central Karachi
additionally watered from GK/K-II/K-III conduits	Sydenham Reservoir (6 mg)			Jamshed	Central Karachi
				Gulshan-e-Iqbal	North East Karachi
NEK Old WTP (25 mgd)	Manghopir PS (105 mgd)	Hub WTP		-	-
Reservoir (10 mg)	Ajmer Nagri PS			Orangi	North West Karachi
				Norht Karachi	North East Karachi
				Orangi	North West Karachi
NEK New WTP (100 mgd)	High Lift PS (75 mgd)	University Reservoir (10 mg)	Sakhi Hasan PS	Gulberg	Central Karachi
Reservoir (10 mg)				North Nazimabad	North East Karachi
			Board Office PS	North Nazimabad	North East Karachi
				Orangi	North West Karachi
				Gulshan-e-Iqbal	North East Karachi
				Gulberg	Central Karachi
COD WTP (115 mgd)	Kidney Hill Res. (5 mg)			Jamshed	Central Karachi
Reservoirs (16 mg)				Kiamari	North West Karachi
				Lyari	Central Karachi
				Saddar	Central Karachi
				Jamshed	Central Karachi
				Liaquat Abad	Central Karachi
Hub WTP (80 mgd)				Orangi	North West Karachi
Reservoir (15 mg)				Baldia	North West Karachi
				SITE	Central Karachi
				Gadap	North East Karachi

Source: KW&SB

(3) Water Distribution Network

1) General

The water distribution network in Karachi covers 18 towns, 6 Cantonments and a Defense Housing Authority (DHA) Area. These 18 towns are included in 5 administrative water supply zones classified by the KW&SB, which is shown on **Figure 33.1.7**. Keamari Town, Bin Qasim Town & Gadap Town which are located in eastern part, western part & northern part of Karachi respectively have huge administrative area, but most area in these towns are out of the KW&SB supply area because of very low population density. Some of the areas in these towns are used for agriculture or are barrens and are directly administrated by the City District Government Karachi (CDGK) Nazims and Union Councils (UCs) or by the some community participatory organizations. Remaining 15 towns are almost 100% of service ratio supplied by piped water supply, water tank-cars or other ways. Cantonments and Defense Housing Authority (DHA) area are out of management by the KW&SB, but are supplied by bulk water system.

2) Water Distribution Network

Water is supplied through water trunk mains from water filtration plants, reservoirs, pumping stations or Dumlottee Wells in the city of Karachi. The distribution reservoirs which are the base of water supply are listed in **Table 33.1.8**. Pipelines with a diametre of 15 in (375 mm) and over in distribution network is called as distribution mains normally in Karachi. The list of the existing distribution pipelines including distribution mains of each town as of the year 2001 is shown in **Table 33.1.9**. The detail of the existing distribution pipelines is attached to **Appendix A33.1**. A total length of the existing distribution pipelines is about 4,850km as of the year 2001. This information was prepared by Water Distribution Wing of the KW&SB, which does not exist in the current organisation. According to this table, about 65 % of the existing pipes are asbestos cements (AC) pipes as shown in **Figure 33.1.8**. If excluding distribution mains (15 in and over), AC pipes account for 70 % of the total. There are many aged pipes which were installed more than 40 years ago. In addition even relatively new pipelines are also mainly AC pipes. Present City Nazim has, however, urged a plan of replacement of the existing distribution network mains which are mainly AC pipes with PE pipes by the “Tameer-e-Karachi Programme (TKP)” for improving and securing the water supply conditions.

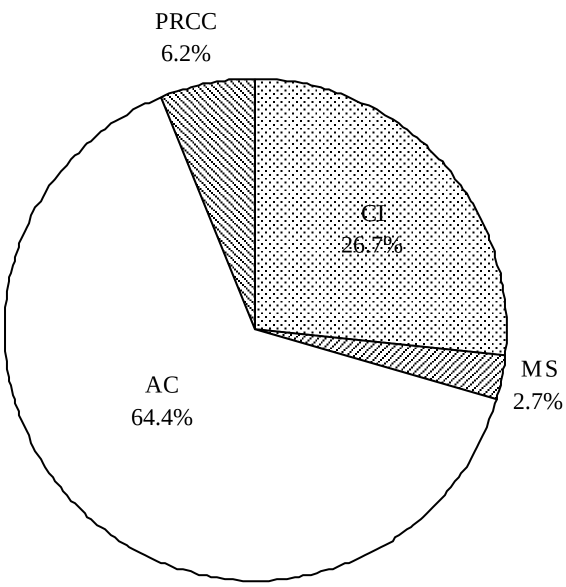
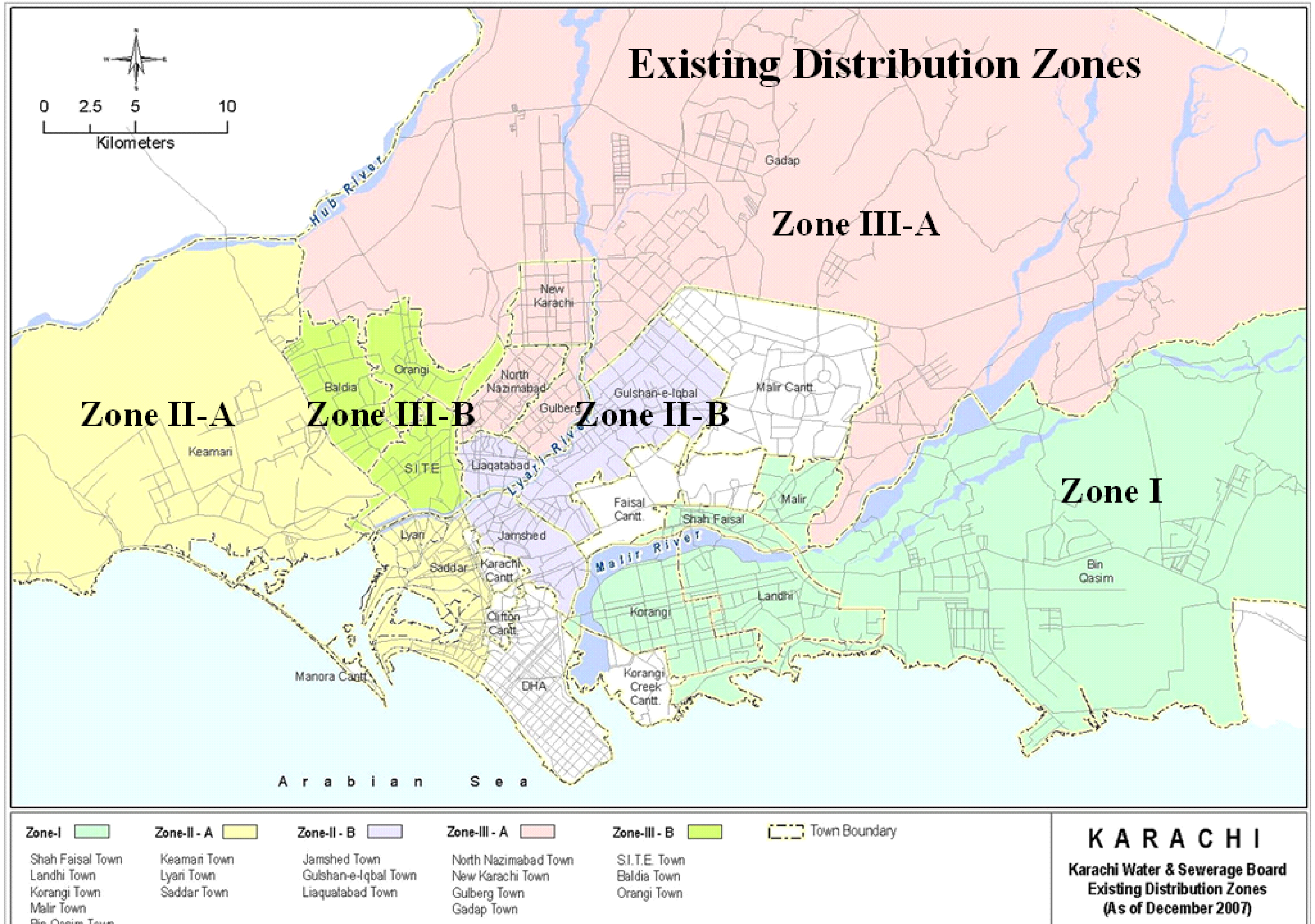


Figure 33.1.8 Proportions of Materials used for Distribution Pipelines



Source: KW&SB

Figure 33.1.7 Present Water Supply Zones

Table 33.1.8 List of Distribution Reservoirs

Reservoir	Construction	Capacity		High Water Level		Low Water Level	
		Mg	m3	+Ft.	+m	+Ft.	+m
Gharo WTP Res. (Plant-1)	1942	6.0	27,277	155.0	47.24	150.0	45.72
Pipri WTP Res. (Plant-1)	1971	10.0	72,737	250.0	76.20	234.0	71.32
Pipri WTP Res. (Plant-2)	1978	6.0	72,737	250.0	76.20	234.0	71.32
NEK (OLD) WTP Res.	1978	10.0	45,461	260.0	79.25	244.0	74.37
NEK (NEW) WTP Res.	1998	10.0	45,461	185.0	56.39	169.0	51.51
COD WTP Res. (Plant-1)	1962	10.0	45,461	150.0	45.72	132.0	40.23
COD WTP Res. (Plant-2)	1971	6.0	27,277	150.0	45.72	132.0	40.23
HubWTP (Manghopir) Res.	1982	15.0	68,191	340.0	103.63	326.0	99.36
University Res.	1971	10.0	45,461	220.0	67.06	*204.0	*62.18
High Service Res. (Abandoned)	1945	20.0	90,922	150.0	45.72	*134.0	*40.84
Low Service Res.	1942	9.0	40,915	103.0	31.39	*87.0	*26.52
Temple Res.	1880	2.0	9,092	61.5	18.75	*45.5	*13.87
Currie Res.	1896	3.2	14,547	61.5	18.75	*45.5	*13.87
Sydenham Res.	1942	6.0	27,277	65.5	19.96	*49.5	*15.09
Orangi Res. (Abandoned)	1982	6.0	27,277	250.0	76.20	*234.0	*71.32
Kidney Hill Res.	1978	6.0	27,277	200.0	60.96	*184.0	*56.08

* : To assume 16ft of water depth
Source: KW&SB

Table 33.1.9 Distribution Pipelines

Name of Zone	Name of Town	Pipeline Length (km)				Total Length (km)
		CIP	MS	AC	PRCC	
Zone-I	Landhi	134.70	0.00	129.51	38.00	302.21
	Korangi	164.21	0.00	148.00	48.48	360.69
	Malir	3.00	0.00	206.20	11.40	220.60
	Bin Qasim	2.40	0.21	12.67	8.52	23.80
	Shah Faisal	0.00	0.00	247.00	10.00	257.00
Zone-IIA	Keamari	0.00	0.00	35.53	3.10	38.63
	Lyari	9.86	1.80	157.48	5.04	174.18
	Saddar	70.52	2.64	119.81	24.36	217.33
Zone-IIB	Jamshed	43.65	5.00	208.25	20.10	277.00
	Gulshan-e-Iqbal	84.34	2.53	293.16	15.72	395.75
	Liaquat Abad	224.00	0.40	535.70	2.50	762.60
Zone-IIIA	North Nazimabad	73.55	0.23	262.63	16.88	353.29
	New Karachi	370.16	0.00	184.08	4.85	559.09
	Gulberg	103.18	2.38	70.97	10.21	186.74
	Gadap	0.00	73.55	44.47	19.04	137.06
Zone-IIIB	SITE	3.16	18.15	145.03	11.74	178.08
	Baldia	4.40	2.49	92.04	7.56	106.49
	Orangi	5.35	19.52	233.87	45.10	303.84
Total Length (km)		**1,296.48**	**128.90**	**3,126.40**	**302.60**	**4,854.38**

Source: KW&SB

KW&SB are currently rationing its supply by regulating entry valves to sub-zones and operating hours of distribution pumps. **Figure 33.1.9** provides an overall picture of how the KW&SB regulate its supplies to retail and bulk customers at present.

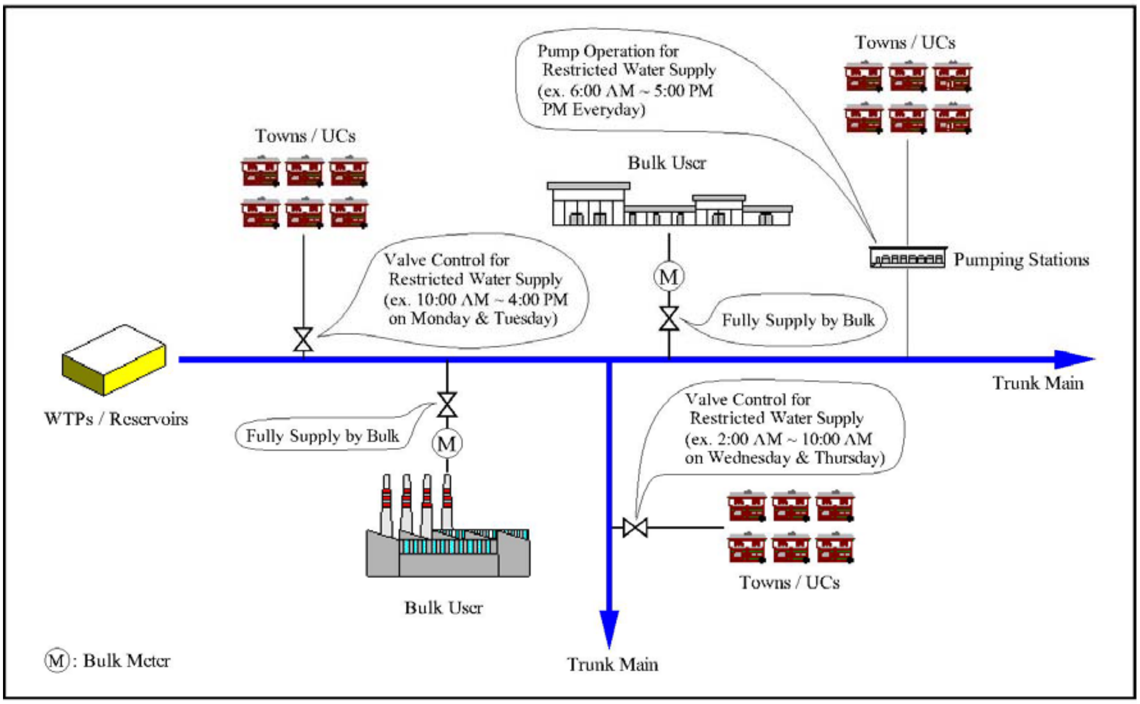


Figure 33.1.9 Methods Used for Water Rationing

A total of 139 distribution pumping stations are operated and managed by the KW&SB. The details of these distribution pumping stations are shown in **Appendix A33.1**. Some of distribution pumps are stopped during power break down, since there is no emergency power supply equipment such as power generator. Suspension of pumping makes water supply situation to accelerate worse. In order to cope with such serious water supply situation, some of the consumers install individual small suction pumps and suck water from distribution pipes forcibly during supply hours. In addition to that, some consumers in low literate areas don't use float valve to avoid the overflow from the under ground and over head tanks and water continues to overflow from the tanks during the supply hours especially in the night time. These are the reasons of serious water supply situation which makes low water pressure and water shortage, and also problems of water quality aggravation such as sewerage contamination caused by negative pressure in the pipes. The details of the result of water quality analysis are described in **Section 4.1 "Water Quality Analysis"**.

There is no water meter on service pipes for individual service connection. Consumers pay water tariff on the basis of plot size hence they pay no attention to any wastage. Awareness for the usage and storage of water is very less in many parts of Karachi. It is, therefore, considered that a consumption rate per capita per day including the wastage and leakage inside the houses is relatively large comparing with an essential water.

3) Water Losses in Distribution Network

KW&SB assume that the water loss in the distribution network is between 30% and 35%. According to Master Plan made in 1985 for Water Supply, water losses in 1985, 1990 and 1995 were assumed to be 40%, 33% and 25% respectively. Deterioration of existing pipes is one of reasons of water leakage at the connection parts of pipelines. And the water leakages at the connection parts are occurred by using low quality material of pipes and poor workmanship either attended by the KW&SB staff or by the contractors. In addition to these causes, there are so many illegal connections, and these illegal users also use water without concern for water usage. Improvement of distribution pipes and service pipes is necessary to cope with these problems, but the improvement does not progress, because of huge cost and the enormous amount of time for these improvement and development. JICA Study conducted the water leakage survey and its results are described in **Section 4.3 "Leakage and NRW Surveys"**. Through the survey it was observed that overflows of the individual water tanks and sacking water by illegal connections were assumed to account for a large share of water losses.

4) Bowser Filling Stations and Water Supply Service by Tank-Cars

The areas where are not in the service area by any water supply or low service quality of water supply are watered by Tank-Cars (**Photo 33.1.1**) which belongs private sectors from 10 bases of Bowser Filling Stations (**Photo 33.1.2**) in the city area. The operations and managements of these Bowser Filling Stations and Tank-Cars are under Rangers. The details about these systems are not clear. Monthly water consumption at each station recorded by Ranger in 2004 is shown in **Table 33.1.10**. According to the KW&SB, there is no report from Ranger about water consumption other than this report.

Photo 33.1.1 Water Tank Cars

Photo 33.1.2 Bowser Filling Station

Table 33.1.10 Bowser Filling Stations

S.No.	Name of the Bowser filling station	Location	UC No.	Monthly Consumption in 2004 (MG)	Operation at Present
1	Muslimabad	Jamshed	UC No.11 (Garden East)	48	Yes
2	Sydhnem	Jamshed	UC No.11 (Garden East)	90	Yes
3	LSR	Gulshan-e-Iqbal	UC No.2 (Civic Center)	90	No
4	Sakhi Hassan	North Nazimabad	UC No.6 (Sakhi Hassan)	84	Yes
5	F.B. Area	Gulberg	UC No.5 (Naseerabad)	105	Yes
6	N.E.K	Gadap	UC No.3 (Gujro)	47.1	Yes
7	Shah Faisal	North Karachi	UC No.8 (Shah Faisal Colony)	4.8	Yes
8	Jamia Millia	Shah Faisal	UC No.7 (Al Falah Society)	19.5	Yes
9	Juma Goth	Shah Faisal	UC No.7 (Al-Falah Society)	16.50	Yes
10	L.I.A	Bin Qasim	UC No.3 (Cattle Colony)	2.04	Yes
			Total:	18.54	

Source: KW&SB

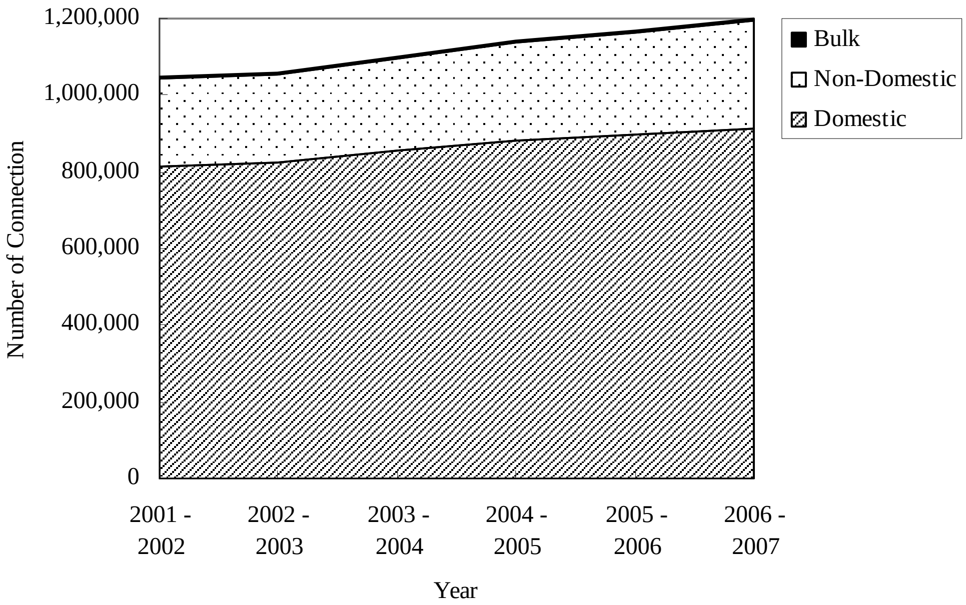
5) Service Connection

The information of the number of service connection counted by the KW&SB in the last 6 years is shown in **Table 33.1.11**. And more detailed information of service connection is shown in **Appendix A33.1**. Number of connection in Cantonments and DHA area is not included in this table. These areas are supplied by bulk supply system. According to the census in 1998, population in Cantonments was 306,165 and population in DHA area was 250,000. It is recognized that number of connection have increased on average of about 3% yearly in the last 5 years. The increase of number of service connection is shown in **Figure 33.1.10**. As mentioned previously, there is no water meter on service connection except some bulk users.

Table 33.1.11 Number of Service Connection

Category	Number of Service Connection					
	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007
Domestic*	816,259	823,931	853,710	879,935	899,270	910,709
Non-Domestic	226,638	230,046	241,214	255,833	264,298	282,048
Bulk	4,113	4,152	4,268	4,440	5,040	5,149
Total	1,047,010	1,058,129	1,099,192	1,140,208	1,168,608	1,197,906
Aug. Ratio	-	101.1%	103.9%	103.7%	102.5%	102.5%
				Average of Aug. Rate		102.7%

* : excluding number of "Addition Stories"
Source: Revenue Data 2001 - 2007, KW&SB



* Source: Revenue Data 2001 - 2007, KW&SB

Figure 33.1.10 Number of Service Connection

6) Water Quality

According to the result of water quality analysis carried out by this study, residual chlorine was found in the outlet of clear water reservoirs at the Water Treatment Plants. On the other hand, there were no residual chlorine in the distribution pipes. Detailed results of water quality analysis are referred to **Section 4.1 "Water Quality Analysis"**.

7) Operation and Maintenance

In order to cope with the problems of the KW&SB, the KW&SB implemented reformation of organisation and arranged operation and maintenance administration function in each town and started the system preparation responding directly to customers. 18 towns are divided into five administration water supply zones as mentioned previously, and these five zones are controlled by each Chief Engineer (CE). Superintendent Engineer (SE) controls each town generally, and Deputy Director (Taxes), Assistant Executive Engineer (E&M), Executive Engineer (Water Supply) and Executive Engineer (Sewerage) function under SE. More detailed organisation of the KW&SB is specified in **Section 3.5.1 "Organisation"**. Routine and non-routine works and operations in each town are listed in **Table 33.1.12**, which is obtained form the questionnaire surveys to Superintendent Engineers (SEs) of all 18 towns who are responsible to the distribution network. Each town SE is authorized to spend Rs.45,000/- to cope with any emergency maintenance within the limits of budget. However the KW&SB staff does not have enough equipment and tools for the emergency requirements. There is a shortage of skilled staff and the workmanship on both the KW&SB and contractors is very poor. Among the KW&SB's facilities, Old Pumping House near NEK New F/P is well maintained and operated.

Table 33.1.12 Routine and Non-Routine Works and Operations (1/2)

Frequency	Routine Work / Operation
Daily:	1) Valve operation. 2) Pumping operation. 3) Repairing of leakage. 4) Removal of contamination. 5) Response to of water shortage complaints. 6) Coordination with area representatives of Karachi Electric Supply Cooperation Limited (KESC). 7) Daily progress reports. 8) Monitoring of development works. 9) Survey of the effected areas. 10) Distribution and collection of routine Dak. 11) Monitoring of Bulk Water Supply.
Weekly:	1) Weekly progress meeting with KW&SB officials. 2) Preparation of schemes / estimates / Planning Commission-1 (PC-1). 3) Meeting with area supervisors for improvement of Water Supply.
Fortnightly:	1) Fortnightly review meetings. 2) Fortnightly progress reports.
Monthly:	Check the following works: 1) Preparation of Salary Bill. 2) Preparation of Overtime Bill. 3) Submission of Quotation Bill. 4) Submission of Quotation for approval. 5) Attendance Report. 6) Meeting with Divisional Accountant (DA) & Finance members for monitoring of proper expenditure.
Quarterly:	1) Check the efficiency of pumping motors. 2) Check the condition of Sluice Valve. 3) Discuss the efficiency of area fitters with site Supervisors and reporting of Fitters on the basis of progress report.
Semi Annually:	1) Cleaning of reservoir. 2) Overhauling of Pumping Machinery. 3) Overhauling of defective Sluice Valve. 4) Rescheduling of water supply schedule as per requirement. 5) Survey of Extended Areas. 6) Replacement of old and leaked water lines. 7) Identifying the possible contaminated points. 8) Cleaning of water supply lines.
Annually:	1) Budget preparation. 2) Submission of Annual Confidential Report (ACR) 3) Closing of last budget expenditure. 4) White Wash of offices / Pump houses. 5) Maintaining of office record.
Other:	

Source: Result of Questionnaire Survey to SE of 18 Towns

Table 33.1.12 Routine and Non-Routine Works and Operations (2/2)

	Non-Routine Work / Operation
1)	Manage water supply of the area after any electric breakdown / out of order of Sluice Valve / disturbing of Sluice Valve / leakage of line / heavy contamination / broken line or heavy leakage.
2)	Maintaining of Government Vehicles.
3)	Damaging of water supply line by excavator.
4)	Survey / coordination with foreign delegation.
5)	Special assignments.
6)	Rescheduling of Bulk Water Supply and proposal.
7)	Additional Charge.
8)	Member of Enquiry committee and its report.
9)	Development works.
10)	Election of labor union.
11)	Special arrangements on public holidays.
12)	Special arrangements on important events.
13)	Submission of working papers.

Source: Result of Questionnaire Survey to SE of 18 Towns

8) Major Problems on Water Supply Service

KW&SB have quite many problems of operation, maintenance and management for water distribution as listed in **Table 33.1.13**.

Table 33.1.13 Major Problems Identified for the Existing System within Each Town

	Major Problems
1)	Shortage of technical skilled staff.
2)	Low Potential of Contractors working with KW&SB.
3)	General Disparity among officers and workers.
4)	Encroachments at various places on waterlines which put severe difficulty in reparing of hidden water leakages and cause water contamination besides wastage of potable water.
5)	Adjustment of valve operation by area residents.
6)	Interruption of valve operation by representatives.
7)	Illegal water connections / poor response from law enforcement agencies for disconnection.
8)	Illegal water connection of Katchi Abadies.
9)	Contamination problems, specially in old city areas, where sewerage & water supply systems are very close each other due to narrowness of streets / less working space.
10)	Insufficient financial capabilities to cope with minor / major works of important natures.
11)	Frequent power breakdowns at pumping stations thereby resulting in suspension of scheduled water supply to the dependent areas.
12)	Extraordinary work load on staff without additional financial support or reward.
13)	Shortage of field staff particularly Fitters, Valve operators, Welders and Line workers.
14)	Limited budgetary diversion.
15)	Long approval procedure.
16)	Political influence.
17)	Short bulk water supply.
18)	Influence of Labor Union.
19)	Old / chocked and contaminated water supply network.
20)	Old pumping machinery with low efficiency.
21)	Rapidly growth in population.
22)	Valve operation due to public / UC's involvement.
23)	Difference between demand and supply.
24)	Restricted water supply network.
25)	Non availability of water supply network in Katchi Abadies and Private.
26)	Low quality of installed pipe materials
27)	Shortage of vehicles for valve operation as well as maintenance work.
28)	Acute shortage of Oil grease & equipment for lubricating machineries.
29)	No security arrangement for safe guard of installed machineries.
30)	Inadequate budged provisions and power delegations to SE (Town).
31)	Non availability of materials, tools and plants for repair work.
32)	No facility of departmental mobile phone.

Source: Result of Questionnaire Survey to SE of 18 Towns

The problems listed as above were obtained form the questionnaire surveys to Superintendent Engineers (SEs) of all 18 towns who are responsible to the distribution network. These problems are almost common to each town and become an obstacle to do appropriate operation, maintenance and management. Conditions of existing service pipes are shown in **Photo 33.1.3** and **Photo 33.1.4**. **Photo 33.1.5** shows a community pumping station which is installed for sucking water from the distribution main forcibly. **Photo 33.1.6** shows illegal connections for Katchi Abadies (Squatter Settlement) across the channel.

Photo 33.1.3 3/4" GIP Service Connection

Photo 33.1.4 4" PVC Plugging by Rubber Tube

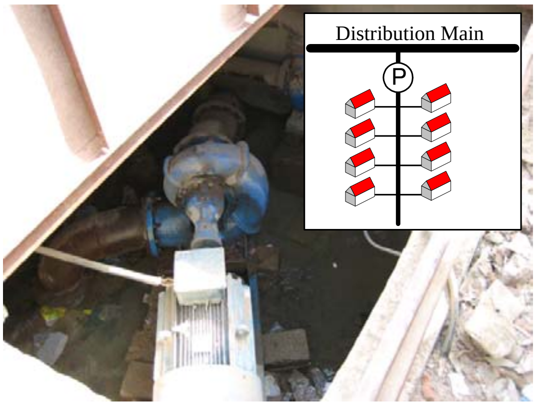


Photo 33.1.5
Suction Pump to suck Water forcibly

Photo 33.1.6
Piping for Illegal Connections across the Canal

(4) Design Criteria

There is no written design standard prescribed by the KW&SB. KW&SB examine design values suggested for project or designs submitted by consultants on each project and allows to use these values or formulas if there is no problem.

KW&SB assume that the per capita demand per day is 54 gallons including non-domestic use and leaks. According to Master Plan for Water Supply prepared in 1985, the major criteria used for planning and designing of the water supply system are as follows;

- Peak factor of day maximum demand : 1.174
- Hourly peak factor : 1.50
- Minimum service water pressure: 0.98 N/cm^2
- Required capacity of service reservoir : 4 to 8 hours of day average demand
- The formula to calculate the water supply network : Colebrook & White formula
- Coefficients for the above formula: e=3.0mm for old age cast iron pipe,
  e=0.3mm for new concrete pipe.

3.3.2 SEWERAGE SYSTEM

(1) Collection System

There are three sewer districts in Karachi City, namely TP-1, TP-2 and TP-3 districts. New Karachi and Orangi Towns both at the right bank side of Lyari River will be included in sewer district of TP-3 after construction of new sub main sewers to Lyari Interceptor. Korangi and Landhi Towns at the left bank side of Malir River have been isolated from sewer district of TP-2 after pressure main from these towns to TP-2 was destroyed by the flood in 1974. KW&SB has proposed new sewage treatment plant for these towns at the left bank side of Malir River. **Table 33.2.1** outlines sewer districts in Karachi City.

Table 33.2.1 Sewer Districts

Sewer District	Related Towns
TP-1 District	SITE, North Nazimabad, North Karachi, Gullberg, Liaquatabad
TP-2 District	Saddar, Jamshed, Faisal
TP-3 District	SITE, Baldia, Lyari, Saddar, Jamshed, Iqbal,
(Korangi District)	Landhi, Korangi
(Orangi District)	SITE, Orangi
(North Karachi District)	North Karachi

Sewer District	Area (ha)	Treatment	Remarks
TP-1 District	5,400	Partly	
TP-2 District	11,800	Partly	
TP-3 District	5,600	Partly	
Total	22,800		
(Korangi District)	8,900	No	Will be connected to proposed new TP by KW&SB
(Orangi District)	2,900	No	Will be connected to TP-3
(North Karachi District)	2,700	No	Will be connected to TP-3

Note: Area is measured on map

Figure 33.2.1 shows geographical relation among these three sewer districts and the locations of three sewage treatment plants.

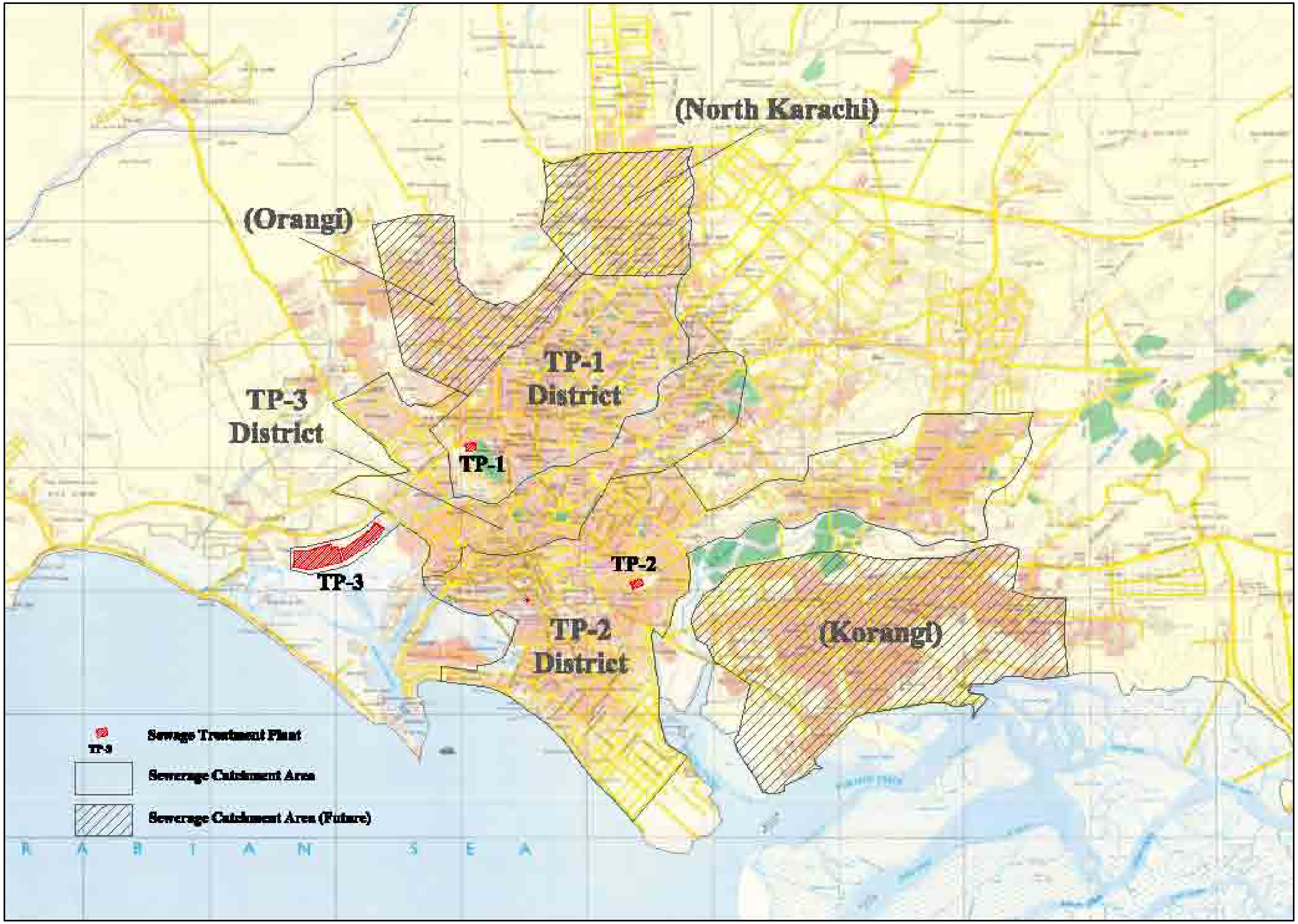


Figure 33.2.1 Sewer Districts of Karachi City

a. Trunk Sewers

Table 33.2.2 outlines major trunk sewers connected to existing sewage treatment plants. Also, **Figure 33.2.2** shows major trunk sewers whose diametres exceed 30 inch.

Table 33.2.2 Major Trunk Sewers Connected to Sewage Treatment Plant

Treatment Plant	Major Trunk Sewer to TP	Size at End / Length
TP-1	Federal Area Trunk Sewer	66 inch / -
	Upper Lyari Trunk Sewer	54 inch / -
	Lower Lyari Trunk Sewer	21 inch / -
TP-2	Malir Trunk Sewer	60 inch / -
	(Pressure Main from Clifton PS)	48 inch / 5.5 km
TP-3	Lyari Interceptor	Box 2 × 2.5 m × 2.0 m / 11.3 km

Lyari Interceptor is newly constructed sewer to intercept sewage generated at the right bank side of Lyari River except sewer district of TP-1. This interceptor will receive sewage from Orangi Town and New Karachi Town in future, and sewage intercepted by the interceptor is conveyed to TP-3. **Table 33.2.3** and **Figure 33.2.3** outline Lyari Interceptor. Flow capacity shown in average flow at the end of the interceptor is about 93 mgd, which is almost two times the treatment capacity of TP-3 of 54 mgd.

Table 33.2.3 Outline of Lyari Interceptor

Sr. No.	Stretch From/To	Size	Length (m)	Slope	Flow Capacity	
					Peak (m^3/sec)	Average (m^3/day)
1	KDA RC Bridge Overhead Bridge	Box 1.5 m × 1.5 m	2,700	1/440	3.96	171,000
2	Overhead Bridge Goli Mar Bridge	1.8 m in dia.	2,650	1/1000	3.15	136,000
3	Goli Mar Bridge A Bridge connecting Sher Shah District and Mara Naka District	Box 2.0 m × 2.0 m	2,900	1/1176	5.21	225,000
4	A Bridge connecting Sher Shah District and Mara Naka District From a railway Bridge	Box 2 × 2.0 m × 2.0 m	2,150	1/2500	7.15	309,000
5	From a railway Bridge TP-III	Box 2 × 2.5 m × 2.0 m	950	1/2500	9.80	423,000 (93 mgd)
Total			11,350			

Source: Design drawings (not as-built drawing)

Note: Capacity in m^3/sec shows peak capacity; Capacity in m^3/day shows average capacity, using Manning's formula with roughness coefficient of 0.015, peak factor assumed to be 2.0

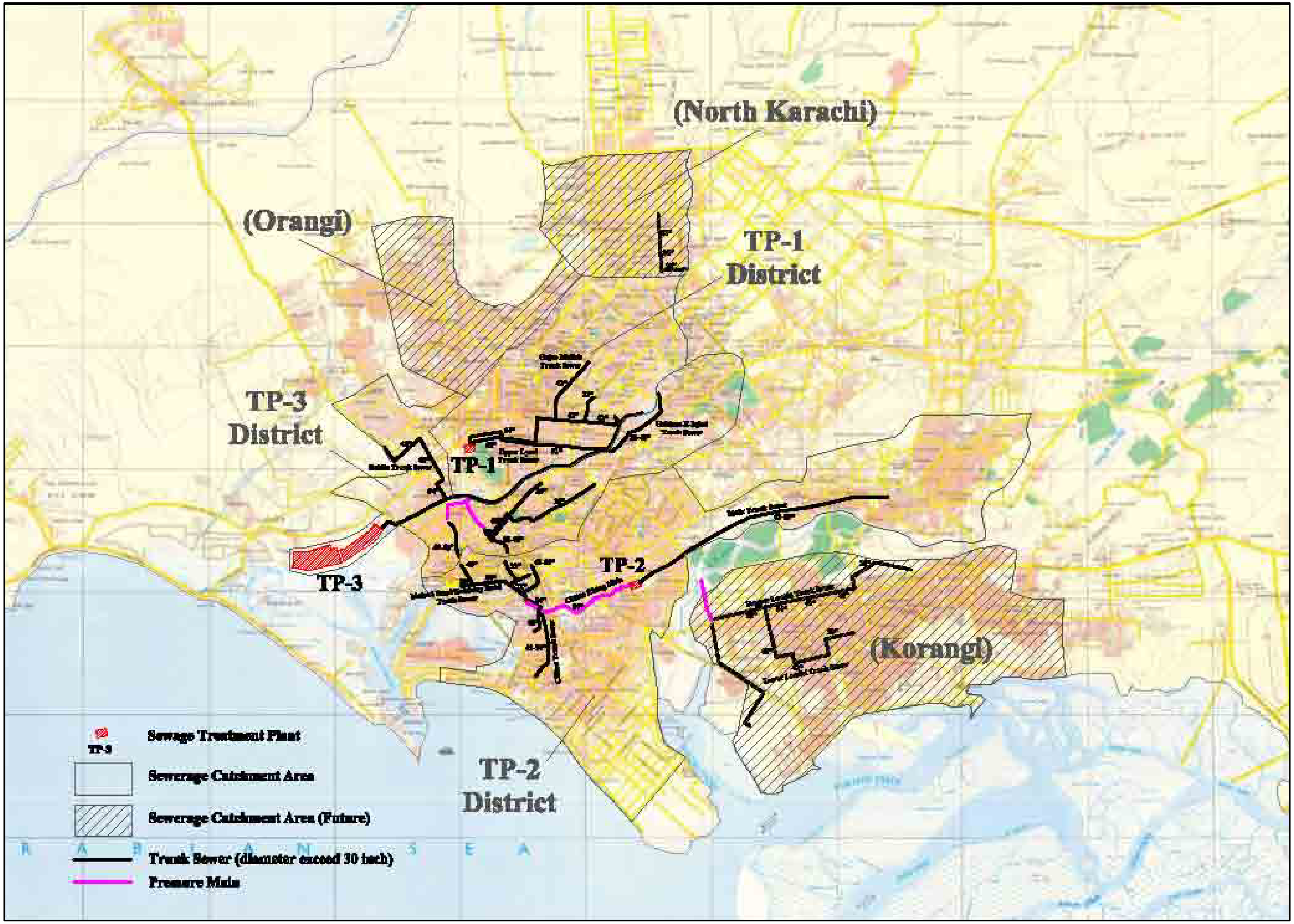


Figure 33.2.2 Major Trunk Sewers whose Diametre Exceed 30 inch.

Figure 33.2.3 Plan of Lyari Interceptor

b. Branch Sewers

Table 33.2.4 outlines branch sewers under each township administration. Sewers in some areas such as Katchi Abadis and Cantonments are not included in the table except those under township; therefore total sewer length shown in the table does not correspond to actual total length.

Table 33.2.4 Town-wise Diametre-wise Sewer Length

(km)

Diametre (inch)	8-15	16-24	27-84	Total
Diametre (mm)	200-380	410-610	690-2130	
(1) Keamari Town	32.2	2.5	0.0	34.7
(2) SITE Town	96.0	10.6	8.8	115.4
(3) Baldia Town	25.4	11.6	4.3	41.3
(4) Orangi Town	35.7	1.2	0.0	36.9
(5) Lyari Town	53.9	12.4	2.4	68.7
(6) Saddar Town	18.0	23.0	31.3	72.3
(7) Jamshed Town	435.3	11.1	13.3	459.7
(8) Iqbal Town	148.2	9.4	6.4	164.0
(9) Sha faisal Town	54.0	6.9	7.9	68.8
(10) Landhi Town	91.1	8.3	11.3	110.7
(11) Korangi Town	258.6	6.3	11.3	276.2
(12) North Nazimabad Town	370.1	17.3	9.5	396.9
(13) North Karachi Town	285.5	11.6	5.0	302.1
(14) Gulberg Town	442.0	36.6	8.5	487.1
(15) Liaquatabad Town	187.8	18.8	49.2	255.8
(16) Malir Town	121.6	24.3	0.2	145.1
(17) Bin Qasim Town	17.8	2.3	0.0	20.1
(18) Gadap Town	203.6	17.2	12.7	233.5
Total	2876.8	231.4	182.1	3,290.3

Source: KW&SB, Townships

c. Outline of TKP

As shown in **Tables 33.2.5** and **33.2.6**, new sewers construction, sewers rehabilitation including replacement, desilting and rerouting works have been done or planned under Tameer-e-Karachi Programme (TKP) initiated by the Government of Pakistan. TKP, subsidised mainly by the Government of Pakistan, Government of Sindh and CDGK, began in July 2004 and is expected to continue until June 2008.

So far, construction of 413,000 feet (126 km) of new sewers, rehabilitation/replacement of 512,000 feet (156 km) of sewers, desilting of 302,000 feet (92 km) of sewers and rerouting /bypassing of more than 177,000 feet (54 km) of sewers either were completed or are in progress. The total cost amounted to be Rs.896 million. In addition, new sewers of 95,000 feet (29 km) are planned to install with the expected budget of Rs.358 million. The total length of new sewers to be constructed under TKP will be 508,000 feet (155 km).

Table 33.2.5 TKP Works either Completed or in Progress

Town		New Line (ft)	Replacement Rehabilitation (ft)	Disilting (ft)	ReRounting or By Pass (ft)	Sanction Amount (in million Rs.)
1	Kemari			11,650		9
2	SITE		21,702	20,905	7,810	23
3	Baldia	3,500	26,300			30
4	Orangi					
5	Lyari	12,300	4,050	120,317		27
6	Saddar	10,300	35,681		3,785	67
7	Jamshed		28,800		35,500	54
8	G. Iqbal	8,740	69,990			70
9	Shah Faisal		22,540		8,700	38
10	Landhi	7,050	100,665		106,165	117
11	Korangi	13,886	52,230	8,861	6,670	50
12	North Nazimabad	41,600	550	100,350		93
13	New Karachi	76,000	49,700	36,550		111
14	Gulberg	31,326	32,081	2,700		61
15	Liaqatabad		41,590	700		45
16	Malir	208,460	13,968		8,850	83
17	Bin Qasim(manholes)					9
18	Gadap		12,250			8
Total (ft)		413,162	512,097	302,033	177,480	896
Total (m)		125,900	156,100	92,100	54,100	

Table 33.2.6 TKP Works under Awards

Town		New line (ft)	New line (meter)	Replacement Rehabilitation (ft)	Disilting (ft)	Re Rounting (ft)	Sanction Amount (in million Rs.)	Estimated Amount (PC-I) (in million Rs.)
5	Lyari			34,470			15	
				2,300	10,183			4
6	Saddar					9,470	13	
				11,650		3,785		36
7	Jamshed			5,600			3	
				39,200			14	
8	G. Iqbal	58,300	17,770				29	
9	Shah Faisal			Improvement no information on length			11	
		13,200	4,023	25,840		18,788		36
10	Landhi			Industrial Area no information on length			30	
11	Korangi			Industrial Area no information on length			47	
				1,670	Rcc no numerical data available	Slab and Rings no numerical data available		5
14	Gulberg			61,085				103
15	Liaqatabad	23,400	7,132				12	
total		94,900	28,926				174	184

(2) Pumping Stations

a. Large Scale Pumping Stations

Clifton Pumping Station

Table 33.2.7 outlines Clifton Pumping Station. This pumping station is located in Saddar Town. The function of the pumping station is pumping sewage generated in some parts of Saddar Town to sewage treatment plant TP-2 in Jamshed Town. Because existing 48 inch (1200 mm) dia. pressure main to TP-2 is old and fragile, it is difficult to pump the whole sewage the pumping station received and increasing sewage in future. The pumping station has bypass pressure main to a nearby nallah for emergency purpose. It is supposed that fairly large amount of sewage is discharged to the nallah at present. KW&SB has proposed a new pressure main to TP-2 to relieve existing one and to reduce bypassed amount.

Table 33.2.7 Outline of Clifton Pumping Station

	Description
Commission	1975
Renovation	1995
Capacity	18 mgd (81,000 m^3/day)
Catchment Area	Part of UC1, 2, 3, 4, 5, 6, 7, 8, 9, 11 of Saddar Town
Facilities	
1. Inlet Pipe	72 inch (1800 mm) in dia.
2. Screen	Manual type bar screen
3. Pump	10,000 gpm (45.5 m^3/min) × 5 nos., Vertical type
4. Pressure Main	48 inch (1200 mm) in dia., 5.5 km length to TP-2
5. Bypass	33 inch (850 mm) in dia., 0.5 km length to Civil Line Nallah by pressure
6. Generator	Very old, out of use
7. Total Installed Capacity	328,000 m^3/day
Operation	Four of five pumps is for lifting to TP-2, working in turn, one pump works at a time
	One pump is for bypass (exclusive use)
Future Expansion Plan	New pressure main to TP-2 is proposed to relieve fragile existing pressure main and to reduce bypassed amount

Photo 33.2.1 Screen Facility of Clifton Pumping Station

Photo 33.2.2   Pumps of Clifton Pumping Station

Photo 33.2.3   Old Generator of Clifton Pumping Station

Photo 33.2.4   Civil Line Nallah, Bypass Outfall from Clifton Pumping Station

Pumping Station PS-2 in Korangi Town

Table 33.2.8 outlines Pumping Station PS-2 in Korangi Town. This pumping station is located in Korangi Town. Its function is to pump sewage generated in Korangi Town and Landhi Town to sewage treatment plant TP-2 in Jamshed Town. As 48 inch (1220 mm) dia. pressure main crossing Malir River to TP-2 was destroyed by a flood in 1974, sewage generated in these two towns is discharged to Malir River from this pumping station without any treatment. A treatment plant of Pakistan Tanners Association located at 3 km east of this pumping station will receive some sewage from this pumping station to dilute strong tannery wastewater for UASB process. Installation of pumps and pressure main for this purpose are in progress.

Table 33.2.8 Outline of Pumping Station PS-2 in Korangi Town

	Description
Commission	1960
Renovation	2006 (Install diesel generator)
Catchment Area	Korangi Town and Landhi Town
Capacity	22.6 mgd (103,000 m^3/day)
Facilities	
1. Inlet Pipe	48 inch (1200 mm) in dia.
2. Screen	Manual type bar screen
3. Pump	4,500 gpm (20.5 m^3/min) × 2 nos., Vertical 3,500 gpm (15.9 m^3/min) × 2 nos., Submergible
4. Pressure Main	48 inch (1220 mm) in dia., 2.0 km length to Malir River
5. Generator	320 kVA (installed in 2006)
6. Total Installed Capacity	105,000 m^3/day

Facilities for TP of PTA (In progress)

1. Pump for PTA (future)	1,200 gpm (5.5 m^3/min) × 5 nos., Vertical
2. Pressure Main	33 inch (840 mm) in dia., 3 km to TP of PTA

Photo 33.2.5 Screen Facility of Pumping Station PS-2 in Korangi

Photo 33.2.6 Pumps of Pumping Station PS-2 in Korangi

Photo 33.2.7 Pump of Pumping Station PS-2 in Korangi for TP of PTA

Photo 33.2.8 Outfall from Pumping Station PS-2 in Korangi to Malir River

Jamila Pumping Station

Table 33.2.9 shows outline of Jamila Pumping Station. This pumping station is located in the southeast of Lyari Town. The function of the pumping station is pumping sewage generated in some parts of Lyari, Saddar and Jamshed Towns to sewage treatment plant TP-3 at estuary of Lyari River through newly constructed Lyari Interceptor along Lyari River. The pumping station has bypass gravity line to a nearby nallah for emergency purpose. KW&SB has proposed new pump to increase capacity. Study team saw some parts of new pump facility at the pumping station site. New pump is expected to install before too long.

Table 33.2.9 Outline of Jamila Pumping Station

	Description
Commission	1947
Renovation	1996
Catchment Area	Part of UC8, 9, 11, 12, 13 of Lyari Town
Capacity	15 mgd (68,000 m^3/day)
Facilities	
1. Inlet Pipe	48 inch (1220 mm) in dia. 36 inch (900 mm) in dia. 33 inch (850 mm) in dia.
2. Screen	Manual type bar screen
3. Pump	6,000 gpm (27.3 m^3/min) × 1 no., Horizontal 4,000 gpm (18.2 m^3/min) × 1 no., Vertical 4,000 gpm (18.2 m^3/min) × 2 nos., Submergible
4. Pressure Main	2 Pressure mains 36 inch (900 mm) in dia., 2.5 km length and 33 inch (850 mm) in dia., 2.5 km length, to an outfall manhole near dhobi ghat (washing place) at Lyari River then go to Lyari Interceptor by gravity
5. Bypass	Overflow pipe from receiving well to nearby Nallah by gravity
6. Generator	520kVA diesel generator
7. Total Installed Capacity	118,000 m^3/day
Future Expansion Plan	New pump will be installed (expected in 2006) 7,000 gpm (31.8 m^3/min) × 1 no., horizontal 4,000 gpm (18.2 m^3/min) × 3 nos., vertical

Photo 33.2.9 Screen Facility of Jamila Pumping Station

Photo 33.2.10 Vertical Pumps of Jamila Pumping Station

Photo 33.2.11 Submergible Pump of Jamila Pumping Station

Photo 33.2.12 Outfall Manhole from Jamila Pumping Station, near a Dhobi Ghat

Chakiwara Pumping Station

Table 33.2.10 outlines Chakiwara Pumping Station. This pumping station is located in the north of Lyari Town. The function of the pumping station is pumping sewage generated in some parts of Lyari, Saddar to sewage treatment plant TP-3 at estuary of Lyari River through newly constructed Lyari Interceptor along Lyari River as Jamila Pumping Station.

Table 33.2.10 Outline of Chakiwara Pumping Station

	Description
Commission	1985
Renovation	-
Catchment Area	Part of UC8, 9, 11, 12, 13 of Lyari Town
Capacity	5.22 mgd (24,000 m^3/day)
Facilities	-
1. Inlet Pipe	36 inch.(900 mm) in dia
2. Screen	Manual type bar screen
3. Pump	3,400 gpm (15.5 m^3/min) × 4 nos., Vertical 2,000 gpm (9.1 m^3/min) × 1 no., Submergible 1,800 gpm (8.2 m^3/min) × 2 nos., Vertical
4. Pressure Main	27 inch (686 mm) in dia., 2.0 km length to Lyari Interceptor
5. Generator	Diesel generator
6. Total Installed Capacity	126,000 m^3/day

Photo 33.2.13 Grit Chamber of Chakiwara Pumping Station

Photo 33.2.14 Vertical Type Pumps of Chakiwara Pumping Station

Photo 33.2.15 Discharging Pipe of Chakiwara Pumping Station

<u>Pumping Station PS-2 in SITE Town</u>

Table 33.2.11 outlines Pumping Station PS-2 in SITE Town. This pumping station is located in the south of sewage treatment plant TP-1. The function of this pumping station was to pump sewage conveyed from Jamila and Chakiwara Pumping Stations at the left bank side of Lyari River to TP-1 before Lyari Interceptor was constructed. The interceptor receives sewage from these two pumping stations now. At present, this pumping station continues to exist as a facility for small pocket near the pumping station. Actual flow the pumping station receives is assumed to be less than 1 mgd depending on operation hour at present.

Table 33.2.11 Outline of Pumping Station PS-2 in SITE Town

	Description
Commission	1958
Renovation	-
Catchment Area	Part of SITE Town
Capacity	9.5 mgd (43,000 m^3/day)
Facilities	-
1. Inlet Pipe	21 inch.(530 mm) in dia
2. Screen	Manual type bar screen
3. Pump	2,200 gpm (15.5 m^3/min) × 3 nos., Vertical
4. Pressure Main	500 m to TP-1
5. Generator	None
6. Total Installed Capacity	22,000 m^3/day

Photo 33.2.16 Screen Facility of Pumping Station PS-2 in SITE Town

Photo 33.2.17 Pumps of Pumping Station PS-2 in SITE Town

b. Other Pumping Stations

Table 42.2.12 outlines other pumping Stations located in Lyari, Saddar, SITE Town, Korangi Town and Kimairi Town, which are located in lower and flat area, the west of Karachi City.

Table 33.2.12 Outline of Pumping Stations in Karachi City (1/2)

	Name of Pumping Station	Name of Drainage Area	Nominal Capacity (m3/day)	Nominal Capacity (mgd)	Capacity of Each Pump (m3/min)	Capacity of Each Pump (gpm)	Type of Pump	MotorPower /Engine Power	Number of Pump		Year of Construction
Lyari Town											
1	Chakiwara Sewage PS	UC-8, 9, Lyari Town	23,725	5.220	8.18	1,800	Vertical	90 kW	2	7	1985
					15.45	3,400	Vertical	132 kW	4		1985
					9.09	2,000	Submergible	44 kW	1		1985
2	Khadda Market Sewage PS, (Ejector 19)	UC-4, Lyari Town	12,408	2.730	5.45	1,200	Vertical	40 HP	2	3	1968
					5.45	1,200	Submergible	22 kW	1		1993-94
3	Haji Pir Mohammad Village Sewage PS, (Ejector 18)	Ali Mohd Muhalla Daryabad, Billal Road, Baghdadi Thana, UC-4, 5, Lyari Town	4,909	1.080	5.45	1,200	Submergible	22 kW	1	1	1993-94
4	Moosa Lane Sewage PS, (Ejector 6)	Mir Mohd Baloch Road, Moosa Lane	5,890	1.296	5.45	1,200	Vertical	40 HP	2	2	1968
5	Juna Masjid Sewage PS	Some areas of UC-2, 6, 7, Lyari Town	5,890	1.296	5.45	1,200	Horizontal	40 HP	2	2	1999
6	Bihar Sewage PS	Some areas of UC-1, 8 and Bihar Colony Tennery Road	10,454	2.300	5.45	1,200	Vertical	40 HP	2	3	1968, 93-94
					5.45	1,200	Submergible	22 kW	1		2003
7	Bakra Piri Sewage PS	UC-11, Nawa Lane	5,863	1.290	5.45	1,200	Submergible	22 kW	1	1	1998
8	UC-36 Chakiwara Road Sewage PS	Lyar, Degree College Area, Lee Market, Moosa Lane, Haji Pir Mohd Road, Baghdadi	21,362	4.700	9.09	2,000	Submergible	33 kW	1	6	1999
					7.27	1,600	Submergible	22 kW	1		2002-03
					8.18	1,800	Vertical	50 HP	4		1998
9	Noor Mohd Village Sewage PS	UC-11, Noor Mohd Village	1,636	0.360	3.41	750	Horizontal	33 kW	2	2	1983-84
10	Jamila Sewage PS	UC-8, 9(portion), 11, 12, 13	68,175	15.000	27.27	6,000	Horizontal	33 kW	1	4	1995-1996
					18.18	4,000	Vertical	-	1		2000-01, 2006
					18.18	4,000	Submergible		1		2001
					18.18	4,000	Submergible	-	1		2005
Saddar Town											
1	Ranchor Line Sewage PS (Ejector-12)	UC-5, 6, Saddar Town	9,163	2.016	5.45	1,200	Vertical	80 HP	3	5	1985
					4.55	1,000	Vertical	40 HP	1		1985
					5.45	1,200	Submergible	22 kW	1		1999
2	Sewage PS (Ejector-14)	Allah Rakha Park, Punjab, Custom House, Saddar Town	8,726	1.920	4.55	1,000	Horizontal	30 HP	2	3	1984
					5.45	1,200	Submergible	22 kW	1		1993-94
3	Pitcher Road Sewage PS	Memon Masjid, Bombay Bazarr, Kagzu Bazar, Quaid-e-Azam, Birth Place UC-3, Saddar Town	8,726	1.920	4.55	1,000	Horizontal	30 HP	2	3	1975
					5.45	1,200	Submergible	22 kW	1		1993-94
4	Clifton Sewage PS	Civil Line, Green Road, Bath Island, Free Road, Clifton Block 3, 4, 5, 7, Civil Hospital,	81,810	18.000	40.91	9,000	Vertical	30 HP	5	5	1984
											1993-94
5	Shereen Jinnah Sewage PS	Shereen Jinnah Colony, Clifton Block 1, 2, UC-2, Saddar Town, and UC-1, Kemari Town	13,635	3.000	8.18	1,800	Vertical	30 HP	4	4	1975
											1993-94

Table 33.2.12 Outline of Pumping Stations in Karachi City (2/2)

	Name of Pumping Station	Name of Drainage Area	Nominal Capacity (m^3/day)	Nominal Capacity (mgd)	Capacity of Each Pump (m^3/min)	Capacity of Each Pump (gpm)	Type of Pump	MotorPower /Engine Power	Number of Pump		Year of Construction
Kimairi Town											
1	Grax Village I Sewage PS	Partly Grax Village Area, Kimairi Town	2,273	0.500	2.27	500	Horizontal	10 HP	2	2	1992-93
2	Grax Village II Sewage PS	Partly Grax Village Area, Kimairi Town	2,273	0.500	2.27	500	Horizontal	10 HP	2	2	1992-93
3	Takri Village Sewage PS	Takri Village Area, Kimairi Town	2,273	0.500	2.27	500	Horizontal	10 HP	2	2	1992-93
4	Manripur Sewage PS	Masroor Colony, Marigi Pws Village	2,273	0.500	2.27	500	Horizontal	10 HP	2	2	1992-93
SITE Town											
1	Pumping station PS2 (Inlet of TP-1)	Bismillah Colony, Jahanabad, Mewashah Graveyyard and its surroundings	43,178	9.500	10.00	2,200	Vertical	-	3	3	1960
Korangi Town											
1	Pumping station PS2 (Inlet of TP-2)	Korangi Town and Landhi Town	102,717	22.600	20.45	4,500	Vertical	-	2	4	1960
					15.45	3,400	Submergible		2		1960/2001

(3) Sewage Treatment Plants

Table 33.2.13 summarizes three existing sewage treatment plants (TPs).

Table 33.2.13 Summary of Three TPs

	TP-1 (SITE)	TP-2 (Mahmoodabad)	TP-3 (Mauripur)
Drainage Area	F.B. Area, Liaquadabad, Nazimabad & North Nazimabad, Part of Orangi Town, Pak Colony etc.	Old city areas, Clifton Societies, Mahmoodabad, part of Azam Basti, Dada Bhai, Sadder, Malir	Old Lyari, Garden East and West, Gulshan-e-Iqbal, PIB colony, Soldier Bazar, Baldia, Nazimabad, North Karachi
Site Area	120 acres (48.6 ha)	120 acres (48.6 ha)	545 acres (221 ha)
Year of Construction	1960/1995 (rehabilitated)	1960/1996 (rehabilitated)	1998
Incoming Trunk Sewers	Upper Lyari Main: 66" (2010mm) Upper Lyari 1: 54" (1650 mm)	Malir Trunk Sewer: 56" (1710 mm)	Lyari Interceptor (2 × 2500mm × 2000mm)
Treatment Process	Trickling filter process	Trickling filter process	Anaerobic + Facultative pond
Major Facilities	Influent pumps – 7 units PST – 6 units TF – 8 units FST – 2 units Anaerobic digesters – 4 Sludge drying beds – 196 units	Influent pumps – 7 units PST – 6 units TF – 8 units FST – 2 units Anaerobic digesters – 4 Sludge drying beds – 196 units	Influent pumps – 3 units AP – 6units FP – 6 units Sludge drying beds
Planned Served Population	1,600,000	1,600,000	2,000,000
Present Served Population	NA	NA	NA
Capacity	51 mgd (232,000 m^3/day)	46 mgd (209,000 m^3/day)	54 mgd (245,000 m^3/day)
Present Flow Rate	25 mgd (114,000 m^3/day)	24 mgd (110,000 m^3/day)	30 – 35 mgd (136,000 – 159,000 m^3/day)
Design Influent Qualities	BOD 385 mg/l SS 555 mg/l	BOD 365 mg/l SS 530 mg/l	BOD 385 mg/l SS 450 – 500 mg/l
Present Influent Qualities	BOD 317 mg/l SS 319 mg/l	BOD 300 mg/l	BOD 370 mg/l SS 388 mg/l
Design Effluent Qualities	BOD 80 mg/l SS 200 mg/l	BOD 80 mg/l SS 200 mg/l	BOD 80 mg/l SS 200 mg/l
Present Effluent Qualities	BOD 80.8 mg/l SS 76.4 mg/l	BOD 100 mg/l	BOD 75 mg/l SS 69 mg/l

Source: KW&SB
NA: information not available

As shown in the table, the actual flow to these three TPs is 79 to 84 mgd (360,000 to 380,000 m^3/day) which is around half their total capacity of 151 mgd (686,000 m^3/day). **Photos 33.2.18** through **33.2.25** show present conditions of these three sewage treatment plants and **Figures 33.2.4** through **6** show general plans of TPs-1, 2 and 3, respectively.

The whole plant has not been operated for two months because the inlet sewers are clogged with deposits and garbage.

Photo 33.2.18 Primary Settling Tank (TP-2, in August 2006)

Primary effluent is sprayed on the filter media.

Photo 33.2.19 Trickling Filter (TP-1, in May 2006)

Though primary settling tanks and trickling filters are operated, final settling tanks are not operated due to the clogging of sludge withdrawal pipes

Photo 33.2.20 Final Settling Tank (TP-1, in May 2006)

Pipes to convey sludges from PST/FST and boxes to distribute sludges to drying beds were broken

Photo 33.2.21 Sludge Distribution Box (TP-2, August 2006)

A few sludge drying beds is working.
Sludge pipes and distribution boxes to drying beds are working. (TP-1)

Photo 33.2.22 Sludge Distribution Pipe and Box (TP-1, September 2006)

A truck conveying dry sludge from drying sludge lagoon can be seen.

Photo 33.2.23 Sludge Drying Lagoon (TP-1, September 2006)

This pipe is the inlet to anaerobic pond. The first desludsing of the anaerobic pond after 8 year operation was going to be done in early September 2006.

Photo 33.2.24 Inlet to Anaerobic Pond (TP-3, in September 2006)

Treated in facultative pond following anaerobic pond, the effluent is discharged to Arabian Sea.

Photo 33.2.25 Effluent (TP-3 in September 2006)

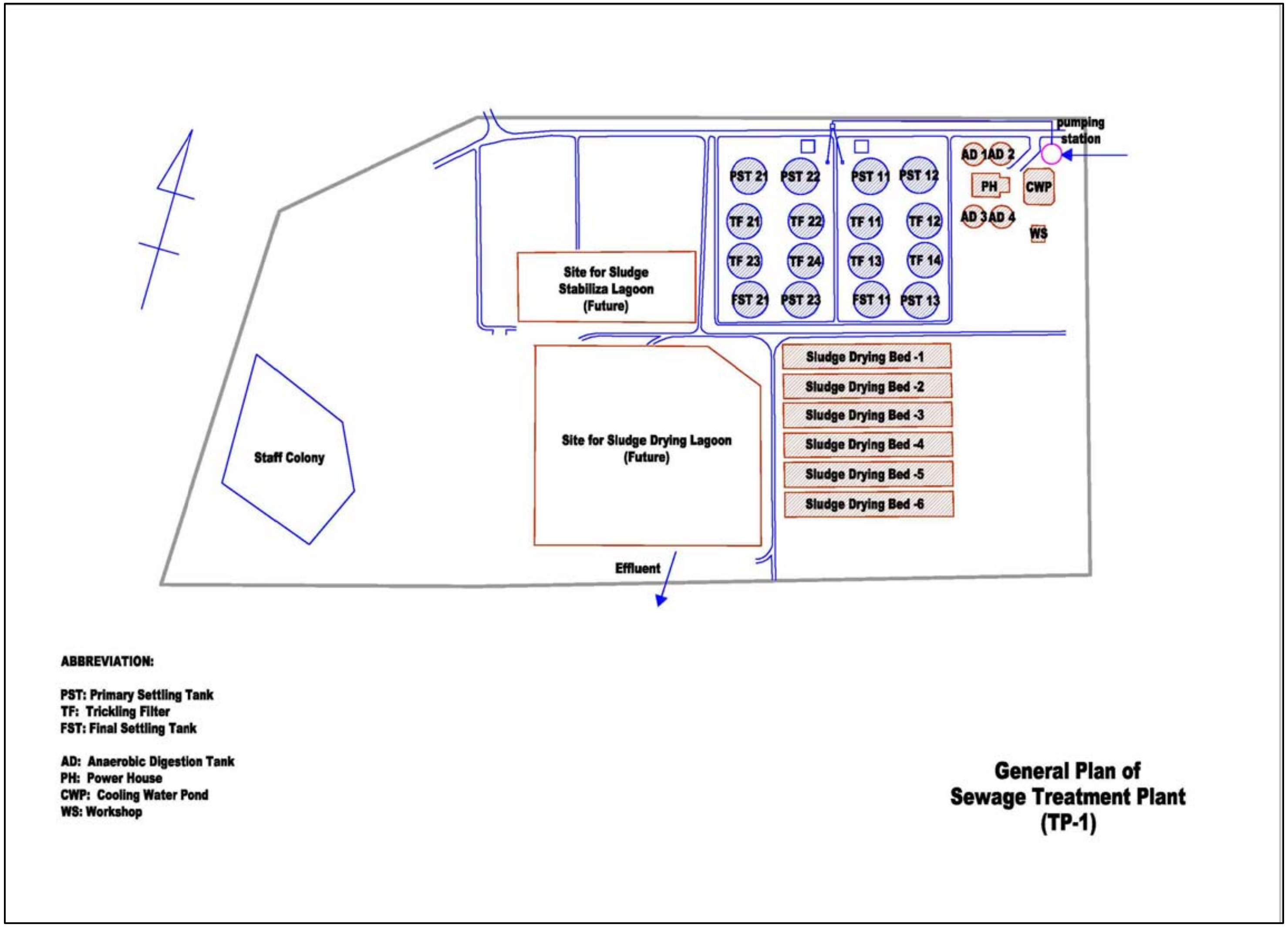


Figure 33.2.4 General Plan of Sewage Treatment Plant TP-1

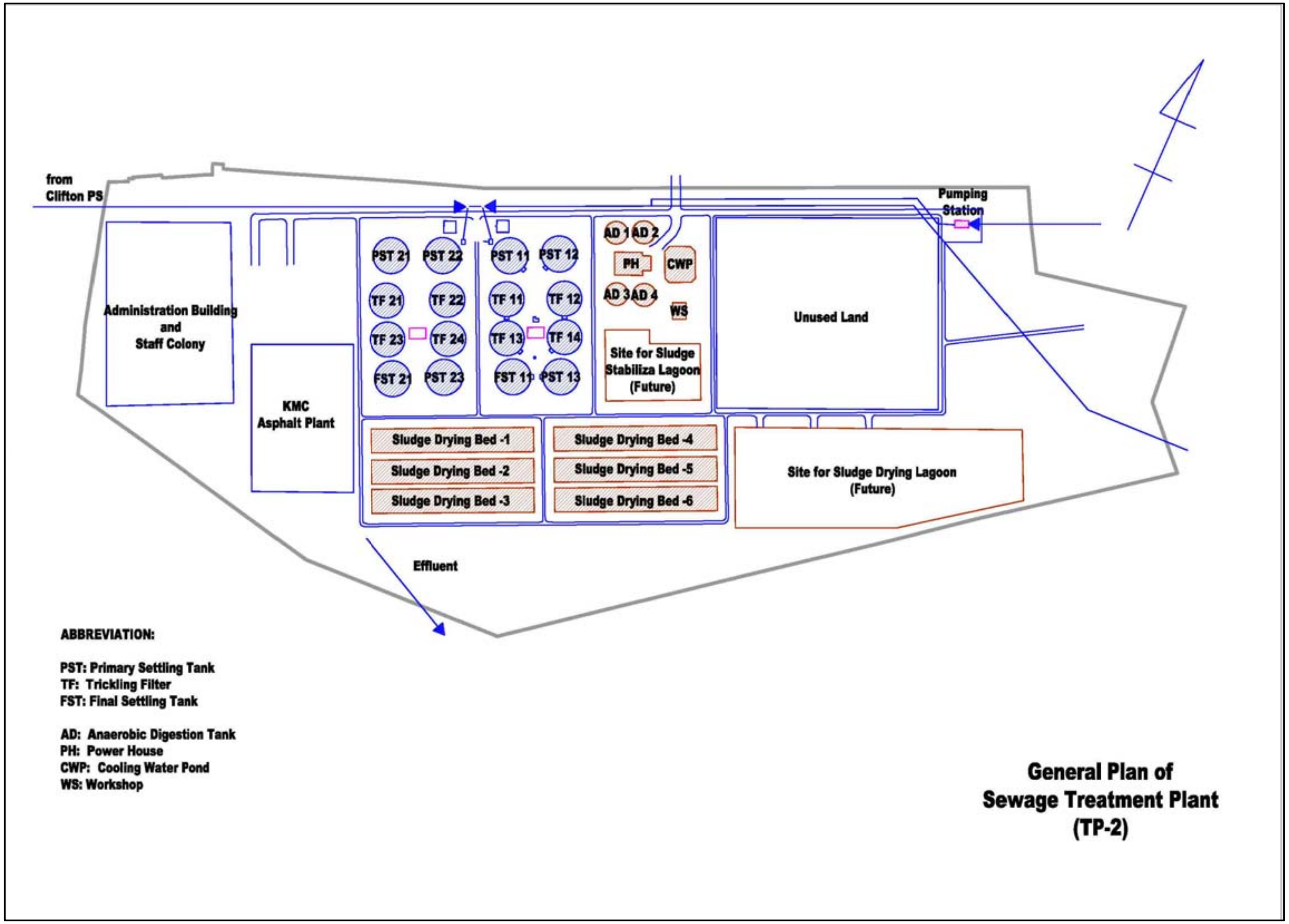
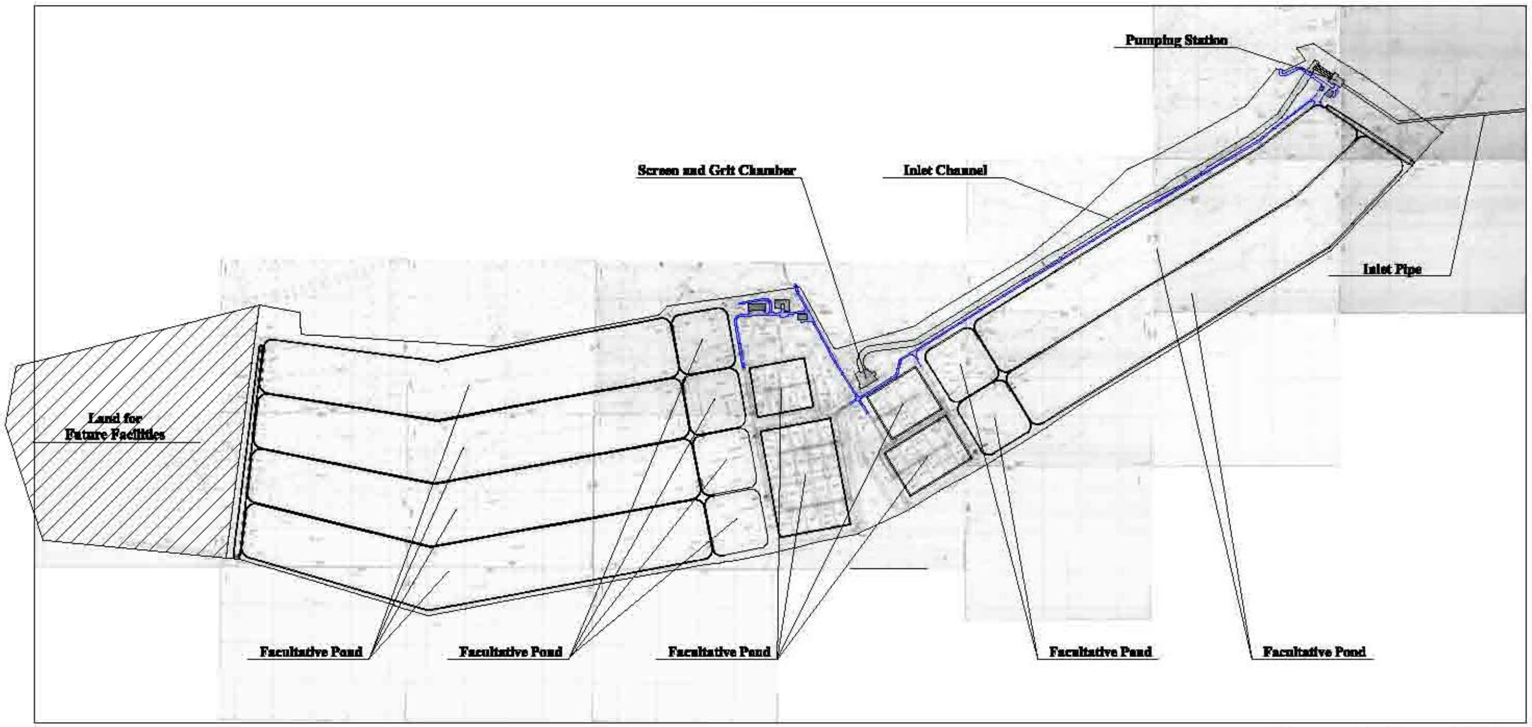


Figure 33.2.5 General Plan of Sewage Treatment Plant TP-2



General Plan of TP-3

Figure 33.2.6 General Plan of Sewage Treatment Plant TP-3

North Karachi TP

In addition to these three TPs, there is an abandoned TP called North Karachi TP. The process applied is oxidation ditch process and the dimensions estimated based on the site visit and the satellite image are as follows.

> Oxidation Ditch: 8 channels (2 channels comprise 1 circuit)*5.5(W)*2.5(H)*215(L)
> Final Settling Tank: 2 tanks*9(W)*3(H)*20(L)
> Sludge Drying Bed:

The construction of the plant began in 1989 and completed in 1993. The construction was done by Karachi Development Authority. However, no information was available about how long it was operated and why it was abandoned. Some dried sludge was seen at the bottom of final settling tank.

Aerators are installed at both ends of channels.

Photo 33.2.26 Oxidation Ditch (North Karachi TP, abandoned)

Some amount of dry sludge is seen at its bottom.

Photo 33.2.27 Final Settling Tank (North Karachi TP, abandoned)

The TP in Pakistan Tanners Association (PTA)

170 to 180 tanners are situated in Korangi area. (Korangi Tanners Cluster). The sewerage system was planned and constructed comprising sewers to collect both tanneries and domestic wastewaters and a treatment plant in Korangi area. Construction cost consists of;

Export Development Fund (subsidy from Ministry of Commerce)	334
PTA	96
Government of Netherlands	40
Government of Sindh/CDGK	22
Total (Rs. million)	492

Capacity of a treatment plant called CETP (Common Effluent Treatment Plant)

10 mgd (45,450 m^3/day) comprising 4 mgd (18,180 m^3/day) of tannery wastewater and 6 mgd (27,270 m^3/day) of domestic sewage. The agreement was made upon in July 2005 between KW&SB and PTA Environmental Society to treat certain amount of domestic sewage at the CETP.

Treatment Process

Equalization, Primary sedimentation, Mixing with domestic sewage, UASB,
Aeration with surface and submergible aerators, Secondary sedimentation

The CETP is designed to meet the NEQS; BOD of less than 80 mg/l and SS of less than 200 mg/l. The Society thinks that it might be necessary in the future to introduce the advanced treatment to use the effluent.

Conveyance of domestic sewage

Korangi Pumping Station of 3 km away from the CETP conveys 6 mgd of domestic sewage which is mixed with tannery wastewater after primary sedimentation.

As for tariff, each of 170 to 180 factories is to pay its tariff to be set based on the quantity and quality of its wastewater. Every facility and equipment related to the PTA-CETP including additional pumps and pipes to convey domestic sewage to the PTA-CETP from Korangi Pumping Station is borne by PTA Environmental Society.

The CETP was already constructed and was expected to begin its operation in a couple of months when pumps and pipes are installed. However, the plant is yet to be operated as of November 2007.

There is another TP within Pakistan Steel Mill premises that mainly treats the domestic sewage generated in the company housing complex. Refer to “3.2.2 (4) Reuse of Treated Effluent” for its details.

Photo 33.2.28 Inlet Pipes and Distribution Box of UASB (TP of PTA)

Photo 33.2.29 Both Surface and Submergible Aerator of Aeration Tank (TP of PTA)

(4) Design Criteria

There are no established design guidelines for sewerage planning in Pakistan. Instead, every consulting firm has its guidelines for several design parametres and uses them in preparing sewerage planning.

<u>Water supply per capita per day</u>
227 to 318 lpcd (50 to 70 gpcd) or 454 lpcd (100 gpcd) if the plot is more than 836 m^2 (1,000 square yard)

<u>Ratio of sewage generation to water consumption</u>
60 to 80 % of water consumption is supposed to be sewage generation or 100% of water consumption if the groundwater level is high.

<u>Peak flow factor</u>
3 times the average flow is maximum hourly flow

<u>Flow velocity formula</u>
Manning formula is used for the calculation of sewers.

Range of flow velocity
Velocity should be in the range between 0.7 and 3.7 m/sec (2.3 and 12 feet/sec) to avoid silting and corroded inner surface of sewers.

Manhole interval
It should be at every 91 to 152 m (300 to 500 feet) and at the changes of sewer direction and pipe diametre.

3.3.3 Stromwater Drainage System

Table 33.3.1 outlines stormwater drainages and nallahs under each township administration. Drainages are artificial water channels for stormwater drainage; on the contrary, nallahs are natural water channels. Many drainages are connected to nallahs and some drainages connected to river directly; Nallahs discharge into rivers such as Lyari River and Malir River receiving stormwater. As sewage collection system in Karachi City is not enough and its maintenance is not satisfactory, stormwater drainage and nallahs have to receive sewage all year long in addition to stormwater in rainy season.

Table 33.3.1 Town-wise Stormwater Drainage/Nallah Length

Town	Depth (m)	Width (m)	Length (km)
1. Keamari Town	1.21	0.91~3.04	7.62
2. SITE Town	2.13	3.65	16.08
3. Baldia Town	1.22	2.43	11.77
4. Orangi Town	1.52	2.43~3.65	34.1
5. Lyari Town	1.37	0.6~13.7	19.4
6. Saddar Town	1.37	3.05	11.14
7. Jamshed Town	1.5	2.43	33.8
8. Iqbal Town	3.64	2.4~15.2	28.0
9. Faisal Town	1.22~4.57	1.52~24.0	20.1
10. Landhi Town	1.22	2.43	35.36
11. Korangi Town	1.52	2.74	36.4
12. North Nazimadad Town	1.22	2.4	30.7
13. North Karachi Town	1.22	2.4	45.1
14. Gulberg Town	1.37	2.4	22.1
15. Liaquatabad Town	1.52	3.65	19.5
16. Malir Town	1.22	3.04	6.15
17. Bin Qasim Town	1.22	3.64	14.63
18. Gadap Town	1.22	3.65	24.43
Total			416.38

Source: KW&SB

There are no exclusive pumping facilities for stormwater drainage in Karachi City. However, many pumping stations called “ejector”, which were constructed for sewage discharge to natural nallahs or rivers have worked as stormwater pumping facilities in rainy season.
Roadside drains are cleaned by KW&SB one to two months before monsoon season comes every year. Removed and collected silt/garbage is conveyed to designated solid waste disposal sites. However, roads are cleaned afterwards by town administration and silt/garbage is transferred to drains again. This is said to be how inundation is caused.
In addition to above mentioned administrative issues, many drains and nallhas have been

already encroached on by illegal houses and buildings. Strong enforcement of building code and other relevant laws is expected.

Another major issue with malfunctioned drains/nallahs is that garbage is easily and routinely dumped to these facilities, which leads to their reduced sections. Comprehensive solid waste management system has to be introduced.

Due to the uncontrolled housing and garbage dumping, no space/access is available to clean it.

Photo 33.3.1 Typical Nallah in Saddar Town

North Karachi Drain receives the sewage of some 300 houses

Photo 33.3.2 North Karachi Drain

The flow is larger in monsoon season than in dry season.

Photo 33.3.3 Lyari River in August 2006

To prevent stormwater from entering into it, a muffler is equipped with rubber tube.

Photo 33.3.4 Improved Muffler

3.4 LAWS, POLICIES AND ADMINISTRATIVE FRAMEWORK

3.4.1 Water Supply and Sewerage

(1) Legislative and Administrative Framework

According to the Constitution of Pakistan, water is a Provincial subject and the responsibility for water related issues rests with the Ministry of Water and Power (MWP). Within the Ministry, exists the 'Water Wing' (WAPDA) to discharge its water related responsibilities. For water related matters, the MWP coordinates efforts primarily between WAPDA, the Indus River System Authority (IRSA), the Federal Food Commission (FFC), as well as other Federal Ministries and Provincial Irrigation and Agriculture Departments amongst others.

The relevant legislation in force includes the WAPDA Act, 1958; The Environmental Protection Act (EPA), 1997 and the IRSA Act, 1992 amongst others; whilst at a more local level the Sindh Local Government Ordnance (SLGO), 2001 and the KW&SB Act, 1996 run in parallel. Whilst the SLGO, 2001 gives the City District Government of Karachi (CDGK) general powers for the provision of water and sanitation services, the KW&SB Act, 1996, provides a more detailed account of specific technical and administrative responsibilities and powers vested in KW&SB as an 'autonomous' body. Also in force are the KW&SB APT Rules, 1987, the KW&SB Efficiency and Discipline Rules, 1987 and the KW&SB Delegation of Powers, 1991 amongst others. Some of these will have been superseded following devolution as the Government of Sindh (GOS) have issued a number of rules and regulations for local government departments. These include ‘Local Fund Budget Rules, 2001’; ‘TMA/UA, APT Rules, 2001’; ‘Contract Rules, 2001’, ‘TMA Rules of Business, 2002’, ‘Conduct of Business Rules, 2001’ amongst others.

More recently the Government of Pakistan (GOP) have issued the ‘National Environmental Policy, 2005’; the ‘National Drinking Water Policy, 2006’ and the draft ‘National Sanitation Policy, 2006. In response to national policy, the GOS have issued the draft ‘Sindh Water Supply Policy, 2006’ and the draft ‘Solid Waste & Sanitation Policy, 2006’. With the advent of these recent policies it may be prudent for the GOS to consider introduction of a unified provincial ‘Water Law’ that seeks to eliminate the overlaps and anomalies by combining, clarifying and simplifying the plethora of existing Acts. Whilst the policies act as ‘guiding principles’, the water laws would need to clearly define roles and responsibilities for all ‘actors’ involved to ensure an ‘integrated approach’ to water resource management, including the standards required for the supply of safe drinking water and disposal of waste water with due care for the environment.
Devolution of water and sanitation services (W&SS) from the Provincial Government of Sindh to the CDGK was enacted as a result of the SLGO, 2001. This was effected by setting up a ‘Water & Sanitation Department’ within the CDGK headed by an ‘Executive District Officer’ (EDO). Along with other ‘departmental heads’ (responsible for provision of services such as Health, Education, Agriculture, Transport, etc.,) the ‘EDO Water & Sanitation’ is responsible to the CDGK and the people of Karachi via a system of Town Municipal Administration (TMA) and Union Councils (UC’s). Due to the size of the city and considering the “essential services” nature of W&SS, it was decided to retain KW&SB as the ‘executing agency’ for W&SS. As such the KW&SB Act, 1996 was not revoked when the SLGO, 2001 came into force.

In accordance with SLGO, 2001; of which Sections 52 and 182 are particularly relevant, KW&SB are responsible for water and sanitation services for Karachi. KW&SB are also responsible for bulk supply of water to various agencies including ‘Cantonments’, such as the Defence Housing Authority (DHA), the Sindh Industrial Trading Estate (SITE), the Karachi Port Trust (KPT) and other major organisations/agencies. These organisations/agencies are responsible for onward distribution of water and collection/disposal of wastewater. There has been much discussion regarding KW&SB taking ownership of the water and sanitation infrastructure within these areas and for provision of services, however, due to poor asset condition, this is yet to be agreed.

Working alongside KW&SB is the ‘Sindh Katchi Abadis Authority’ (SKAA), various Non-Governmental Organisations (NGO’s) and ‘Citizen Community Boards’ (CCB’s) with the aim of improving W&SS and ensuring that all areas and communities throughout Karachi are represented. The idea of CCB’s or ‘beneficiary groups’ taking an active role in the O&M of local schemes has been slow ‘getting off the ground’.

Responsibility for compliance with ‘drinking water standards’, safe disposal of sewage and for compliance with environmental legislation/standards is placed on KW&SB, however, the fragmented nature and responsibility for W&SS provision as described above does not ‘sit well’ with this. KW&SB currently follow and are subject to compliance with the World Health Organisation (WHO), 1971 International Drinking Water Standards and the EPA Standards, for water quality and effluent quality, however, due to lack of effective independent monitoring or ‘policing’, KW&SB are effectively ‘self regulating’.

Whilst KW&SB constitute an autonomous body, in carrying out its duties, KW&SB interact with a number of CDGK departments having either advisory, political, administrative or sanctioning powers over their financial and operational activities. In this event, KW&SB have little ‘autonomous freedom’ and therefore, essentially continue to operate as an executing agency with a number of financial and operational constraints placed on them coupled with a high level of political interference in day to day operations. The Government of Sindh through Legal Notification No. SOVIII/KW&SB/72/2002 re-constituted the Board of the KW&SB. KW&SB is governed by a board of directors of which the Managing Director (MD) of KW&SB is a member and the City Nazim is the Chairman. Other board members include representation from industry as well as government bodies. It is understood that whilst formal board meeting are conducted infrequently, the MD consults on a regular basis with the Chairman of the board and other related CDGK and GOS departments regarding approval/processing of major development projects, approval of budgets, funding, financing, loan repayment, tariff adjustments, water quality/effluent standards compliance etc.

In conclusion, overall, there is sufficient legislation and policy pronouncement already in place, however, the motivation, coordination, resources, participation of beneficiaries and institutional capacity to effectively implement them appear to be sorely missing. Additionally, there would appear to be overlaps and lack of clarity in responsibilities for interrelated agencies and a lot of the legislation is very prescriptive and 'over-specified' which enforces strict bureaucratic routines and stifles the development of new ways of working. Therefore, with the concept of making KW&SB more 'accountable', there is a need for new legislation (or Water Byelaws) that more clearly defines what KW&SB can and cannot do in relation to fulfilling their constituted responsibilities for the provision of water and sanitation services. This will include raising finances, cost recovery mechanisms (tariff setting), service standards, management of human resources, asset O&M, asset creation/disposal etc.

(2) Sector Policy Framework

National policies relevant to the water supply and wastewater services in Karachi include the National Water Policy, the National Drinking Water Policy (see **Appendix A34.1**), and the National Sanitation Policy. The vision that forms the foundation of Pakistan's National Water Policy (Draft) is summarised as:

"By 2025, Pakistan should have adequate water available, through proper conservation and development. Water supplies should be of good quality, equitably distributed and meet the needs of all users through an efficient management, institutional and legal system that would ensure sustainable utilization of the water resources and support economic and social development with due consideration to the environment, quality of life, economic value of resources, ability to pay and participation of all stakeholders."

The overall goals of the National Drinking Water Policy are:

- To ensure safe drinking water to the entire population at an affordable cost in an equitable, efficient, and sustainable manner, and
- To ensure reduction in the incidence of mortality and morbidity caused by water borne diseases.

The overall objectives of the National Drinking Water Policy are outlines as follows:

- To provide a supportive policy and legal framework that facilitates access of all citizens to safe drinking water on a sustainable basis;
- To provide guidelines that will allow consistency and conformity between the drinking water policy and the overall water sector policy, environmental policy, health policy and drinking water quality standards that will facilitate the provision of safe water to all;
- To define an institutional framework within which the sector institutions can more effectively address the challenges they face in the provision of drinking water in all areas of the country;
- To provide a financial framework within which the provision of water supply can be undertaken in a cost-effective, equitable and sustainable manner;

- To identify and facilitate the implementation of as set of key strategies that will help in enhancing access to safe drinking water supply; and
- To provide a framework within which local communities, women and vulnerable groups can be facilitated to enhance their access to safe drinking water.

Pakistan's National Sanitation Policy acknowledges that only about 42 percent of the total population has access to sanitation facilities, and aims to create a framework for "providing adequate sanitation coverage for improving quality of life of the people of Pakistan and to provide the physical environment necessary for healthy life.

At the Provincial level, the Sindh Water Supply, Solid Waste & Sanitation Policies (see **Appendix A34.2**) have been drafted based on the national policy. However, these are currently under review (as of November 2007) by a Technical Review Committee constituted by Government of Sindh (GOS) and are thus yet to come into force.

3.4.2 Environment

(1) Policy and Legal Framework

Laws finding relevance with the modern definition of 'environment' were first enacted in Pakistan in the late 1950's and in the first half of the 60's. Further, the Environment Ministry was established in 1975, as a follow up of Stockholm Declaration of 1972. The most effective period for environmental legislation in the country runs from 1983 to 1997. The first Environmental Protection Ordinance was promulgated in 1983. With this enactment, a series of legislation making process was initiated that culminated in the enactment of the Pakistan Environmental Protection Act, 1997. In 1992, Pakistan participated in the Earth Summit and thereafter became party to various international environmental conventions and protocols. Pakistan developed its National Conservation Strategy (NCS) that became effective from March 1, 1992 and presently acts as the environmental agenda for the country. The National Environmental Quality Standards (NEQS) became effective in 1997. More recently the Ministry of Environment have issued the 'National Environmental Policy, 2005'

a) The National Conservation Strategy (NCS)

The Pakistan NCS is a broad based policy statement aimed at achieving environmentally sustainable economic and social development in Pakistan. The three overriding objectives of the NCS are a) Conservation of Natural Resources b) Sustainable Development and c) Improved Efficiency in the use and management of resources. The NCS specifies the broad guidelines for an integrated effort aimed at protecting the environment and the natural resources of the country. The broad framework provides a comprehensive point of reference for all agencies, departments, private sector companies, financial institutions and donor agencies for undertaking systematic efforts to bring about an effective change for sustainable development.

b) Pakistan Environmental Protection Ordinance 1983

The 'Ordinance' for the first time established the Pakistan Environmental Protection Council and the Federal and Provincial EPA's. It also pioneered in the Pakistan, the requirement of preparing Environmental Impact Assessment (EIA) reports.

c) Pakistan Environmental Protection Act (PEPA) 1997

The Pakistan Environmental Protection Act 1997 (PEPA 1997) is the most important environmental legislative instrument in Pakistan. The Act aims "To provide for the protection, conservation, rehabilitation and improvement of the environment, for the prevention and control of pollution and promotion of sustainable development".

The apex body established under the PEPA 1997 is the Pakistan Environmental Protection

Council that is headed by the Prime Minister of Pakistan. The functions of the Council include enforcement of the PEPA 1997, to establish national environmental policies, ensure their implementation, approve National Environmental Quality Standards, give directions to conserve bio-diversity and renewable and non-renewable resources and consider the national environment report. The Environmental Protection Agencies (EPA's), both at the Federal and provincial levels exist under the Pakistan Environmental Protection Council.

d) National Environmental Action Plan (NEAP)

The NEAP was approved by the Pakistan Environmental Protection Council in February 2001. The development objective of the NEAP was to initiate actions and programmes for achieving a state of environment that safeguards public health, promotes sustainable livelihoods and enhances quality of life of the people of Pakistan. It focused on taking immediate measures to achieve a visible improvement in the rapidly deteriorating quality of air, water and land, through effective cooperation between the government agencies and civil society.

(2) Administrative Framework

The following details some of the important administrative arrangements that have been put in place under the provisions of the Pakistan Environmental Protection Act, 1997:

a) The Pakistan Environmental Protection Council

The apex body established under Section 3 of the Pakistan Environmental Protection Act, 1997 is the Pakistan Environmental Protection Council. It is chaired by the Prime Minister and comprises of all the four provincial Chief Ministers, federal and provincial ministers of environment and up-to thirty five (35) persons, with at least twenty (20) non officials, including representatives of the Chamber of Commerce and Industry, agriculture, medical and legal professions, trade unions, NGO's, scientists, technical experts and educationists. The functions and powers of the 'Council' include the following:

- Approval of the National Environmental Quality Standards (NEQS)
- Approval of comprehensive national environmental policies, within the framework of the NCS
- Provision of guidelines for the protection and conservation of species, habitats and bio-diversity in general and for the conservation of renewable and non-renewable resources; and
- Coordination of the integration of principles of sustainable development into national development plans and policies

b) Pakistan Environmental Protection Agency

The Pakistan Environmental Protection Agency exists under the Pakistan Environmental Protection Council. It is headed by a Director General (DG). The DG may establish such advisory committees as he may deem fit to assist him. Section 5 of the Pakistan Environmental Protection Act 1997, constitutes the Pakistan EPA (The Federal Agency), which is the regulatory institution entrusted with the functions of administering and enforcing the Act and its rules and regulations. These include:

- Preparation, revision, establishment and enforcement of the NEQS
- Establishment of systems for surveys, monitoring, inspection and audit
- Certification of environmental laboratories
- Rendering of advice and assistance in environmental matters
- Encouraging the formation and working of NGO's, community organizations and village organizations
- Taking all necessary measures for the protection, conservation, rehabilitation and improvement of the environment, prevention and control of pollution and promotion of sustainable development

c) Sindh Environmental Protection Agency (SEPA)

Section 8 of the Pakistan Environmental Protection Act, 1997 establishes the provincial EPA's of which one is the Sindh Environmental Protection Agency. The provincial EPA is to exercise powers delegated under Section 26. Many of the federal agency's functions and powers under the Pakistan Environmental Protection Act, 1997 have already been delegated to the Provincial EPA's. **Section 8** gives statutory cover to the Provincial EPA's, which were hitherto functioning under administrative arrangements.

<u>Environmental Reporting</u>

Environmental reporting required as per the provisions of the Pakistan Environmental Protection Act, 1997 is broadly categorized as follows:

i. Initial Environmental Examination (IEE)

The Pakistan Environmental Protection Act, 1997 defines an IEE as "a preliminary environmental review of the reasonably foreseeable qualitative and quantitative impacts on the environment of a proposed project to determine whether it is likely to cause an adverse environmental effect for requiring preparation of an environmental impact assessment".

A proponent of a project falling in any category listed in Schedule I shall file an IEE with the Federal Agency, and the provisions of **Section 12** shall apply to such project.

ii. Environmental Impact Assessment (EIA)

The Pakistan Environmental Protection Act, 1997 defines an EIA as " an environmental study comprising collection of data, prediction of qualitative and quantitative impacts, comparison of alternatives, evaluation of preventive, mitigation and compensatory measures, formulation of environmental management and training plans and monitoring arrangements, and framing of recommendations and such other components as may be prescribed".

A proponent of a project falling in any category listed in Schedule II shall file an EIA with the Federal Agency, and the provisions of **Section 12** shall apply to such projects.

(3) Other Relevant Environmental Legislation

Some relevant environmental legislations not falling within the ambit of the Pakistan Environmental Protection Act, 1997 are listed as follows:

a) Environmental Laws related to Water Pollution (applicable to the Sindh Province)

- The Canal and Drainage Act 1873 (amended in 1952, 1965, 1968 and 1970)
- Sindh Fisheries Ordinance, 1980
- The Factories Act, 1934
- The West Pakistan Water and Power Development Act, 1958 (amended in 1958, 1964 and 1967)
- The West Pakistan Land and Water Development Board (Authority for Payment from Board Fund) Rules, 1966
- The Pakistan Penal Code, 1860 (Section 277)
- Pakistan Environmental Protection Council (Procedure) Rules, 1993

b) Environmental Laws related to Solid and Effluent Management

- The Factories Act, 1934 (See **Section 14**)
- Pakistan Environmental Protection Council (procedure) rules, 1993

3.5 KW&SB'S ORGANISATION AND FINANCIAL MANAGEMENT

3.5.1 Organisation

Considering the size of the city, population density and the complex nature of its mandated responsibilities KW&SB has made significant strides in the water and sanitation arena. However, much is still to be done and the role of KW&SB is changing. KW&SB's changing role has been brought about by new priorities set at National and Provincial level with the introduction of new Water, Sanitation and Environmental Policies, Development and Devolution Plans resulting in a major shift in thinking and policy towards a decentralised, people centric and demand responsive approach. This paradigm shift incorporates the principles of:

- Adoption of demand responsive approaches based on empowerment, full participation in decision making, control and management by communities
- Shifting the role of government from direct service delivery to that of planning, policy formulation, monitoring and evaluation and partial financial support
- Partial cost sharing and 100% O&M responsibility by users (beneficiary groups including local bodies, CCB's)

The reforms also call for substantial 'institutional development' with regard to services, enhancement of technical and managerial capacity, appropriate forms of public-private partnership, private sector participation, use of information systems etc. to achieve sustainability. Additionally, pricing mechanisms to discourage excessive water use, reduction of leakage and UFW, reuse and recycling of sewage, rainwater harvesting etc; are advocated. KW&SB is yet to seriously take up this challenge, however, systematic implementation of 'Improvement Programmes' resulting from this JICA study will go some way in helping KW&SB meet their future obligations.

A diagnostic of the key issues affecting KW&SB are presented in **Table 35.1.1**. These were considered during the 'organisation review' conducted during the first and second phases of the study and have therefore influenced the recommendations, models and strategies in the Master Plan.

Table 35.1.1 Key Issues Requiring Intervention

Business Activity	Key Issues
Institutional Arrangements	Insufficient sector agency coordination/cooperation Insufficient community coordination/involvement Lack of IWRM approach
Utility Management	Lack of adequate regulation (Water Bye Laws) Lack of monitoring/enforcement of existing regulation Insufficient capacity (HR/management expertise) Lack of capacity (IS/IT/workflow systems) Lack of strategy, policy, process development Lack of Process and Performance Management (example UFW reduction, energy and process chemicals efficiency, plant utilisation, labour efficiency, billing/revenue efficiency etc.) Insufficient project management skills and tools for control
Community Participation/Management	Community participation not an accepted approach No formal structural arrangements for dealing with user/beneficiary groups such as NGO's, CCB's
Spatial Planning and Demographic	Fast growth of population – demand outstrips supply Poor compliance with mandated supply coverage
Resources	Insufficient funds/financing to meet current/future demands for services Lack of project and financial control measures Tariffs not based on full cost recovery Poor billing/revenue practices and performance Insufficient pricing mechanisms to regulate/conserve water Lack of sustainable practices/care for the environment/regulatory enforcement
Political Interference	Lack of financial and management autonomy Political influence on infrastructure projects and priorities and day-to-day management activities
Socio-Economics	Low and irregular incomes of a large part of the customer base, resulting in low capacity to pay for services Debt/disconnection policy not addressing underlying problems
Communication, Information and Education	Limited communications, consultation, involvement and public relations activities Lack of awareness campaigns/outreach programmes Low public enlightenment to report problems, water use efficiency and bill settlement (especially Local Bodies)
Operation & Maintenance and Service Provision	Contaminated/depleting (usable/accessible) water sources Low service levels/insufficient water supply and lack of sanitation services, insufficient infrastructure to meet demand Poor quality of water delivered High levels of leakage and NRW Lack of O&M strategy and planning Lack of planned preventative maintenance and supply chain management

Based on the above, it will be necessary for KW&SB to take a more holistic view of the 'water business' in Karachi and to consider the interactions and influences of the various stakeholders that impact KW&SB's operation. These will determine the key 'business drivers' that will need to be developed to ensure that KW&SB meet their business and service objectives now and in future.

(1) Responsibility for Provision of Water and Sewerage Services

Over the years, the provision of water and sanitation services has been undertaken by a variety of agencies. The 'Karachi Joint Water Board' was constituted in 1953, who were responsible for the first major expansion of Karachi's water supply system; taking bulk water from the Indus River.

From 1957, the Karachi Development Authority (KDA) took responsibility for bulk water supply and the Karachi Metropolitan Corporation (KMC) became responsible for water distribution and sewerage within the city. At that time a number of other agencies took responsibility for managing their own 'systems', including the 'Cantonment Board' and other major government organisations such as the Armed Forces, the Karachi Ports Trust (KPT) etc. This is still the case today.

As there was no single agency to plan and execute water and projects at that time, in 1983, the Sindh Government introduced the 'Sindh Local Government (amended) Ordinance, 1983' to bring responsibility within one agency, the KMC at that time, who became responsible for provision of services, the raising of funds and taxes and for the expansion of 'systems'.

The 'Karachi Water and Sewerage Board Act, 1996' was enacted, which served to separate KW&SB from KMC and placed them under the GOS as an autonomous body.

'Devolution Plan', the 'SLGO, 2001' was introduced which placed KW&SB under the CDGK. CDGK established the 'Water and Sanitation' Department' headed by an Executive District Officer (EDO). As the KW&SB Act, 1996 was not revoked, the Water and Sanitation Department – CDGK and KW&SB are one and the same entity; whereby the Managing Director of KW&SB is the EDO Water & Sanitation – CDGK.

To comply with the spirit of the SLGO, 2001, KW&SB have reorganised their operations geographically in-line with TMA's and UC's who have a 'say' in how services are provided within their jurisdictions.

KW&SB's prime responsibility is the development and regulation of water supply and collection and disposal in the city of Karachi. Based on the forgoing, KW&SB need to work in close cooperation with other city agencies to ensure efficient services, including those agencies that manage their own 'systems'.

A Board chaired by the City Nazim (CDGK), is responsible to the GOS for the functioning of KW&SB, whilst the MD-KW&SB takes responsibility for overall day-to-day operations.

The current high-level organisation structure showing the relationship of KW&SB with the CDGK is shown in **Figure 35.1.1**.

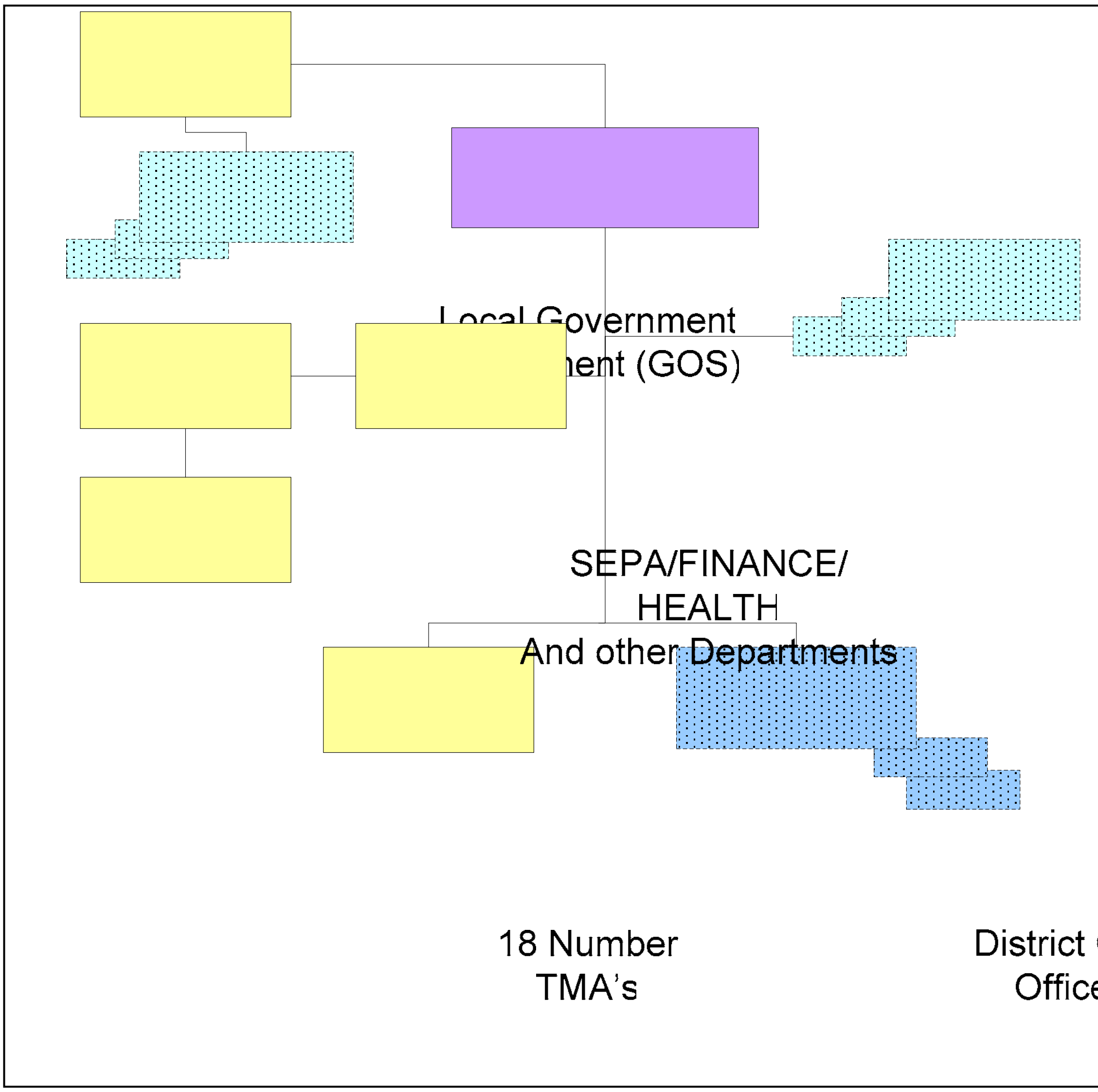


Figure 35.1.1 High Level Organisation Structure

KW&SB's main responsibilities (according to KW&SB Act, 1996 and SLGO, 2001) can be summarised as follows:

- Produce and supply potable water
- Sanction of water and sewerage connections and water supply to tankers
- Levy and collect fees for water and sewerage services
- Make regulations with approval from government
- O&M and construction of water and facilities
- Regulate water supply and inspect water and sewerage connections
- Prepare and submit to government for approval, tariffs and other charges

KW&SB's stated commitments (according to published statement "KW&SB dedicated to serve") are to provide essential water and sewerage services to meet the basic needs of the ever increasing population of Karachi. In spite of all its limitations, KW&SB takes a number of measures to address the issues through efficient means and effective tools.

- Distribution of water in an equitable manner
- Facilitate better environmental conditions
- Water conservation
- Supply of good quality water to citizens
- Complaints management for redressal of complaints
- Fast-track implementation of K-III project
- Additional water from Indus source to meet long term water demand up to 2025
- Supplement existing sources of water by installation of sea-water desalination plant, groundwater recharging and recycling of
- Implementation of Tameer-e-Karachi program (TKP)
- Gradual transformation of KW&SB into a self-sustaining organisation through improved collection of water and sewerage charges
- Progressing towards self-sufficiency

(2) Provision of Services – Current Status

According to the 1998 census, the population of Karachi was 9.89 million at that time and is currently estimated at around 16.0 million. This is expected to double by 2025. It is also estimated that 40-50% of people in Karachi live in informal settlements (Katchi Abadis).

The main sources of water to Karachi are from the Hub and Indus surface water sources. KW&SB currently 'supply' an estimated 595 MGD being a mixture of raw and treated water. The extent of water supply coverage in Karachi is presently estimated at 80% however, supplies are intermittent and average approximately 4 hours/day or every few days. This is less than the national average. The remaining population depend on tankered supplies, open wells, ponds, natural streams, etc. The extent of sewerage coverage in Karachi is presently estimated at 60-65%, however, due to inadequate treatment capacity, only 40% is treated. Coupled with weak enforcement of environmental laws, KW&SB's ability to fulfil its effluent standards are further exasperated by largely 'unregulated' discharge of industrial waste.

Water is supplied via 6 supply schemes (10 plants) and there are currently 3 sewage treatment facilities.

The draft Sindh Water Supply Policy, 2006 states that for urban areas a minimum of 50 lpcd will be provided inside the home through a piped system. According to this it would appear that sufficient water is currently available in Karachi, however, the issue of water losses currently estimated at 30-35% of water into supply requires to be tackled urgently as is NRW currently estimated at 45% of sales. Due to the lack of ability to accurately measure actual production, distribution and consumptions volumes, it is impossible to accurately assess the level of commercial and physical losses. There is anecdotal evidence to suggest that losses due to 'water theft' is high, however, in the absence of systematic and regular auditing and control measures, the extent of this is impossible to ascertain.

As of June 2006 KW&SB's infrastructure included almost 1.5 million piped water supply "units" (connections or accounts) of which "bulk" (metreed) supplies amount to just over 5,000 units. Domestic supplies (Retail) are not metreed and due to the intermittent nature of supplies the general custom and practice is for properties to have ground level and roof level storage tanks. As these are generally not equipped with level controls and due to poor quality water, wastage due to overflows and flushing is high. It would also appear that a large number of suction pumps have been installed by customers to draw water from KW&SB mains at times when flows are 'rationed'. This exacerbates the contamination problems that already exist as a result of negative pressures and ingress of contaminated water resulting from intermittent supplies and deteriorating supply networks.

A certain amount of ambiguity is evident in a number of activities associated with the management and development of water resources and the provision of water and sanitation services. Where clear lines of responsibility are not assigned, close liaison and 'cross-process' understanding is crucial to ensure focus in a number of key areas including the following:

- Identification and development of conventional water sources
- Identification and development of non conventional water sources
- Conservation of the environment with respect to sustainable development
- Pollution control legislation and monitoring
- Provision of accurate information with regard to water resources to ensure that a balanced view is taken by all stakeholders with respect to integrated water resource management
- Public education and community relations with regard to water use and conservation
- Monitoring and maintenance of water quality standards
- Equitable pricing of water/ services

(3) Organisation Arrangements and Management Set-up

KW&SB faces a number of significant challenges in the delivery of its functions. These include funding problems, organisational issues and administrative/management constraints placed on them from the Government of Sindh and CDGK. We believe that KW&SB on the whole have shown considerable dedication and resourcefulness in working within this underlying framework of constraints, however, much could still be achieved to improve operational and commercial performance through increased focus on institutional strengthening and capacity building elements. This will require a focus away from 'supply responsive solutions' (the proposed K-IV project being a case in point) to 'demand responsive solutions', i.e. 'fixing' the existing underlying problems of the existing asset base (namely the poor state of the distribution and sewerage networks and treatment facilities). This requires systematic building of staff and organisation capacity.

The number of employees budgeted (2006) is currently 9327 of which current staff in post is 8260. This is split 3230 staff at City level and 5030 staff distributed throughout the offices within the 18 Towns. An accurate up to date 'picture' of staff numbers is difficult to determine as staff records and payroll 'demands' are administered locally at Town offices by authorised 'Drawing & Disbursement Officers' (DDO's).

Based on the number of connections, the ratio of employees per 1,000 connections is approximately 6 which compares favourably with other major Pakistan cities as well as other major Asian cities where the number of employees per 1,000 connections ranges from 2 to 35. However, it should be noted that whilst the number of staff per 1000 connections is a measure of efficiency, it does not give an indication of the level or quality of service. For example, KW&SB's poor level of performance with regard to supply hours, water quality, revenue collection rate, etc., may compare less favourably with cities with a lower or higher staff ratio.

The latest (November 2007) high-level organisation structure with an indication of the main functional responsibilities is shown in **Figure 35.1.2**.

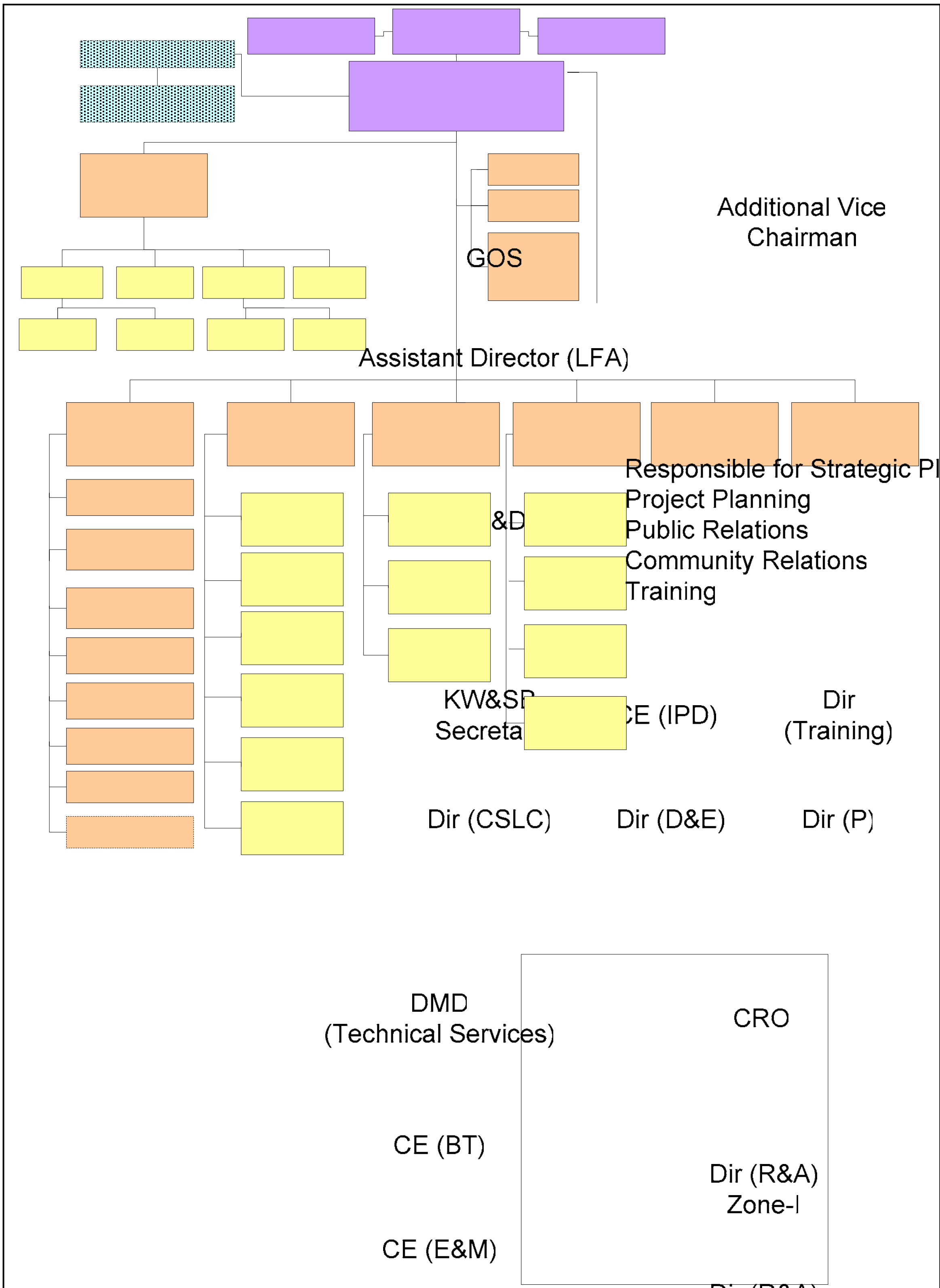


Figure 35.1.2 KW&SB High Level Organisation Structure with Key Responsibilities

Based on the current organisation chart, there appears to be a lack of 'focus' or 'ownership' at policy level for business critical activities such as Customer Services, Systems Development, Corporate Management (strategic planning, business planning, master planning), and HRD amongst other areas. These are discussed in more detail below.

a) Corporate Management

The Deputy Managing Director (Planning & Design) is currently tasked with providing support and strategic direction for the organisation. This department is currently being strengthened for this purpose; recent additions include responsibility for training, public relations and civil society liaison. Most recently, however, the Managing Director has initiated and implemented a number of initiatives, including reorganisations, contracting out of bill printing and customer accounts management and other projects to 'transform' KW&SB into a more 'demand responsive water & sanitation service provider'.

However, critical business activities at policy level such as Master Planning (strategic planning, source development, asset acquisition), Customer Services, Systems Development, Supply Chain Management, Operations & Maintenance Management, Business Development and Community Relations are not centrally 'managed' by 'process owners' or 'process champions' and as a result remain underdeveloped due to lack of focus. This has led to the absence of policy development in these areas as well as other areas such as HRD, Health and Safety, Security, Contingency planning etc. Having said that, the most recent organisation changes have sought to address some of these shortfalls

KW&SB is not 'driven' by a well developed 'Vision' or 'Mission' for the organisation. Whilst KW&SB have stated their intent in terms of their aims, objectives and responsibilities to transform into a more 'customer responsive service provider', this is not widely shared with customers or employees and is not linked to individual, team or departmental targets. With this regard, it is recommended that KW&SB review their strategic intent and modify their vision and mission statements accordingly. This should be done in consultation with as many 'key players' as possible throughout the organisation as well as other 'stakeholders' to ensure 'buy-in'.

There appears to be little coordination between agencies and as such ambiguity in responsibilities between KW&SB and other agencies is evident for pollution control, environmental control, sustainable development of water resources etc. Mechanisms for developing regulatory responsibilities as well as for reporting and coordination with other regulatory bodies do not appear to be a key focus for KW&SB. The current management set-up does not appear to assign specific responsibility or 'ownership' for this function. It is recommended that KW&SB review their focus in this area of activity. For example, working alongside KW&SB is the 'Sindh Katchi Abadis Authority' (SKAA), various Non-Governmental Organisations (NGO's) and 'City Community Boards' (CCB's) with the aim of improving W&SS and ensuring that all areas and communities throughout Karachi are represented. However, this currently appears to be a missed opportunity.

KW&SB's business and operational practices espouse an organisation that provides essential services for the enhancement of public health rather than a commercial entity seeking to make a return on investment. As such, the use of tariff or pricing mechanisms to regulate water usage is not actively or readily applied (KW&SB need to get GOS approval for price adjustments in any case) as the cost of services is highly politicised. KW&SB need to review their efforts and focus in this area and lobby the GOS to ensure a more appropriate cost recovery mechanism is put in place as current tariffs do not provide sufficient revenue for effective O&M, let alone infrastructure renewals.

The main objective of the KW&SB Act, 1996 was to establish an autonomous body, however, the amount of freedom extended to KW&SB in pursuing its mission without undue regulatory or political constraints, in practice, appears to be minimal. Autonomy is primarily constrained by KW&SB's reliance on the GOS and the CDGK for funding its operational deficit. Government approval is also required for large capital intensive schemes, recruitment/promotions for key positions, service rules, pay and conditions etc. Whilst depreciation is currently applied in the accounts, there is no provision for asset renewals and therefore the current strategy will continue to require funding support from both the CDGK and GOS. This will do little to reduce political 'interference' in future.

b) Financial Management

As the KW&SB Act, 1996 is still followed, KW&SB are not required to seek approval of budgets from the CDGK, however, as the City Nazim is Chairman of the Board, he effectively 'approves' KW&SB's finances on behalf of the Board which we understand no longer operates. The rules and regulations relevant to financial management of KW&SB include the following amongst others:

- The Sindh Government and Taluka/Town Municipal Administration (Budget) Rules, 2002
- The West Pakistan Municipal Committees (Works) Rules, 1969,
- The Sindh Local Government (Contract) Rules, 2001
- The Sindh Financial Rules Volume I & II
- The Sindh Local Government (Accounts) Rules, 1983
- KDA Purchase of Store Regulations, 1978

The Finance Department is headed by the Chief Accounts Officer (CAO), supported by directors of 'IT', 'Accounts' and 'Finance & Accounts'. As the CE's and CO's and their DDO's have delegated authority for budgeted expenditure, the Finance Department are essentially responsible for budget preparation and expenditure reconciliation. Transactions, concerning budget expenditure, customer billing, payroll, provident fund/pensions, medical expenses etc. are 'processed' by the IT section. Whilst the Finance Department operate the computer systems associated with these transactions, the systems are decentralised (distributed databases) and therefore the Finance Department essentially perform data entry (batch update) tasks. Although, auditing is conducted, the current system is not robust and data is extremely difficult to reconcile due to the fact that KW&SB do not operate a central database (master data) system. Current systems have been progressively developed in-house and as part of a wider systems development plan it is recommended that these be updated/replaced with tried and tested 'proprietary' application software readily available.

Along with labour costs, the biggest budgeted expenditures are procurement of electricity and chemicals. There is a clear need, therefore, to conduct energy and process optimisation audits to ensure efficient procurement and use of electricity and chemicals. Furthermore, KW&SB may wish to consider introducing a 'central procurement department' for this purpose.

Due to poor revenue recovery, KW&SB do not collect sufficient income to manage their operation without support from the government. Customer arrears are currently approximately 23 billion Rupees.

c) Asset Management

With KW&SB's drive to meet it's obligations to supply an ever increasing demand for water, the prime focus and organisation arrangements (structure, skills, competencies) have been heavily geared towards implementation of new supply schemes. This 'supply driven approach' has led to the relative neglect of effective O&M of existing assets resulting in deteriorating asset condition, poor operational performance and underdevelopment of critical business, commercial and operational activities. The current tariff and revenue collection rate does not provide sufficient funds for effective O&M, let alone infrastructure renewals.

Provision of sanitation infrastructure and services does not appear to be high on KW&SB's agenda. At present there are three treatment facilities, however, it is understood that these are not functioning sufficiently well to meet current effluent standards. The lack of focus on may stem from the fact that KW&SB do not appear to have a responsibility for legislation, management or monitoring of from domestic, non-domestic, industrial or local bodies. This is entrusted to SEPA. Additionally, the current charging mechanism does not provide sufficient revenue for effective O&M, let alone infrastructure renewals.

There is a general tendency for 'senior managers' to keep personal records with regard to recording of assets within their own areas of responsibility. This could lead to the loss of knowledge when staff are transferred or retire. There is a need for a computerised asset register of above and below ground assets. The current distribution network is undergoing digitised mapping as part of the JICA study. The asset register should be populated with asset information including a regular assessment of asset condition, asset valuation and plant criticality in order that asset maintenance, refurbishment and renewals are 'provided for' in a planned and strategic fashion in line with KW&SB's future strategic intent. In this way, an 'Asset Management System' can be developed and integrated with KW&SB's business development plans to ensure that assets are developed based on sound business principles, including the need to meet customer demands for new and improved services.

d) O&M Management

There is no central coordinating role or 'process owner' for O&M activities including the reduction and management of UFW. Currently the CE's report direct to the MD.

Responsibility for operations and maintenance rests primarily with the 3 zonal CE's, the CE (BT), CE (E&M) and the CE (DD&C). Between them, they are responsible for the conveyance of bulk raw water from source as well as for conveyance systems (canals/conduits), reservoirs, trunk mains, transmission mains, distribution networks, pumping stations, drainage systems and sewerage networks, as well as for the O&M of water and treatment facilities. Staff associated with these activities, are dispersed at the various operational sites as well as at the 18 Town offices. Management and administrative staff associated with O&M are also placed at the '9th Mile' and 'HQ' offices.

Policy formulation, setting of departmental targets and objectives is not in evidence at CE level or below.

Based on initial visits it would appear that the asset base is deteriorating, especially the distribution network. Safety standards in relation to the use of Chlorine gas is extremely haphazard in the major water treatment plant visited (COD) and presents a serious hazard to the safety of staff. This facility should be refurbished immediately.

Asset management plans are not in existence and asset information is generally not recorded.

Apart from 'running maintenance', major breakdown, including repairs to mains are contracted out. A system of 'reactive' or breakdown maintenance is practiced. Planned preventative maintenance' is not practiced or planned.

The distribution networks design and set-up as well as management practices have not been geared to reducing or managing leakage or UFW. For example, the various networks are not adequately modelled or set-up by discrete supply zones with adequate ability to measure network performance. The networks are lacking equipment such as flow and pressure measuring devices as well as basic equipment such as 'zonal' metres, isolation or pressure control valves to aid leakage detection, measurement and control. Further, leakage detection equipment and active leakage detection techniques are not practiced centrally or regionally. For best results, this would require the setting up of active leakage teams'. It is recommended that responsibility for reduction of UFW be assigned to the ‘asset owners’, i.e., the managers and operators of the network, with overall responsibility for the ‘process’ assigned to a ‘NRW process owner’ who takes responsibility for reduction of both ‘real’(physical) and ‘apparent’ (commercial) losses.

H&S policy/manuals and contingency/emergency plans are not in existence and H&S practices appear to be ad hoc and at the ‘discretion’ of individual managers within regions. H&S appears to be of low priority at all levels of operation of plants, street works activities etc.

Tankered water deliveries for emergency or other purposes are provided by the ‘Rangers’ who obtain supplies free from KW&SB. This practice should be reviewed as this presents a lost opportunity in terms of revenue and customer service provision.

Statistical process control techniques are not practiced at plants; however various logs are kept at each plant showing power use, run hours, chemical parametres, chemical use, breakdowns etc. There is little formal (written) reporting upwards of plant performance such as treatment volumes/costs/labour/plant breakdowns/power failures/treatment bypassing/quality parametres etc unless instigated by individual managers. Performance is not reported against targets and on the whole process and business reviews do not take place.

KW&SB are responsible for complying with water quality standards and currently uses the ‘Pakistan Drinking Water Standards, (revised), 2002’ and the WHO Standards, 1971 as a guide. However, due to the lack of computerised management and laboratory information systems it is difficult to determine the extent to which KW&SB comply with the relevant standards in force throughout the various stages of the water production/supply/customer process. Whilst water leaving the treatment facilities may comply with the relevant drinking water quality standards, due to the deterioration of the distribution networks coupled with intermittent supplies, the water reaching customer taps will not meet the standards.

The practice of ‘over-chlorinating’ at the treatment facilitates in the hope that residual chlorine will still be present at ‘point of use’ is widely practiced. It is recommended that KW&SB computerise and act on water quality data to verify compliance with and improve on current water quality standards.

Currently KW&SB is effectively ‘self-regulating’ for the purposes of meeting water quality standards, as there is little independent control from the Sindh Environment Protection Agency (SEPA) who are tasked with this responsibility. The same goes for compliance of effluent quality standards.

KW&SB places overall responsibility for various functional activities such as water distribution, sewerage networks, projects, O&M, HRD, customer, commercial, financial and administration under a single ‘geographical head’ (Regional CE and associated Divisional offices). This can lead to dilution of effort or lack of focus in key areas associated within each functional activity.

e) Customer Services Management

As a result or recent organisational changes, responsibility for billing and revenue collection has been contracted out as well as the establishment of complaints handling centres. However, KW&SB do not have a clear customer mandate or ‘charter’ describing the levels of services to be provided and the responsibilities of customers to pay bills, settle arrears and to comply with regulations with respect to illegal connections, tampering with supplies (use of suction pumps) etc. It is recommended that KW&SB review its policy on community relations and customer services in this respect.

Key responsibilities for various aspects of customer services, for example, strategic direction, service aspirations, service initiatives, service ethos/culture etc., are not 'owned' at the 'Centre' or within the Regions. Currently the MD initiates and leads customer service improvement initiatives

KW&SB does not conduct regular customer surveys to ensure that all customers who receive a supply are registered on the billing database. Whilst there is evidence of illegal connections and 'stealing' of water on a large scale, audits are not systematically conducted. Opinion surveys are not used to improve service shortfalls.

Currently monthly billing is practiced (previously annually). In an attempt to increase revenues, current bills include a portion of outstanding arrears and an interest charge for outstanding debt. This is a good approach to revenue management as monthly billing makes the charges more affordable and allows customers to budget their outgoings; however, it remains to be seen to what extent this approach has on reducing receivables and improving collection rates.

Current legislation allows KW&SB to set tariffs and charges with approval from Government, however, it would appear that the current tariff has remained largely unchanged since 1998. Based on initial analysis it is evident that this is not based on a 'full cost recovery' basis and therefore coupled with the current poor billing and revenue recovery performance, revenues are not sufficient to fund KW&SB's operation.

Apart from 'bulk' (metreed) customers, there is no metreing of consumption and therefore the opportunity to base charges on actual consumption is being missed. Metreing is accepted as the most appropriate method of charging and allows charging mechanisms to limit water wastage through applying block tariff pricing, with increased charges for consumption beyond essential use. This would also allow a fair system of subsidy/cross subsidy for those less able to pay.

Whilst KW&SB does have a 'bulk metre unit' (reporting to CE (BT)), responsible for metre reading and metre maintenance, they do not have a 'key accounts' team looking after large customers such as commercial, Industrial or Local Bodies to ensure regular and prompt payment. This warrants future consideration in order to improve collection rates.

The practice of billing or 'taxing' customers who do not have a water supply or sewerage connection does little to encourage payment or enhance revenues. This practice should be reviewed. It is estimated that 70-80% of customers either do not pay or have large arrears, not least the bulk customers, a number of which are government organisations. This is currently being tackled by KW&SB.

Due to lack of training in the customer services arena staff are not well placed to provide improved services, as the required 'skill sets' are not well developed.

KW&SB does not have a 'Customer Service Strategy' or service policy in place. Consequently, customer service practices and standards vary within and across Regions and are highly dependent on local management attitudes towards customer service provision. We therefore recommend that KW&SB considers a strategy that clearly details the organisation's strategic intent with regard to customer services. This should state short and long term service aspirations and service standards to be applied across the State.

Responsibility for key customer activities is fragmented, for example, contact management; head of the complaints cell at the 9th Mile complex reports to the MD, whilst it is understood the new contact centre to be operated by 'Millennium Consultants' will report to the CRO via

Director (Billing). The current set-up does not allow for clear ownership of the whole process from initial contact through to satisfactory resolution. There are no documented procedures relating to contact management and complaints statistics or analysis is not used as a means of eliminating route causes of problems.

f) Information Systems Management

A number of software applications are used and have been developed in-house over the years. These are used to monitor and control payroll, budgets, income, medical expenses, pensions etc. However, whilst KW&SB understand that information systems can be a key 'enabler' to ensuring sustained business improvements, it is not surprising, that office automation and systems in general remain underdeveloped due to the lack of 'ownership', strategic direction, funding and resource (sufficient numbers of qualified and technically competent staff).

Consequently, KW&SB do not have a 'Systems Strategy' in place that clearly details the organisation's strategic intent with regard to IS development and implementation. It is recommended that responsibility is assigned to a central 'process owner' to produce the strategy and for ensuring that systems are developed in accordance with business needs.

g) Human Resource Management (HRM)

The organisation does not have well defined policies or procedures in place for manpower planning, recruitment, performance management/improvement, motivation, succession planning, human resource development or training amongst other key activities. Human Resource Development (HRD) aspects are discussed in more detail in **Section 3.5.3**.

Like other government establishments, KW&SB are bound by various rules and regulation 'imposed' from time to time. Due to the fact that the KW&SB Act, 1996 was not repealed on introduction of the SLGO, 2001, it would appear that KW&SB have adopted both 'legislative paths'.

In relation to Human Resources Management (HRM), the prevalent rules followed include the following:

- KW&SB Employees Appointment, Promotion and Transfer (APT) Rules, 1987
- KW&SB Efficiency and Discipline (E&D) Rules, 1987
- KW&SB Promotion, Confirmation and Seniority Rules, 1987
- KW&SB General Condition of Service Rules, 1987
- The West Pakistan Municipal Committees (Works) Rules, 1969
- The Sindh Local Councils (Leave) Rules, 1961
- The West Pakistan Travelling Allowance Rules, 1961
- The Sindh Civil Servant (Pensions) Rules, 1963
- Pay Structure of Sindh Government (plus local allowances sanctioned under CBA agreement)

The more recent rules pertaining to HRM are shown below, however, at this stage it is not clear to what extent KW&SB are bound by or follow these:

- Sindh Local Government (TMA/UA, APT) Rules, 2001
- Sindh Local Government TMA/UA Servants (Efficiency & Discipline) Rules, 2001

<u>Responsibility for HRM and HRD</u>

Based on the most recent changes to the KW&SB organisation structure (June 2006), the Chief Administrative Officer (CAO) does not hold functional responsibility for HRD or Training activities. The CAO primarily holds administrative responsibility with regard to HRD and Training, along with the main functional responsibilities for his department as follows:

- Administrative processing of appointments, promotion, retirement, transfers, posting, leave etc.
- Conducting investigations and action in line with the relevant E&D Rules in force
- Administering employees welfare activities such as medical arrangement (this is delivered through appointed hospitals, doctors and pharmacies on contract to KW&SB)
- Liaison with the 10 registered unions on staff welfare matters such as grievances and for disbursement of monies for funerals, weddings, religious matters etc.
- Allocation of company vehicles (currently 297)
- Allocation of accommodation to staff (currently 1300 units)
- Allocation of phones at accommodation units and offices

Responsibility for the Training function rests with the DMD (Planning & Design).

Responsibility for HRD ("capacity building and enhancement of human resources") rests with the respective departments; i.e. the Chief Officers and Chief Engineers.

Current HR Practices

Many employees have long service with KW&SB, turnover of staff has been negligible (apart from retirement) and recruitment has effectively been put on hold for the past few years. The practice of promoting staff based almost entirely on seniority rather than on 'ability to do the job' does little to encourage the development of sustainable policies and processes for improved performance. At the same time valuable experience and knowledge is being lost as routines are not in place to capture and transfer knowledge. Unfortunately due to the lack of computerised employee information it is not possible to evaluate performance in the area of HR management generally due to the lack of availability of statistics.

The current policy of internal transfers and promotions from within the organisation and no external recruitment (until most recently, whereby graduate engineers are currently being recruited) despite some obvious skill gaps is becoming more and more evident, not least due to the need to introduce new systems and technologies etc. to improve business, commercial and operational performance.

The current organisational structure is a traditional functional hierarchy. It does not provide the most efficient or effective way of organising the business. The present arrangement reinforces functional 'silo' mentality where each department or function invariably operates in isolation to other departments with little coordination or teamwork across processes or lines of responsibility. This type of set-up potentially exacerbates bureaucracy, inhibits information flow and communications, prevents the sharing of best practice and stifles teamwork, creativity and initiative.

Due to the need for Systems and Process improvements, most of the functional departments within KW&SB are 'reactive' in nature with little time to assume a more 'pro-active' approach.

The current set-up does not encourage communication and as a result the sharing of ideas and learning is limited. When operating through functional lines of control, it is difficult to prevent inefficient practices developing as each department tends to be 'inward looking'. This type of functional arrangement can often result in employees not being aware of 'wider' corporate issues thus preventing the easy movement of employees between functions – based on performance or merit and the greater needs of the 'business'.

The above constraints result from KW&SB's constitution in as much that they are bound by rules and regulations as determined by the GOS from time to time. Like other government establishments KW&SB are bound by standard rules and procedures that are designed as ‘blanket’ procedures and do little to allow KW&SB the autonomous freedom required.

KW&SB’s low level of automation, particularly in the administrative field has led to labour intensive manual practices involving a large number of employees performing clerical, administrative or menial tasks compared to those performing skilled or technical/managerial tasks.

The industrial relations climate is poor which means that change initiatives are often stifled due to union opposition or intransigence. As water is highly politicised, local councillors and political parties are reluctant to ‘rock the boat’ or upset the ‘steady state’ by introducing or forcing through radical changes or reforms. This limits KW&SB’s ability to initiate change within their own organisation, which in turn stifles initiative and enthusiasm for change.

h) H&S Management

It would appear that the general regard for and awareness of health and safety matters, particularly in relation to the handling of chemicals (chlorine gas especially) is low. There is also a lack of clarity concerning the coordination and ‘ownership’ for H&S, specifically with regard to ensuring adequate ‘organisation arrangements’ for H&S management.

There is a lack of formal H&S documentation; namely, ‘H&S Policy’, ‘Local Organisation and Arrangements’ document (which should stipulate specific responsibilities by job type for example, electrical testing, testing of lifting tackle, etc.), ‘Safe Systems of Work’ (for plant isolation, entry into ‘confined’ spaces, lone working, chlorine use etc.

There does not appear to be a ‘process owner’ assigned to take overall responsibility for H&S ‘direction’ and management across the organisation. This is compounded by a lack of formal training in all aspects of managing safety.

The failure to co-ordinate and apply appropriate levels of safety standards and practices and to meet statutory requirements, places KW&SB, its staff, contractors and the general public at risk. KW&SB will need to consider a number of changes to the current H&S set-up and adoption of documented best practice standards as well as ensure trained and qualified staff to co-ordinate and audit H&S practices, to reduce these risks.

i) Project Management

Currently responsibility for large and mega projects rests with the CE (Projects) and CE (Mega Projects). This includes development of K-IV, major sewerage schemes (S-III), desalination and effluent reuse investigations. Invariably, consultants are used for outline design, bid documentation, detailed design and construction supervision. Smaller scale projects, refurbishments, overhauls, major breakdowns etc. are managed by the respective CE’s.

It appears that project management is ‘paper based’ and therefore the extent to which project management tools (software applications) can be used in future to more effectively manage and control project implementation and expenditure is worthy of investigation. There are a number of proprietary software packages available for this purpose.

j) Public/Community Relations management

As a result of recent organisational changes a ‘Mass Communications Officer’ and a Civil Society ‘Liaison Cell’ have been established, however, it is not clear who has been assigned responsibility for the formulation of policies or plans for community or public relations or for the interaction of KW&SB with these groups. School liaison and public education in terms of water conservation, health and sanitation also falls into this category.

Responsibility for Public/Community relations has recently been assigned to the DMD (Planning & Design).

- KW&SB does not have a ‘public/community relations communications strategy’ in place or a Public Relations programme (campaign or schedule of planned events), although PR campaigns are organised when necessary such as the recent K-III publicity campaign.

- There does not appear to be a strategy in place for sharing information with the customer base such as information leaflets, annual performance reviews, revenue campaigns, hygiene campaigns etc. KW&SB do not have a programme of ‘road shows’, open days, school talks etc. to keep the general public informed of latest schemes or for raising KW&SB’s profile in the community.

- There does not appear to be any formal arrangements in place for regular communications or liaison with other government departments, community groups, businesses, schools, local bodies etc.

k) Performance Management

Whilst some information is collated within regions and other information is collated centrally, this is not used for purposes of ‘performance managing’ the business, decision making, or for comparing inter-departmental performance. KW&SB does not have a system in place for performance management that establishes goals and measures for individuals, teams, departments or the board as a whole.

KW&SB does not have an established set of Key Performance Indicators (KPI’s) that are agreed, understood, ‘owned’ or shared throughout the organisation. These would be used to improve processes, service provision etc. through the collection, sharing and acting on relevant management information.

- KW&SB does not have a system in place for performance management that uses internal or external benchmarking activities in order to compare/improve inter-departmental performance as well as overall KW&SB performance with industry best standards.

- KW&SB generates ‘annual accounts’, annual administrative reports’ and ‘annual budget estimates’ but these are not widely distributed or shared amongst the staff. These appear to be the main reports or source of information that could be used by the CDGK to ‘regulate’ KW&SB’s activities. However, there appears to be little regulation or sanction placed on KW&SB regarding compliance with water quality standards, standards, abstraction, or the level of business performance generally.

(4) Strengths and Weaknesses of Current Organisation Arrangements

Based on the foregoing and on discussions with senior KW&SB staff as well as a review of documentation provided regarding current organisation arrangements, practices and procedures, the following organisation strengths and weaknesses have been identified.

Strengths

KW&SB’s workforce and management are technically competent and capable of delivering operational and service improvements. Staff are generally well experienced and exhibit a high degree of personal motivation despite obvious constraints brought about by limitations in organisational development, customer and operational systems and budgets. Managers are generally enthusiastic about the organisation and many have significant experience within the sector. Staff members are loyal to the organisation and many are knowledgeable about the processes in which they are involved. Financial support continues to be provided to KW&SB from the GOS despite disappointing operational and commercial performance.

Weaknesses

Potential weaknesses with recommendations for mitigation are detailed in **Table 35.1.2**.

Table 35.1.2 Organisational Weaknesses Mitigation

Symptom	Recommendations for Mitigation
Lack of clearly defined strategic intent and how this links into individual, team and departmental performance.	Review the strategic intent, vision and mission statement and share these with the entire workforce. This includes the need to prepare and share a KW&SB-wide Corporate Business Plan. Performance targets should be set and measures put in place so that individual and departmental performance supports corporate objectives.
Lack of clearly defined Corporate Strategies.	Define corporate needs and prepare/share strategies with entire workforce. This includes the need for a strategy for asset planning/asset management and development/ asset acquisition; HRD, Customer Services development, etc.
Lack of clearly defined corporate policies and departmental business plans.	Define and share company wide and departmental policies and business plans with appropriate strategies and objectives to enable future improvements.
Lack of clearly defined Business Strategies (operations, customer, commercial, systems, people etc.)	Define departmental strategies, set and agree goals, key performance indicators, measures and action plans for continuous improvement.
There are no clearly defined mechanisms for 'performance managing' the business	Set up a system of performance management that establishes goals and measures for individuals, teams, departments and KW&SB as a whole. This should be a dynamic system that should change as the organisation develops over time.
The use of technology for future development of the business is not well understood or defined.	Prepare IT/Systems strategies that will meet the future corporate business and operational needs.
There are skill gaps in the organisation – human resource development, performance management, regulatory compliance, customer services, communications, corporate and strategic planning, risk management, contingency planning, systems development, community relations and health and safety.	Identify the gaps, train and/or recruit skilled personnel to fill them.
There is no effective job management or work planning system.	Introduce a Job Management System to give better control and information.
Systems for asset management/maintenance are not standardised across functions or departments and the use of computer software or systems to aid asset management/maintenance are not established.	Introduce appropriate technology for the effective management and maintenance of company assets.
Business critical processes are not well defined or 'owned'. For example, Agency Coordination/Government Liaison, Regulatory Compliance, Customer Services, Commercial management, Systems Development, HRD, H&S, Water Quality Management, Supply Chain Management, Operations & Maintenance Management etc.	Define, map and disseminate process routines. Assign key processes to owners or champions. Define and share key policies, strategies and procedures within each process area.
Work routines are generally not recorded to agreed quality standards and a process for sharing best practice is not established.	Codify work practices capturing best practice. Set up training and procedures to ensure the routines are adhered to. Encourage sharing of best practice on a formal basis by service level agreements across process boundaries.
Management information is inadequate and KW&SB	Establish the needs, design and introduce a meaningful

Symptom	Recommendations for Mitigation
struggles to provide any meaningful data to assist with the management of the organisation.	MIS. Train staff in the use of the system.
KW&SB have aspirations to improve customer services, however, does not demonstrate a commitment to being a customer service driven organisation.	All employees should be encouraged to 'think customer', internal and external. Structures need to be geared towards providing customer focus. Recording rather than solving complaints is not enough. Training on customer awareness and customer care should be provided to all existing and new employees.
Customer communication routes require development, including customer feedback.	Develop and agree a customer communications strategy to ensure customers are aware of services, performance against standards and opportunities for feedback. This will enable KW&SB to tailor services to meet changing customer perceptions.
Indications are that KW&SB are not fully utilising Human Resources in terms of efficiency levels as well as numbers of staff employed.	Implement new policies and procedures for staff appraisals, training, development and transfers. Introduce a system of 'succession planning' to ensure the organisation is 'equipped' with competent future leaders.
KW&SB has an aging workforce many of whom have worked for the organisation for many years. Ability to transfer knowledge is being lost.	The age profile will adjust if older employees are released and a programme of recruiting graduates and technicians is introduced. Ensure routines are in place for capture and transfer of knowledge. Ensure a system of equitable career progression based on ability to do the job as well as seniority.
Communications within KW&SB could be improved. There appears to be no mechanism for corporate messages to be cascaded throughout the organisation or for employees to give feedback.	Introduce a fully integrated communication strategy, including written communications, management and team meetings, toolbox talks etc. Feed back loops must be introduced to ensure the views of the workforce are known.
The culture within KW&SB is reactive rather than proactive.	Improve the planning processes and encourage managers and employees to consider the longer term and encourage initiatives for change.
H&S is not well understood or managed.	Assign responsibility for and set up a central H&S support function to ensure compliance with legislation and best practice. Ensure safe systems of work are introduced and that staff are well trained.

Whilst there appears to be a significant number of issues requiring consideration, with the right support from KW&SB's senior management team, each issue creates an opportunity for improvement.

3.5.2 Financial Management

KW&SB was reformed in accordance with the administration reform of Karachi Municipal Corporation (KMC) into City District Government of Karachi (CDGK) in 2001. At present, KW&SB is independently managed under the CDGK. The financial system was also reformed from the system under the former organization. Thus, the financial statements reviewed in this study are limited to those prepared after 2001.

In this study, the financial statements which have been certified by the chartered accountants of "Hashmi and Company" are used for our analysis. The original financial statements were prepared by the Chief Finance Officer of KW&SB. Then, they were subjected to the review and revision by the accountants. Finally, the accountants prepared its certified statements and submitted them to KW&SB with their opinions/comments. There were some differences between the two documents that have not yet been reconciled because of the division of opinions between KW&SB and the accountants. Some figures in balance sheets such as debtors (consumers' balance), deferred revenue, etc. constitute major differences between the two documents. The results of the analysis should therefore be reviewed and revised as necessary when the final versions of the financial statements are made available.

(1) Financial Conditions

a) Trend of Profit and Loss Statement

The financial statements including "profit and loss statement (P/L)" and "balance sheet" (B/S)" are the most fundamental documents to seize the financial management in KW&SB. The P/L for the recent five years is compiled in **Table 35.2.1**. The table shows the annual operation results of water supply and sewerage services. In recent five years, KW&SB recorded consecutively deficit. Although for the beginning two years the revenue covered the direct expenses, it could not cover even the direct expenses for the rest three years.

1. Ordinary profit/deficit: The ordinary results including the both operating and non-operating results recorded the serious deficit, as shown in **Table 35.2.1**. The annual deficit in 2004/05 was Rs.2.36 billion, although that was Rs.0.82 billion in 2000/01. Thus, the accumulated deficit reached to Rs.10.44 billion at the end of the fiscal year 2004/05. This deficit corresponds to the total amount for almost four years of the annual revenue in 2004/05. This trend of the ordinary deficit for the recent five years was illustrated in **Figure 35.2.1**.

2. Revenues from water supply and sewerage services: The business revenue of KW&SB comprises sales of water supply and charges of sewerage service. The respective revenues are furthermore broken down to bulk consumer and retail individual users. As shown in **Figure 35.2.2**, the revenue from water supply accounted for more than 80% of the total revenue. A reason of drastic decrease of the revenue in 2001/02 compared with that in 2000/01 was caused by the application of new tariff effective from the beginning of the fiscal year 2001/02. All consumers were fairly classified into new categories. After 2001/02, the total revenue has increased as shown in the figure, although its trend was no steady.

Of the total water revenue, that from the bulk water consumers accounted for 64% in 2004/05, in spite that the number of the bulk users' connections (4,440 connections) occupies only 0.35% of the total (1.40 million connections) in the same year. The revenue from the retail consumers was only 36% of the total, although the number of the retail consumers accounted for more than 99% of the total. On the other hand, the revenue of sewerage service from the bulk users accounted for 42%. Then, that of the retail users was 58%. Overall percentage shares of the total revenue were broken down as: 54% of water revenue from bulk consumers, 30% from retail consumers, 7% of sewerage service from bulk users, and 9% from retail users.

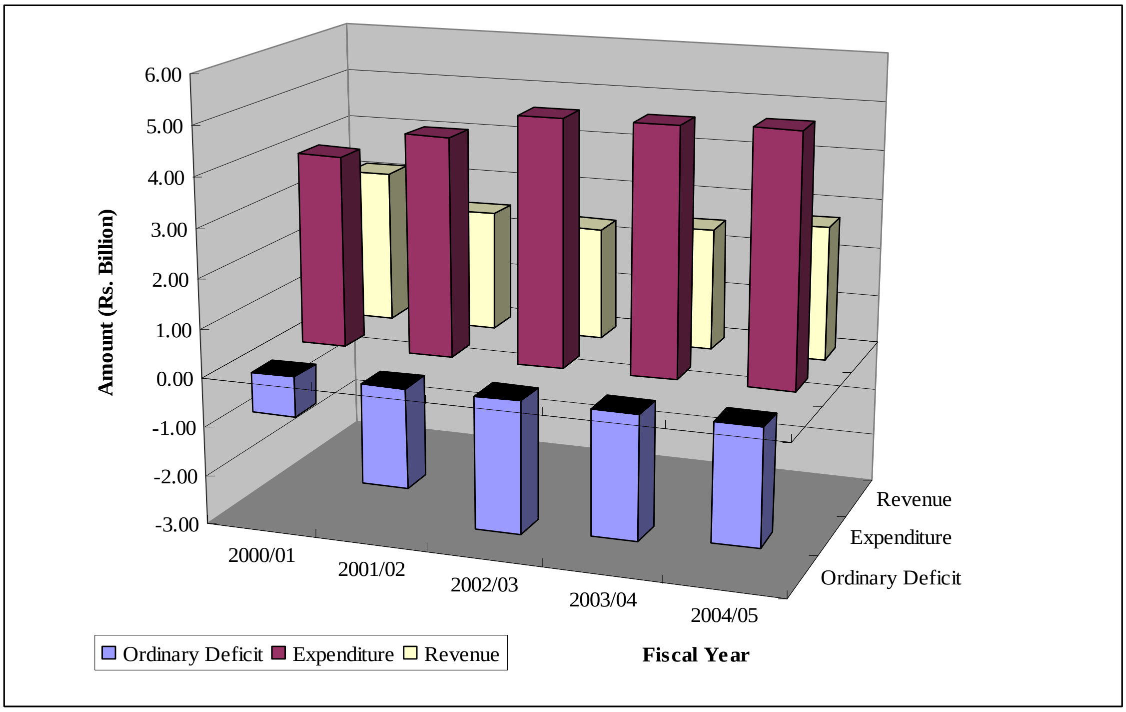


Figure 35.2.1 Operating Performance of KW&SB for Latest Five Years

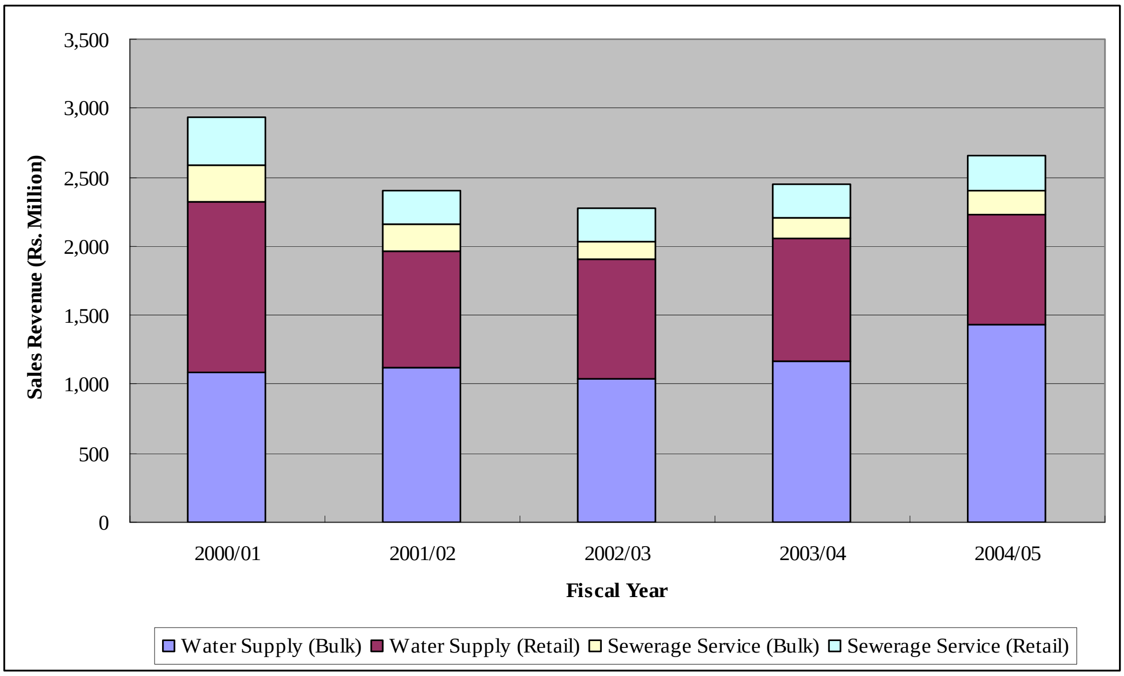


Figure 35.2.2 Details of KW&SB Revenue for Latest Five Years

Table 35.2.1 Profit and Loss Statement: 2000/01-2004/05

(Unit: Rs. in Million)

Item	2000/01	2001/02	2002/03	2003/04	2004/05
Operating Results					
Revenue					
Water Supply					
(1) Water Supply (Bulk)	1,080.62	1,124.06	1,034.88	1,161.49	1,431.15
(2) Water Supply (Retail)	1,236.86	844.85	866.74	899.71	800.89
Sub-total	2,317.49	1,968.91	1,901.62	2,061.20	2,232.04
Sewerage Service					
(3) Sewerage Charges (Bulk)	264.94	196.14	127.25	142.88	176.15
(4) Sewerage Charges (Retail)	350.49	240.61	242.64	250.26	244.42
Sub-total	615.43	436.75	369.89	393.14	420.57
Total	2,932.91	2,405.66	2,271.51	2,454.34	2,652.61
Expenditure					
Direct Expenditure					
(1) Charges of Raw Water to Sindh Gov.	1.05	0.09	0.64	1.41	0.95
(2) Compensation (Salaries and Benefits)	608.81	632.42	773.13	818.58	873.86
(3) Chemicals	15.27	23.59	29.40	15.83	29.22
(4) P.O.L. for Pumping Stations	63.91	60.38	61.92	38.79	44.79
(5) Electricity Charges	1,327.97	1,232.07	1,339.10	1,621.54	1,640.62
(6) Arrears of Electricity Charges			315.58		
(7) Gas Charges			29.14	28.43	23.34
(8) Repair and Maintenance /Improvement	206.80	134.33	108.23	185.04	160.79
(9) Water Supply through Tankers	18.48	1.42			
(10) Vehicles Running Expenses	34.39	29.47	28.93	23.88	37.84
(11) Printing and Stationary	5.26	5.96	5.95	6.58	5.32
(12) Medical	112.48	54.15	62.64	44.00	60.90
(13) Utilities	4.05	4.15	4.38	4.57	4.58
(14) Miscellaneous	10.06	7.80	7.85	8.41	15.68
Sub-total	2,408.52	2,185.82	2,766.90	2,797.07	2,897.88
Indirect Expenditure					
(1) Auditor' Remuneration	0.64	0.64	0.64		
(2) Bad Debts Expenses	315.88	120.28	113.58	122.72	132.63
(3) Depreciation	1,041.33	989.01	939.35	911.06	865.19
Sub-total	1,357.85	1,109.93	1,053.56	1,033.77	997.82
Total	3,766.37	3,295.76	3,820.46	3,830.84	3,895.70
Operating Profit and Loss	-833.46	-890.10	-1,548.95	-1,376.50	-1,243.09
Non-operating Results					
Non-operating Revenue					
(1) Interest Received from Banks	16.06	16.12	9.77	3.88	3.92
(2) Other Income	23.20	35.09	29.51	19.65	63.87
(3) Subsidy from KMC	143.00				
Sub-total	182.25	51.22	39.28	23.54	67.80
Non-operating Expenditure					
(1) Financial Charges on Foreign Loans	169.50	1,190.77	1,183.42	1,183.42	1,183.42
Non-operating Expenditure	169.50	1,190.77	1,183.42	1,183.42	1,183.42
Non-operating Profit and Loss	12.76	-1,139.55	-1,144.14	-1,159.88	-1,115.62
Ordinary Profit and Loss	**-820.70**	**-2,029.65**	**-2,693.09**	**-2,536.39**	**-2,358.71**
Beginning Surplus/Deficit of the Period	3.00	-817.70	-2,847.36	-5,540.44	-8,076.83
End Surplus/Deficit of the Period	**-817.70**	**-2,847.36**	**-5,540.44**	**-8,076.83**	**-10,435.54**

Source: Refer to Table 35.2.3

3. Expenditures: The operating expenditure in the fiscal year 2004/05 was Rs.3.90 billion, as shown in **Table 35.2.1**. Among 17 expenditure items, the top five expenditure items were: (1) Rs.1.64 billion of electricity charges or 42% of the total expenditure, (2) Rs.874 million of compensation (salaries and benefits), 22%, (3) Rs.865 million of depreciation, 22%, (4) Rs.161 million of repair and maintenance, 4%, and (5) Rs.133 million of bad debts expenses, 3%. In addition, a large expenditure item in non-operating expenditure was recorded as Rs.1.18 billion of financial charges. The total expenditure was estimated at Rs.5.08 billion, so the financial charges accounted for 23% of the total. **Figure 35.2.3** illustrates percentage shares of the major expenditure items against the total expenditure including both operating and non-operating expenditures. The major expenditures against the total account for 32% of electricity charges, 23% of financial charges, 17% salaries and benefits and 17% of depreciation.

The financial charges seem to be a heavy burden for KW&SB because the share was 23% of the total expenditure in 2004/05. Although the charges were recorded as Rs.1.18 billion in the P/L, an actual charge was expected as Rs.2.41 billion. The rest charges of Rs.1.23 billion were deferred and recorded into accrued financial charges of long term loans as liabilities in the B/S. Although the charges consist of interest, service charges and commitment charges, the interest occupies the largest portion of the financial charge. The conditionality of foreign loans that KW&SB has borrowed so far is tabulated in **Table 35.2.2**. The annual interest rates were ranged from 11.0% to 2.6%. The outstanding of long term foreign loans was aggregated to Rs.14.48 billion in 2004/05. Incidentally, an average financial charge including local loans was estimated at 14.6% in the same year, that is, the annual financial charge of Rs. 2.41 billion against the outstanding at the beginning of Rs.16.59 billion of the all loans.

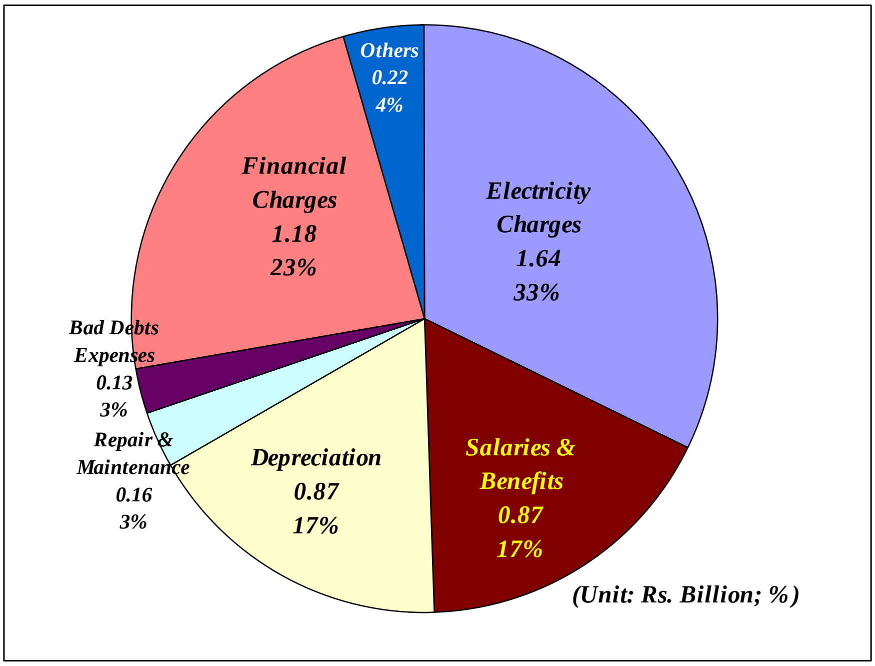


Figure 35.2.3 Share of Major Expenditure Items to Total

4. Expenses tied up with no revenue: At present, KW&SB supplies potable water through tankers and to some public offices at no charges. The expense of "Water Supply through Tankers" is shown in the **Table 35.2.1**. This water service is managed by the Ranger for the areas not served with KW&SB's piped water supply system. In addition, the expenses of no charge water for public offices were also included as a part of water production costs.

Table 35.2.2 Conditions of Foreign Loans and Outstanding at End of June 2005

	Item	A	B	C	D	E	F	G	H
1.	Loan Number	1374-Pak	1652-Pak	1987-Pak	SF-793Pak	SF-1001Pak	SF-1002Pak	L-2747-01	PK-P40
2.	Date of Main Agreement	30-06-1983	24-02-1986	19-05-1993	-	19-03-1990	19-03-1990	25-02-1990	-
3.	Lending Agency	IDA	IDA	IDA	ADB	ADB	ADB	CDC	JBIC (OECF)
4.	Agreed Amount of Loan*1 (in million)	23.00	19.45	163.50	17.89	39.91	26.61	£25.00	¥10,300
5.	Interest (% per annum)	11.0	11.0	11.0	7.0	7.0	7.0	11.0	2.6
6.	Commitment Charges (% per annum)	0.50	0.50	0.50	-	0.75	0.75	0.75	0.10
7.	Service Charges (% per annum)	0.75	0.75	0.75	-	0.10	0.10	-	0.10
8.	Repayment Period in Years	25	25	25	25	35	25	13	20.5
9.	Grace Period in Years	6	6	6	5	10	5	5	5
10.	No. of Biannual Installments	40	38	40	40	50	40	26	41
11.	Repayment Date Each Year	01 Mar & 01 Sep	15 May &15 Nov	01 Mar & 01 Sep	15 May & 15 Nov	15 Jun & 15 Dec	15 Jun & 15 Dec	15 Apr & 15 Oct	20 May & 20 Nov
12.	Repayment Starting Date	01-09-1996	15-05-2000	01-09-2004	15-05-2001	15-12-2007	15-12-2007	15-10-2002	20-11-2004
13.	Repayment Share of Agency against Major Works (%)	75	78	80	78	80	80	100	92
14.	Date of Financial Closure	31-10-1991	30-12-1993	30-06-1998	31-12-1995	30-09-1997	30-09-1997	-	30-09-1999
15.	Outstanding as of End of June 2005 (Rs. Million)	363	628	6,943	826	2,542		1,018	2,153
16.	Financial Charges Imposed by End of June 2005 (Rs. Million)	38	605	6,532	351	1,858		789	171

Remark: *1 In case of no monetary denomination, monetary unit is SDR in million

Furthermore, "Bad Debts Expenses" reckoned up as indirect expenditure every year. These expenses are allocated to a service for Katchi Abadis. The amount of this service corresponds to 5% of the total revenue of water supply and sewerage services. In another words, these expenses were written off as bad debts in the P/L under social consideration. These water supply and sewerage service arrangements come from historical and political vested rights.

b) Trend of Balance Sheet

The B/S of KW&SB for the recent five years from 2000/01 to 2004/05 is compiled in **Table 35.2.3**. In the fiscal year 2004/05, the total assets were estimated at Rs.36.9 billion. The total assets were broken down to Rs.29.4 billion of fixed assets and Rs.7.5 billion of current assets. As a matter of course, liabilities and equity were Rs.36.9 billion. They consist of the following items: Rs.25.2 billion of long term liabilities, Rs.4.6 billion of current liabilities and Rs. 7.1 billion of stockholders' equity.

1. Accounts receivable from consumers: The debtors (consumers' balance) in the current assets are an account receivable from consumers. The amount of the debtors consecutively increased from Rs.4.8 billion in 2000/01 to Rs.6.0 billion in 2004/05, as shown in **Table 35.2.4**. These figures are shown as "considered good" among the total debtors in the table below. Its annual increase rate was 5.8% on average. The total debtors of Rs.6.0 billion were furthermore broken down to Rs.2.6 billion of water supply and Rs.2.8 billion of sewerage services. By the end of the fiscal year 2004/05, the total amount of Rs.3.2 billion was already written off as bad debts, which were listed in "considered doubtful" among the total debtors. They were broken down to Rs.2.8 billion of water supply and Rs.0.4 billion of sewerage services. Thus, the debtors were aggregated to Rs.9.2 billion in 2004/05, if the bad debts had not been written off.

Table 35.2.4 Details of Debtors' Trend: 2000/01~2004/05

(Unit: Rs. Million)

Debtors (Unsecured) (in accumulation)	2000/01	2001/02	2002/03	2003/04	2004/05
Water	4,525	4,870	5,047	5,423	5,683
Considered Good	2,293	2,539	2,621	2,809	2,932
Considered Doubtful	2,232	2,331	2,426	2,615	2,751
Sewerage	2,826	3,008	3,155	3,298	3,480
Considered Good	2,486	2,646	2,775	2,900	3,061
Considered Doubtful	340	362	380	397	419
Total	7,351	7,878	8,202	8,721	**9,163**
Considered Good	4,779	5,185	5,396	5,709	**5,992**
Considered Doubtful	2,572	2,692	2,806	3,012	**3,171**
Bad Debts Expenses (annual figure in P/L)	316	121	114	123	**133**

The annual sales revenues should be included completely as annual income from operational services. As mentioned before, around 5% of the total revenue is set as bad debts and subtracted from the income as indirect expenditure at present. The rest of revenue is considered to be actual income in the year. In addition, approximately 20% of the total revenue becomes accrued income every year, which is named as "considered good for collection". This is reckoned as "debtors (consumers' balance)", i.e., accounts receivable. The accumulation of the debtors included as Rs.5,992 million in the B/S of 2004/05.

After July 2006, KW&SB has issued a newly designed bill to every consumer on monthly basis, although it has distributed its bill once a year before. The new bill includes not only the monthly charge of water supply, sewerage service, conservancy and fire charges, but also arrears in the past. Thus, the consumer has to settle his arrears account step-by-step, if he has left unpaid in the past. In terms of current charge, a consumer has to pay an arrearage charge monthly at an annual rate of 10%, if he does not pay within the due date.

Table 35.2.3 Balance Sheet: 2000/01-2004/05

(Unit: Rs. in Million)

Item	2000/01*1	2001/02*1	2002/03*1	2003/04*2	2004/05*2
Assets					
1. Fixed Assets					
(1) Operating Fixed Assets	22,240	21,231	20,273	19,633	19,069
(2) Work in Progress	4,696	5,196	5,971	6,979	10,301
Sub-total	26,937	26,427	26,243	26,612	29,370
2. Current Assets					
(1) Inventory	-	-	-	-	-
(2) Debtors (Consumers' Balances)	4,779	5,185	5,396	5,709	5,992
(3) Advances and Prepayments	65	61	13	11	9
(4) Receivable from KDA	98	98	98	98	98
(5) Receivable from KMC	206	206	206	206	206
(6) Cash in Bank	810	954	632	531	1,250
Sub-total	5,959	6,505	6,346	6,556	7,556
Total of Assets	**32,896**	**32,932**	**32,589**	**33,168**	**36,926**
Liabilities and Equity					
1. Long Term Liabilities					
(1) Consumer Deposits	130	143	157	172	216
(2) Long Term Foreign Loans	21,052	22,311	23,602	24,445	24,818
1) Principal	13,674	13,907	14,107	14,270	14,473
2) Accrued Financial Charges	7,377	8,404	9,495	10,174	10,344
(3) Long Term Loan from KDA	108	106	105	104	103
(4) Sindh Loan (Government)	58	58	58	58	58
Sub-total	21,348	22,618	23,921	24,779	25,194
2. Current Liabilities					
(1) Current Maturity of Long Term Foreign Loans	674	1,022	1,356	2,189	3,509
1) Principal	52	230	318	338	595
2) Accrued Financial Charges	623	792	1,039	1,851	2,914
(2) Current Maturity of Long Term Local Loans	24	26	27	28	29
(3) Contractor Deposit	399	392	407	444	543
(4) Creditors, Accrued & Other Liabilities	465	439	255	453	579
Sub-total	1,562	1,879	2,046	3,113	4,660
Total of Liabilities	22,909	24,497	25,967	27,893	29,854
3. Stockholders' Equity					
Capital Reserve	3,771	3,771	3,771	3,771	3,771
Internal Reserve/Withdrawals	-818	-2,847	-5,540	-8,077	-10,436
Grant in Aid (for Capital Works)	7,033	7,512	8,392	9,581	13,736
Total of Equity	9,986	8,436	6,622	5,275	7,072
Total of Liabilities and Equity	**32,896**	**32,932**	**32,589**	**33,168**	**36,926**

Remark: *1 Information was based on the documents of 1. and 2. below.
*2 Information was based on the documents of 3 below with some revision by the JICA team.

Source: 1. Chartered Accounts, KWSB Financial Accounts for the Year Ended 30 June 2002, Hashmi & Company
2. Chartered Accounts, KWSB Financial Accounts for the Year Ended 30 June 2003, Hashmi & Company
3. Final Draft, Financial Account 2003/04-2004/05, KWSB

2. Foreign loans: At the end of the fiscal year 2004/05, the foreign loans were recorded in the B/S, which were summarized in **Table 35.2.5**.

Table 35.2.5 Outstanding and Accrued Financial Charges of Foreign Loans in 2004/05

Item	Long Term Liabilities	Current Liabilities	Total
Total of Foreign Loan Liabilities	24.8	3.5	28.3
Principal	14.5	0.6	15.1
Accrued Financial Charges	10.3	2.9	13.2

The details of principal outstanding by lending agency regarding the long-term liabilities were broken down in the 15th line of **Table 35.2.2**. The outstanding of principal was Rs.14.5 billion in total. The accrued financial charges were an accumulation of financial charges which were the sum remaining after subtracting paid financial charges from the entire financial charges in the year. The accrued financial charges mounted up to Rs.10.3 million, accounting for 71% of the principal outstanding. Once adding the current foreign liabilities to them, the total foreign liabilities reached at Rs.28.3 billion, as shown in the table above. The accrued financial charges were Rs.13.2 billion, 87% of the total outstanding principal of Rs.15.1 billion. The total outstanding of Rs.28.3 billion was equivalent to more than 10 years' annual sales of 2004/05.

KW&SB recorded an accumulated deficit of Rs.10.4 billion in 2004/05, as shown in **Table 35.2.3**. This deficit was covered by stockholders' equity and grant in aid. Since the equity was Rs.3.8 billion only, most of the deficit was covered by grants. The details of the respective fiscal years were tabulated in **Table 35.2.6**.

Table 35.2.6 Financial Sources for Accumulated Deficits: 2001/02~2004/05

Grant Sources	2000/01	2001/02	2002/03	2003/04	2004/05
From Federal & Provincial Government					
Grant-in-Aid	2.17	2.15	2.13	2.11	2.09
Grant-in-Funding	3.53	3.53	3.53	3.53	3.53
Grant-in-GOS	1.00	1.00	1.90	2.50	3.04
From Overseas Development Association	0.33	0.33	0.33	0.33	0.33
Greater 100 MGD Water Supply (K-III)	-	0.50	0.50	1.11	4.74
Total	7.03	7.51	8.39	9.58	13.73

Incremental deficits of the respective years were mainly covered by the following agencies, as shown in **Table 35.2.7**.

Table 35.2.7 Agencies for Covering Accumulated Deficits: 2001/02~2004/05

Grant Sources	2000/01	2001/02	2002/03	2003/04	2004/05
Grant-in-Aid	-	-0.02	-0.02	-0.02	-0.02
Grant-in-GOS	-	0.00	0.90	0.60	0.54
Greater 100 MGD Water Supply (K-III)	-	0.50	0.00	0.61	3.63
Total	-	0.48	0.88	1.19	4.15

As shown in the list above, the incremental deficit was covered by the grants from GOS and the K-III project. The total increment of Rs.6.7 billion for the four years was shared as follows: Rs.2.04 billion of GOS and Rs.4.74 billion of K-III project.

3. Inventory: In inventory accounts in the current assets, office supplies and furniture in addition to goods for operation and maintenance like chemicals, tools and parts of pipes, electrical equipment and machinery are included as of the end of the fiscal year. Shortages of these stocks in warehouse will hinder ordinary operation and maintenance of water supply and sewerage services as well as management works. In the B/S, the inventory did not have any figures, although its amount is naturally small as compared with other accounts. Accordingly, this means that the inventory stock may be quite small and in shortage conditions.

4. Operating fixed assets and work in progress: The fixed assets comprise Rs.19.1 billion of operational fixed assets and Rs.10.3 billion of work in progress. The book values of the operational fixed assets decreased year by year because of depreciation. The total fixed value in 2004/05 exceeded the 2000/01 level owing to the positive investment as work in progress during 2003/04 and 2004/05. In particular, the investment of K-III project contributed to the balance of the fixed assets. In order to catch up the water demand increase, consecutive

investments are inevitable for a set-up in water supply and sewage treatment capacity. As a result, the fixed assets increase in keeping with these investment activities. **Tables 35.2.8** and **35.2.9** show the detail conditions of the operating fixed assets and investment records of work in progress at the end of the fiscal year 2004/05.

Table 35.2.8 Schedule of Depreciation Charges up to June 2005 (1/2)

(Unit: Rs.Million)

	Name of Assets	Opening Balance 01-07-2004	Additions/Transfers During the Year	Total Cost	Rate of Depreciation	Depreciation During the Year	Written Down Value Balance
I.	Own Generated Assets (W&S)						
	Category A						
	1. Vehicles	10.90		10.90	10%	1.09	9.81
	2. Office Equipment & Furniture	8.44	1.05	9.49	10%	0.95	8.54
	3. Office Building	0.49		0.49	5%	0.02	0.46
	4. Plants & Machines	12.46		12.46	10%	1.25	11.21
	Total	32.29	1.05	33.33		3.31	30.02
	Category B						
	1. KCH Water Supply Project IDA 1374-Pak	563.34		563.34	5%	28.17	535.17
	2. KCH Water Supply Project IDA 1652	710.90		710.90	5%	35.55	675.36
	3. KCH Water Supply Project ADB793(SF)-Pak	914.02		914.02	5%	45.70	868.32
	4. K.S.D.P.-II ADB Credit 1001-1002 Pak	2,681.36		2,681.36	5%	134.07	2,547.30
	5. KCH Water Supply Project IDA 1987-Pak	11,125.04		11,125.04	5%	556.25	10,568.79
	6. Government Aided Projects	305.49		305.49	5%	15.27	290.21
	7. Work Executed by Self Faineance (KWSB)	4.53		4.53	5%	0.23	4.30
	Total	16,304.68	0.00	16,304.68		815.23	15,489.44
	Category C						
	1. Sewerage Cleaning Machine	14.71		14.71	10%	1.47	13.24
	Total	14.71	0.00	14.71		1.47	13.24
II.	Assets Transferred from KMC						
	1. Lands	2,137.38		2,137.38	-	0.00	2,137.38
	2. Buildings	121.41		121.41	5%	6.07	115.34
	3. Plants & Machineries	19.16		19.16	10%	1.92	17.24
	4. Sewerage Pipe Lines	241.82		241.82	5%	12.09	229.73
	Total	2,519.77	0.00	2,519.77		20.08	2,499.70
III.	Assets Transferred from KDA and KWMB						
	1. Capital Work KWSB	1.68		1.68	5%	0.08	1.60
	2. Capital Work from KDA	364.89		364.89	5%	18.24	346.65
	3. Spares and Stores	7.34		7.34	10%	0.73	6.61
	4. Machineries and Equipments	2.65		2.65	10%	0.27	2.39
	5. Laboratory Inventory	0.48		0.48	10%	0.05	0.43
	6. Other Minor Fixed Assets	0.01		0.01	10%	0.00	0.01
	Total	377.05	0.00	377.05		19.38	357.67

(To be continued)

Table 35.2.8 Schedule of Depreciation Charges up to June 2005 (2/2)

(Unit: Rs.Million)

		Name of Assets	Opening Balance 01-07-2004	Additions/Transfers During the Year	Total Cost	Rate of Depreciation	Depreciation During the Year	Written Down Value Balance
IV.	Capital Scheme (Sewerage)							
	1.	Renovation Scheme of Sewerage in PECHS & KCHS	23.99		23.99	5%	1.20	22.79
	2.	Lyan Sewerage Scheme	60.48		60.48	5%	3.02	57.45
	3.	Ren & Rpl of Water Supply in N.N. & F.B.Area	29.91		29.91	5%	1.50	28.41
		Total	114.38	0.00	114.38		5.72	108.66
V.	Work-in-Progress (Water)							
	Category A							
	1.	KCH Water Supply Project IDA 1987 II Pak	0.00		0.00			0.00
	2.	KCH Water Supply Project ADB 793(SF) Pak	0.00		0.00			0.00
	3.	KCH Water Supply Project ADB 1001 Pak	0.00		0.00			0.00
	4.	KCH Water Supply Sanitation Project L2747-01	3,019.75		3,019.75			3,019.75
	5.	Pumping Conveyance System	639.33		639.33			639.33
	6.	Improvement Project PK-P40 Japan	2,135.99	551.88	2,687.87			2,687.87
	7.	GKBWS Scheme K-III	1,136.09	3,110.27	4,246.35			4,246.35
	8.	Bank Balance with FAP	8.08		8.08			8.08
		- ditto -	39.40	39.40	0.00			0.00
		Total	6,978.64	3,701.55	10,601.38		0.00	10,601.38
	Category B							
	1.	Misc. C-W.I.P.	270.15		270.15			270.15
		Total	270.15	0.00	270.15		0.00	270.15
Grand Total			26,611.65	3,702.60	30,235.44		865.19	29,370.26

Source: Financial Accounts 2004-05 (Draft), March 2006, KWSB

(2) Management Characteristics

On the basis of the financial statements of the water supply and sewerage services, the management diagnosis was conducted to characterise the KW&SB's services in Karachi City. As a result of the diagnosis, several management indices show the management characteristics of KW&SB. **Table 35.2.5** shows the management indices. Referring to these indices, the management conditions in 2002/03 to 2004/05 were discussed from the following points of view: profitability, safety and productivity. Based on the financial indices, the study team points out some financial problems and issues for discussion on the management, aiming sound management solution in the future.

The water supply and sewerage services of KW&SB are managed in the manner of public corporative under CDGK in Karachi City. KW&SB management introduces an international account system and establishes its budgets based on objectively quantitative data and information. Management indices through the diagnosis are one of the most effective sources for reconsideration of management improvement. In **Table 35.2.5**, the indices of Japanese water supply services are listed as statistical standard data of the water supply business in Japan. Most of Japanese water supply services are managed by public service corporations under their municipal government.

a) Analysis of Profitability

During the three years from 2002/03 to 2004/05, the net profit was negative, so no ratio could be calculated as index as shown in **Table 35.2.10**. KW&SB has consecutively recorded negative of operating deficit over recent years. The deficit increased from 2000/01 to 2002/03, but it decreased gradually after 2003/04.

"Turnover of capital" was 0.07 for the three years, as shown in the Line No.2 in the table. This rate of turnover was smaller than the Japanese index of 0.11. Among the capital, equity is recorded as Rs.3,771 million, it is completely withdrawn to cancel of the accumulated deficit for long time. In fact, the accumulated deficit was much more than the stockholders' equity. Thus, the actual rates are considered as negative because of the huge accumulated deficit. In consequence of this negative, grants in aid were appropriated for making up for this condition, as discussed in the sub-section "Trend of Balance Sheet".

As understood from the ratio of net expense to net sales amount in Line No.5, the ratios are more than double of that of the Japanese index. The ratios in these years suggest that the net expenses were more than two times of net sales. The Japanese rate indicates 6% of ordinary profit. On the other hand, KW&SB has recorded almost the same amount of deficit as the total sales after the fiscal year 2002/03.

The Lines of No.16 and No.17 in the table confirm the obvious fact above. In 2004/05, an average unit price was estimated at Rs.21 per 1000 gallon. On the other hand, an average unit production cost was estimated at Rs.40 per gallon. The unit price was only 53% of the unit cost. Incidentally, the Japanese case shows that the percentage was 99%, i.e., Rs.350 per gallon of unit cost to Rs.354 per gallon of unit production cost. This phenomenon gives KW&SB a warning of reconsideration on structure of revenue and expenditure.

b) Analysis of Safety

The current ratio provides a measure of solvency in financial situation. The ratio of KW&SB was more than 300 in 2002/03. In the following two years, the ratios went down but still kept more than 100%. This means that its financial solvency is sufficiently high. It has enough financial capacity for payment. Thus, it is in good condition for solvency, from the viewpoint of index. However, most parts of current assets were account receivables, accounting for 83% in 2004/05. These account receivables for KW&SB were considered to be low cashability.

In consequence of this, the financial liquidity considered through actual current ratio is considered to face liquidity crisis in actuality.

Table 35.2.10 Management Indices of Water Supply and Sewerage Services by KW&SB: 2002/03-2004/05

	No.	Item	Unit	2002/03	2003/04	2004/05	Index in Japan*1
Management	1.	Ratio of Net Operating Profit to Total Capital	%	-	-	-	0.73
	2.	Turnover of Total Capital	-	0.07	0.07	0.07	0.11
	3.	Turnover of Stockholders' Equity	-	(0.60)	(0.65)	(0.70)	0.22
	4.	Capital Adequacy Ratio	%	11.6	11.4	10.2	52.6
	5.	Ratio of Net Expense to Net Sales Amount	%	220	204	191	94
Finance	6.	Current Ratio	%	310	211	163	273
	7.	Fixed Assets Ratio	%	538	521	506	176
	8.	Ratio of Fixed Assets to Long-Term Capital	%	73.2	68.8	65.8	95.3
	9.	Turnover of Account Receivable	-	0.42	0.43	0.45	7.4
	10.	Turnover of Fixed Assets	-	0.11	0.13	0.14	0.12
	11.	Ratio of Depreciation to Fixed Assets	%	4.6	4.6	4.5	3.5
	12.	Ratio of Depreciation to Net Expenses	%	18.8	18.2	17.0	28.6
	13.	Ratio of Interest to Net Expenses	%	23.5	23.5	23.2	18.5
Production	14.	Annual Production per Employee	Rs.1000/ Person	267	300	324	19,900
	15.	Turnover of Raw Material	-	1.4	1.3	1.4	14.1
	16.	Unit Price*2	Rs./ 1000 gallon	-	-	21	350
	17.	Unit Production Cost*2	Rs./ 1000 gallon	-	-	40	354
Labour	18.	Monthly Compensation per Employee	Rs./month /Person	7,579	8,229	8,902	379,000
	19.	Ratio of Compensation to Net Sales Amount	%	34.0	33.4	32.9	22.7
	20.	Ratio of Compensation to Net Expenses	%	15.5	16.3	17.2	22.5
	21.	Number of Employees per Water Supplied*2	Persons/ Mil.gal./day	-	-	22	6.4

Note: *1 Indices of Japanese water supply systems serving more than 300,000 residents with surface water sources.
*2 Annual served volume was estimated at 351 mgd in 2004/05, provided by IT Section as provisional.

The ratios of fixed assets were checked through (a) fixed asset ratio and (b) ratio of fixed assets to long-term capital. The former ratio is desirable to be less than 100%. The real ratio of the KW&SB was more than 500% for the latest three years, which was also more than the Japanese index of 178%. However, even if the former ratio were in worse condition but if the latter ratio were less than 100%, the safety might be fair within the permissible range of safety. The ratio of the KW&SB was less than 80% in the respective years. Thus, the composition of capital and liability is biased to long-term liabilities more than capital. At any rate, KW&SB seems to be in fair condition for fixed assets, as well.

In terms of equity, capital adequacy ratio in the Line No.4 was between 10.2% and 11.6%. This ratio was quite small as compared with the Japanese index. Water supply and sewerage service business is a kind of process industries, so a huge investment is indispensable to establish this business. It is quite important to procure a huge amount of investment capital through stable shareholders. From this point of view, the capital adequacy ratio was too small to keep the financial safety. This is one of the alarms for capital formation.

In terms of turnover of account receivable, it indicates speed of bill collection. The larger index means the better efficiency for capital utilisation. KW&SB recorded a quite worse index like 0.42 to 0.45. These figures were considerably low as compared with the Japanese index of 7.4. These indices mean that KW&SB spend 16-18 times more time to collect bill than the Japanese water supply enterprises.

A period of bill collection is calculated applying the following formula:

Period of Bill Collection = 365 days / Turnover of Account Receivable

Applying this formula, the index 0.45 of the turnover of account receivable in 2004/05 means that it takes 810 days or around 2.2 years to collect bills on average. In general, the turnover should be kept between 6.0 and 8.0, to manage the business in safe condition. Thus, the turnover of KW&SB should be improved as soon as possible for financial safety purpose.

The ratio of depreciation to fixed assets was 3.5% in most cases of Japanese water supply systems. The ratio of KW&SB was almost 4.5, so it was somewhat larger than the Japanese cases. This means that KW&SB set useful lives of major depreciable assets in slightly shorter than Japanese systems. The ratio of depreciation to fixed assts shows a size of depreciation against a book value of fixed assets. An inverse number of the ratio, then, shows an average residual life of fixed assets. For instance, 4.5% in 2004/05 indicates around 22 years of residual life.

The efficiency of fixed assets' utilization is examined through the indices of "turnover of fixed assets". The smaller index indicates that the fixed assets are utilised more effectively. This turnover of KW&SB was between 0.11 and 0.14. These values were similar of the Japanese index, so the fixed assets are utilised almost the same effectiveness as those in Japan.

The ratio of interest to net expenses indicates static safety of financial procurement. The smaller index shows the better soundness of management. The ratio of KW&SB was calculated as between 23.2% and 23.5% as shown in the Line No.13. These values were more serious than that of the Japanese index (18.5%). Moreover, KW&SB could not pay a part of interests within due time and carry forward it to the next year, which was reckoned in accrued financial charges in the B/S. Accordingly, if these accrued financial charges were added to this index calculation, the ratio jumped up to 50.2% in 2002/03, 29.8% in 2003/04 and 24.3% in 2004/05. This was brought about through KW&SB's negotiation with donors. However, KW&SB would rather negotiate with donors for better conditionality and/or look for better financial sources to decrease interest burden.

c) Analysis of Productivity

Main check points of productivity are (1) ratio of compensation to net sales and (2) ratio of compensation to net expenses. The former ratio of KW&SB was between 32.9 and 34.0, as shown in the Line No.19. This was higher than the Japanese index of 22.5%. Although the higher ratio is inevitable for process industry like water supply service, even so more than 30% was too large to manage the water supply and sewerage services. The latter ratio was between 15.5% and 17.2%, in the Line 20. This was lower than the Japanese one of 22.7%. These phenomena were caused by the huge difference between annual sales and expenditure of KW&SB.

As shown in the number of employee per water volume supplied in the Line No.21, the number of staff for water supply services seems to be quite large as compared with the Japanese average. It was 22 persons per million gallon/day, which were more than three times of the Japanese index of 6.4 persons per million gallon per day (14 persons per 10,000 m^3 per day). Thus, the operation program might be improved considering the future management conditions.

Average monthly compensation of KW&SB was recorded to increase from Rs.7,600 in 2002/03 to Rs.8,900 in 2004/05, as shown in the Line No.18. On the other hand, average annual production per employee was calculated as from Rs.267,000 in 2002/03 to Rs.324,000 in 2004/05, as shown in the Line No.14. This annual production was recalculated as from Rs.22,300 per month in 2002/03 to Rs.27,000 per month in 2004/05. Thus, a ratio of compensation per production was calculated as from 0.34 in 2002/03 to 0.33 in 2004/05. In the same manner, the Japanese ratio of compensation per production was 0.23, i.e., Rs.19,900,000 per year of production against Rs.379,000 per month of compensation. These figures are completely the same as the ratio of compensation to net sales in the Line No.19. Eventually, KW&SB should improve the labour productivity from the viewpoint of productivity enhancement.

Yet, the analysis through management indices might be conducted with discretion. In the case of the comparison analysis like conducted in this analysis in particular, the economic and social background of the two countries is too different to compare with each other easily. KW&SB alters its management policy based on these analyses, it should consider its management conditions such as office-automation, telemetric system, labour-saving through remote-control, payment into bank account, outsourcing of metre reading, etc. as well as the results of index analysis.

Finally, purchasing and inventory system is considered in this section. It was usually conducted through an annual purchasing plan usually proposed at the beginning of the fiscal year. However, inventory stock was not included in the B/S. Moreover, turnover ratio of net sales amount to raw material was almost 1.4, as shown in the Line No.10. This value was quite small as compared with the Japanese index of 14.1. This is because the electricity expense was included in the raw materials, accounting for 88% of the total cost of raw materials. This phenomenon was quite distorted composition of expenditure. These important components should be reconsidered as soon as possible, as well.

(3) Problems

In this section, some financial problems are discussed, which were identified through the analysis of financial conditions and the diagnosis of financial statements.

a) Too Small Operating Revenue

The huge deficit in every year mainly would come from too small operating revenue. For the latest few years in particular, the revenue covers only a half of the total expenditure. The accumulated deficit aggregated to Rs.10.4 billion in 2004/05, accounting for around four times of the annual revenue in the same year. Besides, the annual revenue has not been stable for these years. Moreover, some of the revenue can not be counted as actual income because of no charge water. This revenue problem would make KW&SB into difficult position to improve its management.

b) Too Large Operating Expenditure

The operating expenditure for last four years has consecutively increased year by year, in spite of the fluctuating operating revenue. For the recent three years in particular, the total expenditure including non-operating expenditure reached more than double of the total revenue. Of the total expenditure in 2004/05, the top four expenditure items were as follows: (1) Rs.1.64

billion of electricity charges or accounting for 33%, (2) Rs.1.18 billion of financial charges, 23%, (3) Rs.0.87 billion of compensation, 17%, and (4) Rs.0.87 billion of depreciation, 17%. The total of these four items occupies 90% of the total expenditure.

Electricity charge is the most serious component to lift water production cost. It is an essential cost for KW&SB to convey water source from Indus River. Nevertheless, it is a critical cost in operational expenditure, so from the viewpoint of cost saving KW&SB would rather find another way out of purchasing electricity as it is.

Financial charge is also serious component for high water production cost. Moreover, KW&SB could not pay a part of interests within due time and carried forward it to the next year. That is reckoned in accrued financial charges in the B/S of the following year. This would obviously be proof of heavy burden for financial management.

Compensation for workers of KW&SB is an essential component for operation of water supply and sewerage services. This cost would still has plenty of room for improvement and cost saving. Management systems in use in countries that are advanced ought to be instructive with regard to this problem.

c) Financially Ailing Structure

KW&SB confronts structural fiscal deficits. In order to solve this structural problem, KW&SB has to bring about a much more radical reform of the management system. In the first step, it determines a management policy. In case that KW&SB aims to manage the water supply sewerage service as an independent entrepreneur, it would rather adopt a "cost recovery policy". To realize the policy, it must plan a step-wise programme with implementation schedule.

It would be necessary for KW&SB to take the following step for implementing the cost recovery policy:

1) To grasp precisely water production cost and sewage treatment cost. These costs are the most fundamental matter of cost recovery policy. Some investments of this first programme would be necessary to implement this research.
2) To formulate a new tariff system implementation programme to realize the policy. The tariffs correspond to the water production cost and the sewage treatment cost. In addition, they also reflect social welfare policy and public safety as well as KW&SB management policy.
3) To inform stakeholders of the tariffs with data and information, and to reach an accord on these tariffs with them through discussion. Freedom of information would be requisite for KW&SB to succeed in accomplishing its strategy.

d) Excessive Account Receivable

KW&SB has huge debtors (account receivable from consumers) at present. In 2004/05, its amount was Rs.6.0 billion, corresponding to 2.2 times of the annual sales in the same year, or around 15 times of the standard value as a normal utility business. KW&SB ought to be financially very tight due to these huge debtors. This heavy outstanding of the debtors might blunt KW&SB's new financial improvement strategy above. Thus, KW&SB has to work on reducing these debtors and to discuss with the local governments concerned.

e) Undercapitalisation

Equity of KW&SB is Rs.3.8 billion only at present. It accounts for around 10% of the total capital (liability and equity), i.e., Rs.36.9 billion in 2004/05. Water supply and sewerage services are one of the processing industries, so huge capital investment is not indispensable to manage the business soundly. In fact, the average adequacy ratio is more than 50% among many sound entrepreneurs of water supply business in Japan. Around 10% of KW&SB's

capital is too small to manage its undertaking. Thus, KW&SB is thrown into a predisposition to rely on borrowing money. In the near future, KW&SB should make an effort to reinforce its equity through discussions with local governments concerned.

3.5.3 Human Resource Development

Human Resource Management aspects are detailed in **Section 3.5.1** above. However, this sections deals specifically with Human Resource Development (HRD).

There is no longer a central coordinating role at policy level dealing with HRD. This has been devolved to the respective CE's and CO's to manage within their areas of responsibility. KW&SB will need to take care that the lack of a central HRD Department with competent staff to deliver training and development activities, does not dilute their development efforts.

(1) Building Staff Capacity

Programmes for building staff capacity should be aimed at developing technical competencies, process competencies and managerial competencies to ensure efficient operation of all aspects of the business. Currently, apart from a variety of basic skills training courses, skills are developed by means of on-the-job training.

KW&SB can gain significant improvements in business and staff performance by enhancing and aligning skill levels with the stated needs of the business. This will require considerable investment in assessing competencies and tailoring training and development needs of each employee throughout the organisation to meet agreed individual, departmental and corporate objectives. This would lead to the need for introducing a "corporate training and development plan", which will require continuous monitoring and development. Some of the key activities associated with building staff 'capacity', with suggested benefits of taking a planned approach to training and 'capacity building', are outlined below:

- A move towards a competency based organisation
- The ability to identify individuals who are capable of 'moving up' in the organisation
- Improvement in performance for individuals, teams and the organisation as a whole

Based on initial discussions, there appears to be a need to:

- Define and set a policy for human resource development and training that is centrally 'owned'
- Reviews the policy on staff promotions and system of job transfers and ensure that promotional and transfer decisions are based on first hand knowledge of the individual's performance and suitability to fulfil roles that will 'add value' to the individual and to the business
- More emphasis be placed on developing and motivating 'lower grade' staff, clerical staff and engineers at more junior level to enhance performance and output as these grades form the majority of employees compared to the more senior grades
- The introduction of new staff or graduate trainees with qualifications to match areas where expertise is limited, for example customer services, business planning, health and safety, information systems/technology, etc. This process has been recently initiated by KW&SB and is already underway.

(2) Training

Currently responsibility for training rests with the Director (Training) within the DMD (P&D) Department. However, resources are limited and those most training is conducted on-the-job.

KW&SB do not have a formal training policy or documentation regarding the training and development needs of individuals or KW&SB as a whole. However, both internal and external training is provided as funds allow. It is recommended that all training in future is based on individual and departmental development needs and should be targeted and prioritised, rather than be made available to those who have time to attend.

The quality and success of training imparted is not measured or monitored. We recommend introduction of a system that measures the effectiveness of training delivered and the effects of training on the trainee's performance.

(3) Performance Appraisals

Currently KW&SB do not conduct conventional staff performance appraisals. 'Job descriptions' are not widely used and therefore, key tasks and priorities and how these are measured are not always clearly understood. A system for sharing corporate objectives has not been developed and therefore it is not clear how departmental or functional objectives are set and measured to ensure that these contribute to wider corporate goals. A system for sharing departmental objectives has not been developed and therefore it is not clear how individual's objectives contribute to wider departmental objectives.

KW&SB do not have a system in place for formally setting or communicating corporate, departmental or personal performance targets/key performance indicators and performance measures are not formally set or monitored. The current system of 'rewards and recognition' (terms and conditions) does not relate to performance and therefore good performance goes largely 'unrecognised' and poor performance goes largely 'un-checked'.

No or little feedback is given to individuals regarding their performance; consequently, training or future development needs are not formally discussed, agreed or documented. For KW&SB to be a successful service organisation, employees must know what is expected of them and to have the opportunity to learn new skills to improve their contribution to the 'Business'.

Considering the above, it is recommended that a system of performance appraisals is introduced that ensures:

- Each employee has a clear understanding of their role, its purpose, and how they contribute to the achievement of the team and KW&SB goals – performance and expectations are agreed and stated clearly for everyone
- Performance is managed in a way that is relevant to the type of work undertaken by an individual and with standards appropriate to the role
- Performance management is not 'done to people' but is a process in which the employee plays a full part. This will build employee commitment, motivation and job satisfaction
- Consideration is given to 'softer' issues or role specific behaviours such as 'customer service orientation' as well as 'harder' issues when determining performance achievement against targets
- Every employee has a clear performance plan agreed with their line manager and how performance will be measured
- Every employee has a clear understanding of how they are performing and the opportunity and support to build on their performance
- Individuals with responsibility for managing and addressing performance issues have the appropriate training and support to manage effectively
- Data from the performance appraisal process is used to support resource planning, training and development, career management and succession planning
- Objectives for the coming period are set and training and development needs are agreed

(4) Career Development and Progression Planning

Currently, KW&SB do not have a formal policy on career development or a career development and progression planning process, although criteria is well established for promotions and job transfers. Career development/progression is generally based on the following criteria:

- Length of service
- Age
- Experience
- Job history
- Past performance
- Seniority
- Educational background/qualifications

The above criteria is generally accepted by most despite the fact that such an approach does little to motivate those with potential for a more rapid career progression path. The current approach stifles initiative and motivation as good performance on its own does not lead to better terms and conditions or promotional prospects.

Little emphasis is given to training, development and promotional prospects of those lower down the organisation, for example clerical staff or labourers. The system of promoting to vacant positions based on seniority 'leaves them behind'. Equal emphasis and opportunities for further development and enhancement should be open to all employees.

The ultimate aim of a career development programme is to enhance the future performance of the organisation itself through the development and advancement of its employees. It is recommended that individuals take responsibility for their own careers, by introduction of a training and development framework designed to allow all grades and disciplines equal opportunity for advancement.

Introducing a 'new' approach to career development and succession planning would require that KW&SB to give careful consideration to a number of factors, including the following:

- The need for a shift in culture and management willingness to change the current approach to career development and criteria for promotions
- The need to introduce a company policy and philosophy on employee development and career progression that is well communicated and understood by all
- The need to introduce personal training and career development plans for all individuals aspiring to gain new skills and experience or enhance existing skills and knowledge
- The need to introduce a transparent system of performance evaluation that rewards good performance
- The need to introduce a performance management system that leads to career and promotional prospects based on ability and good performance, experience, knowledge, attitude, initiative etc, rather than on seniority or length of service alone
- The need to train and develop managers to help manage their own careers and the careers of their subordinates

CHAPTER 4

FIELD SURVEYS AND ON-GOING STUDIES AND PROJECTS

4 FIELD SURVEYS AND ON-GOING STUDIES AND PROJECTS

4.1 WATER QUALITY ANALYSIS

4.1.1 Water Quality Management

(1) Role of Laboratories

a) General

The Central Laboratory Unit of KW&SB was established in COD Hills Water Treatment Plant. The Laboratory Unit is set up under Chief Engineer of the Bulk Transmission Division. The Chief Chemist is head of the Central Laboratory Unit and responsible for water quality testing not only water treatment plants but also sewage treatment plants. Each water treatment plant has a small testing facility which can examine at least required water quality parametres. At least one lab technician is allocated at each testing room and attempts a daily analysis of raw water and filtered water. In the case of sewage treatment plants, there is only testing laboratory in TP-1 (The first sewage treatment plant in Karachi) within its premise. Consequently, regular water quality test in both TP-2 and TP-3 have not been performed daily. The laboratory attached to the treatment plant also checks out daily behaviour for common sewage parametres such as Total Suspended Solids (TSS), Chemical Oxygen Demand (COD_{Cr}) and Biochemical Oxygen Demand (BOD).

b) Activities of the Central Laboratory Unit

Major activities of the Central Laboratory Unit are as follows;

- Water quality monitoring for distribution network,
- Bacteriological Examination,
- Management of water quality data, and
- Submission of monthly progress report to the Managing Director

The most important task of the Laboratory is collecting samples once a week from representative pumping houses in each township to monitor residual chlorines and coliform count of water to distribute. The Laboratory has basic equipment for bacteriological/microbiological examination. Most Probable Number (MPN) method is adopted for coliform counts of raw water and post chlorinated filtered water. If any coliform is detected, a result is reported to the Chief Engineer who is in charge of relevant Distribution Zone.

Collected data from each water filter plant are compiled and tabularised in a way easy to understand. The monthly progress report of Laboratory Unit prepared by the Chief Chemist is submitted to the Managing Director. The report includes descriptions for quantity & quality of raw water, disinfection by chlorination, chemical & bacteriological examination and recommendations.

c) Current Situations of Laboratory Unit

There is strong evidence that some functional problems of the Laboratory Unit are obviously present. Visual observation shows the following issues.

- No computerised data processing system causes no data maintenance
- Obsolescence of analytical instrument and outdated reagents/chemicals
- Lack of capacity/skills/experience of laboratory technicians

The Laboratory Unit has a great deal of past water quality data. However, the data have been brought down only "Hard Copies" in the old log books and many pieces of paper. No one gets a handle on those data without computerised data management. During the Basic Study, the Study Team expected that the Chief Chemist had past water quality data for the period between 2001 and 2005. Appropriate data were collected and made a transformation to the electric data. Tables of past data are shown in **Appendix A41.1**. Past data are evaluated in **Chapter 4.1.3**.

Analytical instrument for both physico-chemical and bacteriological parametres apparently have been gone out of date. Moreover, due to improper maintenance including no calibration, plenty of instruments have been broken down and abandoned in a corner of the laboratory. A lot of reagents, testing chemicals and standard materials that were likely donated by international agencies are left to stand in the chemical cabinet.

In the background of this situation, previous water quality data do not seem reliable, that is, tested data are nothing but just accumulated. There is no feedback system when abnormal value is obtained among the samples. In order to maintain parallel and independent check on city water supply qualities, assistance from Pakistan Council for Scientific and Industrial Research (hereinafter "PCSIR") and Karachi University is taken periodically to collaborate and examine the quality of water from plants and different pumping houses of distribution system.

(2) Water Quality Issues of Karachi City and Sindh Province

a) Water Supply

According to Pakistan Social and Living Standards Measurement Survey 2004-5, 84 percent of people in Pakistan have access to improved drinking water; it was 53% in late 1980s. The available water is not sufficient and the quality of water is poor due to pollution from chemicals, including heavy metals, nitrate, fluoride and bacteriological contamination. Because of unsafe and insufficient water supply and low sanitation coverage, as well as people's poor hygiene habits, around 60 percent of children suffer from diarrhea that is fatal if not treated in time.

A recently conducted 'Pilot Water Quality Monitoring Program', prepared by the Environmental Protection Agency Sindh for the Provincial Coordination Cell of the National Drainage Program, concluded that the water measured for the Indus River, major wetlands, drains and canals was found contaminated with industrial and municipal waste discharges and had been rendered unfit for human consumption as per the relevant water quality standards. All the industrial effluents from the Kotri Industrial Area are being pumped into the K. B. Feeder and the presence of heavy metals in the Kinjhar Lake can be attributed to Kotri Industrial Area discharges.

Concerns have also been raised by various quarters about contamination in drinking water supply in the distribution network and possible linkages with water borne diseases in the city. The seriousness of the issue can be rated from the fact that in the year 2002, the *Provincial Ombudsman Sindh*, Justice Haziqul Khairi in response to a growing number of reports received from all over the Sindh province about the supply of contaminated drinking water, instituted a study for investigating the claims of the public and assessing the causes of contamination. Regarding the quality of surface water supplied to the consumers, the *Study Report* concluded that about 75% of the water supplied to Karachi is chlorinated. Shortfall in the availability of water for drinking constrains the distribution to intermittent supply that is one of the main causes of water pollution.

The water that leaks through the distribution mains and smaller pipes, particularly the ones that were laid long time before and in the Third Phase of the Bulk Water Supply scheme for Karachi, creates an underground pool during the supply hours. This serves as a nursery to the micro-organisms, including fecal coliform released by the leaky sewers crisscrossing the water supply pipes. Sewage might enter into the distribution system due to vacuum created during idle hours. This is the reason for the gradual depletion of free-active chlorine in the treated water as it proceeds from the filter plant to the distribution network and in its onward journey to the households. The findings of the analysis of the water samples suggest that the water even though treated gets contaminated in the distribution network and on its way to the consumers. This finding suggests that the water as received by the residents is not safe for drinking.

Assessment of ground water quality in the aforementioned *Ombudsman Study Report* indicated that ground water has been over exploited in Sindh and the drying of traditional wells in the vegetable and fruit growing areas in the suburbs of Karachi has occurred. Although water quality has not been tested yet, groundwater pollution by nitrates, pesticides, heavy metals and hydrocarbons discharged into the environment is not negligible. The salinity of groundwater in Southern Sindh, particularly in the coastal areas has increased since over pumping has induced seawater to flow in, causing what is known as seawater intrusion.

The fact, also acknowledged by KW&SB, that 150 mgd (681,900 m^3/day) of water supplied to the consumers is chlorinated and bypasses the KW&SB filter plants is an important indicator of the need of addressing this issue on a priority basis. The *Ombudsman Study Report* says that the water drawn from about 95% of the wells in the city of Karachi is contaminated with sewage bacteria and also contains total dissolved solids beyond permissible limits. The *Ombudsman Study Report* also documents that 90% of the survey sample tests conducted by PCSIR indicate that the water is unfit for drinking purposes referring to as the guidelines set by the World Health Organization (WHO).

There is no regulatory body in the city assigned to keep an independent check on KW&SB's activities. However, other studies have also indicated seriously high levels of contamination in the drinking water supply. Surveys conducted by even civic agencies in the past have indicated the presence of E-coli bacteria in drinking water. These pathogenic bacteria are found in domestic sewage, that clearly shows that sewage is getting mixed up with drinking water. KW&SB refutes these claims and attributes water contamination if any to poor maintenance of storage tanks by end users.

b) Sewerage/Sanitation

About 60-70% of the water supplied to Karachi City is said to return as sewage. A total quantity of 315 mgd (1,432,000 m^3/d) of domestic and toxic industrial wastewater is generated in the city. There are three sewage treatment plants in Karachi. The total design capacity of these treatment plants is 151 mgd (686,000 m^3/d). The untreated sewage is disposed of into the sea through nallahs and rivers including the Lyari and Malir Rivers. The total length of sewers is approximately 3,290 km and ranges from 8 inches (200 mm) to 84 inches (2,130 mm) diametre of trunk sewers, secondary sewers and laterals.

Domestic sewage is a major source of pollution. National Conservation Strategy (NCS) states that almost 40% of deaths are related to water borne diseases. The situation is further aggravated by the addition of untreated wastewater from small-scale industries.

Karachi's untreated wastewater including domestic sewage and industrial wastewater is discharged into the Lyari and Malir rivers, which finally flow into the Arabian Sea. This wastewater has begun to pose a negative influence on the marine environment, as the channel water is contaminated not only with bacteria but also with toxic chemicals. Water pollution also extends a savage threat to wildlife. Animals drink water out of polluted water bodies, ailing lagoons, rivers and streams. This sickens the animals and some may even die. Survival of small invertebrates, micro fauna and flora is also threatened.

The Malir River drains into the Arabian Sea via the Korangi Creek/Ghizri Creek. Korangi

Creek forms part of the Indus Delta that harbours the fifth largest single arid region mangrove forest in the world. The mangroves play an important role in the swampy eco-systems of the Indus Delta. They accumulate silt, accrete shoreline, preventing of erosion for the coastline, beaches and flooding. Their most important function is to provide food, shelter and to serve as nursery grounds for a variety of the larvae and juveniles of marine organisms. They increase primary productivity of the coastal waters. The mangroves support a rich invertebrate fauna dominated by crustaceans and provide food rich habitat to a large number of juveniles, of fish and shrimps. The Korangi and adjoining creeks also support a well established fishing industry. As such the discharges of the polluted city waste is an issue of concern.

The Lyari River flows into the Arabian Sea via the Lyari Estuary/Manora Channel. This discharge also finds its way into the harbor area. The affected area harbors mangrove forestation. Tests conducted in the harbor area have indicated Dissolved Oxygen (DO) and BOD to be at critical levels. The wastewater discharged into the harbour carries on human pathogens and the concentrations of these on the sediments increase the risk of uptake into shell fish and other benthic organisms and hence into the food chain.

In Karachi, drinking water supply lines and open sewage drains in the streets are laid side by side. As a result, water is frequently contaminated when pipes are corroded and/or when pipe joints are inappropriate.

Industrial wastewater contains toxic chemicals in many cases. It is alarming that most industries have been started without proper planning and wastewater treatment plants. They just dispose of untreated toxic wastewater into nearby drains, canals or rivers. There is no doubt that untreated wastewater contributes to major pollution loads into their water bodies in Karachi city.

(3) Water Quality Standard in Pakistan

a) Drinking Water Quality Standards

The basic purpose of making guidelines or standards is to provide safe drinking water to all the citizens. The WHO has provided guidelines for drinking water, which are advisory in nature, and are based on longstanding scientific research and epidemiological findings. The values of various water quality parametres recommended by WHO are the general guidelines. Therefore, different countries have established their own water quality standards to meet their national priorities taking into account their economic, technical, social, cultural, and political requirements. The Pakistan Council for Research in Water Resource (PCRWR) and Pakistan Standard Institution (PSI) have already drafted Drinking Water Quality Standards at National Level. However, the enforcement of these standards is still pending and not approved yet. This matter needs to be addressed on top priority basis.

At present, KW&SB does not have its own water quality standards for drinking water. WHO guidelines for drinking water are adopted as desired value of water treatment processes. In this Study, the WHO Guidelines for drinking water is decided to adopt as targeted Standards tentatively. The latest WHO guidelines which were published in 2005 as the first addendum to the third edition are shown in **Table 41.1.1**:

Table 41.1.1 WHO Guidelines for Drinking Water Quality (2005)

A. Bacterial Quantities

Source/Organisms	Guideline Value
a. All water intended for drinking (E. Coli or thermo tolerant Coliform Bacteria)	Must not be detectable in any 100 ml sample
b. Treated water entering the distribution system (E. Coli or thermo tolerant coliform and total coliform bacteria	Must not be detectable in any 100 ml sample
c. Treated water in the distribution system (E. coli or thermo tolerant coliform and total coliform bacteria)	Must not be detectable in any 100 ml sample In the case of large supplies, where sufficient numbers of samples are examined, must not be present in 95% of samples taken throughout any 12 months period.

B. Chemicals of Health Significance

Inorganic	mg/l	Inorganic	mg/l	Inorganic	mg/l
Antimony	0.005	Copper	2.000	Molybdenum	0.070
Arsenic	0.010	Cyanide	0.070	Nickel	0.020
Barium	0.700	Fluoride	1.500	Nitrate (NO_3)	50
Boron	0.300	Lead	0.010	Nitrite (NO_2)	3.000
Cadmium	0.003	Manganese	0.500	Selenium	0.010
Chromium	0.050	Mercury	0.001		

C. Other Parametres

Inorganic	mg/l	Inorganic	mg/l	Inorganic	mg/l
Colour	15 TCU	1,2 dichlorobenzene	1 – 10	Hardness, pH, DO	-
Taste, Odour	---	1.4-dichlorobenzene	0.3 – 30	Hydrogen sulfide	0.05
Turbidity	5NTU	Dichlorobenzene	1.500	Iron	0.3
Toluene	24 – 170	Synthetic detergents	---	Manganese	01
Xylenes	20 – 1800	Aluminum	0.2	Sodium	200
Ethyl-benzene	2.4 – 2600	Ammonia	1.5	Sulfate	250
Styrene	4 - 2600	Chloride	250	TDS	1000
Monochlorobenzene	10 - 120	Copper	1	Zinc	3

D. Disinfectants and Disinfectant by-Products

Name	Value (mg/l)	Name	Value (mg/l)
Chlorine chlorophenol	600 – 1000	2,4,6-trichlorophenol	2 – 300
2,4-dichlorophenol	0.3 - 40	2-chlorophenol	0.1 - 10

b) National Environmental Quality Standards

The National Environmental Quality Standards for Municipal and Liquid Industrial Effluents has been established and gone through modifications since 1993 as Statutory Notification by the Ministry of Environment, Local Government and Rural Development, Pakistan. The Standards are shown in **Table 41.1.2**.

According to the Standards, BOD into inland waters is regulated not greater than 80 mg/l. Therefore, BOD value of the treated effluent discharged from sewage treatment plant is required below this limit.

Table 41.1.2 National Environmental Quality Standards for Municipal and Liquid Industrial Effluents*

S. No.	Parametre	Into Inland Waters	Into Sewage Treatment	Units
1	Temperature or Temp. increase	≤ 3	≤ 3	°C
2	pH	6 – 9	6 – 9	
3	BOD	80	250	mg/l
4	COD_{Cr}	150	400	mg/l
5	TSS (Total Suspended Solids)	200	400	mg/l
6	TDS (Total Dissolved Solids)	3500	3500	mg/l
7	Oil and Grease	10	10	mg/l
8	Phenolic Compounds (as Phenol)	0.1	0.3	mg/l
9	Chloride (as Cl^-)	1000	1000	mg/l
10	Fluoride (as F^-)	10	10	mg/l
11	Cyanide (as CN^-) total	1.0	1.0	mg/l
12	An-ionic detergents (as MBAS)	20	20	mg/l
13	Sulphate (SO_4^-)	600	1000	mg/l
14	Sulphide (S_2^-)	1.0	1.0	mg/l
15	Ammonia (NH_3)	40	40	mg/l
16	Pesticides	0.15	0.15	mg/l
17	Cadmium	0.1	0.1	mg/l
18	Chromium (trivalent and hexavalent)	1.0	1.0	mg/l
19	Copper	1.0	1.0	mg/l
20	Lead	0.5	0.5	mg/l
21	Mercury	0.01	0.01	mg/l
22	Selenium	0.5	0.5	mg/l
23	Nickel	1.0	1.0	mg/l
24	Silver	1.0	1.0	mg/l
25	Total toxic metals	2.0	2.0	mg/l
26	Zinc	5.0	5.0	mg/l
27	Arsenic	1.0	1.0	mg/l
28	Barium	1.5	1.5	mg/l
29	Iron	8.0	8.0	mg/l
30	Manganese	1.5	1.5	mg/l
31	Boron	6.0	6.0	mg/l
32	Chlorine	1.0	1.0	mg/l

* Statutory Notification, SRO-549(1)/2000, dated August 10, 2000, Ministry of Environment, Local Government and Rural Development, Government of Pakistan.

4.1.2 Evaluation of Water Quality

(1) Terms of Reference for Water Quality Testing

a) Analysed Parametres for Each Sampling Point

Total number of 40 samples of water 2 samples of raw water, 7 samples of treated water (post chlorinated), 18 samples of distributed water, 9 samples of river and drainage water and 4 samples of domestic and commercial wastewater, from 40 different locations, were to be collected in the dry and wet seasons separately and analysed for the physico-chemical and microbiological parametres which were determined by the Study Team. **Table 41.2.1** shows required parametres to analyse.

Table 41.2.1 Chemical and Microbiological Parametres for Testing Water and Wastewater Samples

Raw Water	**Treated Water** Post Chlorination filtered water	**Distribution Water**	**Raw Sewage and Treated Water**	**Domestic and Commercial Wastewater**
02 samples	07 samples	18 samples	09 samples	04 samples
pH	pH	pH	pH	pH
Turbidity	Turbidity	Turbidity		
COD_{Cr}			COD_{Cr}	COD_{Cr}
TDS	TDS	TDS		
Ammonia Nitrogen	Ammonia Nitrogen	Ammonia Nitrogen		
Cadmium	Cadmium	Cadmium		
Total Chromium	Total Chromium	Total Chromium		
Copper	Copper	Copper		
Lead (Pb)	Lead (Pb)	Lead (Pb)		
Mercury	Mercury	Mercury		
Selenium	Selenium	Selenium		
Silver (Ag)	Silver (Ag)	Silver (Ag)		
Zinc (Zn)	Zinc (Zn)	Zinc (Zn)		
Arsenic	Arsenic	Arsenic		
Alkalinity	Alkalinity	Alkalinity		
Elect. Cond.	Elect. Cond.	Elect. Cond.		
Iron (Fe)	Iron (Fe)	Iron (Fe)		
Manganese	Manganese	Manganese		
Boron (B)	Boron (B)	Boron (B)		
Fluorine (F)	Fluorine (F)	Fluorine (F)		
Nitrate	Nitrate	Nitrate		
Nitrite	Nitrite	Nitrite		
Calcium	Calcium	Calcium		
Magnesium	Magnesium	Magnesium		
Sodium	Sodium	Sodium		
Potassium	Potassium	Potassium		
Sulphate ion	Sulphate ion	Sulphate ion		
Chloride ion	Chloride ion	Chloride ion		
	Chlorine	Chlorine		
Coliform	Coliform	Coliform	Coliform	
Faecal Coliform	Faecal Coliform	Faecal Coliform		
Plate Count Bacteria	Plate Count Bacteria	Plate Count Bacteria		
			Ambient Temp.	Ambient Temp.
			Water Temp.	Water Temp.
			BOD	BOD
			Suspended Solids	Suspended Solids
			Total Nitrogen	Total Nitrogen
			Total Phosphorus	Total Phosphorus

b) Methodology

Sampling of water and wastewater was carried out by standard techniques. Samples for the dry season from the identified locations were collected by the sample collection team. The Study Team directly employed the services of water quality technicians from the Laboratory Complex of PCSIR.

Samples of water and wastewater for chemical analysis were carefully collected in plastic containers, samples for BOD were collected in glass bottles and samples for microbiological analysis were collected in sealed sterilized glass bottles and kept in the ice box during transportation and in refrigerator in the laboratory till these were analyzed.

According to the sampling schedule in the dry season, 40 samples of water and wastewater from the identified locations were collected from May 25 to June 14, 2006, in the presence of Mr.

Shahbaz Iqbal, Senior Chemist, KW&SB, who was nominated the Chief Chemist of KW&SB. In the wet season, 40 samples from the same locations were collected from July 29 to August 13, 2006, as per detail given in **Table 41.2.2**. The sampling locations are located in the satellite image maps shown in the respective Sections of this Chapter. The collected samples were analysed for the desired physico-chemical and microbiological parametres by standard analytical methods shown in **Table 41.2.3**.

Table 41.2.2 Details of Sampling IDs with Locations and Date of Sampling

S. No.	Sample ID	Sample Location	Date of Sampling	
			Dry Season	Wet Season
1	RW-1	Before Gujju Headworks, Kinjar System	25-06-2006	03-0806
2	RW-2	Before Hub Pumping Station, Hub-Karachi main Canal	10-06-2006	08-08-06
3	TW-1	Post Chlorined filtered water, Gharo WTP	08-06-2006	03-08-06
4	TW-2	Post Chlorined filtered water, COD WTP	25-06-2006	03-0806
5	TW-3	Post Chlorined filtered water, Pipri WTP (old)	08-06-2006	03-0806
6	TW-4	Post Chlorined filtered water, Pipri WTP (New, Phase-1	08-06-2006	03-0806
7	TW-5	Post Chlorined filtered water, NEK, WTP (old)	03-06-2006	03-0806
8	TW-6	Post Chlorined filtered water, New NEK WTP	03-06-2006	08-08-06
9	TW-7	Post Chlorined filtered water, Hub WTP	10-06-2006	08-08-06
10	DW-1	Landhi Town, No. 26, Babar Market Pumping Station	02-06-2006	29-07-06
11	DW-2	Korangi Town, No. 6, Korangi 5 ½ Pumping Station	25-06-2006	29-07-06
12	DW-3	Malir Town, No. 15, Saudabad Pumping Station	25-06-2006	29-07-06
13	DW-4	Bin Qasim # 28, Cattle Colony # 1 pumping Station	08-06-2006	29-07-06
14	DW-5	Shah Faisal Town No. 3, Pumping Station # 4	25-06-2006	29-07-06
15	DW-6	Gulshan Town, No. 35, NIPA Pumping Station	03-06-2006	29-07-06
16	DW-7	Jamshed Town, No. 46, Gulistan Club Pumping Station	14-06-2006	09-08-06
17	DW-8	Lyari Town, No. 88, Lea Market Pumping Station	14-06-2006	10-08-06
18	DW-9	Liaqatabad Town, No. 100, Board Office PS	03-06-2006	08-08-06
19	DW-10	Saddar Town # 54 Frere Pumping Station	14-06-2006	05-08-06
20	DW-11	Kemari Town # 89 Gulbai Pumping Station	14-06-2006	11-08-06
21	DW-12	Orangi Town # 122, 4/10A, Banaras Chowk P Station	10-06-2006	08-08-06
22	DW-13	Baldia Town Pumping Station 3 ½	14-06-2006	12-08-06
23	DW-14	SITE Town, No. 131 Qasba Pumping Station	10-06-2006	09-08-06
24	DW-15	Gadap Town Surjani Pumping Station	14-06-2006	08-08-06
25	DW-16	North Karachi Town, No. 95, Khawaja Ajmair Nagri PS	10-06-2006	08-08-06
26	DW-17	Gulberg Town No. 99, Azizabzd Pumping Station	15-06-2006	13-08-06
27	DW-18	North Nazimabad Town, No. 107, B/S No. 2 PS	10-06-2006	08-08-06
28	TP-1a	Inlet Chamber TP1	31-05-2006	05-08-06
29	TP-1b	Outlet Chamber, TP1	31-05-2006	05-08-06
30	TP-1c	Suitable point from Lyari River	31-05-2006	05-08-06
31	TP-2a	Inlet Chamber, TP2	25-06-2006	03-0806
32	TP-2b	Outlet Chamber, TP2	25-06-2006	03-0806
33	TP-2c	Suitable point from Malir River	25-06-2006	03-0806
34	TP-3a	Inlet Chamber, TP3	31-05-2006	12-08-06
35	TP-3b	Outlet Chamber, TP-3	31-05-2006	12-08-06
36	TP-3c	Near the sea front	31-05-2006	12-08-06
37	RWW-1	Orangi Area, Orangi Town	10-06-2006	08-08-06
38	RWW-2	Malir Area, Malir Colony Drain	25-06-2006	29-07-06
39	CWW-1	Saddar Area, Pitcher Drain	14-06-2006	10-08-06
40	CWW-2	Zamzama Area, Nahar-e-Khayyam Drain	14-06-2006	05-08-06

The testing team comprised 1 supervisor, 6 chemical analysis technicians and 3 microbiological technicians.

The physico-chemical analysis of water and wastewater was conducted, applying modern established standard procedures as adopted by American Public Health Association (APHA).

Table 41.2.3 Description of Analytical Methods for Testing Physico-Chemical Parametres

S No.	Parametre	Description of Analytical Methods
1	pH	pH was measured immediately after receiving the sample in the laboratory using Digital Ion Analyzer/pH Metre (Orion–710). Standard buffers are used to calibrate the pH Metre.
2	Sodium (Na) & Potassium (K)	Levels of Sodium and Potassium were estimated on Flame Photometre (Corning 410) after appropriate dilutions of the samples. The standards of sodium and potassium were prepared by using 1000 mg/l standards (Merck); the traceability of the standard is traceable to NIST.
3	Calcium (Ca) and Magnesium (Mg)	Calcium and Magnesium were determined by complexmetric titration using standard EDTA as titrant. Erio-chrom Black T was used as indicator for titration of both i.e. Ca and Mg, while Meuroxide was used to titrate Ca alone. Mg was estimated by difference in the two readings.
4	Chloride (Cl^-)	Chloride was determined by argentometric titration, using standard $AgNO_3$ as titrant. Potassium chromate was used as indicator. The standard and indicator used were of A.R grade chemicals. The titrant was standardized with NaCl.
5	Sulphate (SO_4^{2-})	Sulphate was precipitated with $BaCl_2$ as $BaSO_4$, filtered through Whattman 42 filter paper, washed with distilled water and ignited at open flam to be weighed as $BaSO_4$. The sulphate was calculated by stichiometric ratios.
6	Bi-Carbonate and Alkalinity	These parametres were determined by titration with HCl (standardized) bromocresol green was used as indicator. Alkalinity was determined by calculation and reported as $CaCO_3$.
7	Nitrite ($N\text{-}NO_2$)	The nitrite present in water sample was diazotized with sulphanilic acid and coupled with N-1-Napthyl ethylene diamine dihydrochloride. The absorbance of the resultant azo-dye was measured at 525 nm.
8	TDS	TDS was estimated gravimetrically by evaporating a known volume of sample.
9	Turbidity	Turbidity was measured using HACH-2100 Turbidity Metre. The standards used were also from HACH Company.
10	Free Chlorine (Cl_2)	The free chlorine was measured volumetrically using DPD as indicator and Ferrous sulfate as titrant.
11	Fluoride (F^-)	Levels of fluoride were determined through Fluoride Ion Selective Electrode and a Digital Ion Analyzer (Orion 701). The graph is further checked for its accuracy by using standard fluoride solutions 1 and 10 ppm (mg/l).
12	Nitrate ($N\text{-}NO_3$)	Nitrate contents were measured as NO_3-N through Nitrate Ion Selective Electrode and Digital Ion Analyzer (Orion 710).
13	COD_{Cr}	The Chemical Oxygen Demand was determined titrimetrically after refluxing the samples with potassium dichromate.
14	Lead (Pb) and Cadmium (Cd)	Lead and Cadmium were analyzed by Hitachi Z-8000 Atomic Absorption Spectrophotometre, equipped with Graphite Furnace. Commercially available prepared standard (1000 mg/l) was used for the preparation of working standards. The standard itself is traceable to NIST.
15	Iron (Fe), Zinc (Zn), Copper (Cu), Total Chromium (Cr), Silver (Ag) and Manganese (Mn)	Iron, Zinc, Copper, Silver, Chromium and Manganese were also analyzed by Hitachi Z-5000 Atomic Absorption Spectrophotometric technique with air acetylene flame. Prepared standard (1000 mg/l) was used from Merck for the preparation of standards. The standards are traceable to NIST.
16	Arsenic (As) and Selenium (Se)	Arsenic and selenium were analyzed by using Hitachi Z-5000 Absorption Spectrophotometric equipped with Hydride Formation System. The standard used for the preparation of working standard is traceable to NIST.
17	Mercury (Hg)	Cold Vapor technique was employed for the estimation of Mercury by using Hitachi-Z-5000 Atomic Absorption Spectrophotometric. The Mercury standard used is traceable to NIST.

18	Boron (B)	Boron was estimated calorimetrically after developing color with crucumine reagent. The red colour developed was measured at 540nm by using UV-VIS Spectrophotometre.
19	Total Suspended Solids (TSS)	TSS was calculated gravimetrically.
20	Total Phosphorus (PO_4^{3-})	Total phosphate was estimated calorimetrically after the formation of phosphomolybdate complex, measured at 880 nm.
21	Conductivity	Electric Conductivity was measured by using HACH Conductivity/TDS Metre.
22	Ammonia ($N-NH_3$)	Ammonia was estimated calorimetrically.
23	Biochemical Oxygen Demand (BOD_5)	Estimation of BOD_5 was carried out by BOD Trak method. The whole procedure involves five days.

For the determination of Total Coliform and Fecal Coliform organisms, Multiple Tube Method [ISO-9308-2(1990)] was used. Measured volume of the water to be tested was added to sets of tubes containing single and double strength isolation media. After 24 hours incubation at 37°C for Total Coliform and 44°C for Fecal Coliform, the tubes were examined for acid and gas production. Positive reactions in tubes were subcultured into confirmatory media, i.e., *Brilliant Green Lactose Bile (BGLB) broth* for Total Coliform and *EC broth* for Fecal Coliform. The numbers of positive tubes were counted and the MPN was determined from table of statistical probability. Total aerobic bacteria count of each sample was cultivated by spread plate count method, by following Standard Method for the Examination of Water and Wastewater, 20th edition (1998), APHA.

(2) Raw Water

Sampling points of raw water samples (Sample ID is RW-1 and RW-2) were selected for different water systems, i.e. Indus River Water (Kinjar) System and Hub Water System. **Figure 41.2.1** and **Figure 41.2.2** show the locations of raw water sampling points. RW-1 is located in just before Gujju Headworks, Kinjar System and RW-2 is located in before Hub Pumping Station, Hub-Karachi Main Canal.

The test results of two (2) samples of raw water which are collected both in the dry season and in the wet season are given in **Table 41.2.4**. In the dry season, data show that concentration of heavy metals such as Copper, Iron, Manganese and some anions like Chloride, Sulphate and Ammonium of RW-2 are higher than those of RW-1. Electric conductivity of RW-2 is also higher than that of RW-1.

Therefore, the pooled water of Hub Dam makes slow progress in salinisation.

Figure 41.2.1 Location of Sampling Points No.1

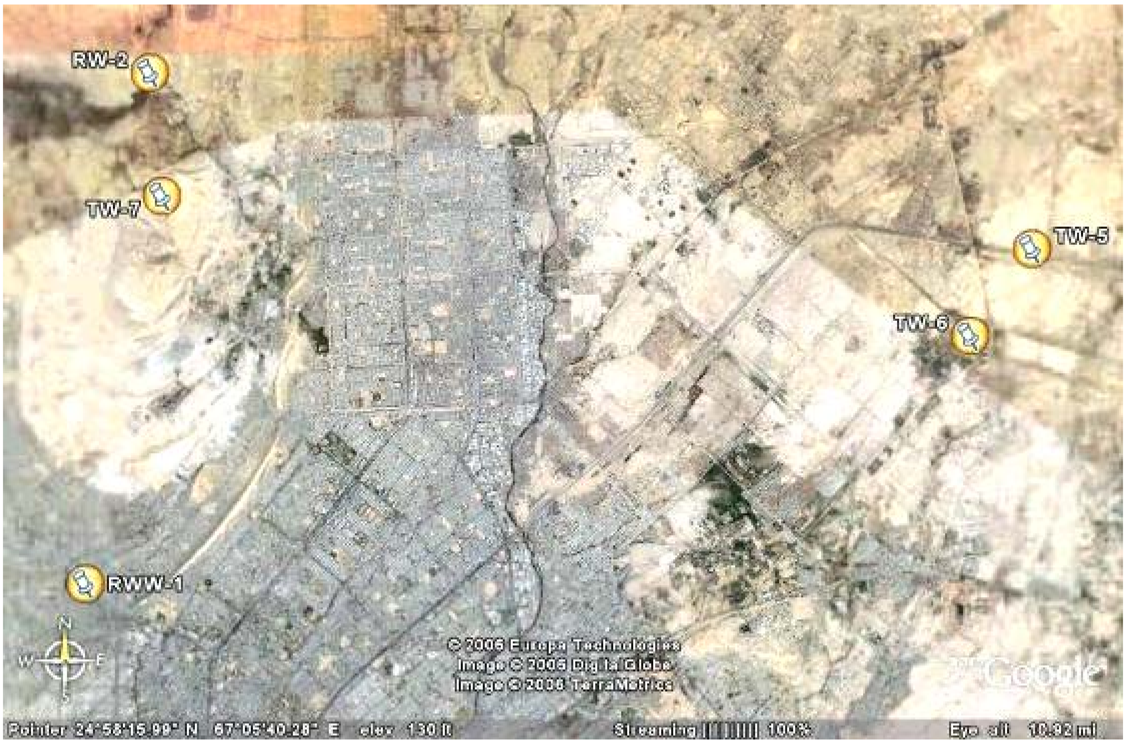


Figure 41.2.2 Location of Sampling Points No.2

Table 41.2.4 Results of 2 samples of Raw Water

S. No.	Parameters	Dry Season		Wet Season		Units
		RW-1	RW-2	RW-1	RW-2	
1	pH	8.20	8.40	8.11	8.29	
2	Turbidity	0.19	0.23	0.55	3.5	NTU
3	COD_{Cr}	42	31	ND	ND	mg/l
4	TDS	292	452	254	280	mg/l
5	Ammonia Nitrogen	0.096	0.326	ND	ND	mg/l
6	Cadmium	0.25	0.19	0.94	0.49	µg/l
7	Total Chromium	ND	ND	2.12	12.1	µg/l
8	Copper	2.75	24.75	5.96	16.12	µg/l
9	Lead (Pb)	2.39	2.62	5.1	2.23	µg/l
10	Mercury	ND	ND	ND	ND	µg/l
11	Selenium	ND	ND	ND	ND	µg/l
12	Silver (Ag)	0.27	ND	5.13	4.95	µg/l
13	Zinc (Zn)	0.011	0.042	0.028	0.031	mg/l
14	Arsenic	6.630	3.192	ND	ND	µg/l
15	Alkalinity	107	112	96	91	mg/l
16	Elect. Cond.	412	696	348	433	µS/cm
17	Iron (Fe)	0.11	0.26	0.165	0.406	mg/l
18	Manganese	7.40	14.12	10.81	17.15	µg/l
19	Boron (B)	ND	8.24	5.85	28.58	µg/l
20	Fluorine (F)	0.058	0.057	0.049	0.042	mg/l
21	Nitrate	15.93	15.93	1.12	3.56	mg/l
22	Nitrite	6	30	6	26	µg/l
23	Calcium	30	47	31	33	mg/l
24	Magnesium	15	18	11	11	mg/l
25	Sodium	35	75	26.5	30	mg/l
26	Potassium	6.4	7.6	6.4	6.7	mg/l
27	Sulphate ion	61	111	48	57	mg/l
28	Chloride ion	40	100	30	38	mg/l
29	Coliform	93	240	1100	1100	count/dl
30	Faecal Coliform	43	150	1100	1100	count/dl
31	Plate Count Bacteria	2.3×10^4	8.4×10^4	4.8×10^4	4.2×10^4	cfu/ml

(3) Filtered Water

7 samples of filtered water with post chlorination were taken from each existing Water Filter Plant. TW-1 is called "Gharo Water Treatment Plant" and located about 60 km of west-bound from the centre of Karachi City. TW-1 turns out to the representative sample because here is the first point of Kinjar System. Location of TW-1 is shown in **Figure 41.2.3**. TW-2 is the location of COD Water Treatment Plant and shown in **Figure 41.2.4**. TW-3 and TW-4 are sampling from the old Pipri Water Treatment Plant and the new Pipri Water Treatment Plant. The Plants are located nearby each other in suburbs of Karachi. Those locations are shown in **Figure 41.2.5**. TW-5 and TW-6 are also from the old/new NEK Water Treatment Plants. TW-7 is Hub Water Treatment Plant which shows different raw water characteristics, because raw waters of Hub Water System and Kinjar Water System (K-III Project) are blended before intake of the treatment plant. **Figure 41.2.6** shows locations of TW-5, 6 and 7.

Results of 7 samples of Treated Water (Post Chlorinated) collected from water treatment plant in the dry and wet seasons are shown in **Table 41.2.5** and **Table 41.2.6**, respectively.

Figure 41.2.3 Location of Sampling Points No.3

Figure 41.2.4 Location of Sampling Points No.4

Figure 41.2.5　Location of Sampling Points No.5

Table 41.2.5 Results of 7 Samples of Treated Water (Post Chlorinated) collected in the Dry Season

S. No.	Parameters	TW-1	TW-2	TW-3	TW-4	TW-5	TW-6	TW-7	Units
1	pH	8.0	7.8	7.7	7.9	7.9	7.9	8.4	
2	Turbidity	0.91	0.34	0.77	0.90	0.24	0.24	0.22	NTU
3	TDS	304	284	278	276	278	276	534	mg/l
4	Ammonia Nitrogen	0.401	ND	0.433	0.290	0.263	0.328	0.470	mg/l
5	Cadmium	0.095	0.304	0.058	0.335	0.913	0.413	0.304	µg/l
6	Total Chromium	ND	ND	ND	ND	ND	ND	ND	µg/l
7	Copper	31.5	10.5	9.5	3.8	5.3	6.0	10.8	µg/l
8	Lead (Pb)	2.09	1.84	1.45	1.29	1.44	1.15	1.54	µg/l
9	Mercury	ND	ND	ND	ND	0.33	ND	ND	µg/l
10	Selenium	ND	ND	ND	ND	ND	ND	ND	µg/l
11	Silver (Ag)	2.97	ND	1.90	ND	0.27	0.80	1.90	µg/l
12	Zinc (Zn)	0.045	0.014	0.015	0.132	0.012	0.318	0.096	mg/l
13	Arsenic	1.474	0.818	ND	0.410	0.736	ND	ND	µg/l
14	Alkalinity	102	102	97	97	97	92	107	mg/l
15	Electric Conductivity	445	400	416	415	404	410	786	µS/cm
16	Iron (Fe)	0.17	0.19	0.14	0.15	0.04	0.11	0.26	mg/l
17	Manganese	11.40	7.12	7.85	7.60	2.40	5.27	9.57	µg/l
18	Boron (B)	14.80	9.96	ND	ND	ND	ND	2.24	µg/l
19	Fluorine (F)	0.058	0.052	0.052	0.057	0.047	0.051	0.042	mg/l
20	Nitrate	14.81	15.15	20.06	21.28	22.17	20.99	21.48	mg/l
21	Nitrite	2.50	3.75	8.75	6.25	2.50	3.75	5.00	µg/l
22	Calcium	34	32	32	31	31	31	53	mg/l
23	Magnesium	17	13	14	14	12	13	19	mg/l
24	Sodium	40	37	37	34	35	35	88	mg/l
25	Potassium	6.4	6.3	6.4	6.4	6.4	6.4	7.7	mg/l
26	Sulphate ion	61	66	58	60	64	62	131	mg/l
27	Chloride ion	52	42	47	47	44	48	118	mg/l
28	Chlorine	0.06	0.03	0.45	0.05	0.03	0.04	ND	mg/l
29	Coliform	< 3	< 3	< 3	11	< 3	< 3	7l	count/dl
30	Faecal Coliform	< 3	< 3	< 3	< 3	< 3	< 3	< 3	count/dl
31	Plate Count Bacteria	100	62	120	280	90	25	450	cfu/ml

Table 41.2.6 Results of 7 Samples of Treated Water (Post Chlorination) collected in the Wet Season

S. No.	Parameters	TW-1	TW-2	TW-3	TW-4	TW-5	TW-6	TW-7	Units
1	pH	7.85	8.05	7.86	8.09	8.15	8.05	8.09	
2	Turbidity	0.53	0.57	1.30	1.40	0.66	2.20	2.00	NTU
3	TDS	306	268	276	260	262	252	318	mg/l
4	Ammonia Nitrogen	0.038	ND	ND	ND	ND	ND	ND	mg/l
5	Cadmium	0.60	0.66	0.54	0.54	0.55	1.06	0.66	µg/l
6	Total Chromium	ND	ND	ND	ND	ND	2.83	ND	µg/l
7	Copper	27.3	5.2	9.2	5.0	2.2	18.3	3.5	µg/l
8	Lead (Pb)	ND	ND	1.92	1.82	ND	2.15	2.17	µg/l
9	Mercury	ND	ND	ND	ND	ND	ND	ND	µg/l
10	Selenium	ND	ND	ND	ND	ND	ND	ND	µg/l
11	Silver (Ag)	7.68	4.18	2.14	8.79	16.18	18.69	6.47	µg/l
12	Zinc (Zn)	0.016	0.020	0.060	0.022	0.018	0.024	0.021	mg/l
13	Arsenic	ND	ND	ND	ND	ND	ND	ND	µg/l
14	Alkalinity	106	96	91	91	91	86	72	mg/l
15	Electric Conductivity	478	360	363	357	358	353	515	µS/cm
16	Iron (Fe)	0.10	0.20	0.13	0.14	0.06	0.40	0.11	mg/l

17	Manganese	10.13	8.12	16.57	8.12	6.87	18.29	5.98	µg/l
18	Boron (B)	24.56	31.42	26.08	3.62	ND	1.70	8.74	µg/l
19	Fluorine (F)	0.056	0.057	0.059	0.052	0.048	0.052	0.049	mg/l
20	Nitrate	6.18	1.94	2.91	2.69	2.91	2.63	9.97	mg/l
21	Nitrite	14.00	7.23	30.00	5.00	2.00	6.00	22.00	µg/l
22	Calcium	40	32	32	31	31	31	42	mg/l
23	Magnesium	13	11	11	11	11	11	14	mg/l
24	Sodium	37.5	30	27	27	25	25	35	mg/l
25	Potassium	7.4	6.6	6.6	6.6	6.6	6.6	7.1	mg/l
26	Sulphate ion	52	54	49	52	52	56	72	mg/l
27	Chloride ion	61	33	36	35	33	33	64	mg/l
28	Chlorine	ND	ND	0.80	0.06	0.32	0.13	0.16	mg/l
29	Coliform	< 3	< 3	< 3	4	< 3	< 3	4	count/dl
30	Faecal Coliform	< 3	< 3	< 3	< 3	< 3	< 3	< 3	count/dl
31	Plate Count Bacteria	270	60	80	170	250	40	120	cfu/ml

(4) Water in Distribution System

Sampling in distribution system is very important for water supply system to check whether the operation and maintenance is done appropriately. 18 sampling points were settled from each township in 3 different water supply Zones. These locations are shown in **Figure 41.2.6**. Results of eighteen (18) samples of Distribution Water are shown in **Table 41.2.7** (dry season) and **Table 41.2.8** (wet season).

Figure 41.2.6 Location of Sampling Points No.6

Table 41.2.7 Results of 18 Samples of Distribution Water collected in the Dry Season

S.No.	Parameters	DW-1	DW-2	DW-3	DW-4	DW-5	DW-6	DW-7	DW-8	DW-9	DW-10	DW-11	DW-12	DW-13	DW-14	DW-15	DW-16	DW-17	DW-18	Unit
1	pH	8.1	7.7	7.7	8.2	7.8	7.8	8.2	8.2	8.1	8.3	8.3	8.2	8.2	8.2	8.2	8.4	8.3	8.1	-
2	Turbidity	0.4	0.2	0.5	0.6	0.5	0.5	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.4	0.2	0.2	0.2	0.2	NTU
3	TDS	278	276	268	290	298	276	288	292	340	274	286	496	320	470	282	430	300	298	mg/l
4	Amm. Nitrogen	0.458	0.341	0.396	0.320	0.280	0.189	0.515	0.354	0.506	0.373	0.380	0.300	0.300	0.831	0.366	0.488	0.319	0.424	mg/l
5	Cadmium	0.244	0.134	0.210	0.155	0.181	0.194	0.065	0.176	0.190	0.248	0.229	0.251	0.202	0.245	0.276	0.408	0.263	0.482	µg/l
6	Total Chromium	ND	ND	4.10	ND	1.65	ND	ND	ND	ND	ND	0.42	ND	ND	ND	ND	ND	ND	0.82	µg/l
7	Copper	4.50	5.75	11.50	9.50	12.00	3.55	3.00	8.75	2.25	7.25	11.75	6.50	7.50	12.00	8.25	10.00	3.75	9.00	µg/l
8	Lead (Pb)	1.89	2.80	1.95	2.07	2.87	2.43	2.79	2,56	2.48	2.06	2.99	3.05	3.36	1.10	1.32	1.32	1.34	1.67	µg/l
9	Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	µg/l
10	Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	µg/l
11	Silver (Ag)	ND	9.17	2.42	6.22	4.32	2.70	12.70	13.50	12.27	17.00	ND	ND	ND	25.92	2.97	7.55	0.27	ND	µg/l
12	Zinc (Zn)	0.617	0.018	0.199	0.193	0.618	0.024	0.018	0.323	0.035	0.603	0.838	0.026	0.179	1.473	0.057	0.905	1.051	0.586	mg/l
13	Arsenic	0.736	0.820	0.654	3.520	1.720	0.492	1.720	1.146	ND	0.900	4.500	ND	1.474	ND	2.046	0.656	0.656	4.500	µg/l
14	Alkalinity	102	102	97	102	107	97	101	102	102	102	102	107	108	108	108	112	101	102	mg/l
15	Elect. Cond.	404	403	403	413	422	406	415	418	493	417	403	764	462	742	410	608	414	420	µS/cm
16	Iron (Fe)	0.10	0.17	0.14	0.14	0.25	0.09	0.64	0.18	0.12	0.23	0.28	0.24	0.20	0.32	0.31	0.24	0.14	0.24	mg/l
17	Manganese	4.50	7.00	5.20	11.60	11.00	4.50	22.85	10.40	5.30	9.42	8.15	9.15	7.87	13.60	25.00	13.27	6.27	33.50	µg/l
18	Boron (B)	9.80	ND	4.72	7.68	9.68	ND	ND	12.60	6.32	9.40	3.72	2.20	5.96	15.10	ND	5.80	5.44	8.44	µg/l
19	Fluorine (F)	0.059	0.041	0.043	0.052	0.055	0.057	0.053	0.055	0.046	0.051	0.064	0.046	0.05	0.051	0.049	0.062	0.061	0.063	mg/l
20	Nitrate	21.58	20.99	19.79	20.07	20.25	15.64	19.70	19.18	19.89	19.35	19.01	20.71	21.58	22.07	21.97	34.25	20.71	21.58	mg/l
21	Nitrite	3	8	8	5	4	4	3	6	4	3	6	4	4	6	6	13	1	3	µg/l
22	Calcium	31	32	32	33	32	30	33	33	34	33	31	51	35	50	30	42	28	33	mg/l
23	Magnesium	12	10	12	13	13	14	13	14	16	13	13	19	15	20	15	18	17	14	mg/l
24	Sodium	35	35	35	37	37	35	35	35	45	35	35	35	75	65	36	62	35	35	mg/l
25	Potassium	6.4	6.4	6.4	6.4	6.5	6.4	6.7	6.7	6.7	6.7	6.6	7.8	7.8	7.4	6.3	7.0	6.4	6.6	mg/l
26	Sulphate ion	51	58	54	58	59	59	58	58	77	54	47	107	57	92	51	92	65	60	mg/l
27	Chloride ion	41	40	41	43	47	43	41	45	58	44	42	113	51	108	41	82	43	45	mg/l
28	Chlorine	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.05	ND	ND	ND	ND	0.06	mg/l
29	Coliform	23	< 3	< 3	< 3	< 3	< 3	< 3	240	< 3	< 3	< 3	< 3	< 3	< 3	<3	< 3	< 3	< 3	Count/dl
30	Fecal Coliform	23	< 3	< 3	< 3	< 3	< 3	< 3	23	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	Count/dl
31	Plate Count Bacteria	1,500	290	540	200	5×10^3	50	220	1.2×10^4	2,200	150	360	160	180	5,200	120	49	2,500	2,500	cfu/ml

Table 41.2.8 Results of 18 Samples of Distribution Water collected in the Wet Season

S.No.	Parameters	DW-1	DW-2	DW-3	DW-4	DW-5	DW-6	DW-7	DW-8	DW-9	DW-10	DW-11	DW-12	DW-13	DW-14	DW-15	DW-16	DW-17	DW-18	Unit
1	pH	7.63	8.23	8.28	8.15	8.15	8.01	8.01	8.24	8.32	8.25	8.17	8.18	8.31	8.16	8.28	8.18	8.16	7.88	-
2	Turbidity	0.6	0.5	1.1	0.4	0.4	1.0	1.7	1.9	1.9	1.0	0.5	2.3	0.5	4.5	1.4	1.7	1.4	1.4	NTU
3	TDS	282	260	256	262	268	260	278	272	354	302	240	356	270	314	270	376	246	270	mg/l
4	Amm. Nitrogen	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.31	ND	ND	0.09	ND	ND	mg/l
5	Cadmium	0.79	0.42	0.75	0.98	0.43	0.47	0.34	0.35	0.33	0.94	0.58	0.62	0.68	0.45	1.16	0.77	0.71	0.25	μg/l
6	Total Chromium	ND	2.15	ND	5.15	1.92	2.15	3.18	ND	3.12	ND	ND	ND	ND	ND	ND	ND	ND	267	μg/l
7	Copper	12.63	11.52	10.25	22.06	8.04	12.83	8.69	5.26	15.40	99.00	4.37	10.71	19.60	8.00	9.82	7.25	7.68	6.25	μg/l
8	Lead (Pb)	4.75	3.14	4.85	6.57	3.94	3.12	3.74	2.32	3.84	4.40	2.15	2.13	ND	ND	ND	53.30	ND	1.82	μg/l
9	Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	μg/l
10	Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	μg/l
11	Silver (Ag)	2.73	6.47	3.94	5.76	4.24	ND	5.26	7.16	10.81	ND	ND	15.62	2.28	15.00	3.84	14.21	2.83	3.14	μg/l
12	Zinc (Zn)	0.004	0.036	0.027	0.068	0.016	0.033	0.019	0.012	0.039	0.046	0.016	0.020	0.021	0.027	0.118	0.038	0.076	0.729	mg/l
13	Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	μg/l
14	Alkalinity	96	96	96	96	96	96	96	101	87	86	91	86	91	77	117	101	91	96	mg/l
15	Elect. Cond.	403	358	357	366	376	364	404	392	519	445	337	505	386	498	378	527	340	383	μS/cm
16	Iron (Fe)	0.25	0.26	0.18	0.35	0.21	0.21	0.31	0.07	0.27	0.14	0.13	0.18	0.52	0.14	0.43	0.18	0.11	0.27	mg/l
17	Manganese	19.48	8.14	9.87	13.8	11.12	8.68	15.18	6.47	11.23	12.01	9.21	8.79	11.16	9.12	3.23	16.57	8.69	13.28	μg/l
18	Boron (B)	21.80	15.49	22.08	3.04	22.56	25.56	2.72	16.96	18.04	ND	4.72	ND	27.80	28.68	28.69	ND	25.80	28.10	μg/l
19	Fluorine (F)	0.049	0.033	0.030	0.047	0.049	0.048	0.044	0.045	0.039	0.044	0.054	0.038	0.040	0.042	0.039	0.054	0.058	0.059	mg/l
20	Nitrate	2.82	0.89	1.06	1.40	9.97	1.51	2.15	2.03	5.31	4.93	2.04	6.34	2.17	6.18	3.56	7.56	2.41	4.24	mg/l
21	Nitrite	9	2	9	2	8	2	6	7	10	5	7	18	80	20	6	10	18	5	μg/l
22	Calcium	33	32	33	32	31	34	32	20	42	25	20	43	30	38	30	40	30	32	mg/l
23	Magnesium	13	10	11	11	12	10	11	11	14	14	11	11	12	12	12	16	11	11	mg/l
24	Sodium	32	29	21.5	30	30.5	30	29	29	45	32	26	37	25	35	27	45	26	26	mg/l
25	Potassium	6.8	6.5	6.6	6.6	6.6	6.4	8.5	6.5	7.0	7.5	6.2	6.9	6.6	6.7	6.9	8.3	6.4	6.6	mg/l
26	Sulphate ion	57	54	55	53	55	47	54	47	86	59	52	72	50	76	50	77	51	44	mg/l
27	Chloride ion	45	32	32	35	36	39	23	32	65	51	28	60	31	48	33	64	30	38	mg/l
28	Chlorine	0.53	ND	0.02	ND	ND	0.18	ND	0.11	0.11	ND	ND	0.16	ND	0.13	ND	ND	0.06	0.13	mg/l
29	Coliform	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	Count/dl
30	Fecal Coliform	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	< 3	Count/dl
31	Plate Count Bacteria	2.9×10^4	5.2×10^3	450	2.5×10^3	3.2×10^3	160	100	1,000	1.2×10^4	890	850	1,100	200	1.7×10^4	2,800	60	1,500	150	cfu/ml

(5) Raw Sewage and Treated Water

In Karachi, there are three Sewage Treatment Plants that are called TP1, TP-2 and TP-3. Trickling Filter Process is applied in the TP-1 and TP-2. The newest treatment plant, TP-3, applies Stabilisation Pond System.

Water quality analysis of sewage was undertaken to assess the treatment efficiency at the existing TP1, TP2 and TP3 by investigating the receiving water quality in the river and sea. In order to identify the sampling point easily, Sample ID was determined as follows;

- ID-"A" means that the sample is "raw sewage" taken from inlet chamber or adequate point.
- ID-"B" means that the sample is "treated effluent" taken from outlet before discharging.
- ID-"C" means that the sample is "discharged water" taken from meeting point of the mainstream of the large river or sea area.

Comparison between ID-"A" and ID-"B" can assess the treatment efficiency of each TP. Removal rate of TSS and BOD may be simple indicators of functional evaluation for TP.

TP1-C is located 400m downstream of confluence of Lyari River and drainage canal from TP1. TP2-C is located in the mainstream of Malir River near the bridge of Korangi By-pass road. TP3-C is located in the seafront of Lyari River close to the mangrove forest.

Figure 41.2.4 indicates all sampling points of raw sewage and treated effluent. Results of samples of each TP collected in the dry and wet seasons are shown in **Table 41.2.9** and **Table 41.2.10**, respectively.

Table 41.2.9 Results of Samples Collected from each STP in the Dry Season

S. No.	Parameters	TP-1			TP-2			TP-3			Units
		A	B	C	A	B	C	A	B	C	
1	pH	7.4	7.4	7.1	7.7	7.5	7.1	7.8	7.9	8.0	-
2	COD_{Cr}	521	521	5937	325	406	198	2500	937	937	mg/l
3	Coliform	2.8×10^7	1.4×10^7	2.4×10^8	1.1×10^6	7×10^4	1.1×10^6	2.3×10^6	3×10^4	1.1×10^3	count/dl
4	Ambient Temp.	38	38	39	32	32	33	35	36	35	^oC
5	Water Temp.	35	35	38	31	31	32	35	37	36	^oC
6	BOD	278	150	1228	144	100	123	188	78	64	mg/l
7	TSS	104	16	176	44	60	36	24	34	52	mg/l
8	Total Nitrogen	292	252	847	221	355	371	243	279	291	mg/l
9	Total Phosphorus	2.17	1.84	0.27	1.67	2.15	1.70	1.66	1.91	1.83	mg/l

Table 41.2.10 Results of Samples Collected from each STP in the Wet Season

S. No.	Parameters	TP-1			TP-2			TP-3			Units
		A	B	C	A	B	C	A	B	C	
1	pH	7.39	7.09	7.22	7.71	6.80	6.84	7.65	7.50	7.12	-
2	COD_{Cr}	161	290	855	145	169	97	177	121	87	mg/l
3	Coliform	2.8×10^6	2.1×10^6	4.3×10^5	4.6×10^6	2.1×10^6	4.0×10^6	4.3×10^4	3.4×10^4	4.0×10^4	count/dl
4	Ambient Temp.	29	29	29	27	28	28	31	30	30	^oC
5	Water Temp.	30	30	31	29	29	29	33	32	29	^oC
6	BOD_5	69	192	549	94	55	85	118	34	128	mg/l
7	TSS	48	72	100	44	48	32	32	38	76	mg/l
8	Total Nitrogen	135	184	839	150	124	115	172	153	78	mg/l
9	Total Phosphorus	2.02	2.45	2.88	1.17	1.17	1.06	2.25	2.64	2.35	mg/l

Figure 41.2.7 Location of Sampling Points of TP-1

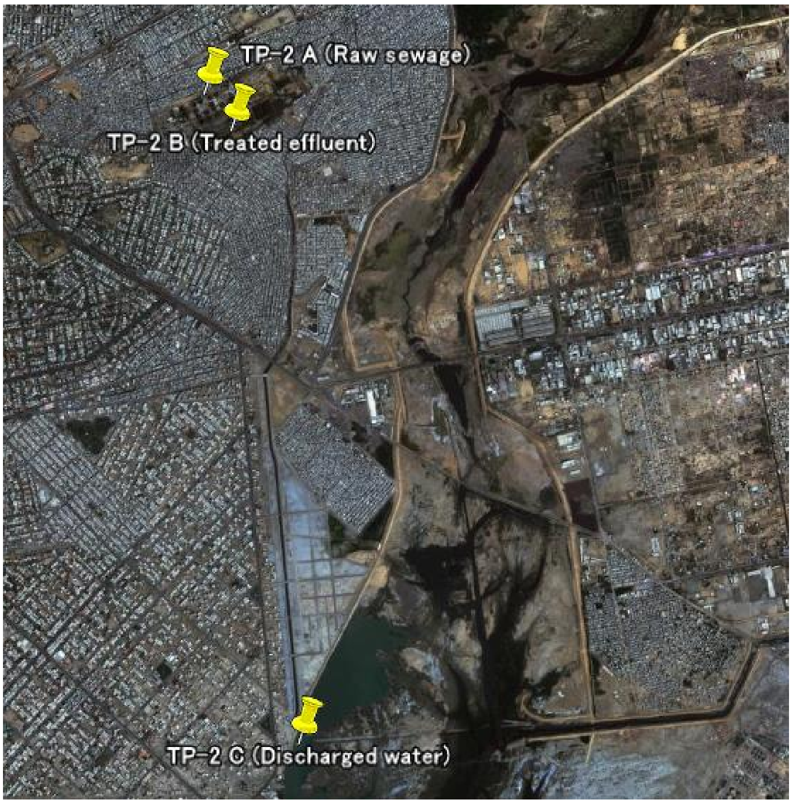


Figure 41.2.8 Location of Sampling Points of TP-2

Figure 41.2.9 Location of Sampling Points of TP-3

(6) Domestic & Commercial Wastewaters

Samples of domestic & commercial wastewater have been collected from the drain/nallah streaming with untreated sewage or wastewater in the representative township. Analysed parameters were same as sewage treatment plant evaluation. RWW-1 (Natural nallah, Orangi Town, in **Figure 41.2.2**) is located in the northern part of Karachi and RWW-2 (Malir Colony Drain, Malir Town, in **Figure 41.2.5**) is located near the International Airport in the east of Karachi. Both sampling points are located in ordinary residential areas which are not sewered. Two other points were selected for commercial areas. CWW-1 is from Pitcher Drain in Saddar Town and CWW-2 is from Nahar-e-Khayyam Drain which flows into Ganda Nallah in Clifton area (both in **Figure 41.2.4**).

Test results of samples collected from domestic & commercial wastewater in the dry and wet seasons are shown in **Table 41.2.11**.

Table 41.2.11 Results of Samples Collected from Domestic & Commercial Wastewater

S.No.	Parameters	RWW-1		RWW-2		CWW-1		CWW-2		Units
		Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	
1	pH	7.3	8.0	8.0	7.0	7.1	7.1	7.0	7.0	
2	COD_{Cr}	73	63	488	268	167	81	385	161	mg/l
3	Ambient Tem.	36	34	32	29	32	31	32	33	^{o}C
4	Water temp.	34	30	31	31	31	30	33	31	^{o}C
5	BOD	100	37	304	231	103	58	194	79	mg/l
6	Suspended Solids	56	14	52	146	32	22	32	34	mg/l
7	Total Nitrogen	414	13	1,746	389	91	236	1,092	224	mg/l
8	Total Phosphorus	0.68	0.46	2.46	4.24	1.44	2.11	1.80	2.43	mg/l

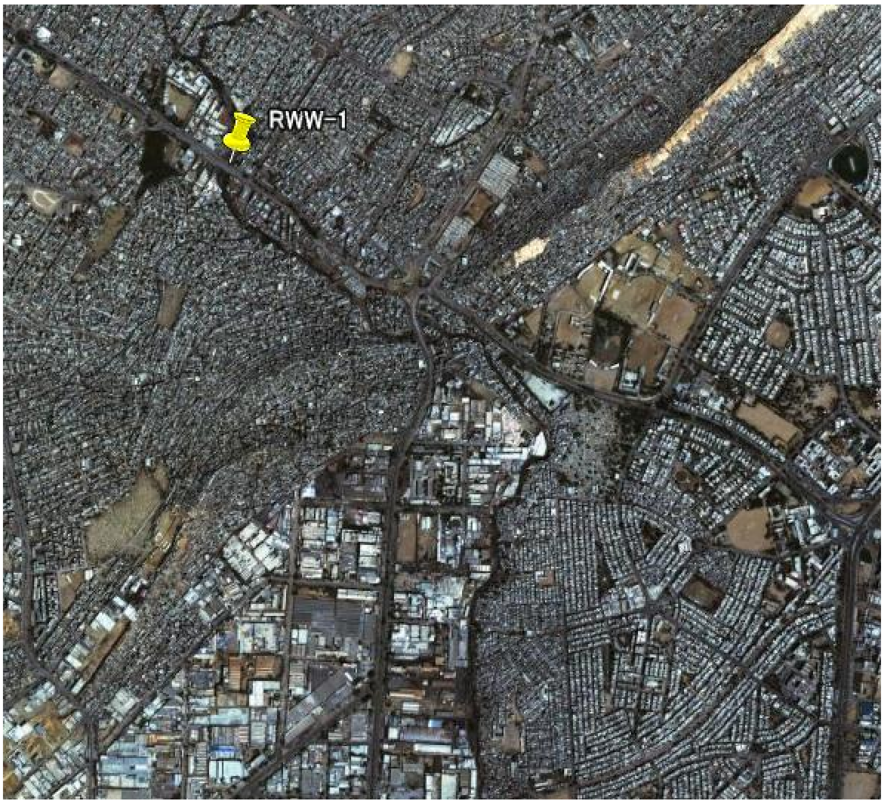


Figure 41.2.10 Location of Sampling Point RWW-1

Figure 41.2.11 Location of Sampling Point RWW-2

Figure 41.2.12 Location of Sampling Point CWW-1

Figure 41.2.13 Location of Sampling Point CWW-2

4.1.3 Results and Discussions

In total, 40 samples of water and wastewater (including 2 samples of raw water, 7 samples of treated (post chlorinated) water, 18 samples of distribution water, 9 samples of raw sewage and treated water river and 4 samples of commercial and domestic wastewater) are analysed for various chemical and microbiological parametres specified by the Study Team in cooperation with Central Laboratory Unit of KW&SB.

According to Scope of Work for the Study, total 31 physico-chemical and microbiological parametres must be examined during the Basic Study Phase. The survey on laboratory capability in Karachi showed that Hexavalent Chromium and Gallium could not be analysed regardless of the reliability of external laboratories. Alkalinity which is a parametre for dosage control of alkaline chemical for coagulation process and Electric Conductivity (EC) which can simply give an indication of water contamination were substituted for those two parametres.

Total Chromium was analysed as a substitute for Hexavalent Chromium (Cr^{6+}). The metal chrome (the Cr elemental substances) itself is harmless and very stable chemically. However, being oxidized, when it becomes the ions of tervalent and hexavalent, it may reach the level where it has significant virulence for human health. Since the chrome present in the nature is tervalent in most cases, toxicity is not much high in comparison with hexavalent one. If Total Chromium concentration is much less than the WHO’s Standards, abundance of hexavalent Chromium is at undetectable order.

Gallium does not exist in free form in the nature, nor do any high-gallium minerals exist to serve as a primary source of extraction of the element or its compounds. While not considered toxic, the data about gallium is inconclusive. Some sources suggest that it may cause dermatitis from prolonged exposure; other tests have not caused a positive effect. It is, however, not found in the chemicals of drinking water standards. An important application is in the compound Gallium Arsenide, used as a semiconductor, most notably in Blue Light-Emitting Diodes (LEDs). Therefore, if it hadn't been for semiconductor industry in the upstream of Indus River, pollution caused by Gallium has never taken place in Karachi’s water supply. Reasons for these circumstances, it was concluded that Gallium analysis is not included in the water quality examination.

(1) Water Supply Samples

Table 41.1.1 shown in **Section 4.1 (3)** gives the limits for drinking water for human consumption, recommended by the WHO. The results show that in 7 samples of treated water (post chlorination) and 18 samples of distribution water, collected in the dry season, the concentrations of analysed chemical parametres have been found within the permissible limits recommended for drinking water for human consumption by the WHO. In some of the samples from the distribution system (Sample ID: DW), iron contents are higher than the recommended limit of 0.3 mg/l. The higher concentration of iron may be attributed to the rusting of aged pipes. The concentration of NO_3-N is found to be comparatively higher in all the samples in the dry season than in the wet season. However, all the samples could meet the limit of standards (less than 50 mg/l). Most water sources are from the surface water which originated from the Indus River. Therefore, concentrations of other heavy metals in water samples are distinctly low.

Although concentration of residual chlorine is either ND (not detected) or very low, both coliform and Faecal Coliform tests have shown good results. Content of residual chlorine is recommended in the range between 0.20 to 0.50 mg/l by KW&SB. Before distributed water reaches the faucet at each house, residual chlorine has been consumed against germs. In general, cross connections may back siphonage of polluted water from leaking point. Moreover, due to intermittent water supply, many customers use their own suction pumps. This is also one of typical causes for water contamination.

Microbiological quality of the collected samples was evaluated by determining the Total Aerobic General Bacteria, Total Coliform and Faecal Coliform counts. In dry season samples of raw water RW-1 and RW-2 showed relatively high Total Aerobic Bacteria, Coliform and Faecal Coliform count. According to WHO Guidelines (Guidelines for Drinking-Water Quality, First Addendum to Third Edition), water for human consumption should not contain any pathogenic bacteria. A zero (or less than 3) Total Coliform, zero (or less than 3) Faecal Coliform and 100 cfu/ml (cfu: colony forming unit) total aerobic bacteria count are appropriate standards for drinking water. Two samples out of seven treated water (TW-4 and TW-7) contain a little high total coliform count, but they have zero or less than 3 Faecal Coliform count. Two samples (DW-1 and DW-8) out of eighteen distributed waters in the dry season contain Total Coliform and Faecal Coliform count. Presence of Faecal Coliform in these samples provides definite evidence of faecal contamination. In the dry season, all of the treated and distribution water samples except TW-1, TW-2, TW-5, TW-6, DW-6 and DW-16 contain high Total Aerobic Bacteria count exceeding the upper limit of 100 cfu/ml.

The raw water samples ‘RW-1’ and ‘RW-2’ collected in the wet season shows high level of total aerobic, Total Coliform and Faecal Coliform. In the treated (post chlorination) water the level of Total Aerobic General Bacteria count exceeds the upper limit of 100 cfu/ml in TW-1, TW-4, TW-5 and TW-7, and in the distribution water the level of Total Aerobic General Bacteria Count exceeds the same upper limit in all the samples, except DW-7 and DW-16. As far as the level of Total Coliform is concerned, with the exception of TW-4 and TW-7, it is within the permissible limit of not greater than 3 count/ml in the treated water as well as distribution water. Regarding Total Faecal Count, it is within the permissible limit of not greater than 3 count/ml.

Even if the General Bacteria is detected, there is no direct relation with the pathogenic bacteria. When large number of General Bacteria is detected, however, there is the doubt where the tap water is polluted by the pathogens. In addition, it is judged that chlorine disinfection has not functioned sufficiently with water treatment process or distribution network system.

(2) Sewage, Domestic & Commercial Wastewater Samples

Table 41.1.2 shown in **Section 4.1 (3)** gives the limits for municipal and liquid industrial effluent as per National Environmental Quality Standard (NEQS) of Pakistan. Water quality of sewage was analysed to assess the treatment efficiency of the 3 existing Sewage Treatment Plants. The water quality test results for the 3 sewage treatment plants are mentioned above in **Table 41.2.9** and **Table 41.2.10**. Raw sewage, treated effluent and discharged effluent qualities were analysed for pH, COD_{Cr}, Coliform, Temperature, BOD, Suspended Solids, Total Nitrogen and Total Phosphorus.

The raw sewage and treated effluent qualities were worse in the dry season than in the wet season as expected. Some BOD reduction at TPs was observed during the dry season. In regard to other parametres, most of obtained data did not meet the effluent standards. In addition, some data were judged as abnormal, for example, quality of treated effluent was worse than that of raw sewage. It is difficult to explain what caused such results. In early August 2006 when sampling and water quality test were done for the wet season, TP-1 and TP-2 had not been operated for the past one month or so.

The water quality test results for domestic & commercial wastewater samples are shown in **Table 41.2.11**. The samples for domestic & commercial wastewaters were taken from the artificial drain and natural nallah which considered representing the whole Karachi city.

Along with the test result of raw sewage and treated effluent, the samples for domestic & commercial wastewaters were also worse for COD_{Cr} and BOD in the dry season than in the wet season as expected. Due to dilution of organic pollutant with rain water, BOD in the wet season meets the Standards except RWW-2.

(3) Past Data Evaluation

The past 5 year water quality data for water supply and sewerage facilities of KW&SB had been transformed to the electric data. Those tables are shown in **Appendix A41.1**. Obtained data are as follows;

- Average Data of Chemical Analysis of Raw & Filtered Water, COD Hills Filter Plant (2001-2005)
- Average Total Coliform count per 100 ml (MPN Method), Bacteriological Analysis Report, of Raw & Filtered Water, COD Hills Filter Plant, (2001-June, 2006)
- Average Data of Chemical Analysis of Raw & Filtered Water, Gharo Filter Plant (2001-2005)
- Average Data of Total Chemical Analysis of Raw & Filtered Water, Pipri Filter Plant (2001-2005)
- Average Data of Chemical Analysis of Raw & Filtered Water, NEK (Old) Filter Plant (2001-2005)
- Average Data of Chemical Analysis of Raw & Filtered Water, NEK (K-II) Filter Plant (2001-2005)
- Average Data of Chemical Analysis of Raw & Filtered Water, Hub Filter Plant (2001-2005)
- Monthly Bacteriological (Total Coliform count/100ml, MPN Method) and Chemical Analysis Data from Pump Houses of Distribution System (2001-June, 2006)
- Average Data of Chemical Analysis of Sewage & Treated Effluent, Sewage Treatment Plant No.1 (2001 to 2005)

Analysed parametres were not the same in all the laboratories, because equipped instrument varies by laboratory. The most best equipped laboratory is in the COD Hills Water Treatment Plant which is home to the Central Laboratory Unit. The Central Laboratory Unit is responsible for the analysis of distributed water samples from specified pump houses located in each township. Once every two weeks, those samples are collected and analysed by the laboratory technicians. Under the present situation, microbiological parametres can be tested in the Central Laboratory Unit only.

Collected past data shows that water qualities were generally “acceptable” throughout the year not only water supply samples but also sewage ones. Apart from pumping and feeding troubles, there is no water quality accident according to the data in the past 5 years. Especially, water quality data from TP-1 indicates that sewage treatment was fully functional to reduce BOD and TSS properly.

4.2 WATER AWARENESS SURVEY

4.2.1 Objectives and Survey Design

(1) Objectives

The people in Karachi have diverse social and economical backgrounds because many people have immigrated to Karachi from other provinces of Pakistan and surrounding countries such as India, Bangladesh and Afghanistan. This diversity significantly affects the usage of water supply and sewerage. For example, the people living in Katchi Abadis, who usually belong to low income group or lower middle income group, are using less water comparing to high income group such as the residents living in Clifton.

Recently, CDGK and Bureau of Statistics, Government of Sindh conducted few socio-economic questionnaire surveys that included some questions on water supply and sewerage. However, the results from their socio-economic reports are not sufficient to support decisions in the formulation of Water Supply and Sewerage Master Plan.

The relevant results tabulated in Socio Economic Survey Report-2005 V-1.0, Karachi Master Plan-2002, CDGK are presented in figures in **Appendix A42.1**. Its results show town-wise water supply and sewerage situation as well as household economic situation to some extent. These results are very important to understand the differences among the 18 towns. However, these results do not disclose the differences in water supply and sewerage conditions in diverse types of settlements such as Katchi Abadis, middle income group and high income group.

Karachi Human Rural Settlement Survey Report-2003, Bureau of Statistics, Government of Sindh also disclosed availability and quality of different types of water supply in rural settlements of Karachi. However, its results related to water supply and drainage are quite limited as shown in figures in **Appendix A42.2**.

Water Awareness Survey conducted in this Study consists of three types of questionnaire surveys (one main survey and two supplementary surveys) as listed below with their designed sample numbers.

1) Water Supply and Sewerage Usage Survey (1,000 samples)
2) Existing STPs Environmental and Social Impact Survey (100 samples)
3) Nala (River) Awareness Survey (100 samples)

The main purpose of Water Awareness Survey is to fully understand the existing water supply and sewerage situation, consumer complaints and demands, and acceptability of water meter and willingness to pay (WtP) for improved water supply and sewerage system in different types of settlements in Karachi. For this purpose, Water Supply and Sewerage Usage Survey is conducted. The results of this usage survey will be systematically used in the consideration of a range of aspects including, area prioritization for improvement, feasibility of metre installation, facility planning, O&M planning, economic analysis, tariff design, and awareness enhancement for the formulation of effective Master Plan. This survey was especially designed to clarify the differences between the poor and the more affluent, and the differences within the poor.

Existing STPs Environmental and Social Impact Survey is a supplementary survey to explore the residents' perception on the potential environmental and social impacts caused by the existing sewerage treatment plants (STPs). The results from this survey will be used mainly for environmental and social considerations and will also be referred in Initial Environmental Evaluation (IEE)/Environmental Impact Assessment (EIA).

The existing sewerage system is built on natural rivers/drainages locally called "Nala". In many places, Nalas are used as a substitute for secondary and trunk sewers. Considering financial constrains of Karachi and utilization of existing system, it is unavoidable to use a number of small Nalas as part of the sewerage system continuously in the future. Because Nalas in Karachi are facing many problems such as encroachment and clogging by garbage, Nala Awareness Survey is designed to capture the perception and demands of local people regarding the improvement of Nalas. The results of this survey will be used in the formulation of Sewerage Master Plan to improve Nalas as part of the sewerage system of Karachi in accordance with the desires of the local people.

(2) Survey Design of Water Supply and Sewerage Usage Survey

a. Main Questions

The questionnaire used for Water Supply and Sewerage Usage Survey (see **Appendixes A42.3 and A42.4**) consists of a large range of aspects (more than 200 questions) regarding water supply and sewerage situation and related perceptions of different types of residents, as listed below.

GENERAL

1) Household General Information
2) Household Economic Situation

WATER SUPPLY

1) Various Water Sources and Their Costs
2) Household Water Supply Equipment
3) Complaints and Demands on Public Water Supply
4) Water Conservancy
5) Acceptability of Water meter
6) Willingness to Pay for Improved Services

SEWERAGE

1) Environmental Awareness
2) Sewerage/Sanitation Options
3) Complaints and Demands on Sewerage
4) Willingness to Pay for New Sewerage Connection

OTHERS

1) Public Health
2) Storm Water Drainage
3) Garbage Disposal

There are many questions which are designed particularly to consider the water supply problems of Karachi. Currently, the people in Karachi are not familiar to the necessity of 24 hour water supply and the demand on 24 hour water supply is not well developed. To analyze this aspect, their WtP for different types of future water supply services (good pressure, 8 hour water supply, 24 hour water supply) are asked in separate questions.

Considering sustainable development of water supply in Karachi in the context of its limited financial and water resources, it is necessary to install water meter to each household in order to improve the cost recovery of waterworks and also to encourage water conservancy. Since most of the households are currently not familiar with water meter, enhancing awareness of the importance of water meter is critical for the sustainable development of water supply system. Therefore, in the interviews with the respondents, the advantages of water meter are well explained before asking them whether they support the installation of water meter. To the respondents who answered “Don’t support the installation of water meter”, their reasons for not supporting it and the conditions on which they will support were asked. The results from these questions will be used to evaluate the feasibility of water meter installation in Karachi.

b. Sampling Design

The survey was conducted in 56 sampling areas of different types of settlements in Karachi. **Table 42.1.1** shows the allocation of 1,000 samples to each type of sampling areas. **Figure 42.1.1** shows the locations of the selected sampling areas of different types.

Table 42.1.1 Sample Number Allocation of Water Supply and Sewerage Usage Survey

Type of Sampling Area	Katchi Abadis	Low&Lower Middle Income Group in Planned Areas	Upper Middle Income Group	High Income Group	Residents in Commercial Area	Bulk Consumers Area	Rural Settlement	Total
Number of Sampling Areas	30	5	4	3	4	3	7	56
Total Sample Number of Each Type of Sampling Area	600	80	64	48	64	48	112	1016

One the main objectives of Water Supply and Sewerage Usage Survey is to understand related problems in Katchi Abadis where about half of the population in Karachi live. To achieve this objective, 600 samples (60% of the total designed samples) are allocated to various types of 30 notified Katchi Abadis over the built-up area of Karachi. From all the sampling areas, household samples were taken randomly using 0.6m high-resolution satellite imagery.

In the analysis of the survey results, the average values for whole Karachi was also estimated using the percentage of each residential type shown in **Table 42.1.2**. This Table also gives post-defined income level criteria for each residential type used in the survey.

Table 42.1.2 Income Range and Population Percentage of Each Residential Type

<table>
<tr><th colspan="2">Residential Type</th><th>Average Monthly Household Income Range Appeared in Water Supply and Sewerage Usage Survey (Post-defined Income Level Criteria)</th><th colspan="2">Corresponding Monthly Household Income Range and Percentage of Each Income Group in Karachi from Socio Economic Survey of Karachi Master Plan-2020</th></tr>
<tr><td rowspan="3">Low&Lower Middle Income Groups</td><td>Katchi Abadi</td><td>Rs. 6,077 – Rs. 13,588</td><td rowspan="3">Rs. 0 – Rs 15,000</td><td>45%*1</td></tr>
<tr><td>Rural Settlement</td><td>Rs. 4,861 – Rs. 12,722</td><td>5%*1</td></tr>
<tr><td>Planned Area</td><td>Rs. 7,079 – Rs. 12,639</td><td>31%</td></tr>
<tr><td colspan="2">Upper Middle Income Group</td><td>Rs. 17,075 – Rs. 30,947</td><td>Rs. 15,001 – 35,000</td><td>17%</td></tr>
<tr><td colspan="2">High Income Group</td><td>Rs. 41,385 – Rs. 109,286</td><td>Rs. 35,001 & Above</td><td>2%</td></tr>
<tr><td colspan="4">Total</td><td>100%</td></tr>
</table>

Note: *1 These percentages are assumed for the calculation of the other percentages.

Figure 42.1.1 Sampling Areas of Water Supply and Sewerage Usage Survey

(3) Survey Design of Existing STPs Environmental and Social Impact Survey

a. Main Questions

The questionnaire used for Existing STPs Environmental and Social Impact Survey (see **Appendixes A42.5** and **A42.6**) consists of about 70 questions regarding existing and potential environmental and social impacts of the three STPs which are under operation in Karachi. The results will be used for environmental and social consideration process of the Study. Main aspects covered in this survey are listed below.

1) Awareness of KW&SB's Work
2) Social Influences of the STP and Effluent Discharge
3) Environmental Influences of the STP and Effluent Discharge

b. Sampling Design

Table 42.1.3 shows the allocation of total 100 samples to each STP. **Figure 42.1.2** shows the sampling areas of the survey. The survey was conducted in residential areas located around the three existing sewerage treatment plants. To find out the geographical extent of environmental and social impact, the sampling areas were set at different directions and at different distances from the STP. Because STP-2 is totally surrounded by residential areas, more than half of the 100 samples are allocated around STP-2. Larger numbers of samples are set down the wind up to about 2km from the centre of smell (primary waste water treatment facilities). Moreover, to find out the influence of discharged effluent from the STPs, samples are also taken around the Nalas where effluent from the STPs discharge into.

Table 42.1.3 Sample Number Allocation of Existing STPs Environmental and Social Impact Survey

Existing Sewage Treatment Plant	STP-1	STP-2	STP-3	Total
Number of Sampling Areas	7	20	4	31
Total Sample taken around Each STP	29	17	54	100

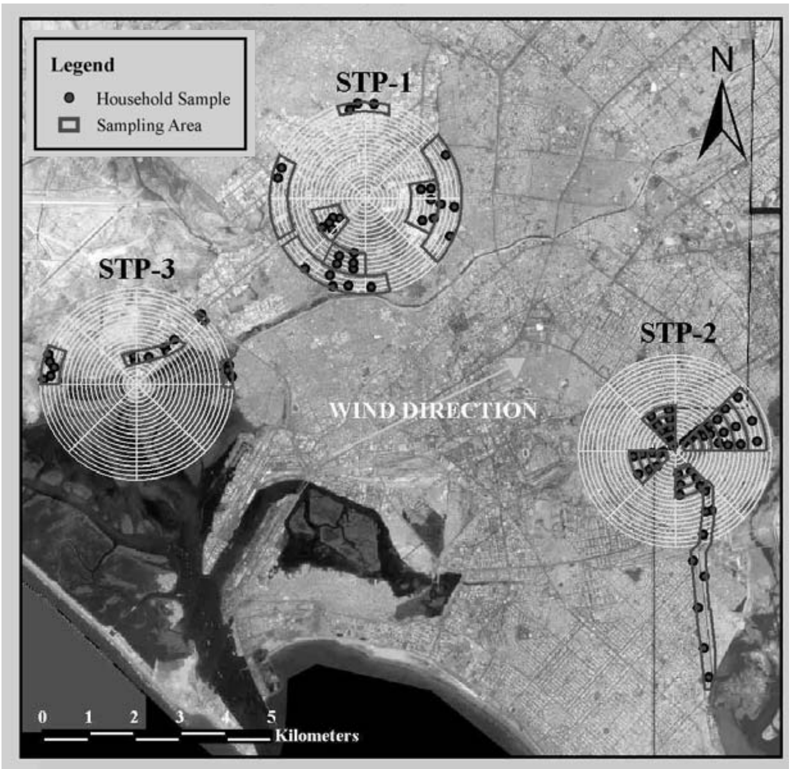


Figure 42.1.2 Sampling Areas of Existing STPs Environmental and Social Impact Survey

(4) Survey Design of Nala Awareness Survey

a. Main Questions

The questionnaire used for Nala Awareness Survey (see **Appendixes A42.7** and **A42.8**) consists of about 110 questions regarding the improvement of small Nalas in communities and large Nalas. This survey is a complementary survey for the sewerage-related part of Water Supply and Sewerage Usage Survey. In the development of questionnaire, the JICA Study Team had discussion with OPP-RTI. Main aspects covered in this survey are as listed below.

1) Construction and Repair Work of Nalas
2) Blockage and Encroachment
3) Flood
4) Pollution and Accident

The results of this survey will be used for the formulation of sewerage master plan which integrates existing Nalas as part of sewerage system while improving water quality of some Nalas. The improvement of Nala includes many social aspects such as demolishment of illegal encroachments along Nalas. Therefore, the questions are designed to clarify the perceptions of the households around different types of Nalas on related social aspects.

b. Sampling Design

In this survey, three types of sampling areas were set in residential areas around Nalas, which are Small Nala Sampling Areas, Large Nala Sampling Areas, and Developed Nala Sampling Areas where Nalas are partly covered or widened (Welfare Colony, Manzoor Colony and North Nazimabard). **Table 42.1.4** shows the allocation of samples to each type of sampling areas. **Figure 42.1.3** shows the sampling areas. Some sampled households belong to high income group. However, about majority of the sampled households belong to Katchi Abadis. Many of them are even encroachers along Nalas.

Table 42.1.4 Sample Number Allocation of Nala Awareness Survey

Sampling Area	Small Nala Sampling Areas	Large Nala Sampling Areas	Developed Nala Sampling Areas	Total
Number of Sampling Areas	5	5	3	13
Total Sample taken around Each STP	40	40	24	104

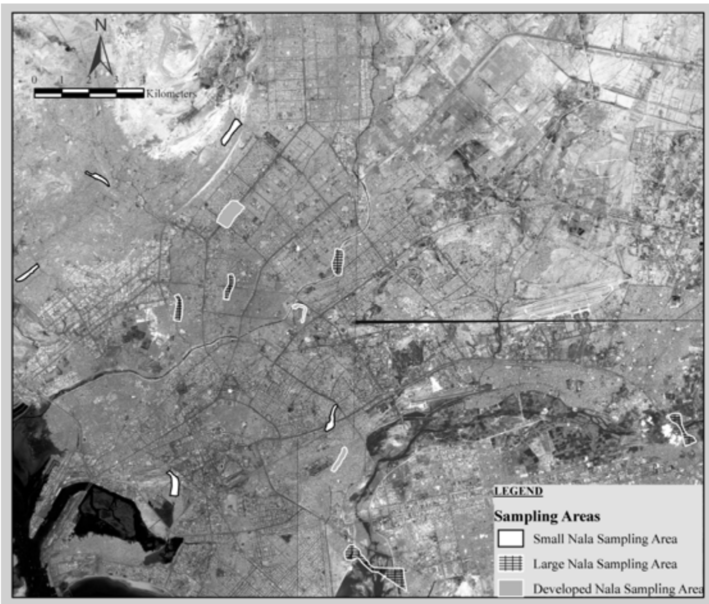


Figure 42.1.3 Sampling Areas of Nala Awareness Survey

4.2.2 Survey Results

(1) Water Supply and Sewerage Usage Survey

Photographs of the observed water supply and sewerage conditions in different types of areas are shown in **Appendix A42.9**. The results of the survey are tabulated and discussed in detail in **Appendixes A42.10** to **A42.12**. The following is the summary of the results.

a. Area Prioritization for the Improvement of Water Supply and Sewerage

1) <u>Water Supply Improvement and Willingness to Pay</u>

1. Small Katchi Abadis (less than 30 acres) have high water line connection rate of more than 60% (90% on average) while large Katchi Abadis (more than 200 acres) have low water line connection rate of less than 60% (28% on average).Water line connection rate is also significantly low in villages and among the residents in commercial areas.
2. In large Katchi Abadis, water line connection rate is much lower than its sewerage connection rate. Main reason of this low water line connection rate seems to be the distance from main streets of planned areas where water distribution mains are installed. In large Katchi Abadis, the willingness to have water line connection is 100% among the un-connected households.
3. The water line connection rates of Low&Lower Income Group in planned areas and Upper Middle Income Group are around 90 %. However among their remaining households of 10%, willingness to have individual water line connection is only about 60% and 30%, respectively. This means many households unconnected to water line in planned areas are already satisfied with their alternative water sources.
4. The water charges that they are paying for line water connection is less than 1% of their average monthly income in most of the residential types. However, the estimated average total expenditure for water including water tankers is around 2.5% of their average income level in most of the residential types.
5. In large Katchi Abadis, where water line connection rate is significantly low, average total expenditure for water is about 9% of their income. In High Income Group and Bulk Consumers such as DHA, where people buy much bottled water for drinking purpose, the total monthly expenditure for water is quite high as well.
6. The average WtP for new water line connection is higher than the average WtP for improved water supply services in Katchi Abadis, Low&Lower Middle Income Group of planned areas, and villages. However, it is other way around in Upper Middle Income Group and High Income Group.
7. In large Katchi Abadis, where people are buying expensive water from Tanker, etc., the average monthly WtP for new water line connection is high, which is around 7% of their average income level. They have strong demand on the expansion of water lines by KW&SB.
8. The WtP for better water supply services is higher in higher income group in general. In large Katchi Abadis, the average WtP for the improvement into 24-hour water supply is significantly high, which is close to 5% of their average monthly income.
9. In conclusion, water distribution network should be expanded in large Katchi Abadis, where connection rate is low but the WtP for new line connection and 24-hour water supply service is significantly high. In Upper Middle Income Group and High Income Group, where WtP for better water supply services are significantly high, the rehabilitation of existing water supply system is more important and sustainable.

2) <u>Sewerage Improvement and Willingness to Pay</u>

1. The sewerage connection rate (percentage of the households connected to sewers locally called “Gutter” and “Gutter line”) is higher than water supply connection rate in general in Karachi except for rural areas, which is estimated at 89% on average. In Upper Middle and High Income Group, the sewerage connection rates have already reached almost 100%.

2. The current level of sewerage charges is only around 0.2% of their household income level.
3. The WtP for new sewerage connection to improve household life is only around 1% of their income in Katchi Abadis and Low&Lower Middle Income Group in planned areas.
4. The WtPs for new sewerage connection to improve both their household life and environment in Karachi are hardly higher than the WtP only for household life improvement. Especially, the households in low and lower middle income groups are not putting their importance on the environment.
5. Considering their high expenditure for water related disease in comparison of their income level, there seems to be potential of higher WtP for sewerage in those areas where sewerage conditions are not desirable. Therefore, it is quite important to raise the awareness on sewerage in Karachi to have the people accept the higher sewerage charges that is necessary for sustainable sewerage improvement in the future.

3) Social Conditions of Different Residential Types

Social characteristics of each residential type are also analyzed below to support proper area prioritization in the social context of Karachi as well as its economical context examined above.

1. About 80% of the respondents in Katchi Abadis and villages were males while this ratio is about 65% in planned urban areas. This suggests higher unemployment ratio, higher labour availability and lower social advance among females in Katchi Abadis and villages.
2. On average 1.7 families belong to one household and 9.2 persons including 2.4 children (blow 10 years old) live in one household in Karachi. These ratios do not differ dramatically among different residential types and income groups.
3. In Katchi Abadis where many immigrants live, only 29% of the households had lived in other urban areas of Karachi before coming to current places. 36%, 8% and 21% of them have come from rural area of Karachi, Interior Sindh and other provinces such as Punjab, respectively
4. Average plot size of household ranges from 90 to 600 square yards mainly depending on their income level. Larger Katchi Abadis usually have larger average plot size.
5. Although the survey was conducted in notified Katchi Abadis, 45% of the households in those Katchi Abadis are built on unleased plots.

b. Current Water Supply Conditions

1) Usage of Different Water Sources and Water Consumption

Table 42.2.1 shows the percentages of the households using different water sources for different purposes.

1. The percentage of the households actually using individual or shared water line connections are 80% in total in Karachi, which is slightly lower than the percentage of the households having water line connections.
2. This table also shows that the percentages of the households using water tankers and wells/bores are both 18%. More than 20% of the households in Katchi Abadis are using water tankers. 28% of Low&Lower Middle Income Group in planned areas are using wells or bore, although about half of this 28% do not use the ground water for drinking purpose because ground water is brackish in many areas.
3. In High Income Group, 30% of the households use bottled water for drinking purpose.
4. 6% and 4% of the households in Karachi use water carrying persons and public water storage tanks.
5. The table also shows that the average number of different types of water sources in use is 1.4 sources in Karachi. In Katchi Abadis, they use individual line connections and water tankers mainly.

Table 42.2.1 Percentage of the Households Using Different Sources

Area Category	Individual Water line Connection (%)			Shared Water Line Connection (%)			Bottled Water (%)			Water Tanker (%)		
	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages
Katchi Abadis	66	69	68	8	7	9	3	1	4	22	21	23
Low & Lower Middle Income Group in Planned Areas	73	65	76	4	6	7	14	1	14	8	8	12
Upper Middle Income Group	81	85	89	2	2	4	15	0	15	2	6	6
High Income Group	71	96	96	3	0	3	30	0	30	7	13	15
Residents in Commercial Areas	46	55	56	27	29	33	31	0	31	4	5	5
Bulk Consumers	68	86	86	0	0	0	19	0	19	18	33	33
Rural Settlements	24	28	28	6	6	7	1	1	2	46	39	47
Estimated Average in Karachi	69	69	73	6	6	7	9	1	9	15	15	18

Area Category	Water Carrying Person (%)			Public Storage Tanks (%)			Well/Bore (%)			Other Water Sources such as Lake (%)			Average Number of Different Water Sources in Use		
	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages	Drinking	Other Usages	All Usages
Katchi Abadis	3	4	4	3	3	4	9	13	14	0	1	1	1.1	1.2	1.3
Low & Lower Middle Income Group in Planned Areas	7	2	8	1	1	2	14	28	28	1	1	1	1.2	1.1	1.5
Upper Middle Income Group	2	4	5	2	0	2	2	13	13	0	0	0	1.1	1.1	1.3
High Income Group	0	0	0	0	0	0	1	5	5	0	0	0	1.1	1.1	1.5
Residents in Commercial Areas	3	3	6	3	3	4	10	23	25	0	0	0	1.2	1.2	1.6
Bulk Consumers	0	0	0	5	4	5	0	2	2	0	0	0	1.1	1.2	1.5
Rural Settlements	8	7	8	20	16	21	11	15	15	10	11	11	1.3	1.2	1.4
Estimated Average in Karachi	4	3	6	3	3	4	9	18	18	1	1	1	1.2	1.2	1.4

6. In large Katchi Abadis, where line water connection rate is low, the total percentage of households not having enough water for more than bathing is 33% while those of High Income Group and Bulk Consumers are only 10% and 4% respectively.
7. 26% of drinking water is bottled water in High Income Group while that is only 2% in Katchi Abadis.
8. The consumption of line water in large Katchi Abadis and villages are only 3% and 24% of the total water consumption for non-drinking proposes. However, this rate is 59% and 91% in Katchi Abadis and High Income Group, respectively. In large Katchi Abadis, water tanker supplies 70% of their water.
9. In large Katchi Abadis, households are spending Rs. 670 per month for water tankers while spending only Rs. 12 per month for individual water line connection. High Income Group also pay significant cost for water tankers, which is Rs. 327 per month on

average. They are also paying Rs. 305 and Rs 1,025 monthly for line water and bottled water, respectively.

10. Average income level of notified Katchi Abadis and Low&Lower Income Group in planned areas are almost the same. However, water supply conditions are quite different between them. The percentages of households not having water line connection are 24% and 8% in Katchi Abadis and Low&Lower Middle Income Group, respectively.
11. 75% of the households without water line connection in Katchi Abadis claimed that their reasons of not having water line connection is the lack of public water supply line coverage in their areas, while only 17% of the households claimed so in Low&Lower Middle Income Group in planned areas.
12. Shared water line connection is not common in Karachi, although the percentage of having shared connection is 35% among the sampled households of Residents in Commercial Areas.
13. In Karachi, about 80% of water tankers are private tanker while only 20% belong to Ranger. Water usage of water carrying person and public water storage are both only few percent of total water consumption even in Katchi Abadis.
14. The usage of well/bore is about 15% of total domestic water consumption. Among those wells and bores, about 80% is bore. Average depth of well/bore structure, and depth of water table in wet season and dry season are 18.8m, 9.5m and 7.1m, respectively.
15. The average daily per capita water consumption in Katchi Abadis is significantly influenced by their area size (ranging from 13 gpcd in large Katchi Abadis to 30 gpce in small ones) because large Katchi Abadis have more difficulty to gain enough water.
16. Outside Katchi Abadis, Bulk Consumers use water the most (59 gpcd) while villages use water the least (17 gpcd). In general, higher income group use more water.
17. It is more difficult to gain water from June to August in Karachi.

2) Conditions of Water Supply-related Facilities and Equipment at Home

1. 45% of installed service pipes are estimated to be made of GI in Karachi. In lower income groups, the percentage of polymeric material such as PVC are higher, which are about 25% in Katchi Abadis and Low&Lower Middle Income Group in planned areas and about 70% in villages.
2. Water meters are installed only in some areas of Bulk Consumers. Those metres are read monthly.
3. In Karachi, water suction pumps are also often used as booster pumps to send water to the overhead tanks of households. 67% of the households in Karachi are using water suction pumps. In Bulk Consumers areas where water meter is partly installed, the usage of water suction pump is relatively low comparing to other urban areas.
4. About 70% and 80% of the households using water line connection have receiving tanks and overhead tanks, respectively, in Karachi.

3) Current Service Level of Line Water Connection

Table 42.2.2 shows the percentages of the water line users who have complain on at least one aspect of each water supply service quality category (water quantity, water quality and public relations) or of all the categories. In the survey, water quality consists of two aspects: water supply hours, water pressure). Water quality consists of four aspects: safety, colour, taste, smell. Public relations consists of five aspects: complaint handling, promptness or repair work, billing and payment services, information notice of KW&SB work, trust on KW&SB officials.

1. In Karachi, 93% of the households have any complain on piped water supply services. In Katchi Abadis, 96% of the households have any complain. The people in Karachi have more complain on public relations of KW&SB (88%) than on received water quantity (61%) and water quality (64%).
2. On the other hand, only 44% of the residents in bulk water supply areas have complain. In bulk supply areas, 89% of the households are satisfied with water quality. It suggests

that there is no significant contamination within their water distribution system. Considering the other areas are using the same water sources for line water, it is important to improve water quality in other areas by removing cross connections and suction pumps drawing dirty water into water lines.

Table 42.2.2 Percentages of Having Complain on Each Service Quality Categories

Categories	Water Quantity	Water Quality	Public Relation	All Service Categories
Katchi Abadis	64%	70%	91%	96%
Low & Lower Middle Income Group in Planned Area	74%	60%	89%	92%
Upper Middle Income Group	39%	60%	81%	92%
High Income Group	35%	59%	75%	85%
Residents in Commercial Area	44%	53%	76%	85%
Bulk Consumers	20%	11%	38%	44%
Estimated Average in Karachi	61%	64%	88%	93%

3. In general, higher income group are more satisfied with current water supply services. For example, 50% of the water line users in Katchi Abadis are not satisfied with hours of water supply while this percentage is only 25% in High Income Group. The satisfaction level among Bulk Consumers is quite high. 83% of them are satisfied with current water supply hours.
4. In general, the water line users have similar satisfaction levels with water quantity, with water quality, and with billing and information notice of KW&SB work. More than 60% of the water line users in Karachi are not satisfied with those aspects.
5. They are especially not satisfied with KW&SB's complain handling and promptness of repair work. 75% of the users in Karachi are not satisfied with those aspects. 70% of them also do not trust on KW&SB officials in Karachi. In large Katchi Abadis, their mistrust on KW&SB is almost 100%.
6. Currently less than 50% of the water line users in Karachi are receiving water daily. More than 30% of them are receiving water two to four days a week. About 10% of them are receiving water only weekly and another 10% claim that water never comes. The situation is more serious in low and lower middle income groups, especially in large Katchi Abadis. The water supply hours per day or each time of water supply is 4.8 hours on average in Karachi, while that of large Katchi Abadis is only 0.7 hour.
7. More than 40% of the users say that water supply frequency and hours are not enough. They are asking for additional water supply of 7.8 hours for summer and 5.3 hours for winter on average in Karachi.

c. Improvement of Revenue Collection

1) <u>Current Billing and Collection</u>

1. Only 66% of water line users are registered in KW&SB in Katchi Abadis, while more than 90% of the users are registered in planned urban areas. In rural areas, only 12% of the users are registered.
2. In Katchi Abadis, only about 40% of the users are receiving water bills although almost all the users receiving water bill pay water charges. Therefore, current low revenue collection rate from Katchi Abadis has its root in KW&SB's billing system.
3. Among Low&Lower Middle Income Group in planned areas, 80% of the users receive water bills and 60% of the users pay water charges. In Upper Middle and High Income Groups, about 90% of the users receive water bills and also pay water charges. Most of Bulk Consumers pay water charges, while most of villagers do not receive water bills and do not pay water charges.

2) Expensiveness of Water Charges

1. More than 60% of the users not paying water charges in Karachi said that they do not pay because water bill is not coming. Even in Katchi Abadis, only 4% of the users not paying answered that it is because they do not have enough money.
2. In Karachi, about half of the line water users think current water supply charges are fair, low or very low, while only 20% and 15% of the users think it is high and very high respectively. We consider these results as a positive sign of potential acceptability of tariff increase required for future water supply improvement.
3. Comparing current water charges with their income level, it is obvious that water charges are not high in Karachi. Therefore, most of the users thinking it is high or very high are expected to understand its lowness after conducting awareness enhancement.

3) Perception on Current Water Tariff Structure and Billing

1. In Karachi, only about 30% of the line water users know that water bill is collected based on household plot size. In Katchi Abadis, only 24% knows it.
2. Monthly billing is more preferred than billing of every six months.
3. The percentage of the users having bank account is about 35% in Karachi, which seems enough to initiate the automatic bill collection using bank accounts.

4) Installation of Water meter and Removal of Suction Pump

The field surveyors explained to the households about the advantages of water meter installation accompanied with the necessary removal of suction pumps that improperly rotate water meter by sucking air when water supply is intermitted.

1. Even before the surveyors' explanation to them, 86% of the water line users in Karachi already know that water suction pumps causes contamination of line water by sucking dirty water into water pipes. After the explanation, almost 80% of the users understand the positive impacts of water meter installation and the removal of suction pumps.
2. 86% of the users in Karachi agreed to support water meter installation. Even in Katchi Abadis, the ratio of supporting water meter is 84%.
3. 80% of the users supporting water meter also answered that KW&SB should put heavy fine to the households using suction pumps continuously to encourage the installation of water mater and the removal of suction pumps.
4. About 75% of the users supporting water meter prefer to pay extra price as part of water charges for the cost of water meter installation instead of paying it at the time of installation at once.
5. Regarding the reasons why about 15% of the users are not supporting water meter, 24% and 34% of their reasons are because of not knowing water meter and because of not able to trust water meter, respectively in Karachi.

d. Organizations for the Maintenance of Water Supply Facilities

1) Permission of Water Line Connection

1. In Katchi Abadis and rural areas, only about 30% and 50% of the households, respectively, know that KW&SB is in charge of public water supply and sewerage services, while this ratio is about 90% in High Income Group.
2. Only about half of line water connections are permitted by KW&SB. 36% of the households having water line connections neither have permission nor know about permission of their connection in Karachi. Interestingly, 10% of the connections are permitted by UC Nazim in Katchi Abadis, while 23% and 15% of the connections are permitted by Town Nazim and UC Nazim respectively in villages.
3.

2) Maintenance and Leakage

1. The water line users think only about 35% of water supply lines are maintained by KW&SB in Karachi. They also think about 15% and 20% of water lines in their areas

are maintained mainly by UCs and household themselves respectively in Karachi. In Katchi Abadis their dependence on UCs is relatively high in terms of the maintenance, while dependence on KW&SB is high in planned urban areas.

2. In Karachi, only 17% of the water line users answered that they would inform KW&SB when they find water leakage outside their houses, while 29% and 41% of the users respectively answered that they would inform UCs and would try to fix it at their cost.

e. Current Sewerage/Sanitation Conditions

1) <u>Satisfaction with Current Sanitation Options</u>

1. In Karachi, most of the toilets/latrines with/without sewerage connection are private toilets/latrines expect for those in villages where about 20% of them are common toilets.
2. Although the sewerage connection rate in Karachi is about 90%, about half of the households are not fully satisfied with their current sanitation conditions.
3. The percentage of the households being satisfied with their sanitation is lowest in large Katchi Abadis and highest in High Income Group and Bulk Consumers.

2) <u>Open Defecation</u>

1. Few percent of the households in Karachi still practice open defecation, mostly in rural areas where 44% of the households practice it, although most of them know that open defecation often cause diseases.
2. In rural areas, about 60% of the households practicing open defecation because they could not afford toilet/latrine while the remaining 40% did not recognize the necessity of toilet/latrine or simply preferred open defecation.

3) <u>Toilet/Latrine without Connection to Gutter or Gutter Line</u>

1. Close to 10% of the households in Karachi use toilets/latrines that are not connected to sewers. In rural areas, 40% of the households still use toilets/latrines without sewerage connection.
2. Majority of those toilets in Katchi Abadis and rural areas are simple pit latrines.
3. 78% of the households using toilets/latrines without connection to sewerage think the effluent from their toilets/latrines pollute the surrounding environment or ground water.
4. In Katchi Abadis, about 20% of the households using toilets without sewerage connection dispose their home wastewater (from kitchen, bathing, etc.) to street surface.

4) <u>Physical Arrangements of Sewerage Connection</u>

1. The most of the toilets/latrines connected to sewerage system have WC style toilet seat (Indian Style). In low and lower middle income groups, most of the households use hand flushing, while majority of the households in High Income Group use tank flushing.
2. 86% and 12% of the sewerage connections in Karachi are connected to gutter lines and closed gutters respectively. Only about 1% of them are connected to open gutters.
3. About 10% of the sewerage connections in Karachi are recognized by the people as being directly connected to the sewers constructed by communities. This ratio is especially high in the large Katchi Abadis in which streets are well organized.

5) <u>Organizations involved in Providing Sewerage Connection and Maintenance</u>

1. In Katchi Abadis, only 22% of sewerage connections have been provided by KW&SB, while UCs and the households themselves respectively provide 27% and 26% of the connections. However, in most of the planned urban areas except for Bulk Consumers, about half of their sewerage connections have been provided by KW&SB.
2. Regarding maintenance of sewer lines, communities/CBOs or households themselves maintain majority of sewers in urban areas. The percentages of areas where their sewers are maintained by communities/CBOs in large Katchi Abadis and High Income Group are

relatively low among those urban areas, which are both about 25%.

3. Only in 8% of Katchi Abadi areas, sewers are mainly maintained by KW&SB, while in about 25% of the planned urban areas sewers are maintained by KW&SB. In village, about 40% of sewers are maintained by UCs.

6) Awareness on Sewerage, Complains and Requests

1. Even in Katchi Abadis, 80% of the sewerage users think that the sewerage form their households should be properly treated at sewage treatment plants although it costs them eventually.
2. Currently only 22% of the households using sewerage in Katchi Abadis knows that people are paying sewerage charge at 25% of water charges. This ratio is higher in High Income Group, which is 65%. On the other hand, almost no one knows it in villages.
3. Although the sewerage connection rate in Karachi is already about 90%, about 70% of the sewerage users have complains on current sewerage conditions. Majority of complains are clogging and overflow from sewers. They also complains on mosquitoes, flies and smell caused by mal-maintenance of sewers.
4. 54% of the sewerage users in Karachi have specific requests to CDGK or KW&SB on sewage disposal. However, only 9 % of the users in Karachi have actually reported their complains about sewerage to CDGK or KW&SB while 22% and 44% of the users have complained to Town Offices and UCs.

f. Storm Water and Solid Waste

1) Storm Water Drainage

1. Most of the areas in Karachi are not served by drainage system.
2. 37% and 17% of the households in Karachi experienced flood below the floorboard and over the floorboard, respectively, at their current dwelling.

2) Solid Waste Management

1. 53% of the households in Karachi do not have any garbage collection facilities in their localities. This ratio reaches 62% in Katchi Abadis. Therefore, 34% and 45% of the households throw out their garbage into Galis in Karachi and Katchi Abadis, respectively.
2. Only 7% of the households in large Katchi Abadis knows that people are paying conservancy at 10% of water charges for CDGK's garbage collection and disposal. This ratio is 56% in High Income Group.
3. 47% of the households in Karachi are not satisfied with current garbage collection services at all.

g. Public Awareness Enhancement

1) Water Save

1. 90% of the households in Karachi know about the water shortage in Karachi.
2. 98% of the households in Karachi already save water when they use public water supply services. However, 86% of them also think that government's effort to promote water save in Karachi is far too little or not enough.
3. About 85% of the households saving water answered that they save water because water is limited resource while only about 15% of them save water because water charges is expensive. The introduction of water meter-based water bill seems necessary to enhance the effectiveness of their water save.

2) Environmental Awareness

1. 85% and 13% of the households in Karachi think that water pollution in Karachi is very serious and serious, respectively. 61% of them think the water pollution in Karachi is mainly caused by garbage, while only 18% and 15% of them respectively think its main cause is domestic wastewater and commercial/industrial wastewater/solid waste.

2. Although 48% of them think that the most polluted environment in Karachi are rivers and channels, 37% of the household still think their residential areas is the most polluted. These results suggest that the discharge of domestic wastewater from living environment may still have many problems although sewerage connection rate is quite high in Karachi.

3) <u>Hygiene Enhancement</u>

1. Because only about one forth of the households in Karachi currently uses domestic water treatment, which is mainly boiling, it is important for KW&SB to improve the water quality of line water.
2. Usage of soap after using toilet and before taking food are 96% and 92% respectively in Karachi. However, cross-connections between water lines and sewer lines often cause serious epidemic of water bone diseases in Karachi.

(2) Existing STPs Environmental and Social Impact Survey

The results of Existing STPs Environmental and Social Impact Survey are tabulated in **Appendix A42.13**. The results are fully discussed in **Appendix A42.14**. Some of the important results are spatially analyzed and presented on satellite imageries in this Appendix. The following is the summary of the results.

a. Awareness on KW&SB's Work

1. Almost all the sampled households think that the pollution of water environment in Karachi is very serious and that sewerage is important to improve water environment as well as living environment.
2. Almost all the sampled households already have sewerage connection to gutter lines, but about 80% of those sewerage users have complains on the sewerage system in Karachi, mainly about clogging and overflow.
3. The most of the households around the STPs think that collected sewage should be treated properly at the STPs and are willing to pay for it.
4. 85% of the households around the STPs know that KW&SB is in charge of sewerage services. However, more than two third of their complains on sewerage are reported to the UCs and less than one third of their complains go to KW&SB.

b. Social Considerations

1. About 95% of the households around the STPs think that their STPs contribute to the improvement of life and environment in Karachi. Moreover, 70% of the households feel pride that their areas contribute to environmental protection with their STP. However, many of the households, which are adjacent to STP-2 and along the Nala used as its discharge point, are not proud of their contribution with STP-2.
2. Former land usages of the STP sites are agricultural land, forest, vacant plot, grave yard, salt industry and drying beds of fish. Some households are aware that there were some conflicts in removing fisherman illegally occupying the land regarding STP-3 and also in locating STP-2 site over the boundary of grave yard. Some claimed that some graves are still inside the STP-2 site.
3. About 10% of the households think the STPs had changed the social and commercial value of the surround lands. Some households pointed out the positive value of the current reuse of effluent from STP-1 for park maintenance and agriculture and a possible increase of land value due to STP-3. However, some households around STP-2 pointed out the decrease of land value due to the influences of the STP including its bad smell.
4. Although 40% of the households neither understand nor accept the reasons why the STPs was constructed there, only about 10% of the households feel unfairness regarding that their area have the STP.

c. Environmental Considerations

1. 8% of the sampled households around the STPs have noticed any environmental impact of the STPs. Some of them answered that greenery has been increased in their areas because of the reuse of wastewater. Some of them are also aware that sludge from the STPs is partly used for agriculture.
2. However, some of them answered that their STPs are causing pollution and mosquito problems. About 20% of the households around the STPs also think the landscape became less beautiful due to the STPs.
3. 35% of the households around STP-2 also think the odour from the STP is a problem. The households located close to the north boundary of STP-2 are significantly affected by the smell. However, because the most of the households seriously affected are within 100m distance from the boundary of the STP, the intensity and travel distance of the smell from the STPs seem to be limited.
4. In the future, smelly facilities of STP should be located at the far side of adjacent residential areas if it is not avoidable to construct STP close to residential areas. It is also important to adopt wastewater treatment technologies that do not cause strong smell. If possible, new STPs should be constructed at least 100m away from residential areas.

(3) Nala Awareness Survey

Photographs of the observed Nala conditions in differently types of sampling areas are shown in **Appendix A42.15**. The results of Nala Awareness Survey are tabulated in **Appendix A42.16** and discussed in detail in **Appendix A42.17**. In this result tabulation, samples from small Nala sampling areas and large Nala sampling areas are re-categorized into small Nala samples (less than 10 feet in width), medium Nala samples (11 to 40 feet in width) and large Nala samples (more than 40 feet in width). The following is the summary of the results.

1. About 20% of the Nalas in Karachi has been expanded in width usually demolishing the encroaching households along Nalas.
2. About 30% and 45% of the households both around small and medium Nalas think that their Nalas should respectively be widened and deepened.
3. More than 69% of the small and medium Nalas are Katcha Nalas. Most of the households think that those Nalas should be Pakka.
4. The most of Nalas in Karachi do not have any rainwater flow most of the time because rain season lasts for only about one month in Karachi. However, unexpectedly, about 70% of the respondents selected that Nalas should not be used for sewage disposal but only for rainwater drainage to improve natural environment.
5. About 90% and 60% of the households living around Nalas have complains about the present conditions of their Nalas and are not satisfied at all, respectively. Most of the households complain of pollution, danger, bad smell, and breeding of mosquitoes and flies in Nalas. About half of the households complain of blockage and overflow.
6. About 40% of the households around Nalas expect CDGK to coordinate and fund the improvement of Nalas in their community. KW&SB, Town Nazim, UC Nazim, Sindh Government and international agencies were also expected by some parts of the households to take these responsibilities.
7. 76% of small Nalas and 56% of medium Nalas are blocked or narrowed. Around 60% and 20% of the main reasons of the blockage and narrowed flow are respectively garbage and encroachment. About 60% of the Nalas in Karachi have encroachment of houses and shops along them.
8. Most of the households living around Nalas think mainly CDGK and Sindh Government should take actions to stop those encroachments for the improvement of living environment.
9. Only 66% of small Nalas, 39% of medium Nalas and 17% of large Nalas have ever cleaned up. Those Nalas were cleaned up few times in the last 10 years on average.

However, majority of these clean up was done only in emergency.

10. Small Nalas are mainly cleaned up by UCs, while medium and large Nalas are mainly cleaned up by CDGK (KMC/KDA).
11. About 80% of Nalas overflows in rainy season (July to August) and the water enters into 35% of the households around Nalas. Flooding is more serious around small Nalas.
12. The damage due to flood have cost households more than Rs. 60,000 in total per household in the last 10 years, which is expensive considering their average monthly household income is less than Rs 18,000 on average.
13. 55% of the households around small Nalas answered their Nalas are significantly polluted. This ratio is higher than 39% for medium Nalas and 33% for large Nalas. About 60% and 40% of the households both around small and medium Nalas answered respectively that garbage and domestic wastewater is main cause of the pollution.
14. 86% of the households around small Nalas think that their Nalas pollute drinking water. Around small Nalas, average WtP for the water quality improvement of their Nalas is more than Rs. 2,000, which is much higher than those of medium and large Nalas.
15. About 40% of the households around Nalas have ever noticed any accidents regarding their Nalas. Majority of the accidents are the falls of people and children into Nalas.
16. Almost all the sampled households answered that they support the construction of trunk sewers along large Nalas/Nadis in Karachi.
17. Most of them also support the ideas of building river front amenity once the water quality of those Nalas/Nadis improve and of taking strict action against encroachment on the riverfront.

4.3 LEAKAGE AND NRW SURVEY

4.3.1 Objectives

(1) General

The aim of this survey is to provide information which will assist with the overall determination of Non-Revenue Water (NRW) which is comprised of several components as shown in the following **Table 43.1.1**.

Table 43.1.1 Definition of Non-Revenue Water

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metreed Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Un metreed Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metreed Consumption</td><td rowspan="7">Non-revenue Water (NRW)</td></tr>
<tr><td>Unbilled Un metreed Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Metreing Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses (UFW)</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metreing</td></tr>
</table>

Source: IWA "Best Practice" Water Balance and Terminology

It was known before the surveys commenced that system pressures are not high and domestic consumers are not metreed, meaning that conventional methods of measuring minimum night flows to determine the amount of leakage occurring within the distribution blocks were not possible.

Nonetheless, it was agreed that the surveys would provide valuable information for a better understanding of several of the components of Non-Revenue Water shown in the above table and of the water use habits under the prevailing poor supply conditions.

(2) Objective

The overall objective of the Leakage Survey is to determine the extent of the losses (and non-revenue water) in the tertiary distribution system and household water systems, within the constraints of un-metreed connections, intermittent and limited daily supplies, and low pressure.

This study is closely related to the formulation of a Non-Revenue Water Reduction Plan. All the data and information obtained from this study will be used to assist with the estimation of the cost, time and manpower required for the implementation of the Non-Revenue Water Reduction Plan.

Past reports completed in 1996 by Mott MacDonald indicated that losses in the tertiary distribution system amounted to 40% of the total system losses. The present state of the distribution system needs to be updated to determine the current situation and to assist with the estimation of losses if the tertiary distribution system were to be pressurized 24 hours per day. Detailed objectives are to determine major sources of leakage and losses from:

- Distribution system pipes and joints
- Service connections
- Household systems including pumps, underground and overhead tanks

And, major reasons for non-revenue water other than physical losses from:

- Receipt of bills
- Payment of bills
- Illegal/unauthorized/non-registered connections

The survey is also intended to provide information on the extent of direct pumping from distribution mains which affects supply systems, and possible sources of contamination which is known to be a problem.

4.3.2 Implementation of Surveys

The methodology for the carrying out of the leakage surveys was as follows:

- Selection of Survey Areas
- Mapping
- Household Surveys
- Household Water Systems and Source of Supply
- Receipt and Payment of Bills
- Determination of Household Consumption
- Flow and Pressure Measurement
- Leakage Detection

(1) Selection of Survey Sites

The criteria adopted was to select two small distribution blocks each with a total of 200-300 services connections in conjunction with relevant personnel of KW&SB. Selection of these sites was done in consideration of the following factors:

- Areas to be reasonably representative of large parts of Karachi
- One area to be intermittent flow, the other a 24 hour supply
- Least disruption to surrounding areas

- Ease of isolation of the survey areas, and measurement of inflow
- Suitability for night work

From initial examinations the areas selected fitted the above criteria with the category of the residential properties being mainly plots between 61 and 120 yd^2. This category forms over 40% of all residential types (excluding flats) and about 50% of the total residential retail billing (the terminology used for un-metreed supplies).

The areas selected were:

• Gadap Town Sector 5, Block B, (Surjani)	3 hour supply every 4 days
• Landhi town J-1 Area (UC 12)	24 hours supply

(2) Mapping

Maps of the selected areas were readily available from the JICA's GIS system and were marked up with the distribution network system for checking on site and selection of the locations for flow and pressure measurement.

(3) Household Surveys

The first task was to draw up a draft questionnaire relevant to the Karachi water supply system to be completed for all the households in the survey areas. Interviews of candidates for the collection of household information were then conducted and a team of four (two male, two female) were selected based on their past experience of conducting similar household surveys.

A training session was held before the surveys commenced to brief the surveyors on the reasons for inclusion of the various questions together with an explanation of the technical aspects of the leakage survey. Following a day of trial surveys discussions were held with the survey teams and the questionnaire was modified to suit the on-site conditions. The questions were chosen to collect information on:

• Housing;	No. and plot size, owned or rented, number of occupants
• Source of Water;	KW&SB, Tanker, shallow well, combination
• Billing Details;	Consumer No., Receiving a bill, paying or not paying
• Storage Tanks;	Dimensions of underground and overhead tanks
• Pumping System;	From distribution pipe, to tanks, combination
• Availability of Supply:	No. of supply hours and days received, water quality
• Other matters	Filter used for drinking water. Any other relevant information

(4) Household Water Systems and Source of Supply

Many houses are equipped with a ground level water storage tank, a small electric pump, usually 0.5 hp, and an overhead tank. Most pumps are connected such that they can pump direct from the distribution main when pressures are too low to fill the ground tank, and for onward pumping from the ground to overhead tank. Direct pumping from the distribution system is illegal but tolerated by KW&SB because it is often the only means possible of obtaining a supply.

Source of supply is generally from KW&SB sometimes supplemented by a shallow well or tanker supplies and occasionally the sole source of supply is a shallow well or water tanker.

(5) Receipt and Payment of Bills

All householders were asked if they received a bill from KW&SB and if so did they pay it. Many householders in Gadap Town who claimed to pay were able to produce the KW&SB new monthly bill with evidence that the bill had been paid.

(6) Determination of Household Consumption

As stated previously there are no domestic metres and alternative methods had to be used to measure consumption.

In Gadap Town fifteen houses were selected and levels for both underground and overhead tanks were measured over a number of days to calculate consumption. Four of these houses were fitted temporarily with domestic water meters to measure inflow when the supply was on. In Landhi Town it was only possible to carry out an interview survey to determine water use habits and estimate household consumption.

(7) Flow and Pressure Measurements

The equipments used for the surveys included:

- Mechanical Listening Rods
- Leak Detector
- Metal Pipe Locator
- Metal Detector
- Pressure Recorder
- Ultrasonic Flow Metres

a) Gadap Town, Sector 5, Block B, (Surjani)

An ultrasonic flow metre was attached to the 12 in (300 mm) AC supply pipeline and when the survey area was isolated the total recorded flow over the 3 hour period from 2.30 to 5.30 am was 658 m^3. The pressure was about 2.5 m head (not accurate on a 0-100 m range recorder) with a high velocity of 1.4 m/s.

b) Landhi Town J-1 Area (UC 12)

The 4 in (100 mm) diametre feeder main was located and an ultrasonic flow metre installed in a temporary chamber. After isolating the block, the maximum recorded flow was about 4 m^3/h and it was suspected that a second feeder main may exist. A flow metre was therefore fitted to a 6 in (150 mm) diametre CI pipe which may also have been a feeder but this recorded a variable flow direction, sometimes a reverse flow of about 9 m^3/h.

A pressure reading on the 15 in (375 mm) diametre trunk main showed a head of less than 2 m whilst the pressure in the distribution system was recorded as zero and sometimes negative.

(8) Leak Detection

In Gadap Town the area was checked by KW&SB staff for visible leakage and five wet areas were located.

In Landhi Town there was no visible leakage since the pressure in the distribution system was either zero or negative.

4.3.3 Survey Results

(1) Gadap Town

a) Distribution System and Water Supply

As stated previously the supply to the survey area is intermittent at 3 hours every 4 days. In response to the questionnaire, the residents gave varying hours of supply of between 1 and 8 hours with an average of 2.7 hours per 4 days more or less confirming the KW&SB schedule.

This area is fed from a 33 in diametre PRCC trunk main through an 12 in (300 mm) diametre AC main reducing to 8 in (200 mm) diametre and into a distribution system comprising of 3 in

(75 mm) and 4 in (100 mm) diametre AC mains.

b) Household Survey

The survey area is in the lower half of the lower middle income group with houses generally on 84 yd^2 plots. The KW&SB tariff system for residential property is based on plot size and all but one of the houses fell inside the category 61-120 yd^2 (one house was 124 yd^2). There was one small shop and one school with 450 pupils. The residents were generally cooperative with only 5 households refusing to take part at all in the survey. Empty services were excluded from the population calculation. The average occupancy rate was 7 persons per household with a minimum of 1 and a maximum of 20. Details of the households are given in the following **Table 43.3.1**.

Table 43.3.1 Survey of Households

Residential Houses			Population for Water Consumption		
Total Units	Not Surveyed	Empty	Measured	Calculated	Total
Excluding 1 School & 1 Shop	No Cooperation 5 Locked 17 Other 3		Maximum 20 Minimum 1 Average 7	25 houses at average number. per household	Estimated population
269	25	11	1693	188	1881

c) Household Water Systems and Source of Supply

As previously stated due to the intermittent supply system households rely on storage for daily water use and pumping is necessary to reach the overhead tanks. The results of the survey are detailed in the following **Table 43.3.2**.

Table 43.3.2 Household Water Systems

No. of Houses	No. of Responses	Houses with underground tank	Houses with overhead tank	Capacity of underground tank m^3	Capacity of overhead tank m^3	Houses with a pump	Pumps connected to distribution
269	228	212	217	Max. 14.4 Min. 0.5 Ave. 4.3	Max. 4.0 Min. 0.3 Ave. 1.7	228	166
	85%	93%	95%			100%	73%

It was observed that tanks are generally half full when the water supply is turned on. Water tanks are an integral part of house construction generally constructed with rendered brickwork and not necessarily water tight. The ground tanks are flush with ground level with a raised portion (about 50 mm) for the cover which is also not water tight. The tanks are easily contaminated particularly during monsoon conditions when inundation occurs.

The connections to the distribution mains do not have a stop tap and the tanks are not equipped with float valves and were observed to overflow during water supply times. Ground tanks are generally located close to the wash/toilet building and observation of the tank water quality raised questions of contamination.

The pumps, purchased by the house occupiers, are generally 0.5 hp electric and the majority are connected such that they can pump direct from the distribution and/or from the ground tank to the overhead tank.

Almost all of the houses have a KW&SB supply only 6 relied solely on tankers and/or their own well. Others used a combination of supplies. The supply sources are given in **Table 43.3.3**.

Table 43.3.3 Household Source of Supply

No. of Houses	No. of Responses	KW&SB Supply	KW&SB Supply only	KW&SB + Tanker	KW&SB +Well	Tanker only	Well only
269	229	223	176	39	8	4	2
	85%	97.4%	78.9%	17.5%	3.6%	1.75%	0.87%

As can be seen over three quarters of households rely solely on KW&SB for their supply. The wells are all shallow and unconfined with a depth of about 2.5 m. The source of the water is not known. It was suspected that wells would contain water from water and sewerage system leakage and from inundation after rains. An analysis by KW&SB on 3 wells showed the following parametres to be outside the WHO limits:

- Colour (only 1 well failed)
- Alkalinity
- Chloride
- Conductivity
- Total dissolved solids
- MPN of Coli Aerogenes organism/100 ml

Only five houses had a filter fitted to the drinking water tap, most boiled water for consumption.

d) Receipt and Payment of Bills

Regarding the receipt and payment of KW&SB bills the response is shown in **Table 43.3.4**.

Table 43.3.4 Receipt and Payment of Bills

No. of Houses	No. of Responses	Receiving a Bill	Not Receiving a Bill	Receiving and paying Bill	Receiving and not paying Bill
269	216	210	6	192	18
	80%	97%	3%	91%	9%

Out of those who did not respond many simply did not know if bills were being received or not. Research revealed that 66% of the houses are owner occupied but there was no difference in the payment pattern between houses which were owner occupied or houses which were rented.

The KW&SB billing system appears to have a high coverage rate and this may be explained to some extent by the fact that all premises are charged a "Water Tax" whether or not the premises is actually connected. The payment of bills is unusually high and does not reflect the overall number of bills paid in the Residential Category which is a mere 22% in the Revenue Data for 2005-6.

There may be an increase in collection due to the new monthly billing system introduced in July 2006. In low income groups throughout the world there is very little, if any, disposable income and the previous annual billing system may have been partly responsible for the low rate of payment. Regular small amounts (e.g. monthly payments) can however be paid if they are affordable and the consumers are willing to pay.

It is interesting to note that out of the 6 households without a connection and receiving a bill, four say they pay, one does not, and one did not respond. As long as the water charge "Tax" exists, illegal connections become largely irrelevant in housing areas since every household is supposed to be billed whether connected or not. This would not be the case for metreed supplies.

e) Household Consumption

In the absence of domestic water metering it was decided to determine household consumption by measuring the daily difference in storage tank levels on a sample of 15 houses. Four houses were fitted with water meters to determine the inflow during supply times. The results are given in the following **Table 43.3.5**.

Table 43.3.5 Household Consumption by Observation of Tank Levels

House Number	Number of Occupants	Ave. Daily Consumption over 3 Days (l)	Ave. Daily Consumption over 5 Days (l)	Comments
72*	4	560	520	House number marked * had a metre fitted
200*	9	990	1,710	
18*	6	N/A	N/A	Incomplete data
271*	4	N/A	N/A	Incomplete data
530	6	960	1,080	
537	5	500	750	
45	13	(260)	780	
39	N/A	N/A	N/A	Incomplete data
627	2	(1,500)	(1,480)	
569	7	(70)	1,050	Consumption in ( ) was disregarded because of its abnormality.
313	6	420	(4,380)	
341	10	400	600	
319	5	500	900	
25	10	500	500	
258	5	900	750	
Total		5,730	8,640	
Average lpcd		5,730 / 60 = 95.5	8,640 / 74 = 116.8	

Observations were made over an eight day period. On supply days tank levels and water usage could not be measured. Between the first and second supply time 3 daily measurements were taken and on 2 days between the second and third supply time. As can be seen the results are highly variable which is not surprising given the intermittent supply situation and the short observation period.

Out of the four houses fitted with metres two could not be accessed for the full period and out of the two remaining, one metre recorded flows within 3% either side of the volumes calculated from tank levels (House No. 200), the other did not correlate with volume gained.

f) Flow and Pressure Measurements

The 12 in (300 mm) diametre feeder pipe was located and a temporary chamber excavated for the Ultrasonic Flow Metre. The flow was initially measured at about 350 m^3/h before isolating the block when the flow reduced to about 200 m^3/h. The velocity was high at 1.4m/s with a very low pressure of about 2.5 m head. The pressure quoted is approximate since the recording range of the instrument is 0-100 m. The supply was provided for approximately 3 hours between 2.30 and 5.30 am. The total calculated flow during the period was 658 m^3.

Ground tanks were observed to be overflowing and it was noted that people run the water to waste for at least 3 minutes as it has a bad odour and is discoloured probably due to turbulence in the previously empty pipes.

With a total maximum available supply of 658 m^3 for a 4 day period, the water consumption works out at about 87 lpcd. Allowing for wastage from tank overflows and running bad quality water to waste the per capita consumption would be about 80 litres per day which is a reasonable figure for low income households. This also compares with the consumption measured using storage tank levels.

g) Leak Detection and Repair

Due to the intermittent supply conditions it was not possible to use traditional methods for leak detection such as acoustic listening devices. It was only possible to detect leaks in the distribution mains by visual observation during dry ground conditions and 5 such leaks were observed. Two leaks were on the 12 in diametre AC main, two on the 8 in and one on a 4 in distribution main.

The Town Water Board officials had neither the equipment, spares or budget to carry out repairs and a special request for funds had to be made through head office. After a two week delay, the town engineers repaired the leaks using concrete. The 12 in diametre main leakage was from a vertical crack, those on the 8 in diametre main were from socket joints, and the 4 in diametre main leak was from a connection which was plugged and a new connection made.

It is normal practice for repairs to be carried out by contract, and whether by contract or direct labour a variety of unconventional repair systems are used due to lack of funds and this has now become accepted common practice. Repairs to AC pipe by first wrapping the fracture or joint with plastic sheeting then applying cement mortar or concrete are accepted practice. These repairs are only effective for a short period and in systems with very low pressure.

After successful repairs to four of the leaks the flow restored it was observed to have reduced by $10m^3$/hr, there was less air in the system and the water ran clean almost immediately.

(2) Landi Town

a) Distribution System and Water Supply

This area is fed from a 15 in (375 mm) diametre PRCC trunk main through a 4 in (100 mm) diametre AC main and into a distribution system comprising of 4 in diametre AC mains. This system replaced an older system also of 4 in diametre AC fed through a 6 in (150 mm) diametre CI main.

A section of the 6 in diametre main was cut out in order to place an isolating valve. The pipe exterior showed signs of corrosion. Internally, there was evidence of heavy encrustation and the growth of nodules together with an accumulation of silt and debris on the pipe invert severely reducing the effective diametre.

The supply to the survey area is said to be 24 hours, 7 days a week but the receipt of water was found to be highly variable throughout the block. Even houses next to each other had different supply conditions. In response to the questionnaire, the residents gave varying hours of supply. About 30% have a 24 hours a day supply, 60% are able to obtain water for a few hours a day and 10% for a few hours a week.

b) Household Survey

The survey area is in the upper half of the lower middle income group with 80% of the houses on 120 yd^2 plots, and the remainder on 128 yd^2 plots. There were five schools and one mosque. The residents were generally cooperative with only 8 households refusing to take part at all in the survey. There were no empty houses but some were locked and others inaccessible for other reasons. The average occupancy rate was 11 persons per household with a minimum of 1 and a maximum of 26. Details of the households are given in the following **Table 43.3.6**.

Table 43.3.6 Survey of Households

Residential Houses			Population for Water Consumption		
Total Units	Not Surveyed	Empty	Measured	Calculated	Total
Excluding 5 Schools 1 Mosque	No Cooperation 8 Locked 11 Other 3	None	Maximum 26 Minimum 1 Average 11	22 houses at average number. per household	Estimated population
220	22	0	1879	263	2142

c) Household Water Systems and Source of Supply

Due to water generally being available on a daily basis less reliance was placed on storage and there were few underground tanks. The predominant system was pumping from the distribution system or well to the overhead storage tank. The results of the survey are detailed in the following **Table 43.3.7**.

Table 43.3.7 Household Water Systems

No. of Houses	No. of Responses	Houses with underground tank	Houses with overhead tank	Capacity of underground tank m^3	Capacity of overhead tank m^3	Houses with a pump	Pumps connected to distribution
220	198	45	183	Max. 7.3 Min. 1.0 Ave. 3.8	Max. 5.1 Min. 0.3 Ave. 1.5	186	182
	90%	22.7%	92.4%			93.9%	91.9%

Almost all houses have a pump and because of the constantly low pressure and volume of the mains supply, most pumps pump directly from the distribution system. Again, the pumps are generally 0.5 hp electric and the majority are connected such that they can pump direct from the distribution and/or from the ground tank or well to the overhead tank.

Also the well water can be mixed with KW&SB water and it is possible by the pump interconnection to accidentally divert well water into the distribution system when pressures in the system are zero or negative.

Almost all of the houses have a KW&SB supply only 27 relied solely on their own well and tanker supplies were not used. The most common supply is a combination of KW&SB water and a well supply as sown in the following **Table 43.3.8**.

Table 43.3.8 Household Source of Supply

No. of Houses	No. of Responses	KW&SB Supply	KW&SB Supply only	KW&SB + Tanker	KW&SB +Well	Tanker only	Well only
220	202	175	93	0	82	0	27
	92%	86.6%	53.1%		46.9%		13.4%

The block is located between the Arabian Sea and the Malir River hence there is ground water and 109 houses have an unconfined shallow well. These are used extensively including for drinking water in view of the poor supply volume from KW&SB. A simple taste test revealed that the well water is saline and an analysis by KW&SB on 3 wells showed the following parametres to be outside the limits of the WHO guidelines:

- Alkalinity
- Chloride
- Conductivity
- Total dissolved solids

- Nitrite
- MPN of Coli Aerogenes organism/100 ml

No one used a drinking water filter, but all said they boiled water for consumption.

d) Receipt and Payment of Bills

Regarding the receipt and payment of KW&SB bills the response is shown in **Table 43.3.9**.

Table 43.3.9 Receipt and Payment of Bills

No. of Houses & Schools	No. of Responses	Receiving a Bill	Not Receiving a Bill	Receiving and paying Bill	Receiving and not paying Bill
220	212	186	26	53	133
	96%	87.7%	12.3%	28.5%	71.5%

As can be seen the KW&SB billing system appears to have a high coverage and once again this may be explained to some extent by the fact that all premises are charged a "Water Tax" whether or not the premises is actually connected. Out of the 26 households not receiving a bill, 22 had a KW&SB supply, the remaining 4 relied on their own well for all supply. Of the 27 houses with a well supply, 8 receive a bill and pay; 12 receive and don't pay; 4 don't receive a bill; and 3 don't know their billing status.

The payment of bills is low and close to the overall figure for the Residential Category rate of 22% and probably reflecting the consumers' dissatisfaction with the KW&SB supply. KW&SB personnel advise that the overall revenue collection rate in Landhi Town is less than 2%.

Again, due to the KW&SB policy of charging a "Water Tax" there was no particular search for illegal connections.

e) Household Consumption

In this block with a poor daily KW&SB supply supplemented by well water it was not possible to attempt to measure household consumption by observing tank levels as the tanks were frequently topped up. Accordingly a detailed interview study was carried out on water use at 13 houses and the results are given in the following **Table 43.3.10** compared to figures given in Mott MacDonald report of 1996.

Table 43.3.10 Household Consumption by Water Use Interviews

Water use lpcd	1996 Report Medium & high Income	1996 Report Low Income	2006 Landhi
Drinking, cooking, food preparation	12	12	7
Dish washing, house cleaning, hand washing	18	12	12
Bathing/Showering	60	30	19
Clothes washing	30	20	13
Toilet flushing	38	6	20
External use (including plant watering)	22	0	6
Total lpcd	180	80	77

Landhi is in the upper half of the lower middle income group and there is some correlation with the low income group figures.

f) Flow and Pressure Measurements

The 4 in diametre feeder main from the 15 in diametre trunk main was located and an ultrasonic flow metre installed in a temporary chamber. After isolating the block, the maximum recorded flow was about 4m^3/h and it was suspected that a second feeder main may exist. A flow metre was therefore fitted to a 6 in diametre CI pipe which may also have been a feeder but this recorded a variable flow direction, sometimes a reverse flow of about $9m^3/h$.

Following days of investigation it was learned that the existing distribution system had been replaced by another system (also 4 in diametre AC) and had been disconnected from the 6 in diametre CI main which now feeds an adjacent area.

A pressure reading on the 15 in diametre trunk main showed a head of less than 2 m whilst the pressure in the distribution system was recorded as zero and sometimes negative. This is not surprising considering the number of pumps directly connected to the distribution system. It was suspected that there were large diametre illegal connections on the trunk main feeding this area but this was never confirmed.

Due to civil disturbances in the Landhi area a full 24 hour flow recording was not possible. Assuming an average flow of 4 m^3/h over a 24 hour period, the average daily supply to the block would be 96 m^3/d. With a population of 2,142 this represents 45 lpcd which clearly is insufficient and explains why the majority of households rely on wells to supplement supplies.

g) Leak detection and repair

Due to the low flow and pressure supply conditions it was not possible to use traditional methods for leak detection such as acoustic listening devices. Also, with almost zero pressure, naturally there was no sign of visible leakage. Therefore there was little point in carry out this work.

(3) Summary of Leakage Survey Results

a) Results

Normal procedures for the measurement of physical losses were followed but the KW&SB system does not allow for meaningful results to be obtained. It is usual to measure the inflow into an isolated block, take household metre readings to determine authorised consumption, trace unauthorized connections and detect all leakage by acoustic listening devices. When all illegal connections have been removed and leaks rectified, the flow is again measured and the decrease in consumption calculated to indicate the volume of losses and leakage.

With intermittent or low supplies coupled with low pressures, and no domestic metreing, it was not possible to listen for leaks or to calculate accurately the authorized consumption. In addition, the policy of imposing a “Water Tax” on all property whether receiving a supply or not negated the issue of illegal connections.

Alternative methods of calculating household consumption were adopted but observation of household water tank levels did not provide meaningful average consumption information due to the short duration and inevitable inaccuracies. In Gadap Town the estimated household consumption did not correspond with the measured inflow. The inflow volume gave a figure of 87 lpcd over a four day period which is about the consumption level one would expect from lower middle income groups in the type of housing encountered.

In Landhi Town, it is thought that a 24 hour supply is given because other unknown constraints restrict supply to 45 lpcd, well below the 80 lpcd consumption level which one would expect. Hence most households supplement the KW&SB supply with well water.

The exercise in Gadap town shows that even at extremely low pressure the distribution system leaked from a fractured pipe, several joints and a household connection and that even temporary repair techniques reduced leakage and improved the initial flow quality which will lead to reduced losses from running water to waste.

Whereas it was not possible to fully quantify the volume of water loss in each block, valuable information was obtained for use with the formulation of a Non-Revenue Water Reduction Plan. Major issues were as follows:

i. Distribution Systems

These are generally old and in very poor condition. Repairs carried out continued to use unconventional methods, and if pressures were raised over 2 m head these and other previous repairs are likely to leak profusely. The one internal examination of a 6 in (150 mm) diametre pipe thought to be 35 years old, revealed external and internal corrosion and a severe reduction in internal diametre due to heavy encrustation on the pipe wall and accumulated debris on the invert.

The KW&SB town personnel lack accurate knowledge of the supply system and the distribution network, and due to lack of resources they are unable to maintain and improve the system and have to accept substandard repair work.

ii. Domestic Connections

KW&SB leave the installation of connections to the consumer supposedly by a plumber licensed by KW&SB and supervised by them. In reality, it is said that licensed plumbers merely sign the application form for a fee and the connections are then made by persons unknown generally unsupervised.

The connections are generally badly installed, in poor condition with signs of internal and external corrosion and are partially blocked with silt and debris. Generally there are no stop taps on the connections.

iii. Household Water Systems

Very many houses have their own “mini” waterworks with a ground level water storage tank, an overhead tank, and a multi-use pump. Where ground water exists and KW&SB supplies are poor, alternative well supply with unsuitable quality are used.

The ground level water tanks are oversized, and observations in Gadap town showed that many leaked profusely, are not fitted with a float valve and frequently overflow. They are vulnerable to contamination as they are not water tight on the surface and subjected to inundation during the rains. The overhead tanks are generally in better condition as they are visible to the owners but as with the ground level tanks there is little understanding for the need to keep them clean.

The pumping systems are mostly quite complex with multi-connections to pump direct from the distribution main to the ground or overhead tank and to pump from shallow wells. Whereas they are easily operated by the owners there is a lack of knowledge on efficient water use, and the health risks from contamination.

Losses could not be measured accurately but were observed from:

- Running water to waste when supplies arrive (Initial turbulence causes discolouration and taste and odour problems).
- Leaking ground tanks
- Overflowing ground tanks and overhead tanks

iv. NRW other than physical losses

Due to the KW&SB policy to impose a “Water Tax” on all premises whether connected or not the Billing Coverage Rate is likely to be high and was calculated at 97.5%. This system leaves little scope for illegal household connections (unauthorized consumption).

However, regarding payment of bills, in the Gadap town survey area 91% of households said they paid whereas statistics from the 2005-6 Revenue Data show a figure of 22% for the Residential Category. In the Landhi survey 78% of households admit that they don't pay which compares well with overall figures for the Residential Category from the KW&SB Revenue Data. These variable figures may be explained to some extent by the fact that the Gadap survey area only received water every 4th day but the volume was adequate, whereas the 24 hour supply in the Landhi area was woefully inadequate. The higher rate in Gadap may also be due to the change to the more affordable monthly billing system.

b) Conclusion

There is no reason to suppose that losses in the distribution are any less than that estimated 10 years ago by the Water Loss Reduction and System Strengthening Project. At that time it was estimated that total losses amounted to 30% of the supply capacity of 334 mgd and distribution losses amounted to 40% of all system losses (approximately 40 mgd).

With the current supply level at approximately 600 mgd and on the safe assumption that leakage has not reduced, distribution losses may well be approaching 80 mgd. This must be borne in mind when considering the need for distribution network improvement.

The following major conclusions may be derived from the Leakage Surveys:

- The system of providing intermittent supplies is unsustainable. Low supply volumes cause households to use contaminated wells the water from which may also contaminate the distribution system. Low and negative pressures in the distribution system also exposes the system to contamination from polluted ground water and there is a sever danger to public health.
- Revenue collection is unlikely to improve significantly with the current system of imposing a "Water Tax" on premises whether connected or not. In addition poor house leads to reluctance to pay and unless a volumetric charging system is adopted there will be nothing to encourage people to adopt efficient water use.
- The distribution system is old and in poor condition. The repairs carried out are substandard and will only last for a short period of time even at the current low pressures. As and when pressures are raised there will undoubtedly be a large increase in the amount of leakage and losses.
- Household connections are probably made by unsupervised and unqualified personnel. They were observed to be of poor quality with bad workmanship and they are generally in poor condition. Ownership of and responsibility for the connection is not clear.
- Household water systems are prone to leakage, vulnerable to contamination and the direct connections to the distribution system, whilst considered necessary in some cases to obtain a supply, are illegal, harmful to the operation of the system and contribute to the high risk of contamination (contaminated water from ground tanks and wells can enter the distribution system via interconnections during times of zero and negatives pressures).
- There is an acute lack of awareness by the consumers on the need for a high standard connection; the illegal status and dangers of pumping from the distribution system; the dangers and health hazard from the various sources of contamination largely caused by their own "mini" waterworks systems; and the need to avoid over use and wastage of water
- The devolution of KW&SB operations to the 18 Towns is largely incomplete. They are under-resourced from finance to equipment; are forced by circumstances to neglect supervision of the installation of connections and powerless to carry out repairs using suitable materials and good workmanship.

c) Recommendations

It is recommended that KW&SB:

- Recognise that NRW problems in the water distribution system lead to poor quality of house, and that the problems are equal to or greater than the bulk water supply problem
- Implement a pilot project in a small hydraulically isolated area with a 24 hour supply at good pressure; install metres at all connections; apply an experimental volumetric water tariff; ban suction pumps and ground tanks; repair leaks; all with the cooperation of the consumers previously educated through workshops
- If this project is successful, progressively implement this improvement on an area by area basis; develop a new water tariff; revise the bylaws accordingly, and progress towards a 24 hour supply with universal metreing with an efficient metre reading, billing and collection system
- Revise the system of making the consumer responsible for the installation of connections, and clearly define ownership and responsibility for connections and metres
- Educate relevant KW&SB staff on the need for the use of good quality materials and good workmanship for the installation of new water mains/connections and the repair of leaks
- Develop a closer relationship with the general public; present the current supply/demand situation in a transparent manner; educate the public on the need for the efficient use of water and to avoid unnecessary losses; the need to pay bills to provide for improved operation & maintenance; and the reasons for, and need to, progress to a metreed volumetric affordable tariff
- Educate consumers on the dangers of direct pumping from the distribution system and the use of water from contaminated wells
- Advise and involve the citizens of Karachi in the operation, maintenance and development of the water supply system for an equitable water supply providing “some for all” and not “all for some”

4.4 ON-GOING RELEVANT STUDIES AND PROJECTS

4.4.1 International Agencies

(1) Water and Sanitation Program

The Pakistan Office of the Water and Sanitation Program - South Asia (WSP-SA) has been extending its support to the KW&SB for institutional reform and strengthening with the objective of transforming the utility into an efficient service provider who operates the water and sewerage services on a financially sustainable basis. The assistance was designed to improve accountability in service provision through institutional reforms and enhanced accountability to consumers.

The recent initiatives of the WSP-SA include ‘Performance Benchmarking’ and ‘Citizen Report Cards’. WSP-SA set the following objectives for the Performance Benchmarking.

- Institutionalize the data collection practice within KW&SB
- Utilize collected data for financial, managerial, administrative and accountability decisions
- Analyses of performance gaps and development of performance improvement plans

Benchmarking involves the measurement of performance on certain key parametres and is expected to serve as an effective tool for comparative assessment to measure, monitor and improve performance and encourage adaptation of best practices in the provision of services.

WSP-SA has decided to pilot a ‘Citizen Report Card (CRC)’project based on user feedback on water and sanitation services in Karachi. It is expected that CRC will provide a rigorous basis and a proactive agenda for communities, KW&SB and local governments to engage in a dialogue to improve the delivery of public services. To this end, surveys were conducted in 9 towns of Karachi to collect views and opinions of customers (450 households / town) on the quality of the water supply and sewerage services provided by the KW&SB. It is expected that the analysis of collected data will be completed by February 2008.

Under the WSP's initiative, two committees on institutional reforms were formed in early 2007. A provincial-level 'Steering Committee' for strengthening the reforms in the water and sanitation sector of Government of Sindh was constituted through a notification issued by the Chief Secretary Sindh on January 23, 2007. The Minister Local Government Department is the Chairman of this committee. A CDGK-Level 'Reform Committee' was established to improve the service delivery through a notification issued by the District Coordination Officer of the CDGK on February 3, 2007. The Chairman KW&SB / City Nazim, CDGK is the Chairman of this committee.

In addition, the WSP has recently commissioned a study titled 'Situation Analysis Report / Water Sector Profile'. The study comprises the following three components.

- A review of physical infrastructure, facilities, water resources, distribution systems and assets both in the formal and informal sector institutions and organizations that manage it within the context of the existing policy/planning framework
- An institutional/policy profile that identifies key organizations, their relationships, and mandates and roles that reflect on their capacities, constraints and relative influence in Water Supply and Sanitation policy, operation and monitoring
- A financial assessment, dealing with public expenditure, revenue flows and potential and prospective external investments and the constraints on mobilizing such investments

On December 19, 2007, the WSP convened a 'Stakeholder Workshop on Water Sector Profile of Karachi' to present the findings of the above study to stakeholders.

(2) Asian Development Bank

a) TA Loan (US$ 10 million)

The Asian Development Bank (ADB) is currently assisting the CDGK and KW&SB under its technical assistance (TA) loan for "Institutional Enhancement for Implementation of Karachi Mega City Development Project (KMCDP)". The amount of the loan is US$ 10 million which is equivalent to 75% of the total project cost of the KMCDP, US$ 13.3 million. The balance US$3.3 million is financed by the Government of Sindh. The KMCDP is intended to address the mega city development needs with a long-term and holistic approach through (i) building capacities at the local level for effective city planning and management and adoption and implementation of commercial principles in the provision of infrastructure and services, (ii) supporting the preparation of infrastructure projects for mega city development that may subsequently be funded by ADB in its loans to Karachi initially over the next four years, and (iii) promoting reforms for sustainable financing. The TA Loan represents the first intervention of a long-term assistance from ADB and will establish the required foundation for effectively utilizing and sustaining future ADB investments in the mega city of Karachi. It is currently envisaged that the TA will be implemented over a period of 48 months starting from early 2007.

The objective of the TA loan project is to prepare for the systematic development of Karachi within the strategic framework and vision for Karachi and the priority investment needs that would emerge from various studies. The TA loan is proposed to be followed by a series of investment interventions which would facilitate achieving the vision for Karachi as one of the great cities of the world. **Table 44.1.1** below presents the components of the TA loan project.

Table 44.1.1 Components of TA Loan Project

Component		Description
A	Capacity Building Facility	Providing resources to refine and upgrade the ongoing work of strategic master plan, including comprehensive capacity building for CDGK, Town Municipal Administrations (TMAs) and other city agencies through advisory services, training and establishing necessary information and communication technology systems.
B	Project Preparation Facility	This facility provides for project preparation and feasibility studies for those sub-projects identified in sectors such as water supply, waste water management, storm water drainage and sewerage, solid waste management, transport and kachi abadis' up-gradation, including modalities for public private partnerships, preparation of detailed designs and related contract documentation. It is intended that the subprojects prepared under this facility would be considered for investment financing in the subsequent phases of interaction with development partners.
C	Establishment of Special Financial Vehicle (SFV)	Establishing and making fully operational the SFV through start up funding for the first three years of its operation on a declining basis over such period.
D	Support for Project Implementation	Providing support and assistance to the Program Support Unit (PSU) in managing and implementing the Project and coordinating Component C. Providing support and assistance to the Local Support Unit (LSU) and Project Working Group (PWG).

It has been agreed that Component A of the ADB TA loan project will include a study focusing on the formulation of a long-term strategy for financial sustainability and institutional development of the KW&SB while Component B will include several project preparation and feasibility studies that are related to the water and sewerage services in Karachi. **Table 44.1.2** provides the scope of works proposed for each study.

Table 44.1.2 Studies Included in TA Loan Project

Study		Scope of Works
(i)	Financial Sustainability and Institutional Development for Karachi Water & Sewerage Board	1) Undertake an in-depth institutional review and suggest institutional arrangements that are consistent with local government decentralization and that combine accountability with the commercial autonomy necessary to run a sustainable water utility 2) Develop a long-term commercialization strategy on a step by step basis, outlining benefits, costs, opportunities and risks at each stage with concrete proposals for making KW&SB a fully sustainable and self sufficient organization 3) Recommend a practical plan on financial sustainability and a sound revenue collection system 4) Undertake and internal organizational review of KW&SB identifying weaknesses, structural constraints and issues of accountability, transparency and responsiveness. Assess human resource needs and suggest improvements in effectiveness, resource mobilization, revenue generation management and accounting system and also design a costed capacity program for KW&SB.
(ii)	Effluent Water Reuse Study for Karachi	1) Estimate the quantities, cost and potential revenues from water that could be made available for various municipal water reuses such as agriculture and landscape irrigation, industrial recycling, groundwater recharges, recreational/environmental uses and non-potable urban uses etc. and develop options comparing these to the costs of abstracting additional water from the Indus River or to the cost of desalination 2) Prepare strategic action plan for wastewater reuse, detailed time bound costed action plan and institutional and operational mechanism
(iii)	Water Balance & Equitable Distribution in Karachi	1) Evaluate total water inflows to the system and to each Town in Karachi; actual and billed consumption; water losses and its components, preparing a water balance strategy 2) Assess problems in the distribution network within towns, including pressure and quality problems, and an equitable and efficient distribution system for Karachi in the short to medium term 3) Recommend possible investment interventions based on the final analyses
(iv)	Developing IT Platforms for Tracking and Maintenance System for KW&SB	1) Develop and implement an Information Technology Based System to keep track of all assets, operations and maintenance procedures 2) Develop a System Control and Data Acquisition (SCADA) System, and identify the appropriate platform interface, transducers and controllers for the improved system, etc 3) Train the KW&SB staff in its use
(v)	Disaster Management Plan for Water Supply & Sewerage Infrastructure in Karachi	1) Devise Emergency Management Plans to minimize and mitigate the damaging effects of both natural and man-made disasters on KW&SB's water and sewerage infrastructure 2) Suggest application of appropriate mitigation technologies, practices and alternate strategies for the strengthening of water and sewerage system infrastructure and uninterrupted operations of the KW&SB in case of emergency 3) Recommend appropriate institutional and operational arrangements and possible investment interventions based on the final analyses

Source: Invitation for Expression of Interest in Water and Sewerage Sector issued by the Local Support Unit, Karachi Mega City Development Project

As part of its on-going initiatives, ADB in collaboration with the Local Support Unit of the KMCDP has prepared a 'Draft Karachi Sustainable Mega City Water and Wastewater Roadmap' in May 2007 with the objective of providing:

- A vision for improving the sector (with quantitative indicators)
- A review of the sector's status and the key issues
- An outline of the investments proposed for the water sector until 2020 and, out of this, a vision of what the ADB loan can finance, and
- An outline of steps for institutional and financial reform of the sector. Key principles of the reform include defined accountabilities for service and a commercial focus.

A series of stakeholders' workshops were convened in Karachi in early June 2007 to discuss this draft roadmap. Nevertheless, this roadmap has not been finalized as of mid-January 2008.

b) Main Loan (US$ 800 million)

Apart from the above TA loan, ADB also plan to provide a main loan of US$ 800 million under the KMCDP to finance a series of investment interventions in various sectors such as water supply, transport and kachi abadis' up-gradation. The loan is proposed to be provided in three tranches. As a result of on-going studies under the TA loan, the following subprojects in the water supply sector have been proposed for implementation under the first tranche (2007 – 2010) of the main loan.

- Construction of a new 100 mgd filtration plant at NEK Old Filtration Plant site
- Expansion of the existing COD Filtration Plant by 84 mgd
- Provision of approximately 20km of 48 in and 36 in water transmission main from Pipri Treatment Plant to Korangi Industrial Area
- Provision of approximately 25km of 36 in water transmission main from Pipri Treatment Plant to Malir Town.
- A Distribution Network Improvement Program (DNIP) which will lead to a rolling program of DNI improvement on a zone by zone basis at the second and third tranches to significantly reduce losses and progressively move towards a 24 hour supply.

This main loan was scheduled to be signed in July or August 2007. However, negotiations are still continuing between ADB and CDGK as of mid-January 2008.

4.4.2 CDGK and KW&SB

(1) CDGK

a) Formulation of 'Karachi Strategic Development Plan 2020'

The project for "Formulation of Karachi Strategic Development Plan 2020" was completed very recently in December 2007. This project was carried out by the City District Government Karachi (CDGK) as one of the components of the "Tameer-e-Karachi Programme (TKP)" under the directives of the President of Pakistan. The consultancy services contract was awarded to the local consultancy firm, M/s. Engineering Consultants International (ECIL), who in collaboration with a foreign consultancy firm, M/s PADCO conducted this important study.

It is expected that the outcome of the study will provide overall guidance for the formulation of master plans for each town and for the framing of development schemes and projects for the Karachi City District in a coordinated manner. Detailed databases to be established in the study on the basis of zonal profiles of 178 Union Councils will enable line agencies to understand in which areas their intervention is urgently required.

The objectives of the project are defined as follows.

- Strengthening urban planning process
- Plan to provide sufficient and affordable serviced lands to cater to housing needs of all income groups with greater emphasis on low-income housing
- Provide planned alternatives to Katchi Abadis in view of E.I.A. of the locality
- Provide an adequate supply of potable water
- Provide most modern garbage collection and disposal facilities to cover 100% population of the Karachi City District
- Provide adequate educational, health and recreational facilities
- Provide adequate transport facilities
- Adequate and reliable drainage and sewerage system
- Growth of industrial areas and free trade zones
- Provide effective road network and other means of communication

This holistic master plan study was commenced in December 2005 with its completion originally scheduled for June 2006. In reality, however, the completion of the study delayed significantly. The Final Report of the study was issued in mid August 2007, and it was just late December 2007 that the strategic development plan proposed in the Final Report was approved in principle by the City Council.

(2) KW&SB

a) K-III Project

The K-III Project is the Stage II of the Greater Karachi Bulk Water Supply (GKBWS) Scheme Phase V, which is designed to provide additional 100 mgd (455,000 m^3/d) of Indus River water to Karachi (95 mgd) and Hub Town in Balochistan (5 mgd). The K-III Project was initiated in June 2003 with the estimated cost of 6.5 billion and completed in May 2006. The President General Pervez Musharraf formally inaugurated the project at the Dhabeji pumping station on May 21, 2006. It was reported that the completion of K-III Project increased the total water supply capacity for Karachi to approximately 630 mgd (2,865,000 m^3/d).

Major bulk water supply facilities constructed under the K-III Project include:

- 15km-long, 3.3m × 3.3m RC water transmission conduit from Gujjo to Dhabeji;
- K-III Pumping Station at Dhabeji;
- Twin MS rising mains from K-III Pumping Station at Dhabeji to Fore-Bay High Point, each 4.59km-long, 72-inch diametre;
- 32.08km-long, 3.3m × 3.3m RC water transmission conduit from Fore-Bay High Point to Pipri;
- 4.14km-long, 3.3m × 3.3 m RC Tunnel Bypass Transmission Conduit;
- 16.8km-long, 3.3m × 3.3m RC water transmission conduit from Pipri to NEK New Pumping Station;
- NEK New Pumping Station;
- Twin MS rising mains from NEK New Pumping Station to NEK Old Reservoir, each 5.32km-long, 66-inch diametre;
- 10.5km-long, 84-inch diametre PRCC pipeline from NEK Old Reservoir to Surjani;
- 6km-long, 72-inch diametre MS pipeline from Surjani to Hub Pumping Station; and
- 30km-long, 24-inch diametre MS pipeline from Hub Filtration Plant to Hub Town in Balochistan.

As part of the K-III Project, a linkage was established for the first time between the Indus River System and Hub System. The two systems were connected with each other by a 16.5 km long, 84 inches diametre pipeline (10.5 km PRCC and 6 km MS) from the Old NEK Reservoir to the Hub Pumping Station. This linkage contributed significantly to the improvement of water supply conditions in the townships of Orangi, Baldia, SITE (both residential and industrial areas), Surjani, North Karachi and parts of Keamari Town, where people had long been suffering from chronic water shortages due to the severe depletion of impounded water in the Hub dam.

b) Rehabilitation and Strengthening of Water Supply System under K-III Project

This project is currently being implemented by the KW&SB as part of the K-III Project. The main objective of the project is to attain a more equitable water supply throughout the city with the effective use of the additional 100 mgd water, which was made available from the Indus River upon completion of the K-III Project in April 2006. The consultancy services contract for design and construction supervision services was awarded to the local consultancy firm, MM Pakistan (MMP) (Pvt) Ltd. in May 2006. The project was originally planned to be completed within a period of 22 months comprising 4 months of survey and design works and 18 months of construction works.

Under the consultancy services contract, MMP is expected to: (a) produce a comprehensive asset map of the existing water conveyance and distribution systems with particular emphasis on water trunk mains 33 to 72 inches in diametre; (b) develop a plan for equitable water distribution; and (c) undertake detailed designs and construction supervision services for a total of 17 packages of water supply system rehabilitation and strengthening works including:

- Rehabilitating nine weak segments of existing water trunk mains 24 to 72 inches in diametre for a total length of 53 km, including leak detection and repair works;
- Installation of flow metres 33 to 72 inches in diametre at 80 key locations selected by the KW&SB, including water treatment works and reservoirs;
- Installation of pressure reducing valves 33 to 72 inches in diametre to control system pressure;
- Replacement of the 3.6 km long, old Dhabeji PRCC rising main with a 72-inch diametre steel main;
- Repairing damaged sections of the Greater Karachi Bulk Water Supply (GKBWS) Conduit;
- Rehabilitation of the Orangi Reservoir; and
- Rehabilitation of the University Reservoir.

The actual implementation of the project was delayed and no physical improvement works have been started as of mid January 2008.

c) K-IV Project

Based on the recommendations of the ad-hoc committee constituted by the Government of Sindh (See **Section 3.2.2**), the KW&SB decided to undertake a feasibility study titled 'Feasibility Study for Future Alternative Route of Bulk Water Supply and Long Term Expansion of Karachi Water Supply System from Kinjhar Lake – K-IV Project of Karachi Water and Sewerage Board'. In December 2005, the KW&SB awarded a consultancy service contract for this feasibility study to a local consultancy firm, Osmani & Company (PVT.) Ltd. The main objective of the study was to explore an alternative route of bringing additional 1,200 cusecs (650 mgd) of Indus River water from the Kinjhar Lake to Karachi, which is economical and technically viable and will also enhance the reliability of the bulk water supply system from Kinjhar Lake to Karachi from the risk management point of view. The study was commenced on December 19, 2005 and completed in May 2007.

8 alternative routes were identified as technically feasible and financial analyses were conducted for each option with respect to its requirements for capital and O&M costs. The study also recommended that three water treatment plants, each having an ultimate treatment capacity of 260 mgd, 260 mgd and 130 mgd. **Figure 44.2.1** shows the locations of the raw water conveyance route and three water treatment plants proposed by the study.

K-IV Project is proposed to be implemented in 5 phases of each 130 mgd to be developed at intervals of every 4 years during the next 20 years as shown in **Table 44.2.1**.

Table 44.2.1 Proposed Implementation Schedule of K-IV Project

Timeframe	Phasing	Incremental Capacity
2007 to 2011	Stage A of Phase 1	130 mgd
2011 to 2015	Stage B of Phase 1	130 mgd
2015 to 2019	Stage A of Phase 2	130 mgd
2019 to 2023	Stage B of Phase 2	130 mgd
2023 to 2027	Stage A of Phase 3	130 mgd

The total project cost for Phase 1 (260 mgd) was estimated at Rs. 18.7 billion which consists of Rs. 15.8 billion for Stage A (130 mgd) and Rs. 2.9 billion for Stage B (130 mgd).

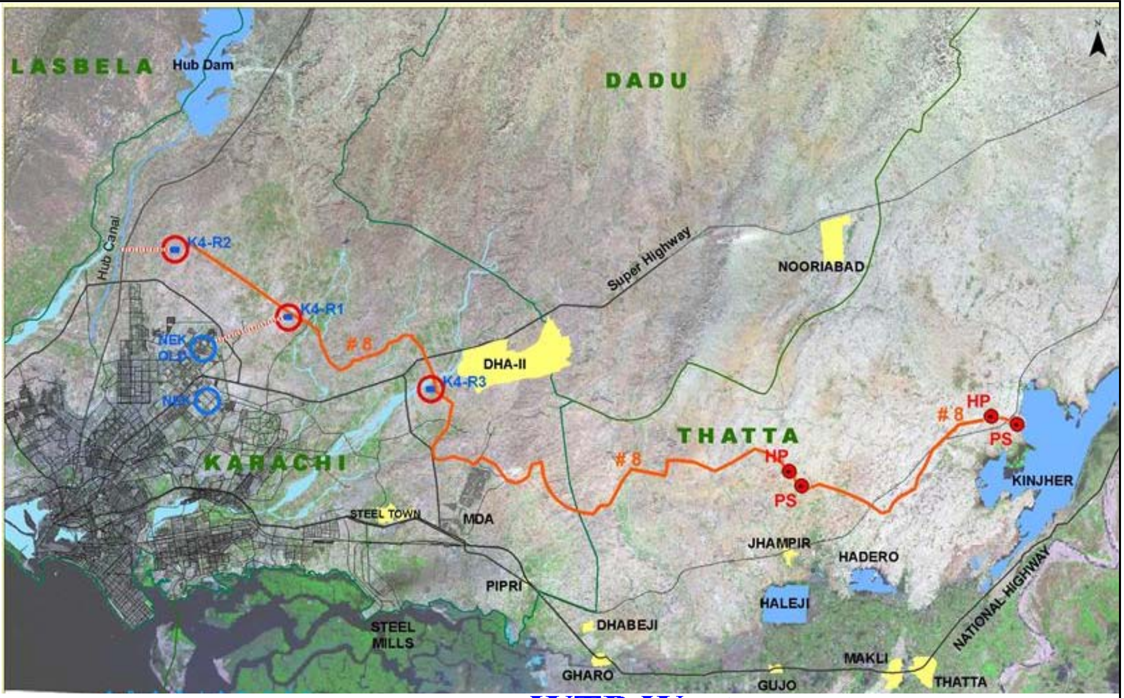


Figure 44.2.1 Water Conveyance Route Proposed by K-IV Study

(Source: K-IV Project Executive Summary, OSMANI May 2007)

WTP West

WTP Central

WTP East

CHAPTER 5

OVERVIEW OF EXISTING CONDITIONS AND IDENTIFICATION OF MAJOR PROBLEMS

5 OVERVIEW OF EXISTING CONDITIONS AND IDENTIFICATION OF MAJOR PROBLEMS

5.1 WATER SUPPLY SYSTEM

5.1.1 Overview of Existing Conditions

Over recent years, the level of water supply service provided to the urban population of Karachi has been very poor. As a result of the current rationing system operated by the Karachi Water & Sewerage Board (KW&SB), water is only available on an intermittent basis and even then the pressure is low, quantity is small, and quality is poor. In most parts of the urban area, water is supplied once or twice a week, each time for the duration of several hours. KW&SB regulate supplies to sub-zones by opening and closing feeder valves from the trunk mains and regulating the hours of operation of distribution pumping stations. In contrast, some parts of the urban area, noticeably in the north and northeast, have a better level of service, primarily due to their proximity to the sources and the difficulty of isolating sub-zones during the rationing process. Residents in these areas tend to misuse or waste water. In the absence of a volumetric charging system, there is nothing to encourage them to adopt efficient water use.

In the past, large capital investment works were implemented mostly for the purpose of developing large bulk supply schemes to bring water from distant water sources to Karachi. This has created a huge backlog of replacement, reinforcement and extension in the water distribution system. As a result, many water distribution pipes in the system have already been undersized and deteriorated, and the current levels of leakage and non-revenue water in the distribution system are unacceptably high. The existing water distribution network comprises about 4,850 km of pipelines of which about 65% are asbestos cement pipes and 26% cast iron. In most parts of the urban areas, residents are obliged to spend money on ground level water tanks, suction/booster pumps, roof-top storage tanks, and water filters, and even then water must be boiled prior to drinking. While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high. Many households are compelled to use secondary sources of water such as shallow wells or tanker supplies just to meet their basic needs. Our field surveys revealed that many ground level water tanks leak profusely, are not fitted with a float valve and frequently overflow. They are vulnerable to contamination as they are not water tight on the surface and subjected to inundation during the rains. The overhead tanks are generally in better condition as they are visible to the owners but as with the ground level tanks there is little understanding for the need to keep them clean.

While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high.

Tanker water costs in the order of Rs.70/m^3 to Rs.90/m^3; it is an expensive option as compared with the KW&SB's existing domestic tariff for bulk customers i.e. Rs.10/m^3, given the fact that many tanker operators collect water from filling stations that are connected to the KW&SB's piped water supply system. Where tanker supplies are unaffordable, people have no option but to use untreated subsoil water or go to the river to bathe or wash their clothes. Low and negative pressures in the distribution system also exposes the system to contamination from polluted ground water and there is a sever danger to public health. The expense of not having an adequate supply of potable water is compounded by the inevitable medical bills resulting from the treatment of water-borne diseases (typhoid, cholera, and hepatitis are common) and the loss of income due to sick time. In the light of the poor water supply situation, many residents in Karachi have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges.

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There was little or no evidence of a problem of affordability in the Water Awareness Survey conducted as part of the JICA Study. Clearly a major problem is willingness to pay. Much depends on the quality of service as illustrated by the Leakage Survey in Landhi Town where there is a very poor supply (only 8% of consumers pay their May 2007 bill). Another fact emerging from the Water Awareness Survey is that 60% of those questioned on none payment said simply that they did not receive a bill. The new complaints management system has a high proportion of complaints that the bill was not received. In addition, more than half of the retail consumers interviewed said that they are not satisfied with the quantity & quality of water, and the billing & information system. 75% are not satisfied with the way KW&SB handle complaints and 70% do not trust KW&SB officials.

It is estimated that in Karachi substantial water losses and leakage occur due to the following:

- An aging network lacking maintenance and repair
- No planned leakage control system
- Poor workmanship and materials used for pipe and joint repairs. It is said that lack of funds prevents the purchase of spare pipe, repair collars etc. The current practice of using rubber tubing and cement rendered plastic for repairs has become the accepted norm of KW&SB.
- Poor workmanship and materials for service connections carried out by the consumer (rarely the declared registered plumber) which are largely unsupervised by KW&SB staff
- Household water systems comprising ground and overhead tanks and an electric pump usually directly connected to the distribution pipe cause large losses due to leakage and overflows which go unchecked because there is no volume charge

While leakage is said to be 30 to 35% of water distributed at present, there is no scientific means to verify this percentage in the absence of system-input metreing and retail supply metreing. This percentage could be much higher if it includes leakage occurring in service connection pipes, ground-level water reservoirs and roof-top storage tanks owned by customers. In the absence of retail supply metres, there is no boundary between the responsibilities of the KW&SB and its customers for the repair and maintenance of the service installation. The KW&SB's responsibility could extend to ground-level water reservoirs, roof-top storage tanks and even up to the internal fittings and faucets inside customers' houses. Under the circumstances, there is no point in discussing leakage in Karachi in comparison with other cities of the world where retail supply metres are installed and any leakage or wastage occurring at the downstream of the metre is registered as being 'accounted-for water' to the water utility.

The magnitude of leakage also varies significantly depending on the duration of supply and the system pressure applied in the water distribution network. As such, there is no point either in discussing the current level of leakage in Karachi in comparison with other cities where water is supplied for much longer hours or at a higher pressure. It would be possible in Karachi that without substantial improvements to the existing distribution system leakage could increase to 60 to 70% once the system is fully pressurized and water is supplied 24 hours on a regular basis.

Similarly, with the imposition of a 'Water Tax' on all premises, it would not be useful to discuss non-revenue water in Karachi in comparison with other cities of the world where non-revenue water is determined as being the difference between (a) the system input volume (total volume of water distributed into the system) and (b) the volume of water for which revenues are actually collected.

While there are no reliable figures, and there is little information on this matter there are thought to be many illegal connections. Many houses are known to have more than one connection to tap pipelines to maximise the time they have water. It is also known that illegal connections have been made to the trunk/secondary mains system as these pipelines are always full. Supplies to large Katchi Abadis are generally poor due to the distance from the distribution system and very long, above ground, illegal connections to the nearest pipeline (often referred to as spaghetti connections) are clearly visible. Little is done to disconnect illegal connections. The law is rarely, if ever, enforced by those charged with these duties and there is known to be a degree of political and other interference. In addition, the policy of imposing a "Water Tax" on all property regardless of whether receiving a supply or not often negates the issue of illegal connections.

KW&SB does not at present use domestic metreing. Metreed supplies (referred to as bulk supplies) are confined to government departments, large industrial complexes and other large consumers including housing development areas with their own distribution systems, commercial high rise buildings, hotels etc. The un-metreed or "retail" category forms the majority of KW&SB consumers. KW&SB charge a monthly rate for domestic consumers in accordance with the size of the property. Bills are produced monthly for about 1 million retail (domestic un-metreed) consumers and about 5,000 bulk metreed consumers. It had been hoped that a combination of monthly billing introduced for "retail" consumers in July 2006 with the inclusion in the bill of 5% of arrears and the imposition of a 10% surcharge on unpaid amounts would lead to a rapid improvement in the collection rate. Although there were some early gains when the monthly billing system was introduced there has been no significant improvement. The system of bill delivery to the consumers does not work efficiently, the level of service is so poor that consumers see no reason to pay, and disconnection of supply and other punishments have proved unworkable.

KW&SB's billing and collection records on retail customers for the month of May 2007 show that overall a mere 23.6% of the bills printed and delivered to the KW&SB offices for distribution to the consumers were actually paid; 31.2% of the monthly water billing was recovered (32% for sewerage) and 6.7% of the arrears were paid (8.2% for sewerage). Similar records on bulk customers for the month of May 2007 show that 41.4% of the bills issued were actually paid; 37.5% of the monthly water billing was recovered (44.6% for sewerage). These are unacceptably low considering the generally good supply conditions in the bulk supply system and the consumers' high ability to pay.

5.1.2 Identification of Major Problems

Most of the problems discussed in **Section 5.1.1** are related to the water distribution system. In contrast, there seem to be fewer and less urgent problems in the bulk water supply system. Although the present water treatment capacity is insufficient and therefore a large volume of raw water is still being supplied without treatment, the addition of new water treatment capacity is not considered as being a high priority at present given the poor conditions of the existing distribution network. The overall picture is that there are many more urgent problems in the water distribution system than in the bulk water supply system.

The overall picture is that there are many more urgent problems in the water distribution system than in the bulk water supply system.

The problems discussed in **Section 5.1.1** are closely related to each other and are often mutually reinforcing.   They can broadly be categorized as follows:

- ▫ Poor conditions of the existing water distribution system
- ▫ Lack of KW&SB's autonomy in the day-to-day operation and management of the services
- ▫ KW&SB's weak financial capacity
- ▫ Absence of measured supplies and volumetric charging system (imposition of 'Water Tax')

Table 51.2.1 provides the symptoms and consequences of these problems.

Table 51.2.1   Major Problems Identified by JICA Study

Major Problems	Symptoms	Consequences
Poor conditions of water distribution system	▫ Intermittent water supply ▫ High level of leakage ▫ Low system pressure ▫ Contamination ▫ Inequitable distribution	▫ Customers' distrust in KW&SB and the services it provides ▫ Reluctance to pay for the services ▫ Insufficient revenues
Lack of autonomy	▫ High level of receivables ▫ Tanker supplies ▫ Illegal connections ▫ Low tariffs	▫ Insufficient revenues ▫ Low morale of KW&SB staff
Weak financial capacity	▫ Delay in capital replacement ▫ Delay in system expansion ▫ Poor current maintenance ▫ Poor working environments (offices & equipment) ▫ Reliance on Government funding (OPEX and CAPEX)	▫ Deteriorating services ▫ Deteriorating assets ▫ Low morale of KW&SB staff ▫ Political interference
Absence of measured supplies and volumetric charging system	▫ Absence of system input metreing and retail supply metreing ▫ No incentives for efficient use of water ▫ No boundary of responsibilities for maintenance of service connections between KW&SB and its customers ▫ No means to estimate leakage and non-revenue water ▫ Negates the issue of illegal connections (retail users)	▫ No control of water supply system ▫ Misuse and wastage of water ▫ 'Leakage', 'non-revenue water' and 'illegal connections (retail users)' being indefinable

Major problems of Water Supply System:

- ▫ **Poor conditions of water distribution system**
- ▫ **Lack of autonomy**
- ▫ **Weak financial capacity**
- ▫ **Absence of measured supplies and volumetric charging system**

Our assessment indicated that these problems have either directly or indirectly emanated from the KW&SB's financial constraints. **Figure 51.2.1** illustrates the vicious circle of the KW&SB's operations. It shows how KW&SB's financial constraints keep intensifying and thereby deteriorating the quality of the service. It is also because of its financial constraints that KW&SB have to rely on government subsidies to sustain its operations, which in turn makes KW&SB quite vulnerable to political interference in the day-to-day management and operation of its services.

These problems have either directly or indirectly emanated from the KW&SB's financial constraints.

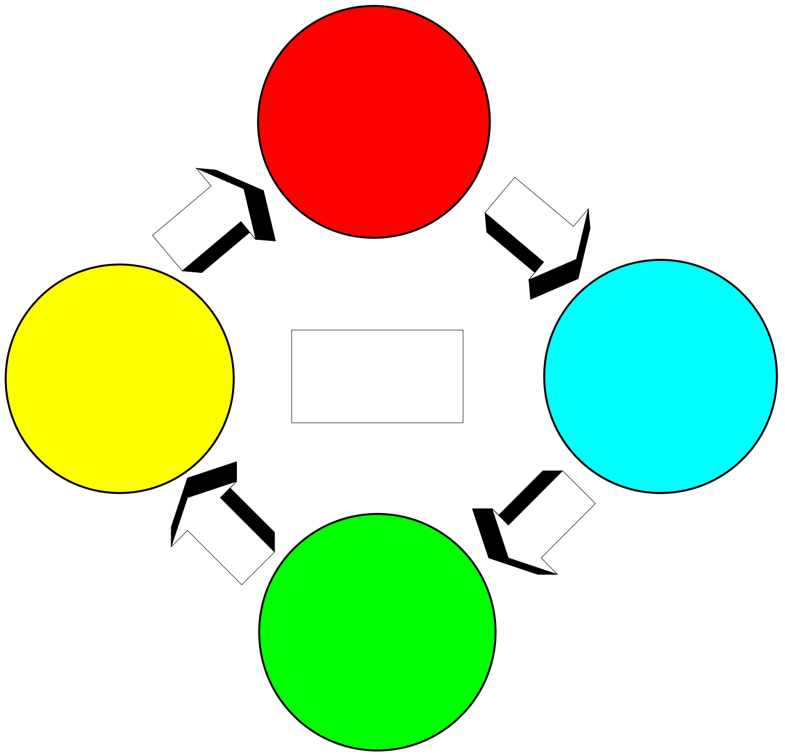


Figure 51.2.1 Vicious Circle of KW&SB Operation

A substantial improvement to water service quality will be required to break this vicious circle. It is the considered opinion of this JICA Study team that a substantial improvement to water service quality can be achieved by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. This view is shared by ADB in its Draft Karachi Sustainable Mega City Water & Wastewater Roadmap, May 2007.

A substantial improvement to water service quality will be required to break this vicious circle.

5.2 SEWERAGE SYSTEM

5.2.1 Overview of Existing Sewerage Conditions

In spite of increasing amount of sewage generation due to the rapid urbanization of the city, major sewerage facilities such as trunk sewers, pumping stations and sewage treatment plants have not been constructed since 1998. It is apparent that the situation brings about serious insufficiency of sewerage facilities. For example, the total capacity of three existing sewage treatment plants amounts to 151 mgd (about 690,000 m^3/d) in contrast with the current sewage generation of 315 mgd (about 1,430,000 m^3/d) or the total capacity of sewage treatment plants is less than a half of the sewage generation.

The actual flow to these treatment plants, on the other hand, is less than their total capacity and is reported to be 90 mgd (about 410,000 m^3/d) which is less than 30% of the sewage generation.

It means that more than 70% of the total sewage generation is discharged to rivers and finally flow into Arabian Sea with no treatment. Several reasons have been raised for this small ratio of coverage. One reason is that, collected sewage does not reach sewage treatment plants due to the absence of trunk sewers although sewage is collected at its origin to some extent. Another reason is that trunk sewers and relay pumping stations do not function as planned due to the aged facilities and/or insufficient capacities.

(1) Sewer Networks

As branch sewers and trunk sewers are not sufficient in length and capacity, much sewage is discharged to rivers through stormwater drainages and nallahs without treatment, which deteriorates water qualities in receiving water bodies. In the same way, there are some small pumping stations called "Ejector" to pump up sewage of lower pockets to stormwater drainages or nallahs. In addition, many existing sewer are aged and some of them are needed to replace or rehabilitate.

(2) Pumping Stations

All the pumping stations have a long history. As a whole, equipment in pumping stations such as screens, grit chambers, pumps, motors, generators, sub stations are very old, and some pumps are not functional even though they are listed in inventory. For this reason, it is supposed that the flow to pumping stations exceeds the actual capacity, or surplus flow overflows to nearby nallahs. Almost all the large scale pumping stations have power generators, but many of them do not work satisfactorily at the time of power failure because of their unsatisfactory maintenance and insufficient fuel.

In case of Clifton PS, pressure main from the pumping station to TP-2 is old and fragile, therefore the actual operation of pumps is limited to the permissible flow of the pressure main.

(3) Sewage Treatment Plant

As described in **Section 3.3.2 Sewerage System**, all of three TPs have received smaller flows than the design values due to the insufficient collection system. Besides, final settling tanks of TP-1 have not been operated for a long time due to the clogging of their sludge withdrawal pipes. In TP-2, pipes conveying primary and secondary sludges to sludge drying beds were broken and no sludge has been withdrawn from settling tanks. Sooner or later, these pipes will be clogged as in the case of TP-1 and no settling would be done. No information is available when these problems occurred and how they were going to be solved.

Since there is no reference available to show what parametres were applied in designing these three TPs, the capacities of TP-1 and TP-2 are evaluated referring to major design parametres described in the Design Guidelines of Japan as shown in the **Table 52.1.1.**

Table 52.1.1 Design Criteria in Design Guidelines of Japan

Name of Facility	Design Parametres
Primary Settling Tank	Overflow rate in the range between 35 and 70 $m^3/m^2/d$
Trickling Filter	Hydraulic loading of less than 15 $m^3/m^2/d$ if influent BOD is 200 mg/l BOD volumetric loading of less than 1.2 $kg/m^3/d$
Final Settling Tank	Overflow rate in the range between 20 and 30 $m^3/m^2/d$

Anaerobic and facultative ponds applied in TP-3 are difficult to evaluate, because in spite of design criteria found in various literatures they have wide ranges and little information is available on the actual performance of these facilities. The process applied in TP-3 will be evaluated in the future only if the influent characteristics including its flow rate and the influent water quality approach its capacity.

The capacities of TP-1 and TP-2 are evaluated supposing influent BODs are 385 mg/l for TP-1 and 365 mg/l for TP-2, respectively, BOD removal rate at PST is 40% and filter media depth is

1.5 m. **Table 52.1.2** shows calculated overflow rates of primary and final settling tanks, hydraulic loading and BOD volumetric loading of trickling filters.

Table 52.1.2 Calculated Loadings

	TP-1	TP-2
Overflow rate of primary settling tank ($m^3/m^2/d$)	25	23
Hydraulic loading of trickling filter ($m^3/m^2/d$)	21	19
BOD volumetric loading of trickling filter ($kg/m^3/d$)	3.23	2.75
Overflow rate of final settling tank ($m^3/m^2/d$)	76	69

In both TP-1 and TP-2, the number of primary settling tanks (PSTs) is 6 and that of FSTs is 2, which leads to the greater overflow rate of FST than that of PST. In any sewage treatment process, FSTs need to have larger surface area than PSTs for effective solid liquid separation prior to effluent discharge. It is recommended to convert the present combination of 6 PSTs and 2 FSTs to that of 4 PSTs and 4 FSTs by changing the sewage flow.

Design Guidelines of Japan propose surface loading of less than 15 m^3/m^2/day and BOD volumetric loading of less than 1.2 $kg/m^3/d$ for high rate trickling filter process which is supposed to give the effluent BOD of less than 70 mg/l. In this regard, TP-1 and TP-2 have sufficient primary and secondary sedimentation tanks to treat the design flow only if the above-mentioned conversion is done.

However, the trickling filters are short on numbers to treat the design flow, especially in terms of BOD volumetric loading. To begin with, it is recommended to measure water qualities of the plant influent, the primary effluent and the secondary effluent and to measure the actual flow rate for a certain period of time on a regular basis. By doing this, the real treatment capacities of these two TPs can be evaluated and it will be possible to judge when it is needed to extend the treatment facilities.

5.2.2 Identification of Major Problems

Major problems about sewerage facilities are identified as follows.

Absence of comprehensive master plan

The master plan for sewerage implementation was once prepared in 1988, but the plan itself was not comprehensive and hence not pursued in the later stage. It is needed to prepare comprehensive master plan for sewerage implementation in line with the city planning, to implement sewerage facilities based on it and to revise the plan on regular basis taking social and physical changes into account.

Limited budget allocation for sewerage facilities

Since the tariff collected in water supply and sewerage sector is very limited, the budget allocated for sewerage sector is limited, too. With the limited budget, it is almost impossible to operate and maintain existing sewerage facilities so as they function as planned and to extend or newly construct sewerage facilities to meet the future requirements.

Improper operation and maintenance of sewerage facilities

Mainly due to the limited budget and personnel allocated for operation and maintenance of sewerage facilities, existing facilities are not operated properly. Improper maintenance might lead to earlier aging of facilities and non-compliance with the effluent quality standard.

Insufficient sewerage facilities

As described above, existing sewerage facilities for sewage collection and its treatment are far from sufficient in quantity to serve the large population of Karachi City. Additional sewage collection system including branch sewers, trunk sewers and pumping stations need to be constructed to improve living environment of the citizen. In the same manner, existing sewage treatment plants need to be extended and new plant(s) has to be implemented to treat all the generated sewage to improve water qualities of public water bodies, especially of Arabian Sea.

Insufficient information on facilities

Sewers, pumping stations and sewage treatment plants consist of civil structures, mechanical and electrical equipment. For efficient and effective operation and maintenance of these facilities, it is needed to equip their as-built drawings, list and specifications on site. However, site surveys by the JICA Study Team found that there was little information on these items, especially about sewers except for Lyari interceptor.

Insufficient record of operation and maintenance works

In the same manner, little information in written form is available on the performance of pumping and treatment facilities such as flow rates, operation hours, water qualities, facility failures and repairs and so forth.

Absence of operation and maintenance manual

Manuals for operation and maintenance of sewerage facilities (O/M) are not available. It is very difficult to operate and maintain sewerage facilities in a proper way without O/M manuals.

CHAPTER 6

WATER DEMAND FORECAST

6 WATER DEMAND FORECAST

6.1 POPULATION

6.1.1 Karachi Strategic Development Plan 2020

The City District Government Karachi (CDGK) has completed a formulation of Karachi Strategic Development Plan 2020 (hereinafter referred to as the "KSDP-2020") for the target year of 2020 as one of the components of the "Temeer-e-Karachi Programme (TKP)" under the directives of the President of Pakistan. It is expected that the outcome of KSDP-2020 will provide overall guidance for the formulation of master plans for each town and for the framing of development schemes and projects for the Karachi City District in a coordinated manner.

The study on the formulation of KSDP-2020 was commenced in December 2005 and its completion was originally scheduled for June 2006. The tenure of the study was extended for another six months, postponing the completion of the study until December 2006. It is understand that the study was not finalised by December 2006 and finally completed in August 2007.

During the period of the study on the formulation of KSDP-2020, the CDGK issued a control version 2 (CV-02) of a draft report of KSDP-2020 in December 2006. The JICA Study follows the population projection made by KSDP-2020, which was approved by the Steering Committee held on 2nd October 2006. Therefore, a preliminary plan described in the Progress Report No.2 issued at the end of February 2006 was prepared in accordance with the CV-02 report of KSDP-2020. Afterward, the CDGK issued CV-03 report at the end of January 2007 and the JICA Study Team received it officially through JICA Islamabad Office and also the KW&SB at the beginning of February 2007. Preliminary plan in the Progress Report No.2 has been modified based on future population and land use plan stated in the CV-03 report. Modified water supply and sewerage master plans (hereinafter referred to as the "JICA Master Plan") were explained in the Interim Report which was submitted at the end of July 2007.

At the Steering Committee Meeting for the presentation and discussion of the Interim Report held on 8th August 2007, the Steering Committee requested JICA to revise JICA Master Plan in accordance with the final report of KSDP-2020 which would be issued at the meddle of August 2007. After the meeting, both parties signed "the Minutes of Understanding" on the revision of JICA Master Plan on 9th August 2007.

CDGK issued the final report of KSDP-2020 on 15th August 2007. It was confirmed that the report was the final version and that there will be no further change, by the letter of City Nazim Karachi on 4th October 2007. Then JICA was agreed and accept additional work to modify JICA Master Plan in line with KSDP-2020 by the JICA's letter dated on 25th October 2007.

6.1.2 City Population

(1) Population in 2005

CDGK conducted population censuses in 1961, 1972, 1981 and 1998. KSDP-2020 shows town-wise population of Karachi City in year of 2005 as shown in **Table 61.2.1** based on past trends in population growth. Per annum population growth rate of 4.2 % has been adopted from 1998 to 2005 for estimating the total population in 2005.

Table 61.2.1 City Population in 2005

No.	Town	Area *		Population in 2005 *	Population Density	
		(acre)	(km^2)		/acre	/km^2
1	Keamari	106,217	429.8	583,640	5.5	1,358
2	SITE	6,286	25.4	709,944	112.9	27,908
3	Baldia	7,217	29.2	616,722	85.5	21,116
4	Orangi	5,803	23.5	1,098,859	189.4	46,792
5	Lyari	1,977	8.0	923,176	467.0	115,388
6	Saddar	5,967	24.1	935,566	156.8	38,744
7	Jamshed	5,790	23.4	1,114,235	192.4	47,553
8	Gulshan-e-Iqbal	13,260	53.7	949,351	71.6	17,692
9	Shah Faisal	2,901	11.7	509,915	175.8	43,434
10	Landhi	9,670	39.1	1,012,391	104.7	25,870
11	Korangi	10,247	41.5	829,813	81.0	20,011
12	North Nazimabad	4,127	16.7	753,423	182.6	45,111
13	New Karachi	5,058	20.5	1,038,865	205.4	50,753
14	Gulberg	3,417	13.8	688,580	201.5	49,796
15	Liaquatabad	2,685	10.9	985,581	367.1	90,705
16	Malir	4,395	17.8	604,763	137.6	34,002
17	Bin Qasim	137,961	558.3	480,854	3.5	861
18	Gadap	355,798	1,439.9	439,674	1.2	305
	sub-total	688,776	2,787.4	14,275,352	20.7	5,121
19	Cantonment	31,336	126.8	464,882	14.8	3,666
20	Defence	9,454	38.3	379,596	40.2	9,922
	sub-total	40,790	165.1	844,478	20.7	5,116
	Total	729,566	2,952.4	15,119,830	20.7	5,121

*: Karachi Strategic Development Plan 2020 (August 2007)

(2) Future Population

Future population until 2025 which is the target year of JICA Study has been projected as shown in **Table 61.2.2** and **Figure 61.2.1**.

Table 61.2.2 Population of Karachi City (× 1,000)

Year	1961	1972	1981	1998	2005	2010	2015	2020	2025
Population	1,912.6	3,498.6	5,395.4	11,335	15,120	18,529	22,594	27,550	32,506

source: 1) 1961, 1972 and 1981: Karachi Development Plan 2000, June 1991
2) 1998: Adjusted by KSDP - 2020 (August 2007) based on 1998 census data of 9.96 million
3) 2005 to 2020: Projected by KSDP - 2020 (August 2007)
4) 2025: Projected by JICA Study (see **Appendix A61.1** in detail)

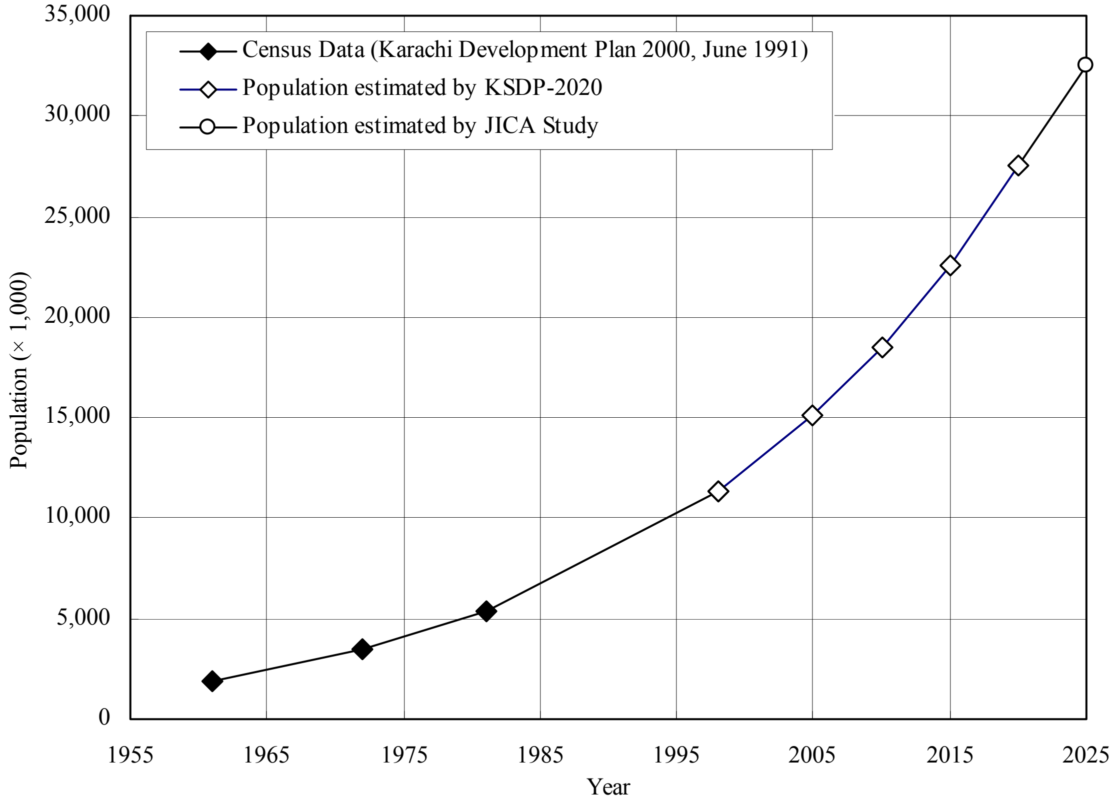


Figure 61.2.1 Population of Karachi

For the population projection, KSDP-2020 adopted annual population growth rates as shown in **Table 61.2.3**. **Table 61.2.4** shows the actual annual population growth rates of Karachi City in the past.

Table 61.2.3 Annual Population Growth Rate

	1998	2005	2010	2015	2020	2025
Population (×1000) *	11,335	15,120	18,529	22,594	27,550	32,506
Growth Rate		4.20%	4.15%	4.05%	4.05%	3.36%

*: 1) 2005 to 2020: Projected by KSDP - 2020 (August 2007)
2) 2025: Projected by JICA Study (see **Appendix A61.1** in detail)

Table 61.2.4 Past Annual Population Growth Rate

	1961	1972	1981	1998
Population (×1000) *	1,912.6	3,498.6	5,395.4	11,335
Growth Rate		5.49%	4.81%	4.46%

*: 1) 1961, 1972 and 1981: Karachi Development Plan 2000, June 1991
2) 1998: Adjusted by Karachi Master Plan - 2020 (CV-03, January 2007) based on 1998 census data of 9.96 million.

It is noted that the JICA Study was requested to use the future population projected in KSDP-2020 for preparing the master plan of water supply and sewerage system in Karachi City at the Steering Committee Meeting held on 2nd October 2006, because of the uniformity of city plans for all the related sectors.

6.1.3 Town-wise Population

KSDP-2020 has also projected the future town-wise population in 2020 as shown in **Table 61.3.1** in consideration of spatial growth strategies such as densification, infill and expansion.

Table 61.3.1 Town-wise Population Projection in 2020

S. No.	Town Name	2005			Projected Increase in Population for 2020				Total Projections for 2020		
		Population	Area (acre)	Density	Densification	Densification + Infill	Infill + Expansion	Status Quo	Population	Density	% increase
1	Keamari	583,640	106,217	5	-	-	1,340,272	-	1,923,912	18	230
2	SITE	709,944	6,286	113	184,585	-	-	-	894,529	142	26
3	Baldia	616,722	7,217	85	-	-	493,378	-	1,110,100	154	80
4	Orangi	1,098,859	5,803	189	-	-	330,066	-	1,428,925	246	30
5	Lyari	923,176	1,977	467	-	-	-	46,159	969,335	490	5
6	Saddar	935,566	5,967	157	187,113	-	-	-	1,122,679	188	20
7	Jamshed	1,114,235	5,790	192	445,694	-	-	-	1,559,929	269	40
8	Gulshan-e-Iqbal	949,351	13,260	72	-	1,424,027	-	-	2,373,378	179	150
9	Shah Faisal	509,915	2,901	176	101,983	-	-	-	611,898	211	20
10	Landhi	1,012,391	9,670	105	-	809,913	-	-	1,822,304	188	80
11	Korangi	829,813	10,247	81	-	995,776	-	-	1,825,589	178	120
12	North Nazimabad	753,423	4,127	183	226,027	-	-	-	979,450	237	30
13	New Karachi	1,038,865	5,058	205	-	207,773	-	-	1,246,638	246	20
14	Gulberg	688,580	3,417	202	206,574	-	-	-	895,154	262	30
15	Liaquatabad	985,581	2,685	367	-	-	-	49,279	1,034,860	385	5
16	Malir	604,763	4,395	138	-	-	302,382	-	907,145	206	50
17	Bin Qasim	480,854	137,961	3	-	-	1,672,699	-	2,153,553	16	348
18	Gadap	439,674	355,798	1	-	-	2,638,044	-	3,077,718	9	600
	sub-total	14,275,352	688,776	21	1,351,976	3,437,489	6,776,841	95,438	25,937,096	38	82
19	Cantonment	464,882	31,336	15	-	464,882	-	-	929,761	30	100
20	Defence	379,596	9,454	40	-	303,677	-	-	683,273	72	80
	sub-total	844,478	40,790	21	0	768,559	0	0	1,613,034	40	91
	Total	15,119,830	729,566	21	1,351,976	4,206,048	6,776,841	95,438	27,550,130	38	82

source: KSDP - 2020 (August 2007)

As shown in **Table 61.2.3**, population of Karachi City will increase about 12.43 million for 15 years from 2005 to 2020. The population to be increased in fringe 3 towns of Keamari, Gadap and Bin Qasim is 5.65 million of them and remaining population of 6.78 million will be increased in a central area including other 15 towns, cantonments and DHA as shown in **Figure 61.3.1**.

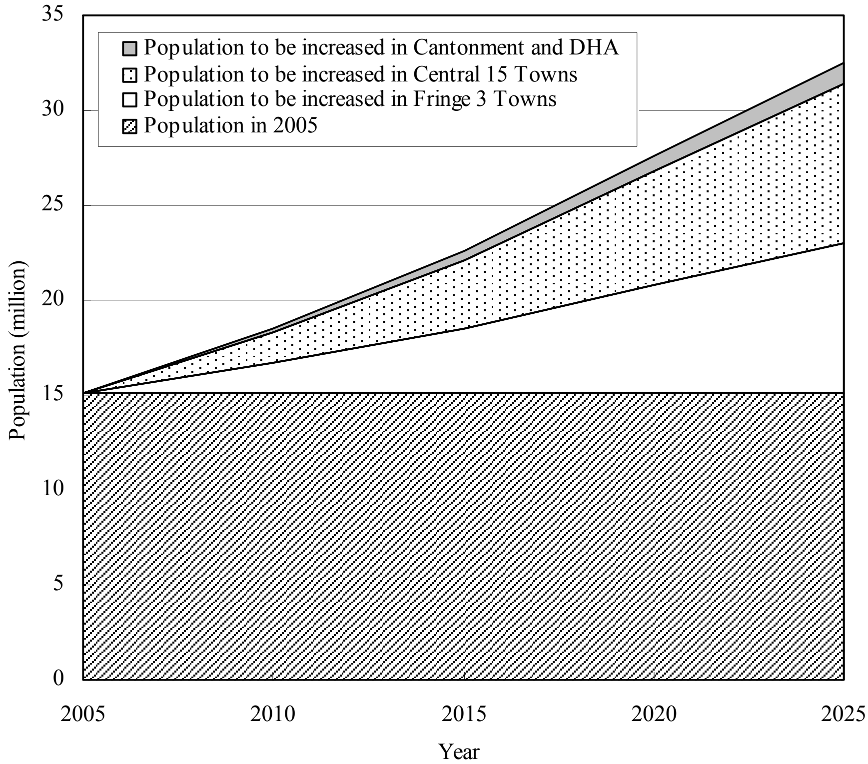


Figure 61.3.1 Area-wise Distribution of Population to be increased by 2025

KSDP - 2020 has considered spatial growth strategies that are densification, infill, expansion and status-quo. The population in the fringe 3 towns will be increased mainly by the expansion through developments of on-going and new large housing schemes. **Table 61.3.2** shows a status of on-going large housing schemes. These housing schemes can accommodate the population to be increased in the fringe 3 towns.

Table 61.3.2 Status of On-going Large Housing Schemes

SR. No.	Neme of Scheme	Year of Notification	Current Occupancy Status	Location
1	Scheme No.25-A (Shah Latif)	1980	5 %	Bin Qasim
2	Scheme No.33	1971	20 %	Gulshan-e-Iqubal, Gadap, Cant.
3	Scheme No.42 (Hawk's Bay)	1983	5 %	Keamari
4	Scheme No.43 (Halkani)	1986	0 %	Gadap
5	Scheme No.45 (Taisar)	1986	5 %	Gadap
6	New Malir Project - 1	1996	0 %	Bin Qasim

source: KSDP - 2020 (August 2007)

The population in the central area will be increased by the densification and infill. However, Lyari and Liaquatabad Towns which is already high population density are not expected to increase those population.

The future town-wise population is shown in **Table 61.3.3** and attached to **Appendix A61.1**. It is noted that although KSDP - 2020 does not include town-wise population in 2010, 2015 and 2025, town-wise population in those years are estimated by JICA Study considering town- wise population increase trend from 2005 to 2020.

Table 61.3.3 Town-wise Population

No.	Town	Area*		Population				
		(acre)	(km^2)	2005*	2010	2015	2020*	2,025
1	Keamari	106,217	429.8	583,640	951,187	1,389,516	1,923,912	2,458,308
2	SITE	6,286	25.4	709,944	760,563	820,931	894,529	968,127
3	Baldia	7,217	29.2	616,722	752,023	913,379	1,110,100	1,306,821
4	Orangi	5,803	23.5	1,098,859	1,189,374	1,297,320	1,428,925	1,560,530
5	Lyari	1,977	8.0	923,176	935,834	950,930	969,335	987,740
6	Saddar	5,967	24.1	935,566	986,879	1,048,073	1,122,679	1,197,285
7	Jamshed	5,790	23.4	1,114,235	1,236,459	1,382,221	1,559,929	1,737,637
8	Gulshan-e-Iqbal	13,260	53.7	949,351	1,339,866	1,805,587	2,373,378	2,941,169
9	Shah Faisal	2,901	11.7	509,915	537,882	571,235	611,898	652,561
10	Landhi	9,670	39.1	1,012,391	1,234,496	1,499,374	1,822,304	2,145,234
11	Korangi	10,247	41.5	829,813	1,102,888	1,428,551	1,825,589	2,222,627
12	North Nazimabad	4,127	16.7	753,423	815,407	889,328	979,450	1,069,572
13	New Karachi	5,058	20.5	1,038,865	1,095,843	1,163,794	1,246,638	1,329,482
14	Gulberg	3,417	13.8	688,580	745,229	812,788	895,154	977,520
15	Liaquatabad	2,685	10.9	985,581	999,095	1,015,211	1,034,860	1,054,509
16	Malir	4,395	17.8	604,763	687,686	786,579	907,145	1,027,711
17	Bin Qasim	137,961	558.3	480,854	939,563	1,486,611	2,153,553	2,820,495
18	Gadap	355,798	1,439.9	439,674	1,163,113	2,025,871	3,077,718	4,129,565
	sub-total	688,776	2,787.4	14,275,352	17,473,387	21,287,301	25,937,096	30,586,891
19	Cantonment	31,336	126.8	464,882	592,367	744,403	929,761	1,115,119
20	Defence	9,454	38.3	379,596	462,874	562,190	683,273	804,356
	sub-total	40,790	165.1	844,478	1,055,241	1,306,594	1,613,034	1,919,474
	Total	729,566	2,952.4	15,119,830	18,528,629	22,593,894	27,550,130	32,506,366

*: KSDP - 2020 (August 2007)

6.1.4 Population Density

Based on the future town-wise population and the size of the area covered by each town shown, the population density of each town is calculated as shown in **Table 61.4.1**. The geographical distribution of the calculated density is illustrated in **Figures 61.4.1** and **61.4.2** for the year 2005 and 2025 respectively.

Table 61.4.1 Town-wise Population Density

No.	Town	Area		Population Density (/km^2)				
		(acre)	(km^2)	2005	2010	2015	2020	2,025
1	Keamari	106,217	429.8	1,358	2,213	3,233	4,476	5,719
2	SITE	6,286	25.4	27,908	29,898	32,271	35,164	38,057
3	Baldia	7,217	29.2	21,116	25,749	31,274	38,009	44,745
4	Orangi	5,803	23.5	46,792	50,646	55,243	60,847	66,451
5	Lyari	1,977	8.0	115,388	116,970	118,857	121,157	123,458
6	Saddar	5,967	24.1	38,744	40,869	43,403	46,492	49,582
7	Jamshed	5,790	23.4	47,553	52,770	58,990	66,575	74,159
8	Gulshan-e-Iqbal	13,260	53.7	17,692	24,969	33,648	44,229	54,810
9	Shah Faisal	2,901	11.7	43,434	45,816	48,657	52,121	55,585
10	Landhi	9,670	39.1	25,870	31,546	38,315	46,567	54,819
11	Korangi	10,247	41.5	20,011	26,596	34,449	44,024	53,598
12	North Nazimabad	4,127	16.7	45,111	48,823	53,249	58,645	64,041
13	New Karachi	5,058	20.5	50,753	53,537	56,856	60,904	64,951
14	Gulberg	3,417	13.8	49,796	53,892	58,778	64,734	70,691
15	Liaquatabad	2,685	10.9	90,705	91,949	93,432	95,240	97,048
16	Malir	4,395	17.8	34,002	38,665	44,225	51,004	57,782
17	Bin Qasim	137,961	558.3	861	1,683	2,663	3,857	5,052
18	Gadap	355,798	1,439.9	305	808	1,407	2,138	2,868
	sub-total	688,776	2,787.4	5,121	6,269	7,637	9,305	10,973
19	Cantonment	31,336	126.8	3,666	4,671	5,870	7,332	8,793
20	Defence	9,454	38.3	9,922	12,098	14,694	17,859	21,024
	sub-total	40,790	165.1	5,116	6,393	7,915	9,772	11,628
	Total	729,566	2,952.4	5,121	6,276	7,653	9,331	11,010

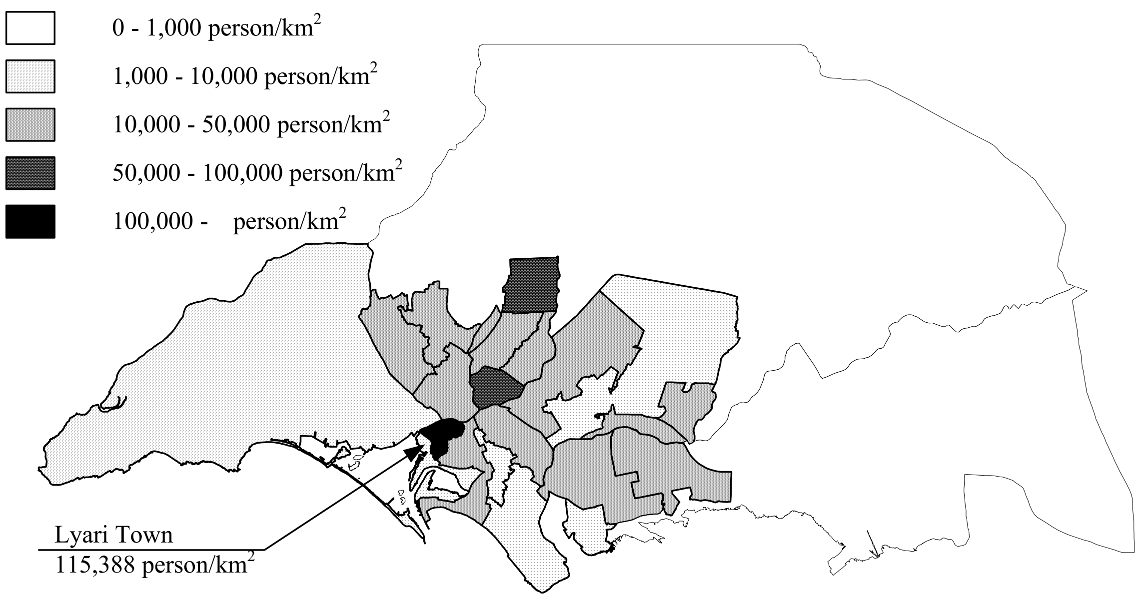


Figure 61.4.1 Population Density in 2005

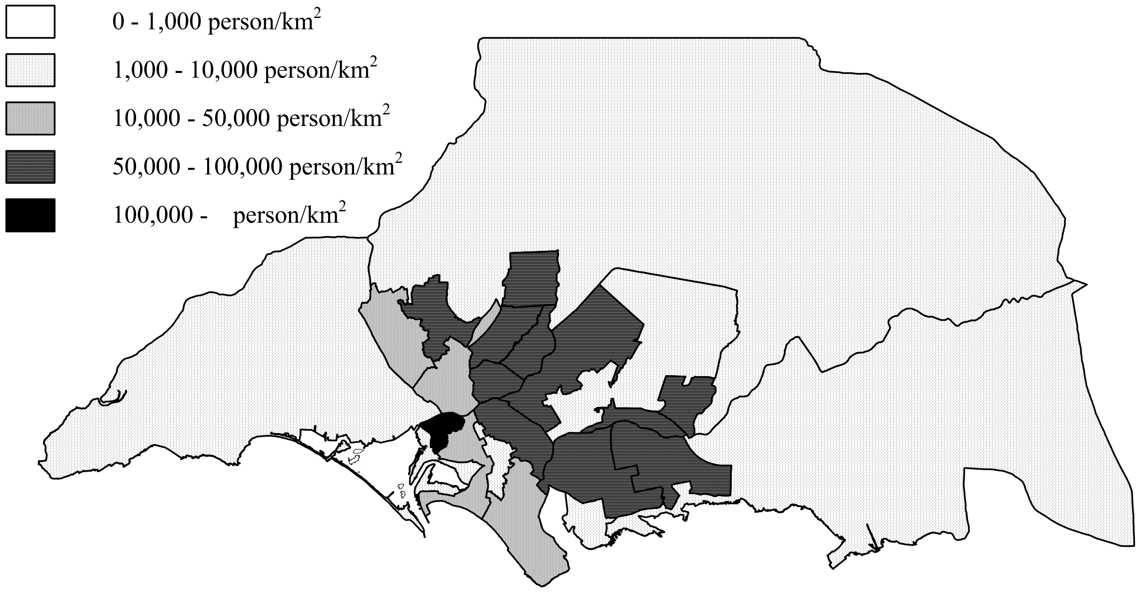


Figure 61.4.2 Population Density in 2025

As can seen in **Table 61.4.1** and **Figure 61.4.1**, the population density of Lyari Town in 2005 is about 115,000 persons/km^2. The overall average population density of Karachi City in 2005 is 5,100 persons/km^2. It increases to 35,000 persons/km^2 if three towns, namely Keamari, Bin Qasim and Gadap Towns are excluded. These figures are extremely high in comparison with other populated Asian cities as shown in **Table 61.4.2**.

Table 61.4.2 Population Density of Major Asian Cities

City Name	Density(/km²)	Densest district
Manila, Philippines	41,014	
Mumbai, India	29,434	
Macau, People's Republic of China	16,521	Freguesia de Santo Antonio (98,776/km²), Macau Peninsula (59,284/km²)
Seoul, South Korea	16,391	
Dhaka, Bangladesh	14,608	
Tokyo, Japan	13,800	Nakano (20,098/km²)
Jakarta, Indonesia	11,360	Central Jakarta (18,292/km²)
Taipei, Taiwan	9,626	Daan (27,476/km²)
Delhi, India	9,339	
Singapore	6,389	
Hong Kong, People's Republic of China	6,206	Kwun Tong (55,000/km²)
Kuala Lumpur, Malaysia	6,072	
Bangkok, Thailand	4,051	
Colombo, Sri Lanka	3,305	
Shanghai, People's Republic of China	2,700	Huangpu (126,500/km²)
Ho Chi Minh City, Vietnam	2,571	Cholon (50,637/km²)
Beijing, People's Republic of China	906	Xuanwu (38,303/km²)

source: Wikipedia (http://en.wikipedia.org/wiki/List_of_selected_cities_by_population_density)

6.2 WATER DEMAND

6.2.1 Present Water Supply Status

(1) Existing Water Supply Capacity

Present water supply system of Karachi City has a bulk water supply capacity of 600 mgd as shown in **Table 62.1.1** and a filtration capacity of 440 mgd as shown in **Table 62.1.2**. This figure does not include bulk water supply of bulk water from Gujjo Headworks to Pakistan Steel Mills and Port Qasim Authority which have their own bulk water transmission facilities (canals and pumping stations) and filtration plants.

Table 62.1.1 Bulk Water Supply Capacity

Bulk Water System	Capacity	Actual Supply
GK System	280 mgd	300 mgd
Haleji System	20 mgd	30 mgd
K-II System	100 mgd	120 mgd
K-III System	100 mgd	100 mgd
Dumlottee Wells	20 mgd	0 mgd
Hub System	80 mgd	80 mgd
Total	600 mgd	630 mgd

Source: KW&SB

Table 62.1.2 Present Filtration Capacity

Filtration Plant	Capacity
Gharo Filtration Plant	20 mgd
Pipri Filtration Plant	100 mgd
NEK Old Filtration Plant	25 mgd
NEK New Filtration Plant	100 mgd
COD Filtration Plant	115 mgd
Hub Filtration Plant	80 mgd
Total	440 mgd

Source: KW&SB

Actually as of the end of year 2006, the KW&SB supply bulk water of about 630 mgd beyond the capacity as shown in **Table 62.1.1** and detailed in **Section 3.3.1**.

(2) Water Losses

In the absence of flow measurements at the exits of service reservoirs and filtration plants as well as at the customers' service connections, it is impossible to accurately establish the ratio of water losses in the existing water supply system. The ratio of technical water losses (Unaccounted-For-Water, UFW, such as physical losses, metre inaccuracy and unauthorized consumption) in the transmission and distribution system from filtration plants to customers is reported to range from 20% to 35% of water supply capacity (see **Table 62.1.3**). For the definition of UFW, refer to **Section 9.3 "Reduction of Non-revenue Water"** of this report.

Table 62.1.3 Water Losses reported by Agencies Concerned

Source	Technical Losses (UFW)
PC-1 Form for Water Loss Reduction & System Strengthening Project, KW&SB, February 2001	range of 30% to 35%
An Overview of KW&SB, Briefing to Rukhsana Saleem (Additional Chief Secretary, Local Government, Govt. of Sindh) by MD of KW&SB, 13th January 2007	30 – 35 %
Karachi Strategic Development Plan 2020 (August 2007), CDGK	20%, 25 %

In addition, the water supply system has another water loss called bulk (raw) water losses. Bulk water losses occur in the bulk water transmission system from bulk water intake facilities to filtration plants (leakages, penetration and evaporation) and at filtration plants (backwash water, discharge as sludge, plant water and leakages). In general, water loss at filtration plant ranges from 3% to 10% of plant capacity (water supply capacity from the plant). Filtration plants in Karachi normally have a recovery system which is a recycle system of backwashed water used at filtration system and settled sludge discharged from clarifier or sedimentation basin. Therefore the water loss at filtration plant seems to be relatively small. If including water losses in the bulk water transmission system, bulk water losses can be assumed to be about 10% of the plant capacity. This means that bulk water requires 1.1 times of the plant capacity. **Figure 62.1.1** illustrates the types of water losses within the water supply system of Karachi.

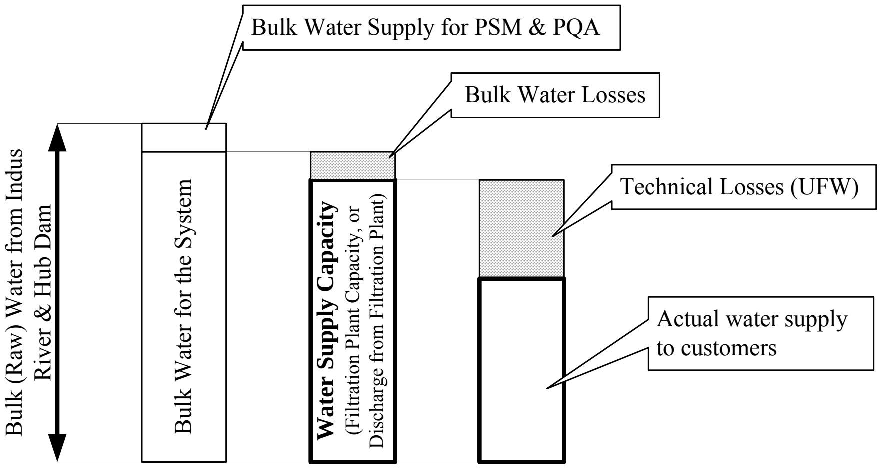


Figure 62.1.1 Definition of Water Supply Capacity and Water Losses

(3) Per Capita Bulk Water Demand

As already mentioned in **Section 6.1**, the population of Karachi City in 2006 is estimated at 15.8 million. Therefore, per capita bulk water demand in 2006 can be calculated as follows:

$$\frac{630 \text{ mgd}}{15.8 \text{ million}} = 39.9 \text{ gallon/capita/day (181.3 lpcd)}$$

At present the KW&SB supply bulk water of about 40 gallon per capita per day (gpcd) or 180 litres per capita per day (lpcd) for Karachi Water Supply System.

6.2.2 Assumptions Used for Water Demand Forecast

(1) Service Ratio

The socio-economic survey conducted in KSDP - 2020 has indicated that the piped water supply ratio in Karachi is 89%. For reference, our survey which was conducted mainly at Katchi Abadis during basic study period in 2006 showed that the service ratio (water line connection rates) was estimated at about 82%. Based on these results, JICA study has adopted 90% as the current average service ratio in Karachi in 2005. This means that 90 % of population in Karachi use the KW&SB water through pipelines or by tankers and the remaining 10% of population may depend mainly on groundwater. On the other hand, KSDP – 2020 says that about 60 % of the households are connected to the supply network at present. Considering the average groundwater withdrawal of about 30 mgd (Feasibility Study to explore Groundwater Sources in Karachi District, KW&SB, 2004), however, only 5 % to 10 % of population can access to groundwater other than the KW&SB water. Because there is no alternative bulk source except the KW&SB water and groundwater, as a result, about 90 % of population is using the KW&SB water. Water of about 17 mgd is supplied by tankers from 10 bowser filling stations according to the KW&SB data in 2004.

The service ratio is assumed to increase gradually from the current service ratio of 90% to 100% by 2015 as shown in **Table 62.2.1**. KSDP-2020 also proposed a plan to make service ratio 100% by 2015. The 100% service ratio means that all the households in Karachi connect to the piped water supply system and as such receive treated water from the system.

Table 62.2.1 Future Service Ratio

Year	2005	2010	2015	2020	2025
Service Ratio	90.0%	95.0%	100%	100%	100%

(2) Water Losses (UFW) Reduction

In the absence of flow measurements at the exits of service reservoirs and filtration plants as well as at the customers' service connections, it is impossible to accurately establish the UFW in the existing water distribution system. As mentioned previously, the current UFW in the transmission and distribution system from filtration plants to customers is seemed to be 20% to 35% of water supply capacity. It is assumed that through the implementation of the Distribution Network Improvements (DNI) which will be to replace all the exiting distribution network mains with new PE pipes during the next 20 years, UFW will be reduced to 15 % by 2025. Details of the UFW reduction measures are discussed in **Section 9.3 "Reduction of Non-Revenue Water"** of this report.

(3) Non-Domestic Water Consumption

Although there is not enough quantitative data, according to the data on revenue collection and bulk water supply customers provided by the Financial Department of the KW&SB, domestic water consumption accounts for about 60% of the total water consumption in Karachi. At present, therefore, non-domestic water consumption is assumed to be 40 % of the total water consumption. In future, however, this proportion is expected to decrease gradually to about 35% in 2025 as a result of water conservation efforts such as recycling and reuse of wastewater and introduction of desalination system exercised by large industrial and commercial consumers. From 2008 a desalination plant with a capacity of 3 mgd at DHA area will be operated for supplying water to Clifton Cantonment and DHA area.

(4) Proposed Domestic Per Capita Water Consumption

As mentioned above, at present bulk water of 40 gpcd is supplied to the customers in Karachi. JICA study assumed that 40 gpcd is also adopted for bulk water demand for the year 2025. Although the bulk water demand of 40 gpcd in 2025 is the same as the present demand, domestic per capita water consumption will increase because of the reduction of technical losses and water-saving efforts of non-domestic consumers. In other words, unless the technical losses decrease and the non-domestic consumption is conserved, the domestic per capita water consumption in 2025 will be the same as that in 2005. The future technical losses (UFW), the proportion of domestic water consumption and bulk water losses in 2025 are set at 15%, 65% and 10% respectively as discussed previously. Taking these ratios into consideration, the domestic per capita water consumption in 2025 is calculated at 20.1 gallons or 91.6 litres as illustrated in **Figure 62.2.1**.

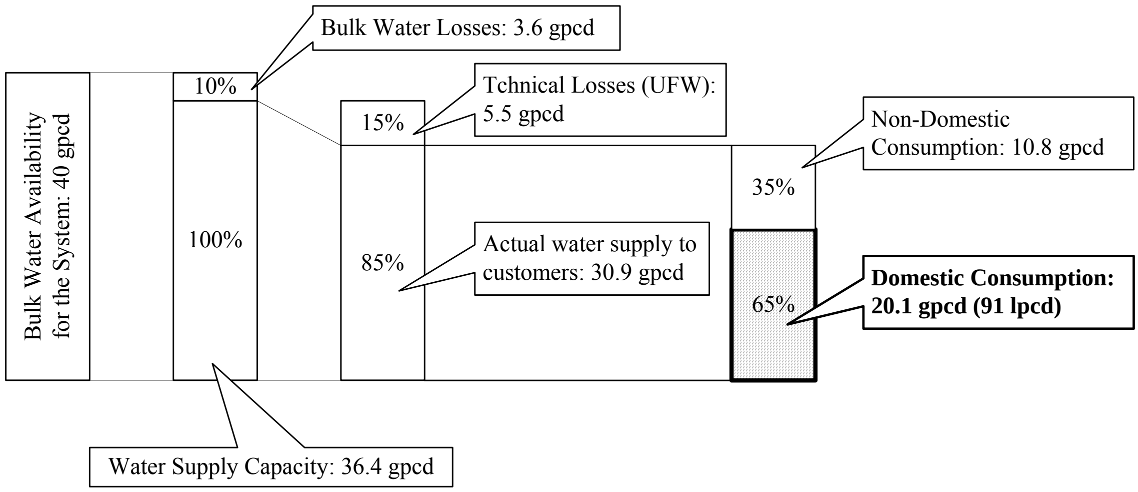


Figure 62.2.1 Per Capita Domestic Water Consumption in 2025

(5) Evaluation of Domestic Per Capita Water Consumption

Domestic per capita water consumption (gallon per capita per day: gpcd or litre per capita per day: lpcd) is an important design factor for estimating future domestic water consumption. People use water for a wide variety of activities. Some of these are more important than others, for example, having a few litres of water to drink a day is more vital than washing clothes. The need to wash hands and feet before prayer may be felt to be more important than other uses. It is, therefore, difficult to estimate how much an individual needs on an average.

Local Government Department, Government of Sindh, announced “Sindh Water Supply Policy” on May 2006. It says that “water will provided inside the house, through piped water, to meet the minimum requirement of 50 litres per person per day”. WHO also reported in “Water Demand Management and Pollution Control, April 2001” that minimum basic needs of water is 50 lpcd and in many cities in Middle East and North Africa, the average water consumption of 70 lpcd is common.

Table 62.2.2 shows domestic per capita water consumptions of major Asian cities. Average per capita consumption of major Asian cities listed in **Table 62.2.2** is calculated at 112.9 lpcd (24.9 gpcd). Considering meteorological condition (average rainfall and dependence on the Indus River) and living standard (GNI), it is deemed reasonable to set domestic per capita water consumption of Karachi to less than 112.9 lpcd (24.9 gpcd).

For reference, per capita consumption of Amman, Jordan, is 80 lpcd (Performance Indicators of Water & Sanitation Utilities in Middle East & North Africa, World Bank, 2003). Living environments of Amman are almost the same as Karachi. Both countries are Islamic countries. Average rainfall in the last 30 years of Amman is 270 mm and GNI of Jordan is US$ 2,500.

Table 62.2.2 Per Capita Water Consumptions of Major Asian Cities

City	Population*1	lpcd*1	Average Rainfall*2	Remarks	
				Country	GNI*3
Colombo	642,163	119	2,313	Sri Lanka	1,160
Delhi	13,782,976	110	779	India	720
Dhaka	10,358,000	115	2,144	Bangladesh	470
Ho Chi Minh	2,749,941	167	1,882	Viet Nam	620
Jakarta	9,695,600	77	1,903	Indonesia	1,280
Kathmandu	1,519,410	68	1,360	Nepal	270
Kuala Lumpur	1,420,000	132	2,390	Malaysia	4,960
Manila	12,660,788	127	1,715	Philippines	1,300
Phnom Penh	532,130	104	1,356	Cambodia	380
Vientiane	616,221	110	1,563	Lao PDR	440

*1: Water in Asian Cities, ADB, 2004
*2: average for 30 years from 1971 to 2000 (mm), Japan Meteorological Agency
*3: GNI: Gross National Income (US$/capita/year), World Development Indicators 2006, WB
Note: Average rainfall of Karachi from 1962 to 2005 is 128.1 mm. Meteorological Department, Government of Pakistan
GNI of Pakistan is 690 US$/capita according to World Development Indicators 2006, WB.

Considering increase of living standard by the target year of 2025 in Karachi, therefore, the JICA study will adopt at least 75 lpcd even for low-income group as domestic per capita water consumption. In this case average domestic per capita water consumption can be calculated at about 90 lpcd.

Table 62.2.3 shows bulk water requirements in 2025 in the following three cases.

Case 1: Per capita consumption is the same as Asian cities' average of 112.9 lpcd.

Case 2: Per capita consumption is JICA study's recommendation of 91.6 lpcd (Per capita bulk water demand is 40 gpcd which is the same as current one).

Case 3: Per capita bulk water demand is 54 gpcd which was used for past planning of the KW&SB.

Table 62.2.3 Comparison of Bulk Water Demands

	unit	Case 1	Case 2	Case 3
Per Capita Consumption	lpcd	**112.9**	**91.6**	123.7
	gpcd	24.9	20.1	27.2
Ratio of Domestic Consumption	%	65.2	65.2	65.2
Technical Loss (UFW)	%	15.0	15.0	15.0
Population	million	32.506	32.506	32.506
Water Demand	mgd	1,457	1,182	1,596
Bulk Water Loss	%	10.0	10.0	10.0
Bulk Water Demand	gpcd	49.3	40.0	**54.0**
	mgd	1,602	1,300	1,755

On the other hand, present bulk water availability for Karachi Water Supply System is:

Indus River	:	645 mgd (1,200 cusecs)
Hub Dam	:	75 mgd
Total	:	720 mgd

CDGK have requested the Federal Government for granting an additional water right of 1,200 cusecs from Indus River for Karachi Water Supply System. Assuming that this request will be approved by the Federal Government, the bulk water availability for Karachi Water Supply System will be:

Indus River	:	1,290 mgd (2,400 cusecs)
Hub Dam	:	75 mgd
Total	:	1,365 mgd

Table 62.2.4 shows a water balance of bulk water demand as shown in **Table 62.2.3** and expected bulk water availability in 2025 of 1,365 mgd.

Table 62.2.4 Water Balance of Bulk Water

	unit	Case 1	Case 2	Case 3
Bulk Water Demand	mgd	1,602	1,300	1,755
Bulk Water Availability	mgd	1,365	1,365	1,365
Water Balance	mgd	- 237	65	- 390
	cusecs	- 441	121	- 725

In case of adopting Case 1 or Case 3, the CDGK should apply for an additional water right of 237 mgd (441 cusecs) or 390 mgd (725 cusecs) again. Therefore, JICA study recommends adopting Case 2 by the following reasons:

- Water right from the Indus River for Karachi city is 1,200 cusecs as of the end of December 2007 and an additional water right from the Indus River of 1,200 cusecs has not been approved yet. There is a restriction on water sources for Karachi city.
- Considering environments surrounding Karachi city such as meteorological phenomena and lack of water sources, although the economic growth of Karachi is necessary for increase of population, strict demand management is indispensable for sustaining its growth.
- There is no quantitative flow data for water supply system such as bulk water amount, supply from filtration plants and reservoirs, transmission and distribution flows and consumption of connections. Therefore, no one knows a necessity of additional water quantitatively.

(6) Future Water Supply Capacity

The future water supply system should require a water supply capacity corresponding to the water demand as shown in **Table 62.2.3**. At the Steering Committee held on 2 October 2006, it was agreed that for bulk water supply the on-going K-IV study should provide the required input. According to the latest information on K-IV Project, it is envisaged that the present water supply capacity will be increased by 650 mgd to 1,190 mgd under the K-IV Project. The K-IV Project proposes to construct three filtration plants (650 mgd in total; 260 mgd × 2 plants and 130 mgd × 1 plant) in Gadap Town. In case of applying Case 2, therefore, the future water supply capacity of 1,190 mgd would cover water demand of Case 2 which is 1,182 mgd. If Case 1 or Case 3 would be selected, it should be necessary to plan and develop additional bulk water transmission system and filtration plant in addition to K-IV Project.

(7) Seasonal Peak Factor

Water demand generally fluctuates throughout the year. Water supply facilities (such as filtration plants) are usually planned based on the maximum day water demand. The water demand that has been discussed in this sub-section is the average day water demand, which is usually multiplied by a peak factor (the ratio of the maximum day water demand to the average day water demand) to determine the maximum day water demand.

The peak factor is normally estimated by analyzing the past trend of monthly water demand fluctuation. However, it is not available in the case of Karachi since no flow measurement has been conducted in the past. Furthermore, it is envisaged that the future water demand in Karachi would be heavily constrained by the limited availability of bulk water from the water sources. Under the circumstances, there is no point in discussing about seasonal peak factors.

6.2.3 Future Water Demand

(1) Water Demand of Each Case in 2025

Future water demand of each case is summarised in **Table 62.3.1**. It should be noted that the water demand means water consumption (total of domestic and non-domestic water consumptions) plus technical water losses (total technical losses from outlet of filtration plant to customers through transmission system, reservoirs and distribution system).

Table 62.3.1 Water Demand of Each Case in 2025

	unit	Case 1	Case 2	Case 3
Bulk Water Demand (see Table 62.2.3)	mgd	1,602	1,300	1,755
Bulk Water Loss	%	10.0	10.0	10.0
Water Demand	**mgd**	**1,457**	**1,182**	**1,596**
Water Supply Capacity see **Section 7.3** in detail)	mgd	1,270	1,270	1,270
Balance	mgd	-187	88	-326

As explained previously, in case of applying case 2, the future water supply capacity of 1,270 mgd would cover water demand of case 2 that is 1,182 mgd. If case 1 or case 3 would be selected, it should be necessary to construct additional bulk water transmission system and filtration plant in addition to K-IV Project. Considering current situation such as meteorological condition, bulk water availability, on-going studies and financial background of water supply system, in this study case 2 have been adopted for the future development plan for Karachi.

(2) Future Water Demand

In order to calculate future water demand, water loss is estimated as shown in **Table 62.3.2** as a target of water loss reduction. In the early stage of water loss reduction measure, its effect is not seen immediately. If the actual water loss is proved quantitatively and is smaller than the figure shown in **Table 62.3.2** as the results of flow measurement, the KW&SB should strive not to fall below the target of water loss in **Table 62.3.2**.

Table 62.3.2 Expected Future Water Loss (UFW) Ratio

Year	2005	2010	2015	2020	2025
Technical Loss (UFW)	35.0%	33.0%	28.5%	21.5%	15.0%

Based on this assumption, the future water demand is calculated as shown in **Table 62.3.3** and **Figure 62.3.1**.

Table 62.3.3 Future Water Demand

		unit	2005	2010	2015	2020	2025
a	Population	× million	15.120	18.529	22.594	27.550	32.506
b	Per Capita Bulk Water Demand	gpcd	40.0	40.0	40.0	40.0	40.0
c	Bulk Water Demand: a × b	mgd	604.8	741.1	903.8	1,102.0	1,300.3
d	Bulk Water Loss	%	10.0%	10.0%	10.0%	10.0%	10.0%
e	Water Demand: c / (1+d)	mgd	549.8	673.8	821.6	1,001.8	1,182.0
f	Water Loss (UFW)	%	35.0%	33.0%	28.5%	21.5%	15.0%
g	Total Supply to Customers: e × (1-f)	mgd	357.4	451.4	587.4	786.4	1,004.7
h	Ratio of Domestic Consumption	%	60.0%	60.4%	61.7%	63.2%	65.2%
i	Domestic Consumption: g × h	mgd	214.4	272.6	362.3	497.3	655.3
j	Non-domestic Consumption: g × (1-h)	mgd	143.0	178.8	225.1	289.1	349.5
k	Service Ratio	%	90.0%	95.0%	100%	100%	100%
l	Served Population: a × k	× million	13.608	17.602	22.594	27.550	32.506
m	Per Capita Consumption: i / l	lpcd	71.6	70.4	72.9	82.1	91.6

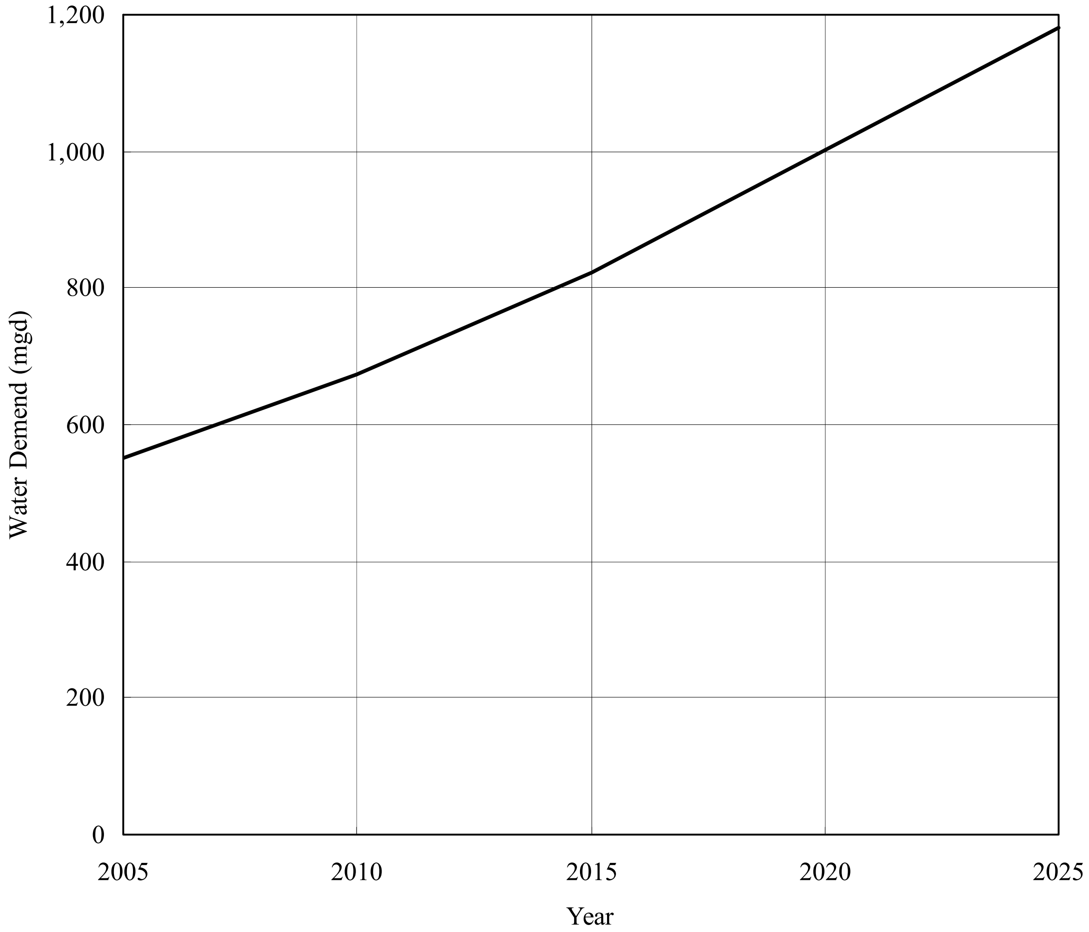


Figure 62.3.1   Future Water Demand

(3) Efficiency of UFW Reduction

Figure 62.3.2 demonstrates how important it is to reduce UFW from the current 35% to 15% in 2025. If UFW continues to remain at the present level without reduction, it would increase the technical loss drastically as shown in **Figure 62.3.2** and **Table 62.3.4**. In this case, the total water loss in 2025 would exceed 400 mgd, which is equivalent to two third of the current total bulk supply of 630 mgd.

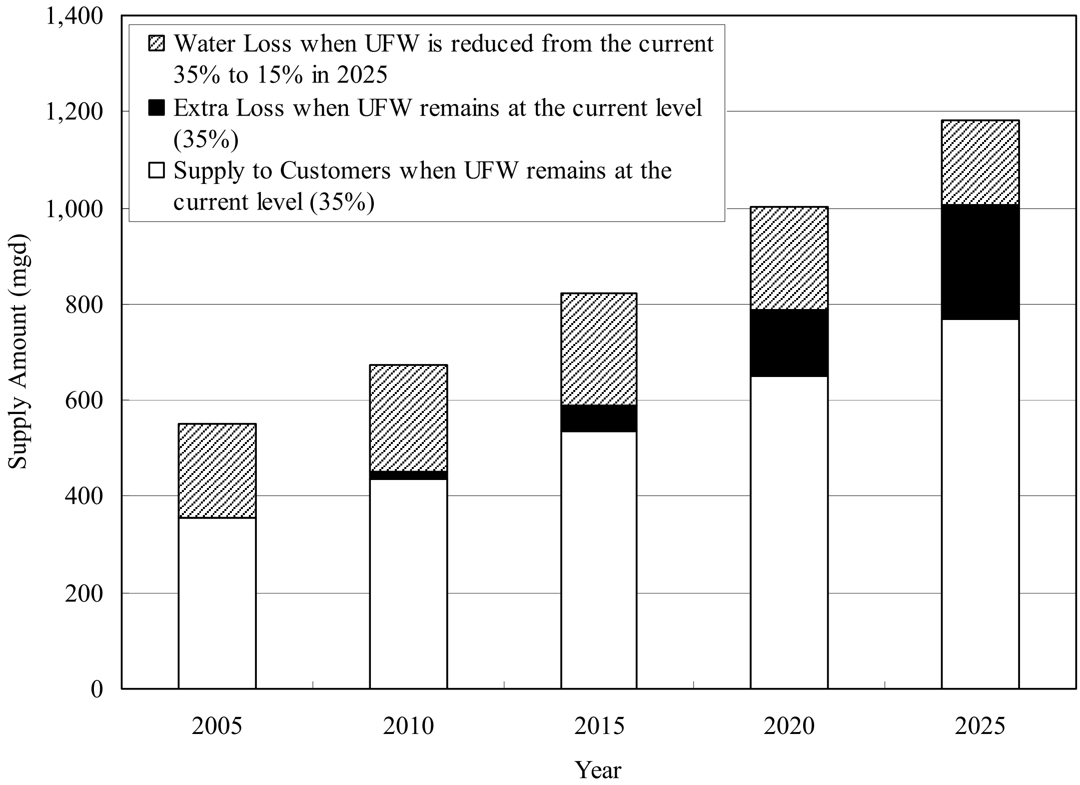


Figure 62.3.2 Supply to Customers With & Without UFW Reduction

Table 62.3.4 Supply to Customers With & Without UFW Reduction

	unit	2005	2010	2015	2020	2025
With UFW Reduction Measures, 35% to 15% in 2025						
Water Loss (UFW)	%	35.0%	33.0%	28.5%	21.5%	15.0%
Water Demand	mgd	549.8	673.8	821.6	1,001.8	1,182.0
Total Supply to Customers	mgd	357.4	451.4	587.4	786.4	1,004.7
Water Loss	mgd	192.4	222.3	234.2	215.4	**177.3**
Without UFW Reduction Measures, keeping of the present level of 35%						
Water Loss (UFW)	%	35.0%	35.0%	35.0%	35.0%	35.0%
Water Demand	mgd	549.8	673.8	821.6	1,001.8	1,182.0
Total Supply to Customers	mgd	357.4	437.9	534.0	651.2	768.3
Water Loss	mgd	192.4	235.8	287.6	350.6	**413.7**

(4) Future Water Demand of Each Town

Future Water Demand of each town, cantonment and DHA from 2006 to 2025 is summarised in **Table 62.3.5** and attached in **Appendix A61.1**.

Table 62.3.5 Future Water Demand of Each Town

No.	Town	Area		Total Water Demand (mgd)				
		(acre)	(km2)	2005	2010	2015	2020	2025
1	Keamari	106,217	429.8	12.33	24.75	40.99	56.98	73.31
2	SITE	6,286	25.4	32.56	34.18	35.88	38.33	40.79
3	Baldia	7,217	29.2	10.58	17.15	24.54	30.01	35.63
4	Orangi	5,803	23.5	24.96	27.45	30.33	34.02	37.91
5	Lyari	1,977	8.0	22.41	22.61	22.90	23.70	24.59
6	Saddar	5,967	24.1	69.99	70.51	71.15	73.94	76.71
7	Jamshed	5,790	23.4	28.81	35.46	42.57	48.77	55.27
8	Gulshan-e-Iqbal	13,260	53.7	41.88	57.32	75.00	98.36	121.99
9	Shah Faisal	2,901	11.7	22.33	23.20	24.12	25.50	26.93
10	Landhi	9,670	39.1	32.03	37.30	43.49	52.86	62.40
11	Korangi	10,247	41.5	28.79	36.01	44.19	56.20	68.30
12	North Nazimabad	4,127	16.7	24.32	25.95	28.03	31.44	35.03
13	New Karachi	5,058	20.5	24.55	25.83	27.39	29.86	32.47
14	Gulberg	3,417	13.8	21.24	23.05	25.22	28.26	31.48
15	Liaquatabad	2,685	10.9	30.22	29.54	29.20	30.31	31.51
16	Malir	4,395	17.8	38.10	39.94	42.20	47.13	51.84
17	Bin Qasim	137,961	558.3	31.19	58.33	87.67	122.58	155.34
18	Gadap	355,798	1,439.9	10.42	33.33	64.79	97.72	130.58
	sub-total	688,776	2,787.4	506.71	621.93	759.67	925.94	1,092.09
19	Cantonment	31,336	126.8	21.60	26.81	32.55	39.64	46.48
20	Defence	9,454	38.3	21.50	25.03	29.37	36.24	43.48
	sub-total	40,790	165.1	43.10	51.84	61.92	75.88	89.96
	Total	729,567	2,952.5	549.81	673.77	821.60	1,001.82	1,182.05

CHAPTER 7

WATER SUPPLY MASTER PLAN

7 WATER SUPPLY MASTER PLAN

7.1 PLANNING ASSUMPTIONS

This section discusses the planning assumptions, based upon which our master plan for water supply system in Karachi has been formulated.

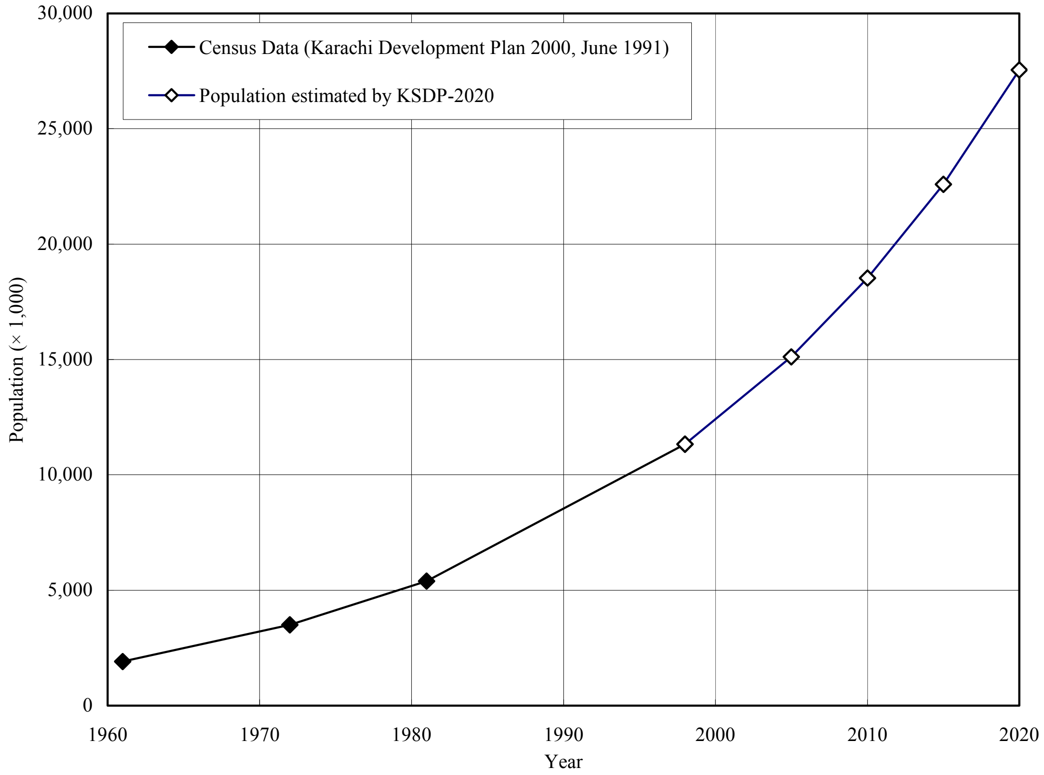
7.1.1 Population and Development Patterns

In August 2007, CDGK issued the final report on Karachi Strategic Development Plan 2020 (Final Report, August 2007). This report indicated that the total population of Karachi was 15.2 million in 2005 and it would increase to 27.5 million in 2020. The report also predicted that more than 45% of the projected population increase during the 15 years from 2005 to 2020 would occur in the three towns located on the outskirts of the Karachi City, namely Keamari, Gadap and Bin Qasim whereas the balance 55% in the remaining 15 towns. This was based on the perception that during the next 15 years significant developments would take place on the outskirts of the city in particular in the southern part of Gadap Town. **Figure 71.1.1** shows the population projections made by the Karachi Strategic Development Plan 2020 (Final Report, August 2007). **Figure 71.1.2** illustrates the future land use envisaged by the same plan.

Karachi's total population was 15.2 million in 2005 and it would increase to 27.5 million in 2020.

We believe that the Karachi Strategic Development Plan 2020 (KSDP-2020), once it is approved and authenticated by higher authorities, will serve as a guiding principle, based on which all infrastructure development schemes for all public service sectors, such as water supply, sewerage, solid waste disposal, electricity, gas, telecommunication and roads will be developed. For this reason, we decided to develop a water supply and sewerage master plan for Karachi based on the population projections, future land use patterns and other basic data provided in the KSDP-2020 (Final Report, August 2007).

It has been projected that 45% of the population increase during the 15 years from 2005 to 2020 would occur in the three towns located on the outskirts of the Karachi City, namely Keamari, Gadap and Bin Qasim while the balance 55% in the remaining 15 towns.



Year	1981	1998	2005	2010	2015	2020
Population (1,000)	5,395.4	11,335	15,120	18,529	22,594	27,550
Average Annual Growth Rate (%)		4.46%	4.20%	4.15%	4.05%	4.05%

Figure 71.1.1 Population Projection by KSDP-2020 (Final Report - August 2007)

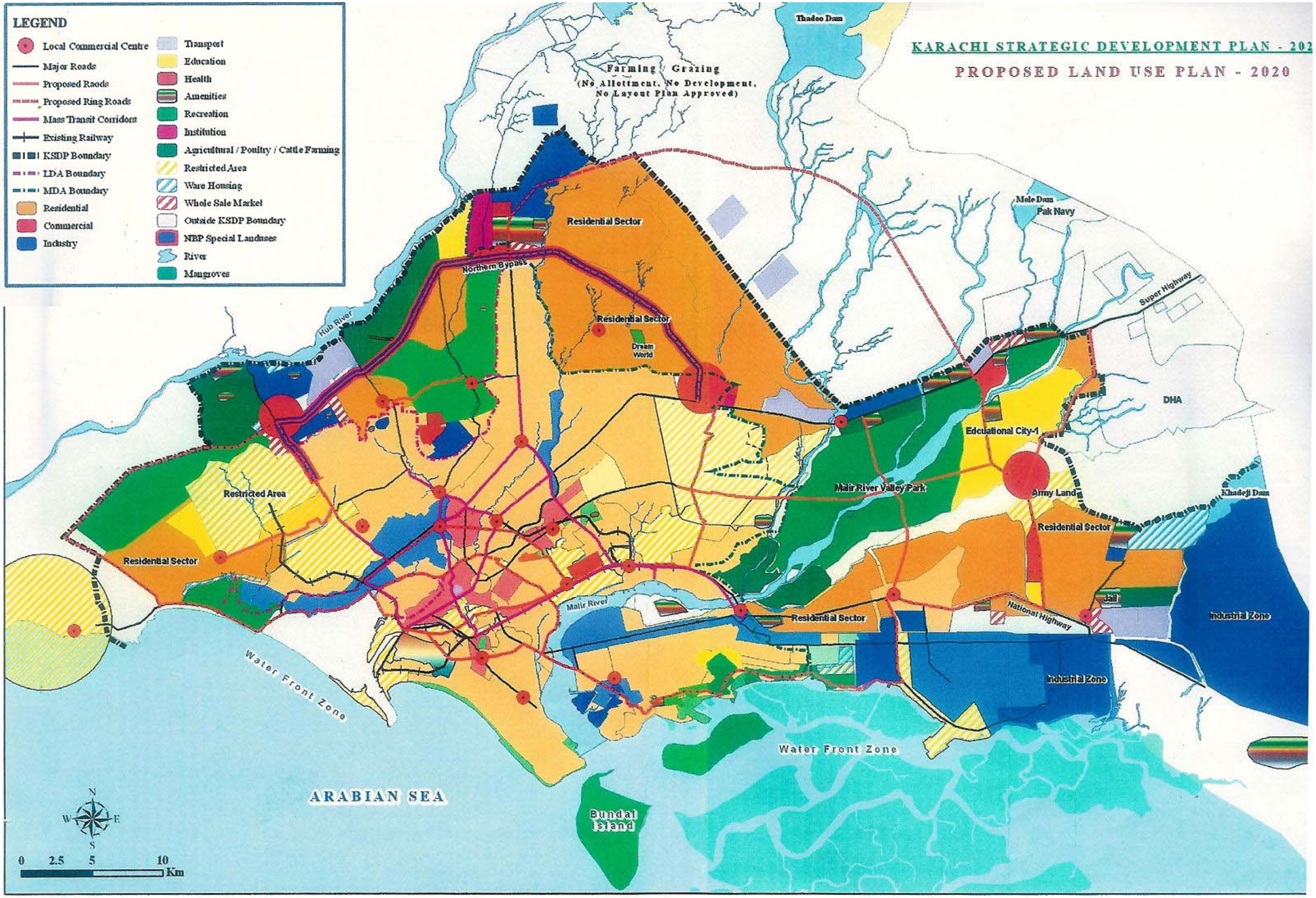


Figure 71.1.2 Land Use Plan Proposed by KSDP-2020 (Final Report - August 2007)

7.1.2 Water Sources

Despite the significant population increase envisaged by the KSDP-2020 (Final Report-August 2007), there has been no definite plan for increasing the capacity of water sources to meet the increasing water demand. In this respect, the KSDP-2020 has proposed the use of several modern technologies to increase the water supply capacity. They include the construction of sea water desalination plans, reuse of effluents from sewage treatment plants for recharging groundwater aquifers, and the development of dual water supply systems and dual sewerage systems. However, most of these technologies are not considered financially viable both at present and in the foreseeable future.

Sea water desalination will not provide a viable solution for a mega city like Karachi unless there is a remarkable technical breakthrough that substantially reduce both CAPEX and OPEX of desalination. Our review of existing studies on the development of regional groundwater resources indicated that the exploitability of groundwater in the region is very low.

In the light of the immense size of the water demand in the city, there is no doubt that Indus River will continue to remain as the only viable water source for Karachi in the foreseeable future. This view was first indicated by the 1985 water supply master plan study for Karachi conducted by Sir M. MacDonald and Partners (principal consultant) and Associated Consulting Engineers (local associated consultant). The study made a review of all potential water sources in the Karachi region, which included the Indus River and other surface water and groundwater sources, seawater desalination, and the indirect reuse of treated sewage effluents for the recharge of aquifers and substitution of existing non-potable uses. As a result, the study indicated that the Indus River and desalination are the only two sources that could technically meet a large water demand in Karachi. The study also indicated that the cost of desalination for the foreseeable future was prohibitive and that desalination should therefore be considered as a last resort. The study then concluded that the Indus River was the only viable water source for Karachi.

This view was endorsed by a special committee formulated by GOS in 2002. The committee comprised representatives from the Planning and Development Department of GOS, Irrigation and Power Department of GOS, and Karachi Water & Sewerage Board (KW&SB), prepared a report on long term water supply plan for Karachi up to the year 2025, and submitted the report to the Central Development Working Party (CDWP) on November 14, 2002, which was evaluating the PC-I of the scheme “Assured Water Supply for Karachi – upgrading Kinjhar Lake System” at that time. In summary, the report provided the following major findings and recommendations.

(Findings)

- Existing allocation of 1,200 cusecs from Indus would be fully utilized in 2005 with completion of the 100 mgd K-III project. The population of Karachi was ever growing and additional requirement up to year 2025 was estimated to be another 1,200 cusecs thus the total requirement would be 2,400 cusecs.
- The present scheme of assured water supply for Karachi be treated as Phase-I to cater short-term Assured Water Supply for Karachi City up to year 2005. The Phase-II of this scheme would be required for long-term requirement of water supply to Karachi to cater requirements beyond 2005 and up to 2025.

(Recommendations)

- For growing water demand of Karachi the allocation for Karachi up to Vision 2025 may be increased by another 1,200 cusecs raising the total allocation to 2,400 cusecs by the Government under a national cause without affecting supply of water quota of the Thatta District for agriculture purposes. Once additional allocation was allowed then a 2-stage study programme for expansion of system would have to be initiated.
- Stage-I: Study by the Irrigation and Power Department of GOS for increasing capacity

in the system from the KB Feeder Upper up to the Kinjhar Lake without affecting the stability of the Kotri Barrage.

- Stage-II: Feasibility study by KW&SB in consultation with the Irrigation and Power Department of GOS from the Kinjhar Lake to Karachi determining the most economically viable, technically feasible and secure route.

Based on the committee's recommendations, CDGK requested the GOP to grant an additional quota of 1,200 cusecs (650 mgd) from the Indus River to meet the future water demand of the Karachi City. Furthermore, KW&SB since October 2005 has been conducting the K-IV Study, the main objective of which is to recommend on the most economical and technically viable route for conveying additional 1,200 cusecs of Indus water from the Kinjhar Lake to Karachi. The study examined several alternative routes and recommended the most economical route as a result of the comparison of capital and annual operating costs to be required for each alternative. Further, the study also identified the sites for construction of three water treatment plants each having an ultimate treatment capacity of 260 mgd, 260 mgd and 130 mgd. **Figure 71.2.1** shows the locations of the raw water conveyance route and three water treatment plants proposed by the study. In January 2008, the President Pervez Musharaff while presiding at the 'foundation stone unveiling ceremony' of the 'Corridor Project' at Governor's House assured the Federal Government's supports towards the implementation of the K-IV Project. A newspaper article describing this event is attached as **Appendix A71.1**.

In developing a water supply master plan for Karachi, the JICA Study assumed that Karachi would be granted an additional quota of 1,200 cusecs from the Indus River and a total of 2,400 cusecs of Indus River water would be made available at the Kinjhar Lake for abstraction by KW&SB. This is based on our strong belief that if this additional quota is not granted, then there will be no such a large population increase or significant developments as have been envisaged by the KSDP-2020 (Final Report-August 2007).

Karachi would be granted an additional quota of 1,200 cusecs from the Indus River and a total of 2,400 cusecs of Indus River water would be made available at the Kinjhar Lake for abstraction by KW&SB. If this additional quota is not granted, then there will be no such a large population increase or significant developments as have been envisaged by the KSDP-2020 (Final Report - January 2007).

The Department of Irrigation and Power of GOS is currently responsible for the operation and maintenance of the Kotri Barrage, KB Feeder Upper and Kinjhar Lake while KW&SB's responsibility for the operation and maintenance of the bulk water supply system starts from the KG Canal that withdraws the impounded water of the Kinjhar Lake. It is likely that this demarcation of responsibilities will remain unchanged in future and as such it is assumed that any infrastructure development required for enabling KW&SB to withdraw additional 1,200 cusecs from the Kinjhar Lake would be planned, designed and implemented by GOS and that GOS would also be responsible for the operation and maintenance of such additional infrastructure. Instead, it is assumed that KW&SB would pay GOS a raw water charge at the rate of Rp.0.5 per 1,000 gallons (Rp.0.11 per m^3) to compensate GOS for part of the costs incurred with respect to the construction, operation and maintenance of such infrastructure.

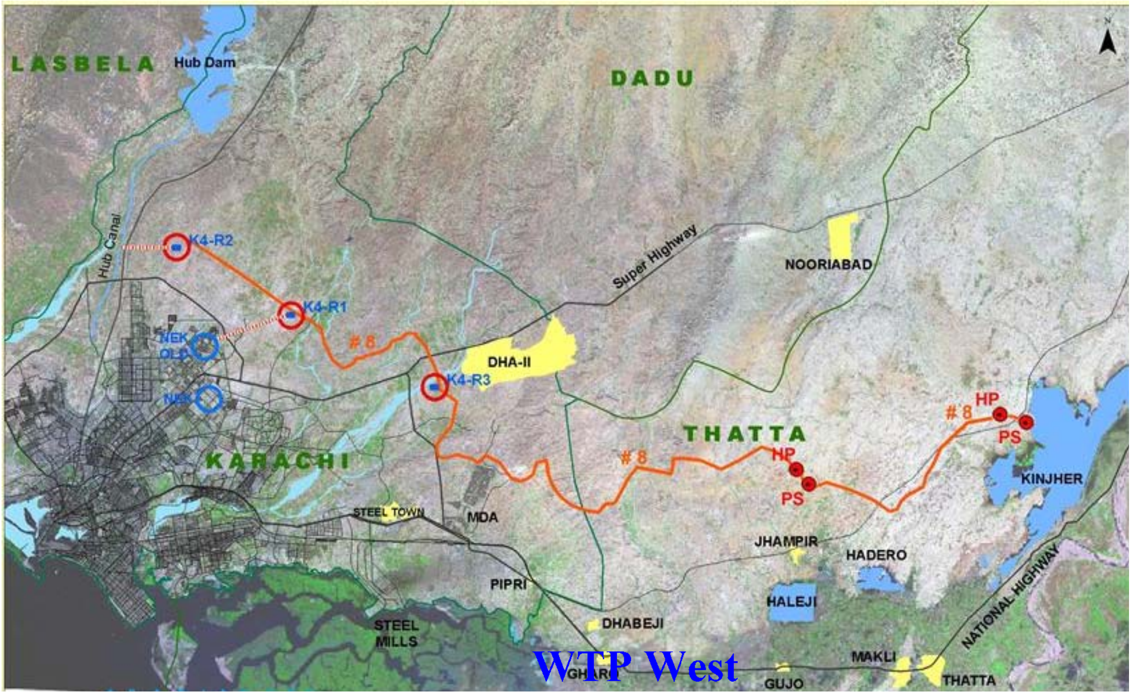


Figure 71.2.1 K-IV Project (Source: K-IV Project Executive Summary, OSMANI May 2007)

7.2 BASIC POLICIES, GOALS AND STRATEGIES

WTP Central

This section discusses the following basic policies adopted for the formulation of the water supply master plan.

WTP East

- Demand Management Approaches
- Separation of Bulk and Retail Supplies
- Zone-wise Management of Retail Supply
- Implementation of DNI on a Financially Sustainable Basis

Basic Policies Adopted for the Formulation of the Water Supply Master Plan
(1) Demand Management Approaches
(2) Separation of Bulk and Retail Supplies
(3) Zone-wise Management of Retail Supply
(4) Implementation of DNI on a Financially Sustainable Basis

7.2.1 Demand Management Approaches

It is estimated in **Section 6.2** that at present the volume of the actual bulk water supply to Karachi is 630 mgd, and that the current per capita bulk water supply capacity is about 40 gallons or 182 litres. Multiplying this by the total population of 15.12 million in 2005, the total volume of bulk water conveyed to Karachi through the bulk water supply system in the same year is estimated at 604.8 mgd. Assuming 10% water losses in the bulk water supply system (including evaporation in open canals and losses at water purification plants), the volume of water that was actually made available for Karachi in 2005 is estimated at 549.8 mgd (604.8/1.1). With the leakage in the distribution system being assumed at 35%, the volume of water actually used by customers is estimated to be 357.4 mgd (549.8 × 0.65). Further, if 40% of this volume is used for non-domestic purposes, water used for domestic purpose is estimated at 214.4 mgd (357.4 × 0.60). Dividing this by the total served population of 13.608 million, which is 90% of the city's total population in 2005 (15.12 million) estimated by the KSDP-2020 (Final Report-August 2007), the domestic per capita consumption rate in 2005 is estimated at 15.76 gallons (71.6 litres) per day. No accurate assessment of leakage in the distribution network is possible at present. The per capita consumption rate will further reduce if the actual leakage is greater than 35%.

KSDP-2020 estimated that Karachi had a total population of 15.2 million in 2005 and also projected that the total population would increase to 27.5 million in 2020. It is envisaged from this projection that the Karachi's total population could reach 32.0 million in 2025, which is almost double of the present total population. On the other hand, the possible increase in the capacity of water sources over the same period is estimated to be only 1,200 cusecs (650 mgd) as discussed in **Section 7.1**, which is less than the capacity of existing water sources i.e.720 mgd. These observations suggest that Karachi will continuously be subjected to severe water constraints over the planning horizon of 2025.

Our observations suggest that Karachi will continuously be subjected to severe water constraints over the planning horizon of 2025.

Karachi is located in the arid region where annual precipitation is as small as less than 200 mm. There is no prospective surface or underground water source available within or in the vicinity which can be developed in a large scale to cater for the enormous water demand of the mega city. Karachi seems to be one of the few cities in the world, which lies in the arid region, yet accommodates as many as 16 million people.

With the exploding population and limited availability of water resources, one must choose whether (a) to provide rather abundant supplies to a limited number of people in the city or (b) to provide essential supplies to as many people in the city as possible. Given the public nature of water supply service, it is obvious that one should choose the latter option. It is therefore extremely important to ensure that this option is successfully implemented through **'Demand Management Approaches'** which provide both general public and business entities with strong incentives to voluntarily restrict their water consumption within truly essential purposes. There should be a consensus reached by all stakeholders that making future water supply development plans based on unconstrained water demands is not a proper approach in the case of Karachi.

There should be a consensus reached by all stakeholders that making future water supply development plans based on unconstrained water demands is not a proper approach in the case of Karachi.

The central part of the demand management approaches will be the introduction of measured supplies with a volumetric charging system whereby all retail and bulk customers will be charged based on their actual consumption. This will be further reinforced by the introduction of a new water tariff structure which will provide both domestic and non-domestic customers with strong incentives for efficient use of water. The tariffs will be structured to differentiate essential water needs from non-essential water needs. Low tariffs would be applied to essential water needs while those who consume beyond essential needs should be severely penalized. Minimizing leakage, wastage and illegal connections will also constitute the core part of the demand management approaches.

Demand Management Approaches

Goals

All consumers in the city including government and business entities are being highly conscious about water conservation and voluntarily restrict their consumption within truly essential purposes.

Strategies

- **Introduction of measured supplies with a volumetric charging system whereby all retail and bulk customers will be charged based on the actual consumption**
- **Introduction of a new water tariff structure which will provide both domestic and non-domestic customers with strong incentives for efficient use of water**
- **Implementation of efficient metre reading, billing and collection**
- **Minimizing leakage, wastage and illegal connections**
- **Implementation of mass media campaigns for enhancing consumers' awareness on water conservation**
- **Mandatory use of water-saving equipment and devices in newly constructed houses and buildings such as low-volume toilets, low-flow showerheads, water faucets with flow restrictors or aerators.**
- **Subsidizing large-scale commercial and industrial users part of their investment costs for water conservation including internal recycling of used water.**

7.2.2 Separation of Bulk and Retail Supplies

KW&SB is currently supplying water to the entire Karachi District plus two union councils in the Thatta District of the Sindh Province. In the near future, KW&SB is also expected to supply treated water to the Lasbela District of the Balochistan Province. This demonstrates that KW&SB is playing a role of the regional bulk water supplier.

The bulk water supply to two union councils in the Thatta District was initiated based on the notification issued by the GOS on August 23, 2004, which expanded the administrative area of KW&SB to include two union councils in the Thatta District, namely Dhabeji and Gharo. A copy of this notification is attached as **Appendix A72.1**.

The bulk water supply to the Lasbela District of the Balochistan Province was decided by the GOP during the approval process of the K-III project. The PC-1 documents of the project stipulated that out of 100 mgd of Indus water transferred from the Kinjhar Lake to Karachi under the K-III project, 95 mgd would be distributed to Karachi while the remaining 5 mgd to the Lasbela District. In accordance with this PC-1, a 27 km-long, 24-inch diametre water transmission pipeline was constructed from the Hub Filtration Plant to Lasbela as part of the K-III project. GOS and Government of Balochistan (GOB) are currently negotiating over (a) who should be responsible for the operation and maintenance of the transmission pipeline, and (b) the water tariff KW&SB will charge GOB for water it receives from KW&SB.

Under the Pakistani constitution, water is a provincial subject. However, GOP also performs a number of functions and responsibilities in the water sector, mostly relating to inter-provincial matters. The water supply to Balochistan under the K-III project is a good example of this. Because of the inclusion of the supply to Balochistan, the K-III project was given a status of an inter-provincial project and the entire project cost was subsidized by GOP. Both GOP and GOS have legitimate roles in shaping of policies and strategies for the water and sanitation sector in the region. It is obvious that the bulk water supplies to the Thatta and Lasbela Districts are the consequence of these policies and strategies. However, it should be noted that these policies and strategies often conflict with sound business and commercial principles.

Development of a new bulk water supply scheme to bring water from the Indus River to Karachi requires a large-scale investment which would simply exceed the financial capability of the service provider. Thus, part of the investment cost would have to be subsidized either by GOP or GOS. The reality is that in the past the entire capital costs required for the development of the bulk water supply system were subsidized either by GOP or GOS. The cost required for operation and maintenance of the bulk water supply system is also significantly large because of the long distances covered by the system. All these considerations lead to a conclusion that managing the bulk water supply system on a full cost recovery basis would not be feasible - at least within the planning horizon of 2025. On the contrary, retail water supply in Karachi can be managed on a full cost recovery basis with sound business and commercial principles. This is why we recommend the separation of bulk and retail supplies.

Managing the bulk water supply system on a full cost recovery basis would not be feasible – at least within the planning horizon of 2025. On the contrary, retail water supply in Karachi can be managed on a full cost recovery basis with sound business and commercial principles. This is why we recommend the separation of bulk and retail supplies.

Figure 72.2.1 demonstrates the basic concept of the proposed separation. **Figure 72.2.2** illustrates the relationship between the bulk and retail suppliers after the separation. It is recommended that in the long run bulk and retail supplies should be managed and operated by different organisations.

It is recommended that in the long run bulk and retail supplies be managed and operated by different organizations.

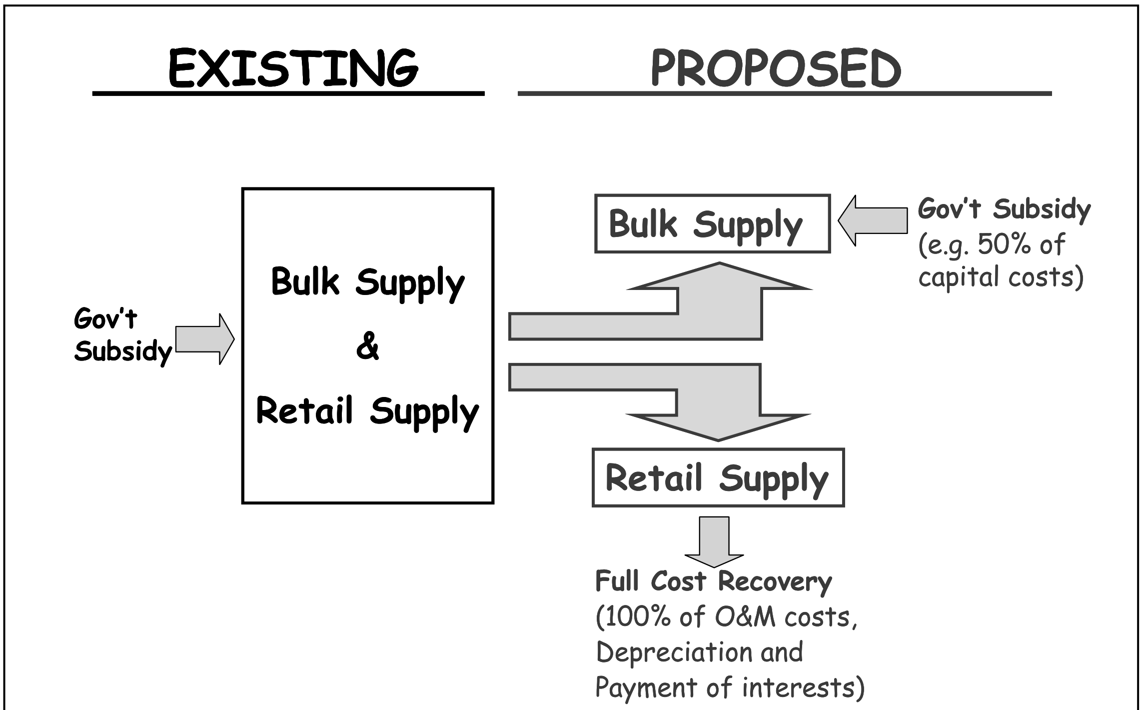


Figure 72.2.1 Separation of Bulk and Retail Supplies

Figure 72.2.2 Bulk and Retail Suppliers after Separation

The ultimate objective of the proposed separation is to enable the retail supplier to provide customer-focused, efficient water supply and sewerage services on a financially sustainable basis. This requires the insulation of the retail supplier from external interference in the micromanagement aspects of its operation, including the employment of staff, disciplining workers for poor performance, offering rewards and promotions based on good performance, handling of payment defaulters and illegal/unauthorized connections, recovery of arrears, etc. Experience indicates that as long as retail suppliers are dependent on government subsidies they will remain vulnerable to political interference in the day-to-day management of the services and in the technical execution of projects.

The ultimate objective of the proposed separation is to enable the retail supplier to provide customer-focused, efficient water supply and sewerage services to its customers.

This requires the insulation of the retail supplier from external interference in the micromanagement aspects of its operation.

Experience indicates that as long as retail suppliers are dependent on government subsidies, they will remain vulnerable to political interference in the day-to-day management of services and in the technical execution of projects.

It is expected that the proposed separation would enhance the overall efficiency in the operation and maintenance of the water supply system. Since KW&SB in the past has been the only organization responsible for the management and operation of both bulk and retail water supply systems, there has been no absolute necessity for measuring flows at key strategic locations in the system. However, with the separation of the bulk and retail supplies, there will be an absolute necessity for accurately measuring flows at the locations where water is delivered to the retail supplier as shown in **Figure 72.2.2**.

Separation of Bulk and Retail Supplies

Goals

An institutional framework is in place whereby a competent retail supplier (or suppliers) can provide water supply and sewerage services on a full cost recovery basis with sound business and commercial principles.

Strategies

- ❑ **All stakeholders agree to the separation of the bulk and retail supplies.**
- ❑ **Conduct a separate study to identify necessary changes to existing laws, ordinances and regulations and draft detailed legal provisions to put the separation into effect.**
- ❑ **Propose such changes for approval of legislators.**

7.2.3 Zone-wise Management of Retail Supply

KW&SB has divided the entire Karachi City into five distribution zones, namely Zone I, Zone II-A, Zone II-B, Zone III-A and Zone III-B. This division was made for administrative purposes only, and from the hydraulic point of view each zone is not completely separated from others. **Figure 72.3.1** shows the locations of the existing five distribution zones. Zone I straddles the Malir River, and so do Zone II-A and Zone II-B the Lyari River. Zone III-A straddles both rivers. Retail service in each distribution zone is managed by a Zonal Chief Engineer. However, bulk customers in the zone such as cantonments, DHA, PSM, PQA and industries do not fall under his responsibility; they fall under the responsibility of the bulk transmission department. The same department is also responsible for operation and maintenance of water trunk mains that are passing through these distribution zones. **Table 72.3.1** presents the towns included in each of these five distribution zone.

KSDP-2020 (Final Report-August 2007) discussed in **Section 7.1** proposed that the water and wastewater services in Karachi should be managed and operated by each town. This however would not be a feasible option at least in the foreseeable future because of (a) the complexity of the existing water distribution system in which one water trunk main is supplying a number of towns whereas many towns are supplied by more than one water trunk main, and (b) the significant economic disparities between towns, making it difficult for some towns (such as Orangi, Baldia and Lyari) to cross-subsidize tariffs from the rich to the poor because of their weak revenue bases.

Table 72.3.1 Existing Distribution Zones

Zone	Town
Zone I	Shah Faisal
	Landhi
	Korangi
	Malir
	Bin Qasim
Zone II-A	Keamari
	Lyari
	Saddar
Zone II-B	Jamshed
	Gulshan-e-Iqbal
	Liaquatabad
Zone III-A	S.I.T.E.
	Baldia
	Orangi
Zone III-B	North Nazimabad
	New Karachi
	Gulberg
	Gadap

Instead, we propose that Karachi should be divided into three distinct hydraulic zones each separated from others by two major rivers in Karachi i.e. Malir and Lyari Rivers. The rationale is that there is only a limited number of exiting water mains and sewer pipes that have been laid across these rivers and they can easily be located for installation of isolation valves or bulk flow metres. Further, separation of hydraulic zones by rivers would allow for more prudent approaches for planning of the sewerage system than by the administrative boundaries of the towns. **Figure 72.3.2** shows the locations of the proposed three hydraulic zones. **Table 72.3.2** presents the towns and cantonments included in each hydraulic zone. Because of its immense size, Gadap town is separated into the three hydraulic zones with its major part being in the Zone Central. Although the main part of Keamari town is located in the Zone West, a small fraction of the town on the left bank of the Lyari River is included in the Zone Central. The other 16 towns are not divided either by the Malir or Lyari River.

Karachi should be divided into three distinct hydraulic zones by the two major rivers in Karachi i.e. Malir and Lyari Rivers.

Table 72.3.2 Proposed Hydraulic Zones

Hydraulic Zone	Town	Cantonment / DHA
Zone West	Keamari (Main)	
	S.I.T.E.	
	Baldia	
	Orangi	
	North Nazimabad	
	Gulberg	
	Liaquatabad	
	New Karachi	
	Gadap (Fraction)	
Zone Central	Lyari	Malir
	Saddar	Faisal
	Jamshed	Karachi
	Gulshan-e-Iqbal	Clifton
	Shah Faisal	Manora
	Malir	DHA
	Gadap (Main)	
	Keamari (Fraction)	
Zone East	Landhi	Korangi Creek
	Korangi	
	Bin Qasim	
	Gadap (Fraction)	

The size of the city is too large for a single retail entity to manage and operate water supply and sewerage services efficiently. It is therefore recommended that water supply and sewerage services in each hydraulic zone be managed and operated by an independent organization. Each organization will be responsible for operation and management of water supply and sewerage services within its own hydraulic zone, including the operation and maintenance of water trunk mains, leakage and NRW reduction, collection of tariffs, employment of staff and dealing with customer complaints. It will purchase treated water in bulk from the bulk supplier at the immediate downstream of filtration plants, service reservoirs, or pumping stations as the case may be, and distribute it through water trunk mains into various towns located within its hydraulic zone. The organization will also be accountable for collection, transportation and proper treatment of sewage generated in its hydraulic zone. Its revenue base would include not only retail consumers but also bulk consumers such as cantonments, DHA, and other industrial, commercial and governmental entities within the zone. Tariffs would be different from one zone to another reflecting the actual revenue requirements of each zone, provided that they should be subjected to the prior approval of an independent regulatory body.

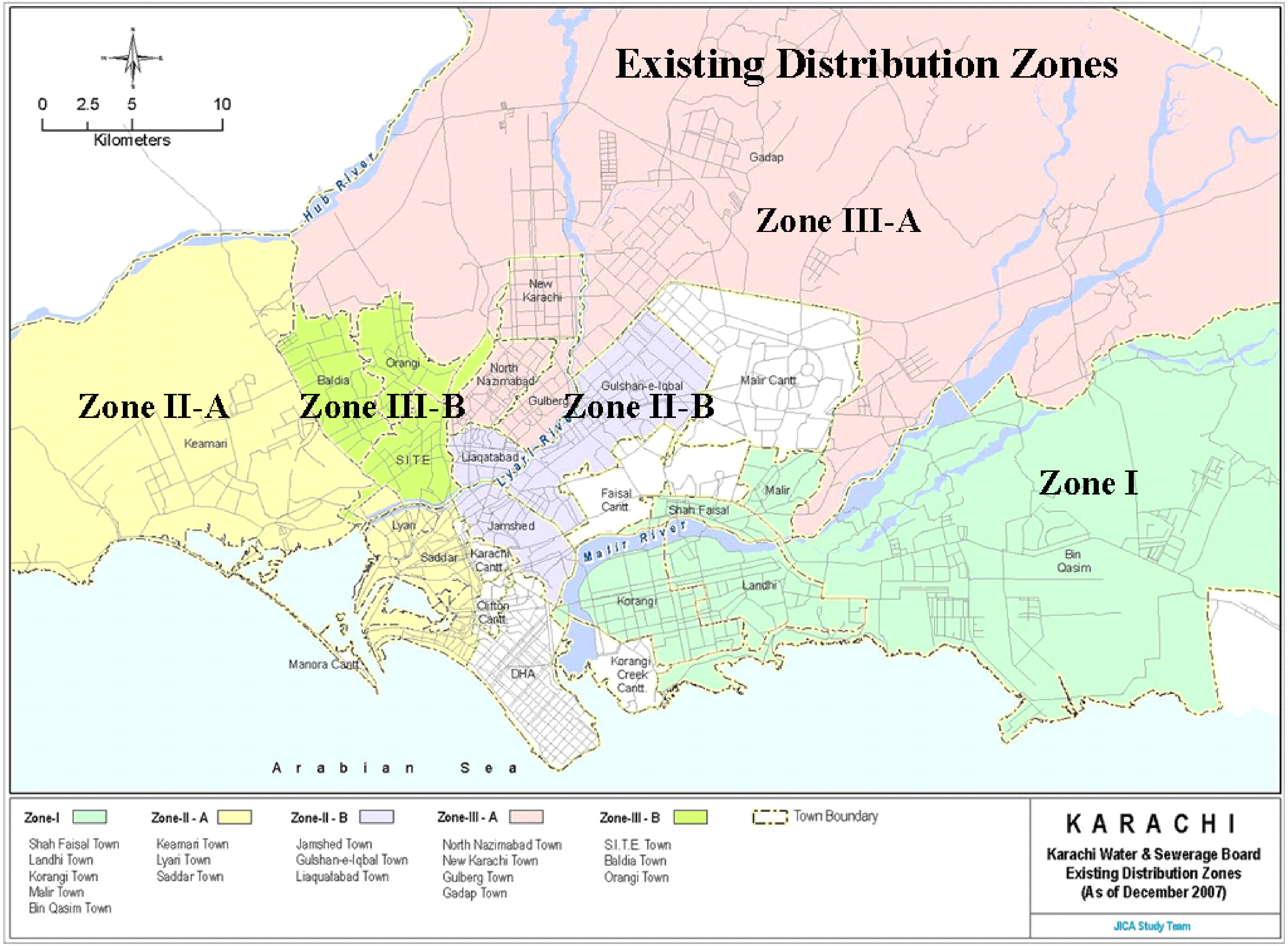


Figure 72.3.1 Existing Distribution Zones

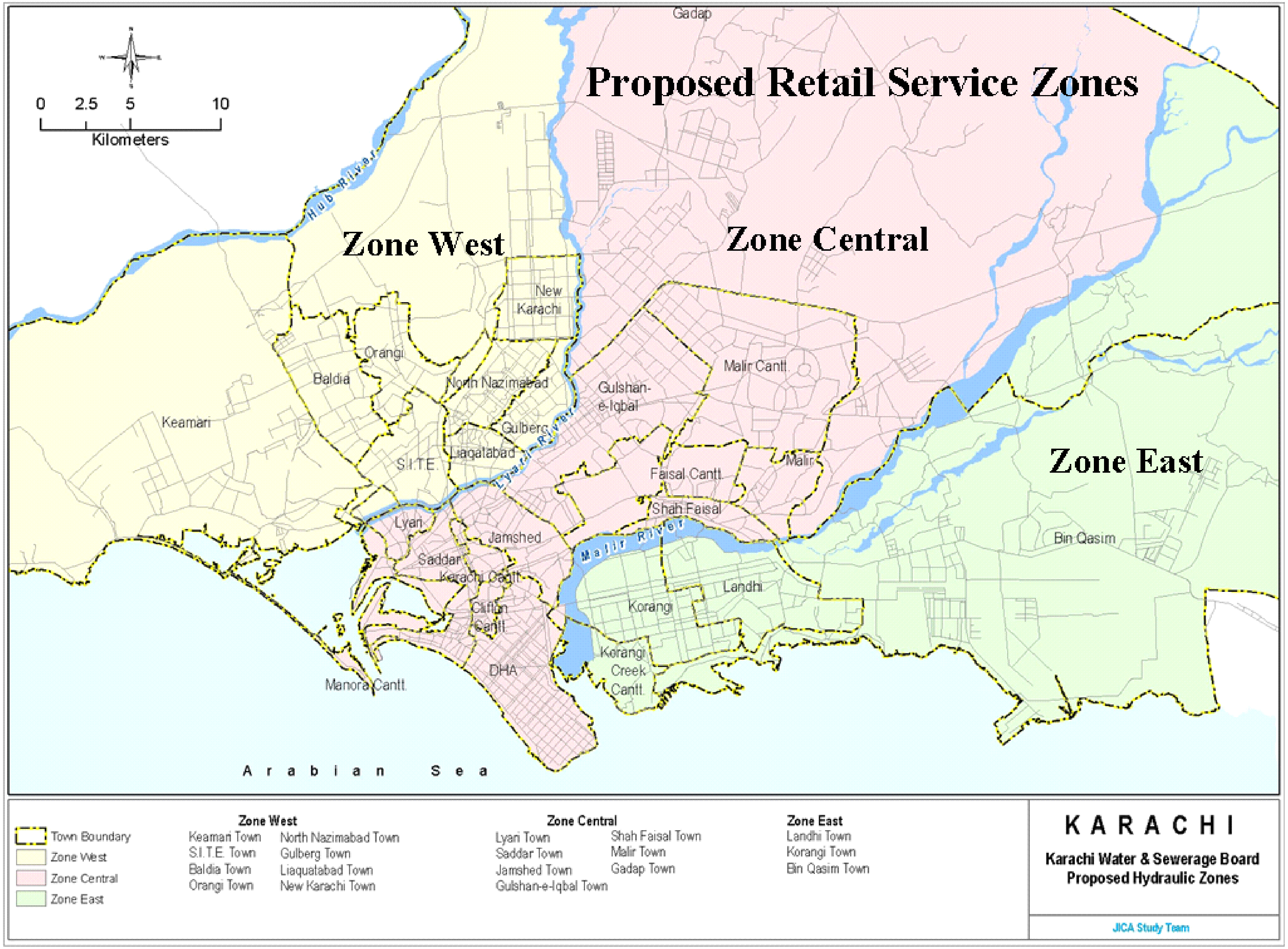


Figure 72.3.2 Proposed Hydraulic Zones

The size of the city is too large for a single retail entity to manage and operate water supply and sewerage services efficiently. It is therefore recommended that water supply and sewerage services in each hydraulic zone should be managed and operated by an independent organization.

The advantages of having zone-wise management will be as follows:

- Each organization will be held directly accountable for the quality of the services it provides including the levels of leakage and NRW occurring in its zone
- Water supply and sewerage services can be managed and operated on a competitive basis in that each organization's performance will be evaluated on the basis of common performance indicators (PIs)
- Increase the ease with which equitable distribution can be attained
- Increase the ease with which both technical and non-technical losses can be monitored and reduced. Each zone will be further divided into a number of leakage/NRW control districts, which can be hydraulically isolated whenever necessary to monitor or control leakage and NRW.
- Increase the ease with which customer focused approaches can be implemented. For example, the time required to respond to customers' problems/complaints can be shortened.

Zone-wise Management of Retail Supply

Goals

Retail entities provide efficient water supply and sewerage services to its customers on a competitive basis and with accountability. This relates not only to the quantity and quality of water supplied but also to the improved efficiency in revenue collection, system maintenance, and response to customer problems/complaints.

Strategies

- **All stakeholders agree to the zone-wise management of water supply and sewerage services.**
- **Conduct a separate study to identify necessary changes to existing laws, ordinances and regulations and draft detailed legal provisions to put the proposed zone-wise management into effect.**
- **Propose such changes for approval of legislators.**

7.2.4 Implementation of DNI on a Financially Sustainable Basis

Assessment of the existing water supply conditions in **Section 5.1** revealed that:

- While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high;
- The overall picture is that there are many more urgent problems in the water distribution system than in the bulk water supply system;
- In the light of the poor water supply situation, many residents in Karachi have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges;
- Many problems have either directly or indirectly emanated from the KW&SB's financial constraints; and
- A substantial improvement to water service quality is the only way to break the 'vicious circle' as depicted in **Figure 51.2.1**.

It is the considered opinion of this JICA Study team that a substantial improvement to water service quality can be achieved by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. This view is shared by ADB in its Draft Karachi Sustainable Mega City Water & Wastewater Roadmap, May 2007.

It is only if customers are satisfied with the quality of the service they receive that they find themselves willing to pay for the service. The water awareness survey conducted as part of the JICA study indicated that many households were willing to pay higher charges for a reliable supply of good quality water. With regard to the actual supply of water, the clear targets for the improved quality of the service can be summarized as follows:

- satisfy the customers' water demands so that they no longer need to utilize secondary sources (such as shallow wells and tanker supplies)
- water should be of a potable standard (this would make filtering and boiling of water unnecessary) and be aesthetically pleasing
- water should be supplied at an adequate pressure (this would make the use of suction/booster pumps and roof-top storage tanks unnecessary)
- water should be available on a 24-hour continuous basis to keep the supply system always full of water and under pressure to avoid both contamination and excessive air entrainment (this would make the use of ground-level water reservoirs unnecessary)

These improvements can only be attained through the implementation of distribution network improvements (DNI). The existing water distribution net work comprises about 4,850 km of pipelines of which about 65% is asbestos cement pipes and 26% cast iron. Much of the system is old and in very poor condition. Many pipelines in the system have already been undersized and deteriorated, and the current levels of leakage and non-revenue water are unacceptably high. DNI will embrace the rehabilitation of water trunk mains and distribution network and the refurbishment of service connections including installation of revenue metres. Where necessary, it will also include improvements to the existing sewerage system. Since DNI would require huge investments and more than 10 years of timeframe to complete it across all areas of Karachi, it can only be implemented on an area-by-area basis in a progressive way. In the short to medium term, the costs associated with DNI will have to be recovered from the tariffs charged to customers. This is necessary to implement DNI on a financially sustainable basis.

DNI can only be implemented on an area-by-area basis in a progressive way.

In the short to medium term, the costs associated with DNI will have to be recovered from the tariffs charged to customers. This is necessary to implement DNI on a financially sustainable basis.

It is therefore recommended that customers in areas where DNI has already been completed (and receiving an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis) would pay a water charge that is some multiple of the current level of water charges, whereas customers in areas where DNI has not been completed (and continuously receiving the current level of service with intermittent supply) would continue to pay the current level of water charges. This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

Customers in areas where DNI has already been completed would pay a water charge that is some multiple of the current level of water charges. On the other hand, customers in areas where DNI has not been completed would continue to pay the current level of water charges.

This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

The current level of sewerage service charge is well below the level that would be necessary to ensure cost recovery in the medium and longer term, i.e. including the costs of building or extending the sewer network. With the introduction of a measured water supply, the current approach, whereby the charge for sewerage service is a proportion (25%) of the charge for clean water supply, will have the effect of linking the sewerage charge directly to the volume of clean water supplied. As such it will be in line with international practice. However, the 25% premium for sewerage service is certainly not sufficient to cover the costs of operating and maintaining the sewer network and sewage treatment plants. We suggest that this should be increased to 50% of the charge for clean water supply once the quality of sewerage service has been improved. The evidence from the water awareness survey mentioned above suggested that the priority need of the public with respect to the sewerage service is the smooth, uninterrupted removal of sullage and excreta from their home and their vicinity. For this reason, we recommend that DNI should also include improvements to the existing sewage system wherever it is found necessary. Meanwhile, customers in areas where the sewage system has already been improved through DNI would pay a sewerage service charge that is 50% of the charge for the improved service level of clean water supply which, as has been stated above, is already some multiple of the current level of water charges. In contrast, customers in areas where the sewage system has not been improved would continue to pay the current level of sewerage service charge, which is 25% of the charge for clean water supply.

DNI should include improvements to the existing sewage system wherever it is found necessary.

Meanwhile, customers in areas where the sewage system has already been improved through DNI would pay a sewerage service charge that is 50% of the charge for the improved service level of clean water supply, which is already some multiple of the current level of water charges. In contrast, customers in areas where the sewerage system has not been improved would continue to pay the current level of sewerage service charge, which is 25% of the charge for clean water supply.

Examination of the financial statements of KW&SB for recent years shows an extremely worrying trend as regards its short term financial positions. Over recent years, KW&SB has continuously been operating in deficit. The annual deficit ranges from Rp.2,000 to 2,700 million (US$33.3 to 45.0 million) as shown in **Table 72.4.1** below. **Figure 72.4.1** illustrates these deficits as compared with annual revenues. At the end of the fiscal year 2004/05, the accumulated deficit totalled to Rp. 10,435 million (US$173.9 million). These deficits have eventually been subsidised by GOP and GOS.

Table 72.4.1 Accumulated Deficit of KW&SB Rp.million

Fiscal Year	2000/01	2001/02	2002/03	2003/04	2004/05
Profit/Loss of the Fiscal Year	-820.70	-2,029.65	-2,693.09	-2,536.39	-2,358.71
Accumulated Surplus/Deficit at start of Fiscal Year	3.00	-817.70	-2,847.36	-5,540.44	-8,076.83
Accumulated Surplus/Deficit at end of Fiscal Year	-817.70	-2,847.36	-5,540.44	-8,076.83	-10,435.54

Source: Profit and Loss Statements, KW&SB

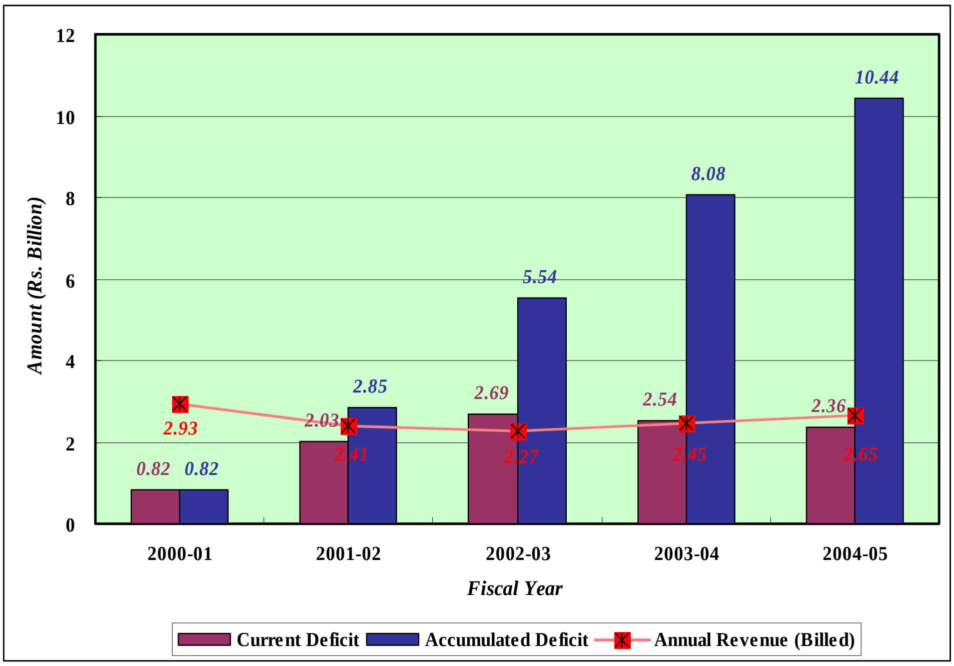


Figure 72.4.1 Revenues and Deficits of KW&SB

This demonstrates that KW&SB is not financially capable of taking new loans for implementation of DNI. DNI will involve not only physical improvement works; it will also include improvements to many institutional aspects, such as the introduction of a dual pricing system, elimination of illegal and unauthorised connections, and the strict enforcement of laws on payment defaulters. As such, it is very likely that the implementation of DNI would face severe political interference if it is financed by Government subsidies. It is therefore necessary to create a new institutional framework, whereby DNI can be implemented on a loan financing basis without any Government subsidies.

Implementation of DNI on a Financially Sustainable Basis

Goals

In the short to medium term, retail entities will generate the revenues sufficient to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis).

Strategies

- **Implement DNI on an area-by-area basis in a progressive way.**
- **Introduce a dual pricing structure in that customers in areas where DNI has already been completed (customers receiving an improved level of service) would pay a water charge that is some multiple of the current level of water charges.**
- **Include improvements to the sewerage system in the scope of DNI.**
- **Increase the level of sewerage service charge to 50% of the charge for clean water supply in areas where an improvement to the sewerage system has already been made.**
- **Create a new institutional framework whereby DNI can be implemented on a loan financing basis without any Government subsidies.**

7.3 SYSTEM DEVELOPMENT PLAN

7.3.1 Expansion of Filtration Plants

As explained previously the bulk water source availability from the Indus River and Hub Dam for the Karachi Water Supply System in 2025 is 1,332 as listed below.

Future Bulk Water Availability			: 1,365 mgd
Indus River	: 1,290 mgd	(2,400 cusecs: ft^3/s)	
Hub Dam	: 75 mgd		
Supply to Pakistan Steel Mills, Port Qasim, etc.			: 33 mgd
Bulk Water Availability for Water Supply System			: 1,332 mgd

Of the bulk water of 1,332 mgd, about 630 mgd is being supplied to customers as of the end of year 2006. About 420 mgd of water is supplied after filtration and the remaining water is directly supplied without filtration.

At present two projects are being conducted for adding the filtration capacity. One is ADB Project and the other is K-IV Project. ADB Project is considering to construct two filtration plants at NEK Old (100 mgd) and COD (85 mgd). K-IV Project has proposed three filtration plants (260 mgd × 2 plants and 130 mgd × 1 plant = 650 mgd) for next 20 years. As of the end of the December 2007, PC-1 for first phase of the K-IV Project is in the process of approval. Therefore, the JICA study takes these two projects into account for preparation of water supply master plan as shown in **Table 73.1.1**. The filtration capacity of the Karachi Water Supply System is expected to be 1,270 mgd.

Table 73.1.1 Future Water Supply Capacity

Filtration Plant	Capacity	Remarks
Gharo Filtration Plant	20 mgd	existing
Pipri Filtration Plant	100 mgd	existing
NEK Old Filtration Plant	25 mgd	existing
NEK New Filtration Plant	100 mgd	existing
COD Filtration Plant	115 mgd	existing
COD Filtration Plant (expansion)	85 mgd	ADB Project
Hub Filtration Plant *	75 mgd	existing
K-III Filtration Plant at NEK Old	100 mgd	ADB Project
K-IV Filtration Plants	650 mgd	K-IV Project
Total	1,270 mgd	

source: KW&SB
* : considered to "95% level of reliability of the Hub River Yield"

Two proposed plants to be constructed at COD and NEK Old (K-III) by ADB Project are for treating water which is directly supplied to customers without filtration now and that is not to say that the supply capacity increases due to the construction of these two filtration plants. Therefore, for the planning purpose, total capacity of these two plants of 185 mgd is considered to be included in the existing capacity regardless of those completions. These plants are expected to be constructed by the year 2011.

7.3.2 Stage-wise Development Plan

(1) Construction Schedule of Bulk Water Supply Facilities proposed by K-IV Project

K-IV Project has proposed 3 filtration plants located in the western part, central part and eastern part of Gadap Town in accordance with its implementation schedule as shown in **Table 73.2.1**. Constructions of three plants are divided into 5 stages (130 mgd each). On the other hand, canals & conduits will be constructed by three stages, which capacities are 260 mgd respectively.

Table 73.2.1 Implementation Schedule of K-IV Project

Timeframe	Staging	Supply Capacity to be increased	Filtration Plant		Canal & Conduit
			Capacity	Location	
2007-2011	1 A	130 mgd	130 mgd	Central	260 mgd for Zone Central
2011-2015	1 B	130 mgd	130 mgd	Central	-
2015-2019	2 A	130 mgd	130 mgd	West	260 mgd for Zone West
2019-2023	2 B	130 mgd	130 mgd	West	-
2023-2027	3 A	130 mgd	130 mgd	East	260 mgd for Zone East

source: K-IV Project, Greater Karachi Water Supply Scheme (Executive Summary, May 2007)

The K-IV Project has recommended a construction of new filtration plant with a capacity of 130mgd at Zone Central first. **Figure 73.2.1** shows a stage-wise development plan proposed by K-IV Project against the water demand projected by JICA study mentioned in **Section 6.2 "Water Demand"**. In this case, however, Karachi City is facing a water shortage almost the every year in the future.

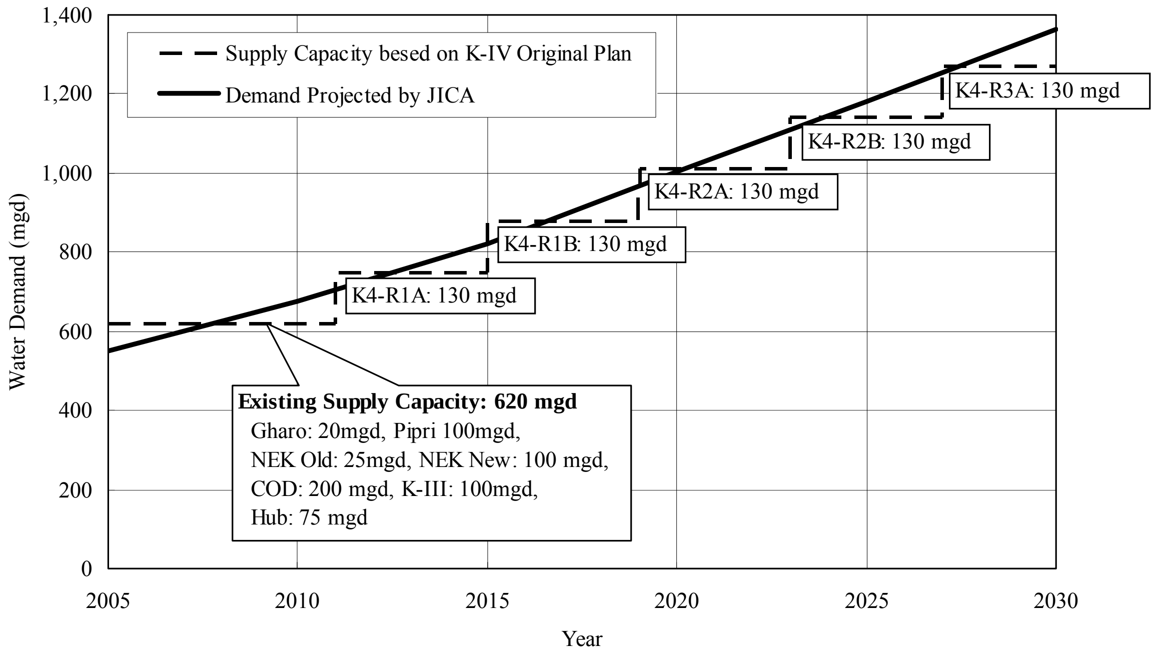


Figure 73.2.1 Stage-wise Development Plan proposed by K-IV Project

(2) Proposed Construction Schedule of Bulk Water Supply Facilities

As of the end of the December 2007, PC-1 for the first phase of the K-IV Project is in the process of approval. The first phase of the K-IV project includes land acquisitions for all canals and conduits to be constructed by K-IV Project, bulk water transmission facilities (260 mgd) from Kinjhar Lake and filtration plant (130 mgd). The filtration plant will be constructed at the central area of Gadap Town. The first phase project has been already ongoing and its components can not be changed by the JICA Study. Therefore, the first filtration plant with a capacity of 130 mgd will be constructed at the central.

Table 73.2.2 shows a zone-wise water balance in 2025 which is a target year of the study. As seen in **Table 73.2.2**, if the filtration plant with a capacity of 130 mgd would be constructed at the zone central, the further expansion of its capacity should not be needed anymore. Instead, it is necessary for zone west and zone east to construct a filtration plant with a capacity of 260 mgd respectively considering a balance between the water demand and the supply capacity.

Table 73.2.2 Water Balance of Each Zone in 2025

Zone	West	Central	East
Zone-wise Demand (mgd)	346	534	307
Zone-wise Supply Capacity (mgd)	75	425	120
List of the Existing Filtration Plants*	Hub: 75 mgd	NEK Old: 25 mgd NEK New: 100 mgd COD: 200 mgd K-III: 100 mgd	Pipri: 100 mgd Gharo: 20 mgd
Balance(mgd)	-271	-109	-187

*: Data from KW&SB

JICA Study proposes an alternative stage-wise development plan against the original implementation schedule of K-IV Project, as shown in **Table 73.2.3** and **Figure 73.2.2** under the following conditions.

- Completion year of the first stage, which is the year of 2011, should be kept.
- Project components of the first stage should be kept.

- Interval of each stage should be at least 4 years which is original intervals of staging proposed by K-IV Project as shown in **Table 73.2.1**.
- Canal construction for bulk water supply to filtration plant, which capacity is 260 mgd, should not be double and more at one stage.
- Water supply capacity in 2025 should exceed the demand in 2025.
- Period of water shortage (supply shortfall) should be minimised.

Table 73.2.3 Proposed Implementation Schedule

Timeframe (Construction Period)	Stage	Filtration Plant	Bulk Transmission	Remarks
2009-2011	Stage I	130 mgd × 1 plant at Zone Central	260 mgd for Zone Central	Same Plan as the K-IV Project
2014-2016	Stage II	130 mgd × 2 plants at Zones West and East	260 mgd for Zone West	Modified Plan from the K-IV Project
2019-2021	Stage III	130 mgd × 2 plants at Zones West and East	260 mgd for Zone East	

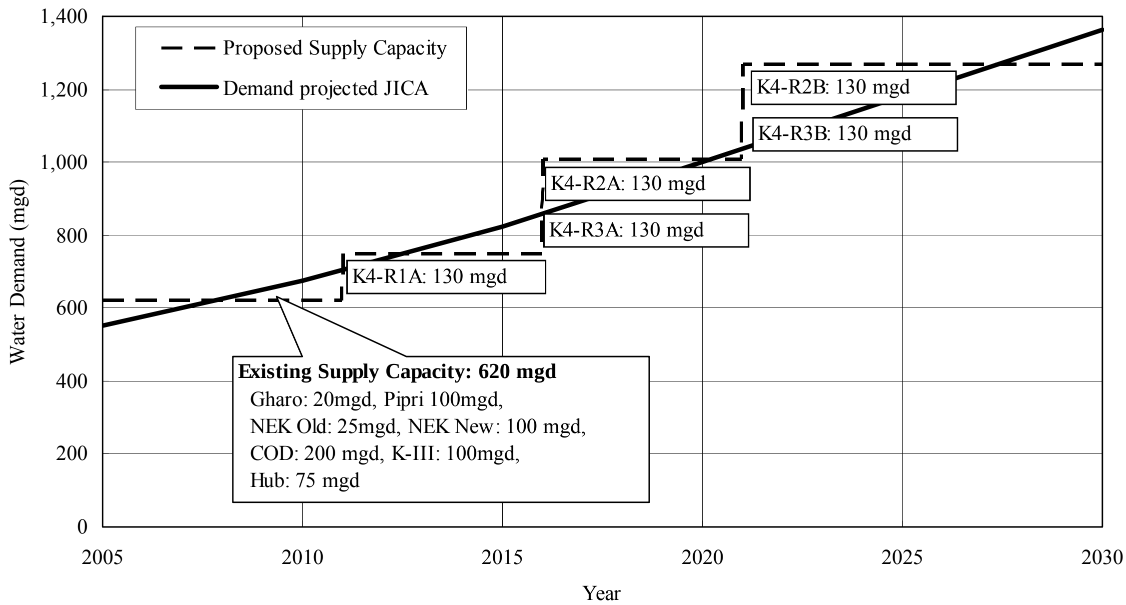


Figure 73.2.2 Recommended Stage-wise Development Plan

(3) Proposed Development Plan

To meet the increasing water demand in Karachi, the water supply capacity of the filtration plants is proposed to be expanded in three stages as shown in **Figure 73.2.2**. Target year of each stage is as follows:

Stage I (Short term)	: 2016
Stage II (Medium term)	: 2021
Stage III (Long term)	: 2025

In the stage I the capacity will be expanded by 130 mgd to meet the water demand in year 2016. However, the increased capacity will meet only the demand of 2012 as shown in **Figure 73.2.2**. Considering the magnitude of the development scale, water right of the Indus River, future water supply situation and time frame, this is the best choice for the Karachi Water Supply System. The stage II and stage III consist of an expansion of 260 mgd respectively. The increased capacities of those stages are to meet the water demand in 2021 and 2025 respectively. **Table 73.2.4** shows a water balance between future water demand and planned supply capacity of the proposed water supply development plan. In 2011 just before the completion of a new filtration plant of 130 mgd by K-IV Project, the system will face a water shortage of 88 mgd.

Table 73.2.4 Water Balance of the Proposed Plan

Year	2006	2011	2016	2021	2025
Total Demand (mgd) *	580	708	863	1,043	1,187
Supply Capacity (mgd)	620	620	750	1,010	1,270
Balance(mgd)	40	-88	-113	-33	83

*: including a water supply to Barochistan of 5 mgd

Table 73.2.5 shows a water balance between future water demand and planned supply capacity at each zone.

Table 73.2.5 Water Balance of Each Zone

Target Year		2006	2011	2016	2021	2025
Zone West						
Supply Capacity	mgd	75	75	75	205	335
Water Demand*	mgd	191	222	264	310	346
Balance	mgd	-116	-147	-189	-105	-11
Zone Central						
Supply Capacity	mgd	425	425	555	555	555
Water Demand	mgd	286	338	401	475	534
Balance	mgd	+139	+87	+154	+80	+21
Zone East						
Supply Capacity	mgd	120	120	120	250	380
Water Demand	mgd	104	148	198	258	307
Balance	mgd	+16	-28	-78	-8	+73

*: including a water supply to Barochistan of 5 mgd

In conclusion, the stage-wise development plan is proposed as shown in **Figure 72.2.3**.

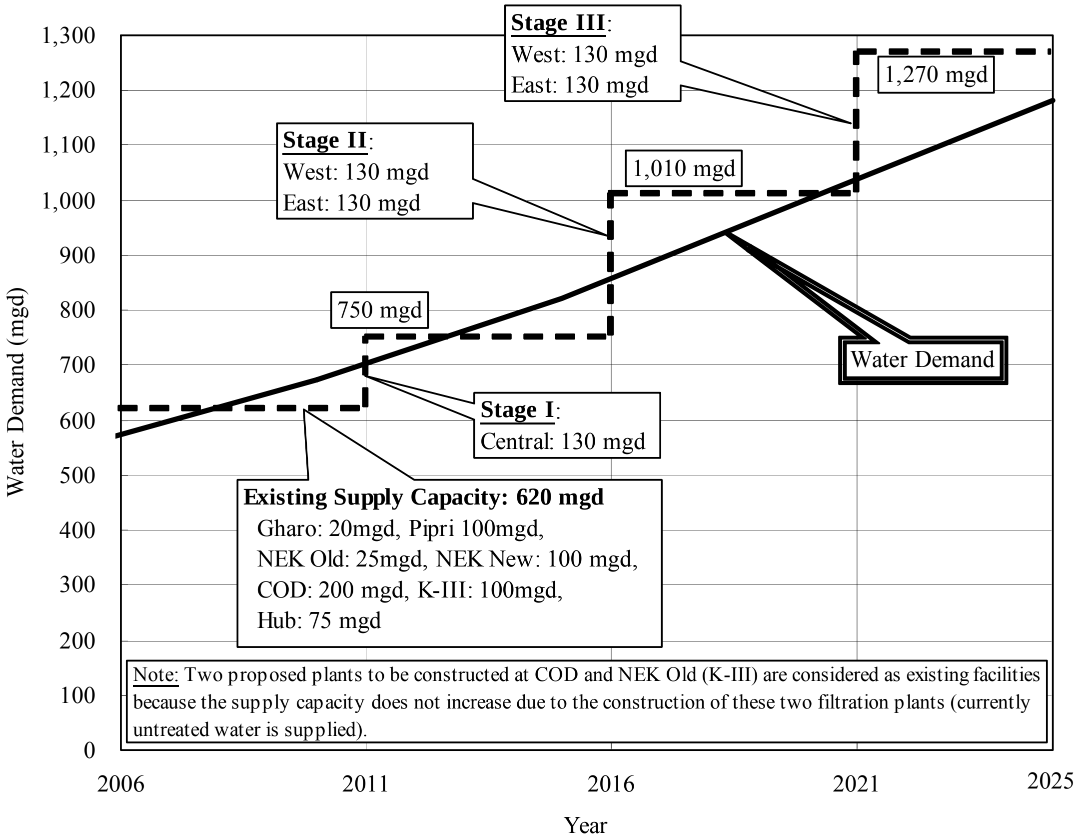


Figure 73.2.3 Stage-wise Development Plan for the Target Year of 2025

7.3.3 Water Supply Plan

Considering the magnitude of the future Water Supply System in Karachi and topographical features of Karachi City, JICA study recommends the zone-wise management of the retail supply in that water supply area will be divided into 3 zones (Zone West, Zone Central and Zone East) by two main rivers flowing through Karachi City, namely Ryari River and Malir River. Each zone will be managed and operated by an independent organization or by a different business unit of the same organization. Zone-wise water demand is shown in **Table 73.3.1**. **Figure 73.3.1** shows the schematic water supply plan for the system in 2025.

Table 73.3.1 Zone-wise Water Demand

	2006	2011	2016	2021	2025
Total Demand	580	708	863	1,043	1,187
Zone West*	191	222	264	310	346
Zone Central	286	338	401	475	534
Zone East	104	148	198	258	307

*: including a water supply to Barochistan of 5 mgd

Water supply plan for each zone was formulated based on the following policies:

- eliminating the use of several bulk pumping stations and a large number of small size distribution pumping stations for energy cost saving,
- supplying water by gravity as much as possible, and
- keeping minimum dynamic water pressure of 10 m in distribution system.

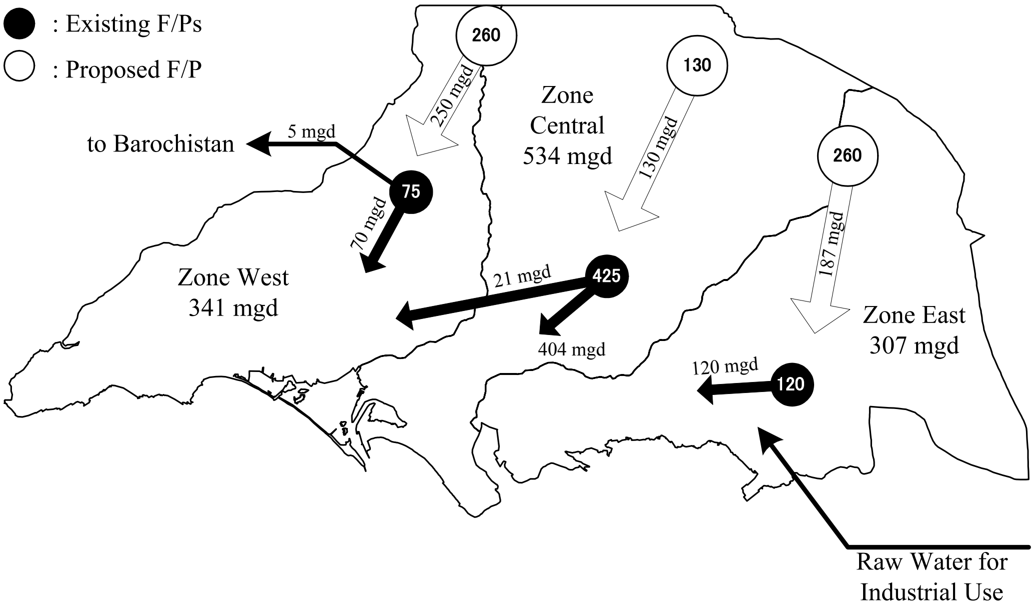


Figure 73.3.1 Schematic Water Supply Plan for Each Zone in 2025

As a result the proposed water supply system in 2025 is shown in **Figure 73.3.2** and detailed hereinafter. The alternative studies related to water supply system are attached to **Appendixes A73.1** to **A73.4**.

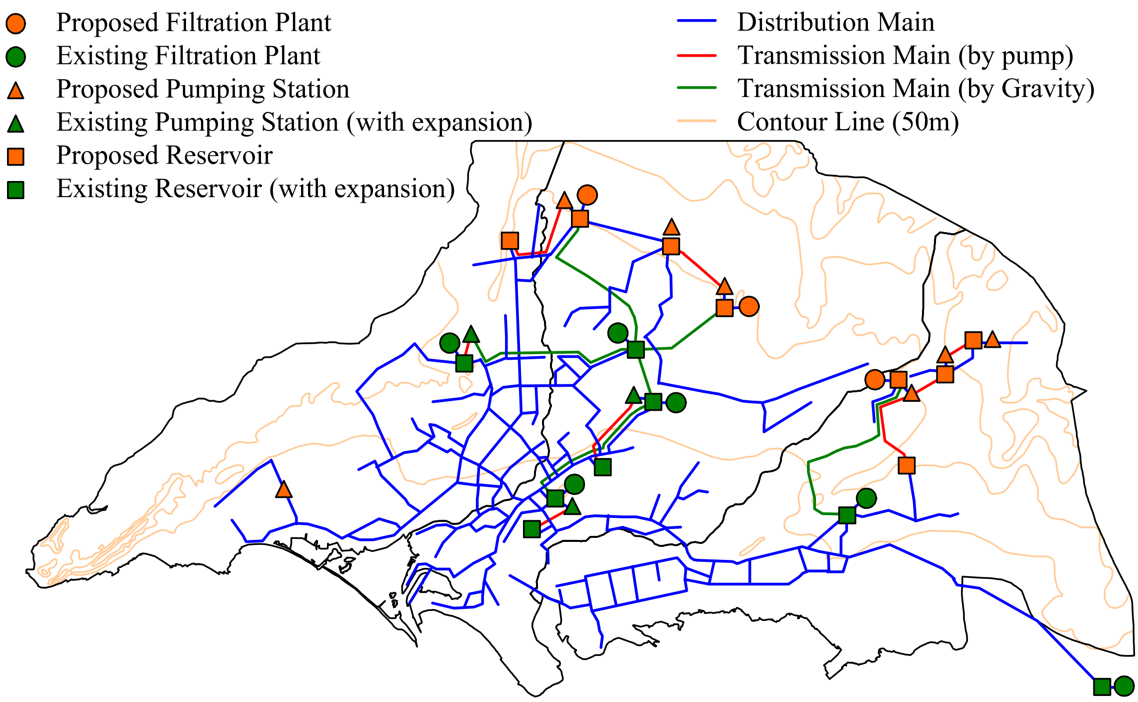


Figure 73.3.2 Proposed Water Supply System in 2025

For reference, definitions of water supply facilities are illustrated in **Figure 73.3.3**. Especially transmission and distribution systems are defined as follows:

Transmission System (transmission pumping station and transmission main) transfers filtered water to reservoirs by pumping or by gravity, not to supply water directly to customers. Transmission main should not have any branches for distribution or bulk supply. Flow rate of the transmission system is equal to daily water demand.

Distribution System (distribution pumping station, trunk distribution main and distribution network main) supplies filtered water from reservoirs to customers. The design capacity of distribution system is needed to be 1.5 – 2.0 times of daily water demand considering hourly demand fluctuation. For example, during the night people use less water, but in the morning and evening people use much more water.

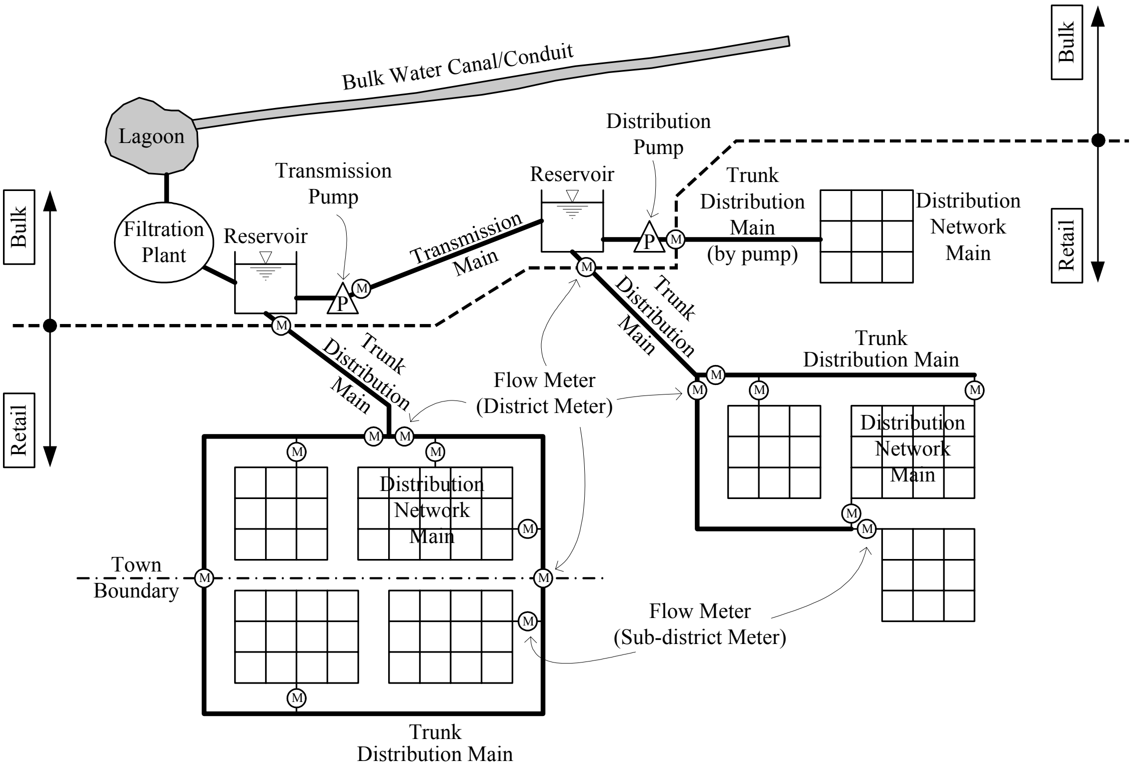


Figure 73.3.3 Typical Water Supply System

7.4 WATER SOURCES

Table 74.1.1 summarises planned future water sources of the KW&SB's water supply.

Table 74.1.1 Water Sources for the Target Year of 2025

Water Source	Capacity	Remarks
Kinjar Lake (The Indus River)	645 mgd (1,200 cusecs; ft^3/s)	Existing
Kinjar Lake (The Indus River)	645 mgd (1,200 cusecs; ft^3/s)	Additional planned by K-IV Project
Hub Dam	75 mgd	Existing
Dumlottee Wells	0 mgd	To be abandoned
Total	1,365 mgd	

In addition to the current bulk water of 1,200 cusecs (645 mgd) from Kinjhar Lake, another 1,200 cusecs (645 mgd) will be also taken from Kinjhar Lake for 2025 by the implementation of K-IV Project. It is estimated that 75 mgd can be taken from Hub Dam at the probability of 95% based on a hydrologic analysis, for the KW&SB's water supply including water supply to part of Barochistan District. For reference, flow data of the Indus River above the Kotri Barrage and withdrawals at the Kotri Barrage from 1976 to 1984 (Feasibility Study for future expansion of Karachi Water Supply System, December 1985) are attached to **Appendix A32.1**. On the other hand, existing Damlottee Wells will not be suitable for the KW&SB's water source any more, since its production has been decreasing year by year. At present it is used only in a limited period of rainy season.

CDGK have requested the Federal Government for granting an additional water right of 1,200 cusecs from Indus River for Karachi Water Supply System. As of the end of December 2007, however, an additional water right from the Indus River of 1,200 cusecs has not been approved yet. In developing a water supply system, Karachi would be granted additional 1,200 cusecs of quota from the Indus River and a total of 2,400 cusecs of the Indus River water would be made available at the Kinjhar Lake for abstraction of the KW&SB. This is based on a strong belief that if this additional quota water were not granted, then there would be no such large population increase or significant developments in future as has been envisaged by KSDP – 2020 (August 2007).

7.5 BULK WATER SUPPLY SYSTEM

7.5.1 Existing Bulk Water Supply System

Present bulk water supply system for Karachi City has a capacity of 600 mgd as shown in **Table 75.1.1**. This figure does not include bulk water supply of bulk water from Gujjo Headworks to Pakistan Steel Mills and Port Qasim Authority which have their own bulk water transmission facilities (canals and pumping stations) and filtration plants. Actually as of the end of year 2006 the KW&SB supplied bulk water of about 630 mgd beyond the capacity as shown in **Table 75.1.1** and detailed in **Section 3.3.1**. **Figure 75.1.1** shows a schematic diagram of the existing bulk water supply system.

Table 75.1.1 Bulk Water Supply Capacity

Bulk Water System	Capacity	Actual Supply
GK System	280 mgd	300 mgd
Haleji System	20 mgd	30 mgd
K-II System	100 mgd	120 mgd
K-III System	100 mgd	100 mgd
Dumlottee Wells	20 mgd	0 mgd
Hub System	80 mgd	80 mgd
Total	600 mgd	630 mgd

source: KW&SB

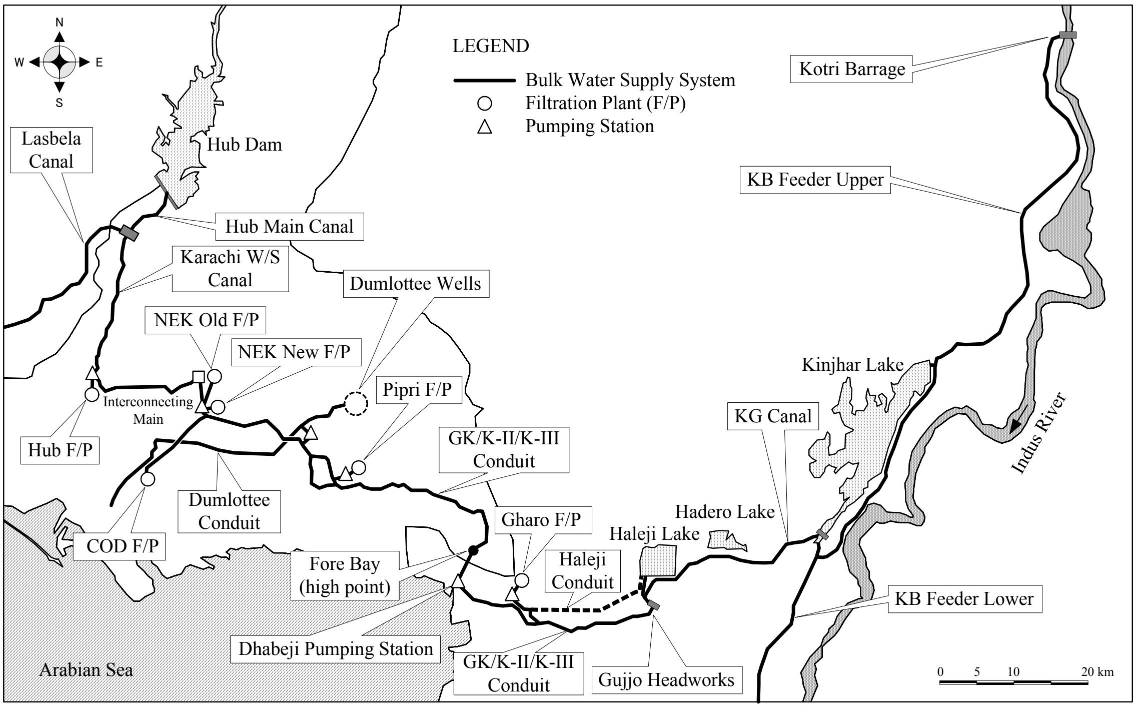


Figure 75.1.1 Existing Bulk Water Supply System

7.5.2 Proposed Bulk Water Supply System

(1) Canal and Conduit

Existing bulk water supply systems including GK, K-II and K-III bulk water supply systems will be continuously used for the future system. The existing bulk water supply system from Hub Dam to Manghopir Pumping Station (P/S) will be also used continuously. The periodical and proactive rehabilitation and repair works for the existing bulk water canals and conduits are proposed, since the existing bulk water canals and conduits are very old. It is also recommended that the KW&SB should measure the actual flow rates of these canals and conduits for identifying current status of the bulk water supply system. As a result the KW&SB may need to review and improve those capacities.

On the other hand, Damlottee Conduit will be abandoned by 2025 because of the permissible yield of the Damlottee Wells. At present K-III system transfers bulk water to Manghopir P/S through K-III Pumping Station (P/S), NEK Old Reservoir and NEK-Hub Link Main for making up for the water shortage of Hub Dam. In the proposed system, water pumped up from K-III P/S will be filtered at new F/P (K-III F/P) near NEK Old F/P and then distributed to customers. Therefore, no water goes to Manghopir P/S from the K-III system. **Figure 75.2.1** shows a proposed Greater Karachi Bulk Water Supply System from Kinjhar Lake to Karachi City considering actual bulk supply amount and on-going projects of the expansion of COD F/P and construction of K-III F/P which have been proposed by the KW&SB by using ADB Loan.

In addition to the existing bulk water supply system, three canals with a total capacity of 780 mgd (260 mgd × 3 canals) will be constructed by K-IV Project. Those canals will transfer bulk water from Kinjhar Lake to three filtration plants which will be also proposed by K-IV Project. The capacity of future bulk water supply system is summarised in **Table 75.2.1**. **Figure 75.2.2** shows a proposed arrangement between bulk water canals and filtration plants which will be constructed by K-IV project.

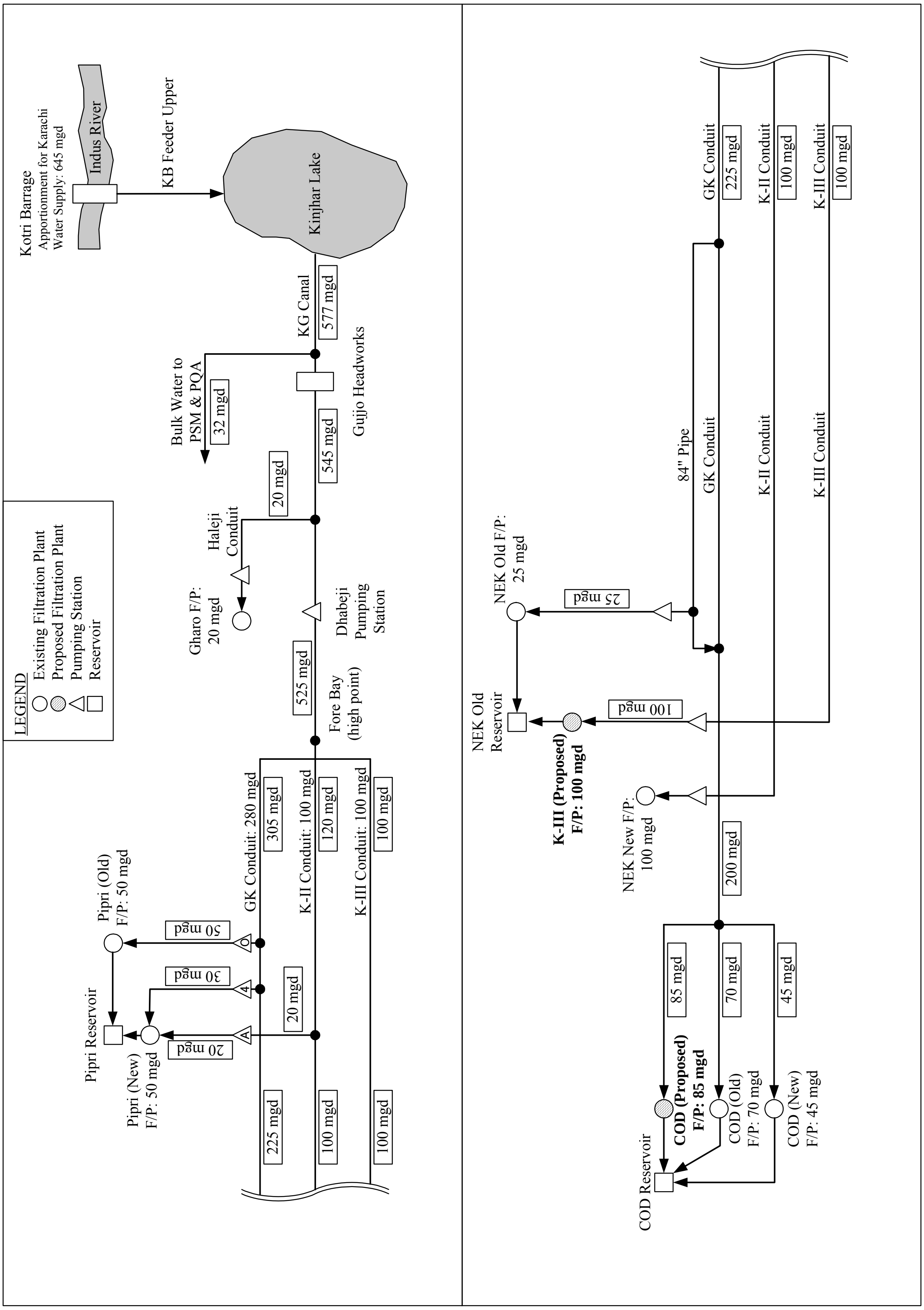


Figure 75.2.1 Future Greater Karachi Bulk Water Supply System

Table 75.2.1 Future Bulk Water Supply Capacity

Bulk Water System	Existing Capacity	Future Capacity	Remarks
GK System	280 mgd	305 mgd	Existing
Haleji System	20 mgd	20 mgd	Existing
K-II System	100 mgd	120 mgd	Existing
K-III System	100 mgd	100 mgd	Existing
Dumlottee Wells	20 mgd	0 mgd	to be abandoned
Hub System*	80 mgd	75 mgd	Existing
K-IV System	780 mgd	780 mgd	Proposed
Total	600 mgd	1,400 mgd	

source: KW&SB

* : considered to "95% level of reliability of the Hub River Yield"

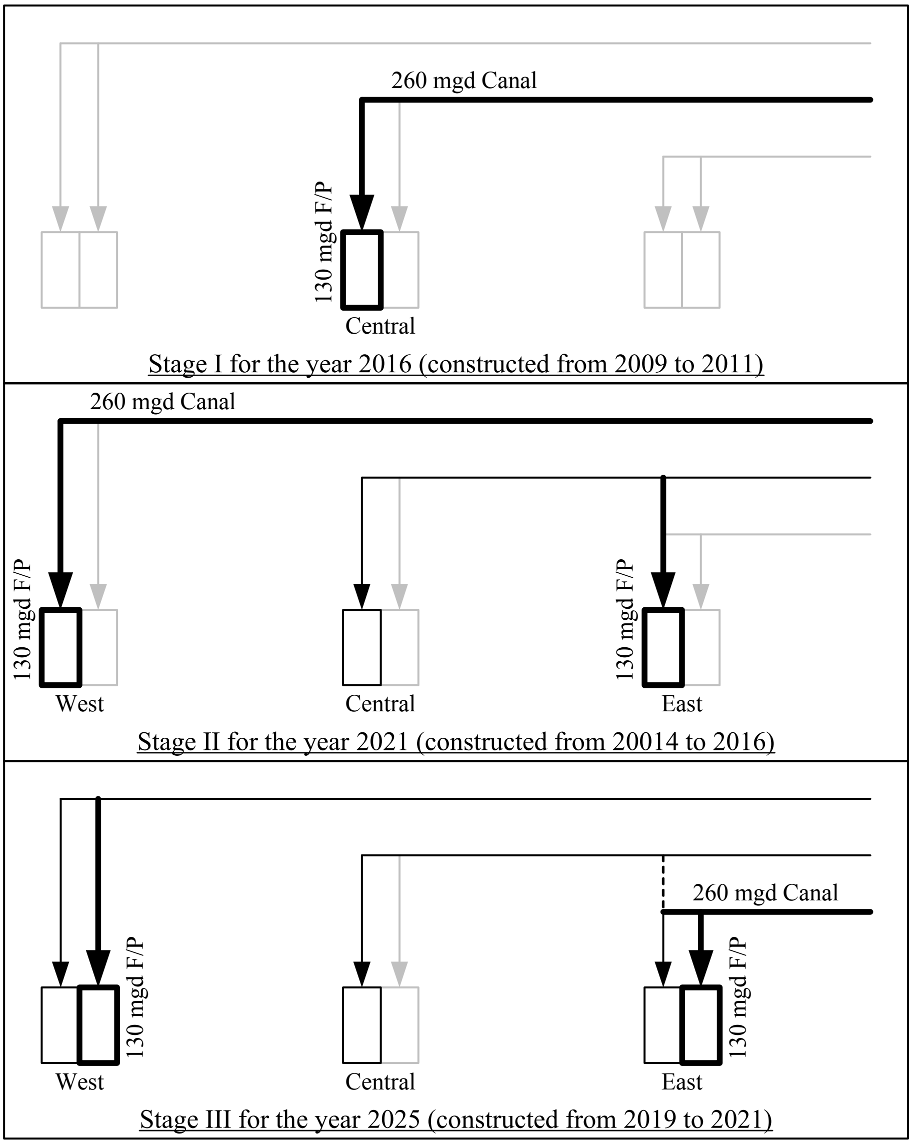


Figure 75.2.2 Proposed Arrangement between Canals and Filtration Plants constructed by K-IV Project

(2) Bulk Transmission Pumping Station

The bulk transmission pumping stations for the target year of 2025 which are used mainly as intake pumping station at filtration plants except Dhabeji P/S are listed in **Table 75.2.2**. The life span of the pumping equipment is assumed to be 15 years. Therefore, the pumping equipment in all the existing pumping stations should be replaced by 2025.

Among the KW&SB's facilities, NEK Old Pumping House near NEK New F/P is well maintained and operated. Mechanical and electrical equipment at this pumping house is being kept in good condition. This is able to become a model for others to emulate for operation and maintenance of mechanical and electrical equipment not only at other P/Ss but also at F/Ps.

Table 75.2.2 Bulk Transmission Pumping Stations in 2025

Sr.No.	Name of Pumping Station	Year of Construction	Total Capacity (MGD)	Running Capacity (MGD)	Pumps & Motors					Generator
					Total No. of Pumps	No, of Stand-By Pumps	Capacity of Each Pump (MGD)	Pump Head (ft)	Electric Motor (KW)	Capacity (MW)
1	Dhabeji (Phase-I)	1959	120	48	5	3	24	210	Diesel+Gas	0.25
2	Dhabeji (Phase-II)	1971	125	100	5	1	25	210	1050	--
3	Dhabeji (Phase-III)	1978	125	100	5	1	25	210	1050	--
4	Dhabeji (Phase-IV)	1997	125	100	5	1	25	210	1050	4.52
5	K-II (Dhabeji)	1998	175	140	5	1	35	210	1635	--
6	K-III (Dhabeji)	2006	210	140	6	2	35	210	1635	--
7	Gharo (Old)	1943	37	23	3	1	5	170	Diesel	0.5
		1982			6	2	2.0	170	74.6	
		2002			2	1	5.0	170	149.1	
8	Gharo (New)	1953	40	21	2	1	10	170	Diesel	0.5
		1997			5	2	2.0	170	93.2	
		2002			2	1	5.0	170	186.4	
9	Pipri (old)	1971	75	50	6	2	12.5	100	260	1.5
10	Pipri (Phase IV)	1994	50	37.5	4	1	12.5	56	132	1.25
11	Pipri (New)	2000	60.48	51.84	14	2	4.32	100	111.9	0.6
12	Hub (New)	2006	175	105	4	1	35	168	1350	-
	(Manghopir)				2	2	17.5	168	750	
13	NEK (Old)	1978	80	35	4	2	12.5	160	372.9	1.25
					6	4	5	160	111.9	
14	Low Lift (at NEK New)	1998	175	105	5	2	35	40	232.7	-
15	K-III (at NEK New)	2006	135	90	6	2	22.5	160	391.5	-

In addition to the existing bulk pumping stations, two bulk pumping stations between Kinjhar Lake and Filtration Plants are proposed for new bulk water transmission system to be constructed by K-IV Project. Details of new pumping stations are summarised in **Table 75.2.3**.

Table 75.2.3 Details of New Bulk Pumping Station

Pumping Station	Stage	Capacity	Total Dynamic Head (m)	Power Plant Required (MW)
1st Stage Pumping Station	Stage I	130 mgd	41	3.9
	Stage II	260 mgd	41	7.8
	Stage III	260 mgd	41	7.8
2nd Stage Pumping Station	Stage I	130 mgd	74	7.1
	Stage II	260 mgd	74	14.2
	Stage III	260 mgd	74	14.2

source: K-IV Project, Greater Karachi Water Supply Scheme (Executive Summary, May 2007)

On the other hand, the study proposes that the following seven existing bulk pumping stations are eliminated for future bulk water supply system for energy cost saving.

- 9th Mile Pumping Station
- Low Service Reservoir Old Pumping Station

- Low Service Reservoir New Pumping Station
- Ajmer Nagri Pumping Station
- Temple and Currie Pumping Station
- Dumlottee Pumping Station
- Board Office Pumping Station

7.6 WATER FILTRATION PLANTS

7.6.1 Proposed Filtration Plants

Table 76.1.1 shows a list of zone-wise filtration plants (F/Ps) proposed in 2025. Production of all the F/Ps is expected to keep their design capacities without overload operation.

Table 76.1.1 Filtration Plants in 2025

Filtration Plant	Zone	Capacity (mgd)	Remarks
Hub F/P	West	75	Existing
West F/P	West	260	proposed by K-IV Project
Sub-Total of Zone West		**335**	
NEK Old F/P	Central	25	Existing
NEK New F/P	Central	100	Existing
COD F/P	Central	115	Existing
	Central	85	expansion by ADB Project
KIII F/P	Central	100	proposed by ADB Project
Central F/P	Central	130	proposed by K-IV Project
Sub-Total of Zone Central		**555**	
Gharo F/P	East	20	Existing
Pipri F/P	East	100	Existing
East F/P	East	260	proposed by K-IV Project
Sub-Total of Zone East		**380**	
Total		**1,270**	

At present water for K-III F/P and COD F/P to be expanded is supplied directly to customers without filtration. It is, therefore, recommended that such water should be treated at filtration plant. Asian Development Bank proposes the construction of K-III F/P and expansion of COD F/P (Draft Karachi Sustainable Mega City Water and Wastewater Roadmap, May 2007, ADB). K-III F/P with a capacity of 100 mgd will be constructed at/near the site of NEK Old F/P and COD F/P with a capacity of 85 mgd will be expanded at the existing COD F/P. It is, however, noted that the construction of K-III F/P (100 mgd) and the expansion of COD F/P (85 mgd) are not the increase of water supply capacity because water of 100 mgd for K-III F/P and 85 mgd for COD expansion is being supplied directly to customers without filtration.

New F/Ps (260 mgd × 2 plants at Zone West and Zone East and 130 mgd × 1 plant at Zone Central) are proposed for future water supply system. As described in **Section 7.3 "System Development Plan",** West F/P, Central F/P and East F/P are expected to start its production by year 2016, 2011 and 2016 respectively.

New F/Ps will consist of large capacity lagoon (520 mg) for storing 2 days bulk (raw) water and for grit chamber in case of coming turbid water from the Kinjhar Lake (K-IV Project, Greater Karachi Water Supply Scheme, Executive Summary, May 2007). As well as the existing process, the rapid sand filtration system is recommended for the proposed treatment process. The proposed treatment process consists of receiving chamber, sand filtration and chlorination and is shown in **Figure 76.1.1**. This process was designed with consideration of the bulk water quality (see **Table 76.1.2**) and the existing process. In addition the space for rapid mixing basin and flocculation/sedimentation basin should be kept for future treatment process due to deterioration of bulk water quality. If the turbidity is found as high level continuously, it is recommended constructing rapid mixing basin and flocculation/sedimentation basin as pre-treatment to remove turbidity.

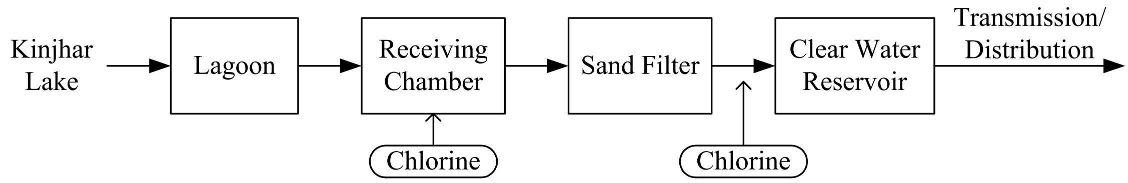


Figure 76.1.1 Proposed Water Treatment Process for New Filtration Plant

Table 76.1.2 Bulk Water Quality of KG Canal before Gujjo Headworks

Parametres	Unit	Dry Season (June 2006)	Wet Season (August 2006)
pH		8.20	8.11
Turbidity	NTU	0.19	0.55
Iron	mg/l	0.11	0.165
Manganese	μg/L	7.40	10.81
Ammonia-Nitrogen	mg/l	0.096	ND
Faecal Coliform	count/dl	43	1,100

source: Progress Report No.1, September 2006

7.6.2 Rehabilitation and Improvement of Existing Filtration Plants

The design life for the filtration plants is generally shown in **Table 76.2.1**. The design life for concrete structures is 50 years and the design life for mechanical and electrical equipment is 15 years. Once the design life is exceeded, the facilities will be abandoned and new facilities will be constructed, if necessary.

Table 76.2.1 Design Life for the Filtration Plants

Intake Facilities		Life Time (years)
	Pump House (concrete structure)	50
	Mechanical and electrical equipments	15
Filtration Plant		
	Tank and basin (concrete structures)	50
	Mechanical and electrical equipments	15

At present (as of 2007) the KW&SB are proposing PC1 for the rehabilitations of the existing plants including Gharo F/P, Pipri (old 25 mgd × 2 plants) F/P, COD F/P and NEK Old F/P. The rehabilitations to the existing plants should include not only repair of the existing facilities and equipment but also some improvements based on plant safety, process control, and the need for continuous water supply. Plant safety is the most important aspect of the proposed improvements. Most filtration plants do not have safety measurement equipment for chlorine gas and some plants do not use a chlorinator for chlorination. Therefore safety and health improvements have been set as the highest priority. Process control improvements such as installing flow metres are set as the second priority. Therefore the rehabilitation and improvement of the existing filtration plants include, but are not limited to;

- Replacement of a top layer of filter media
- Rehabilitation of all valves, fittings and other accessories for filter basin
- Rehabilitation of backwashing system for filter basin
- Replacement of chlorinators and accessories and improvement of safety measurement equipment for chlorination system

- Replacement and repair of chemical dozing equipment including pipelines and other accessories
- Installation of level indicators at reservoirs
- Installation of flow metres at outlet of reservoirs
- Rehabilitation of standby generating set
- Repair of steel structure
- Repair of leakages from the water retaining structures and pipelines
- Repair and replacement of damaged flooring, walls, doors and windows where ever required.
- Arrangement of lighting system for security along the boundary line

Other F/Ps of NEK New F/P, Hub F/P and Pipri (new 50 mgd plant) are recommended to be rehabilitated at Stage III from 2019 to 2021.

7.7 WATER TRANSMISSION SYSTEM

7.7.1 General

Existing water transmission system will be improved by dividing water supply areas of Karachi into three zones of Zone-West, Zone-Central, and Zone-East. The estimated zone-wise demands in 2016, 2021, and 2025 are shown in **Tables 77.1.1** and **77.1.2**.

The future land use map in 2025 including future roads proposed in Karachi Strategic Development Plan 2020 (Final, August 2007) is shown in **Figure 77.1.1**. A contour map of Karachi is generated using GIS software from Digital Elevation Model developed based on 1:50,000 topographic maps prepared by Survey of Pakistan during 1991~1995. The created contour map is shown in **Figure 77.1.2**.

Based on these basic conditions and information, new filtered water transmission system including trunk distribution mains for the three zones is proposed as seen in **Figure 77.1.3** in consideration of;

- eliminating the use of several bulk pumping stations and a large number of small size distribution pumping stations for energy cost saving,
- supplying water by gravity as much as possible, and
- keeping minimum dynamic water pressure of 10 m in distribution system.

Flow diagram of the proposed system in 2025 is shown in **Figure 77.1.4**. Flow diagrams of the proposed systems for intermediate years of 2016 and 2021 are attached to **Appendix 77.1**. As the result of a preliminary hydraulic analysis, pumping will be required only for transferring water from filtration plants to the distribution reservoirs in order to supply water to relatively high altitude area.

The details of proposed reservoirs, filtered water transmission mains, transmission pump stations and network analysis are further explained in the following sub-sections.

Table 77.1.1 Zone-Wise Water Demand (1/2)

Zone-Wise Water Demand in 2011

Zone-West

Demand		
Town		
1	Keamari (West)	17.64 mgd
2	SITE	34.56 mgd
3	Baldia	18.59 mgd
4	Orangi	28.00 mgd
12	North Nazimabad	26.34 mgd
13	New Karachi	26.11 mgd
14	Gulberg	23.47 mgd
15	Liaquatabad	29.43 mgd
18	Gadap (West)	12.87 mgd
Canttonment		
Other Authority		
Other District		
	Barochistan	5 mgd
	Total Demand	222.01 mgd
Production		
FP		
	Hub	80 mgd
	Total Production	80 mgd
	Remainded Production	-142.01 mgd

Zone-Central

Town		
3	Keamari (Port)	10.20 mgd
5	Lyari	22.65 mgd
6	Saddar	70.72 mgd
7	Jamshed	36.86 mgd
8	Gulshan-e-Ibal	60.92 mgd
9	Shah Faisal	23.40 mgd
16	Malir	40.46 mgd
18	Gadap (Central)	22.64 mgd
Canttonment		
①	Manora	0.39 mgd
②	Malir	15.27 mgd
③	Karachi	1.00 mgd
④	Crifton	0.89 mgd
⑤	Faisal	6.88 mgd
Other Authority		
	DHA	25.88 mgd
Other District		
	Total Demand	338.16 mgd
FP		
	NEK Old	25 mgd
	NEK New	100 mgd
	COD	115 mgd
	K-III	100 mgd
	Total Production	340 mgd
	Remainded Production	1.84 mgd

Zone-East

Town		
10	Landhi	38.56 mgd
11	Korangi	37.70 mgd
17	Bin Qasim	64.52 mgd
18	Gadap (East)	3.78 mgd
Canttonment		
⑥	Korangi	3.60 mgd
Other Authority		
Other District		
	Thatta (as Low Water)	
	Total Demand	148.16 mgd
	Grand Total of Demand	**708.33 mgd**
FP		
	Gharo	20 mgd
	Pipri	100 mgd
	Total Production	120 mgd
	Grand Total of Production	**540 mgd**
	Remainded Production	-28.16 mgd

Zone-Wise Water Demand in 2016

Zone-West

Demand		
Town		
1	Keamari (West)	32.34 mgd
2	SITE	36.36 mgd
3	Baldia	25.63 mgd
4	Orangi	31.06 mgd
12	North Nazimabad	28.71 mgd
13	New Karachi	27.88 mgd
14	Gulberg	25.83 mgd
15	Liaquatabad	29.42 mgd
18	Gadap (West)	21.76 mgd
Canttonment		
Other Authority		
Other District		
	Barochistan	5 mgd
	Total Demand	263.98 mgd
Production		
FP		
	Hub	75 mgd
	Total Production	75 mgd
	Remainded Production	-188.98 mgd

Zone-Central

Town		
3	Keamari (Port)	11.83 mgd
5	Lyari	23.06 mgd
6	Saddar	71.68 mgd
7	Jamshed	43.79 mgd
8	Gulshan-e-Ibal	79.66 mgd
9	Shah Faisal	24.38 mgd
16	Malir	43.19 mgd
18	Gadap (Central)	42.95 mgd
Canttonment		
①	Manora	0.47 mgd
②	Malir	18.52 mgd
③	Karachi	1.21 mgd
④	Crifton	1.07 mgd
⑤	Faisal	8.34 mgd
Other Authority		
	DHA	30.73 mgd
Other District		
	Total Demand	400.88 mgd
FP		
	NEK Old	25 mgd
	NEK New	100 mgd
	COD	200 mgd
	K-III	100 mgd
	Central	130 mgd
	Total Production	555 mgd
	Remainded Production	154.12 mgd

Zone-East

Town		
10	Landhi	45.36 mgd
11	Korangi	46.59 mgd
17	Bin Qasim	94.79 mgd
18	Gadap (East)	6.68 mgd
Canttonment		
⑥	Korangi	4.36 mgd
Other Authority		
Other District		
	Thatta (as Low Water)	
	Total Demand	197.77 mgd
	Grand Total of Demand	**862.64 mgd**
FP		
	Gharo	20 mgd
	Pipri	100 mgd
	Total Production	120 mgd
	Grand Total of Production	**750 mgd**
	Remainded Production	-77.77 mgd

Table 77.1.2 Zone-Wise Water Demand (2/2)

Zone-Wise Water Demand in 2021

Zone-West

Demand	
Town	
1 Keamari (West)	47.69 mgd
2 SITE	38.83 mgd
3 Baldia	31.11 mgd
4 Orangi	34.76 mgd
12 North Nazimabad	32.13 mgd
13 New Karachi	30.36 mgd
14 Gulberg	28.88 mgd
15 Liaquatabad	30.53 mgd
18 Gadap (West)	30.21 mgd
Canttonment	
Other Authority	
Other District	
Barochistan	5 mgd
Total Demand	309.50 mgd
Production	
FP	
Hub	80 mgd
West	130 mgd
Total Production	210 mgd
Remainded Production	-99.50 mgd

Zone-Central

Town	
3 Keamari (Port)	12.52 mgd
5 Lyari	23.87 mgd
6 Saddar	74.53 mgd
7 Jamshed	50.03 mgd
8 Gulshan-e-Ibal	103.06 mgd
9 Shah Faisal	25.79 mgd
16 Malir	48.11 mgd
18 Gadap (Central)	64.06 mgd
Canttonment	
① Manora	0.57 mgd
② Malir	22.37 mgd
③ Karachi	1.46 mgd
④ Crifton	1.30 mgd
⑤ Faisal	10.07 mgd
Other Authority	
DHA	37.64 mgd
Other District	
Total Demand	475.36 mgd
FP	
NEK Old	25 mgd
NEK New	100 mgd
COD	200 mgd
K-III	100 mgd
Central	130 mgd
Total Production	555 mgd
Remainded Production	79.64 mgd

Zone-East

Town	
10 Landhi	54.75 mgd
11 Korangi	58.61 mgd
17 Bin Qasim	129.36 mgd
18 Gadap (East)	10.03 mgd
Canttonment	
⑥ Korangi	5.27 mgd
Other Authority	
Other District	
Thatta (as Low Water)	
Total Demand	258.01 mgd
Grand Total of Demand	**1,042.87 mgd**
FP	
Gharo	20 mgd
Pipri	100 mgd
East	130 mgd
Total Production	250 mgd
Grand Total of Production	**1,015 mgd**
Remainded Production	-8.01 mgd

Zone-Wise Water Demand in 2025

Zone-West

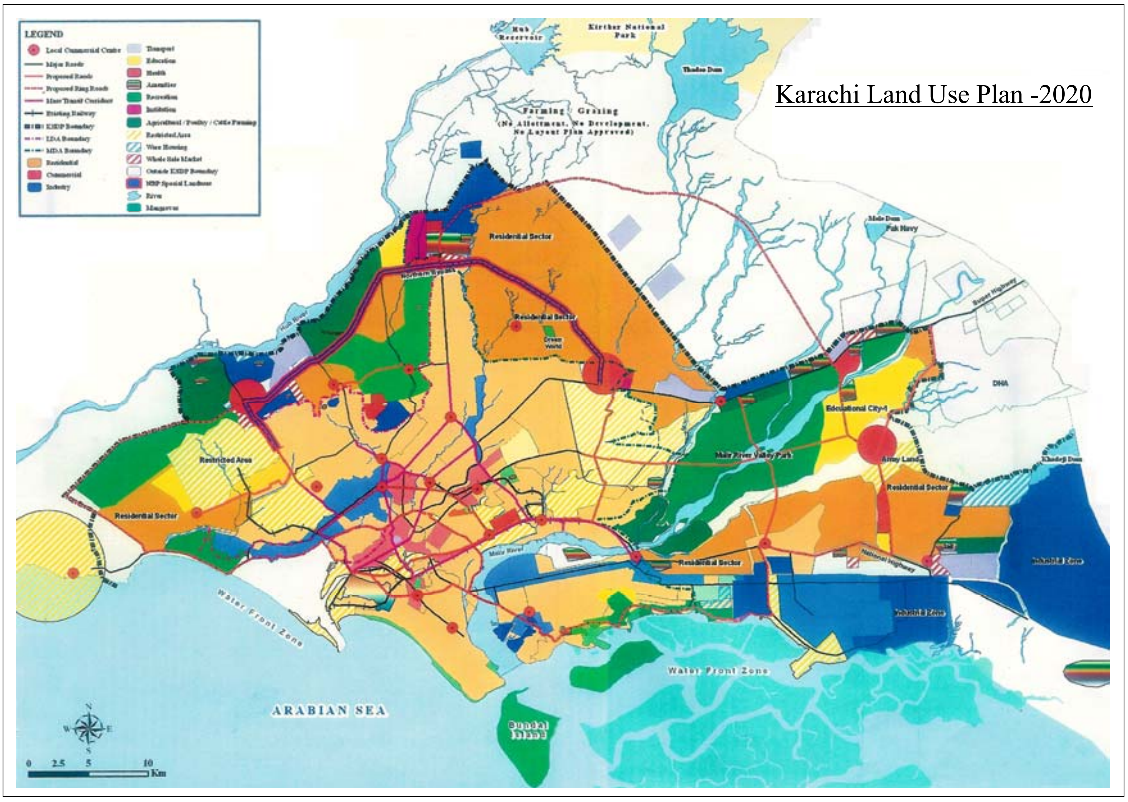
Demand	
Town	
1 Keamari (West)	60.22 mgd
2 SITE	40.79 mgd
3 Baldia	35.63 mgd
4 Orangi	37.91 mgd
12 North Nazimabad	35.03 mgd
13 New Karachi	32.47 mgd
14 Gulberg	31.48 mgd
15 Liaquatabad	31.51 mgd
18 Gadap (West)	36.22 mgd
Canttonment	
Other Authority	
Other District	
Barochistan	5 mgd
Total Demand	346.27 mgd
Production	
F/P	
Hub	75 mgd
West	260 mgd
Total Production	335 mgd
Remainded Production	-11.27 mgd

Zone-Central

Town	
3 Keamari (Port)	13.09 mgd
5 Lyari	24.59 mgd
6 Saddar	76.71 mgd
7 Jamshed	55.27 mgd
8 Gulshan-e-Ibal	121.99 mgd
9 Shah Faisal	26.93 mgd
16 Malir	51.84 mgd
18 Gadap (Central)	79.84 mgd
Canttonment	
① Manora	0.65 mgd
② Malir	25.33 mgd
③ Karachi	1.66 mgd
④ Crifton	1.47 mgd
⑤ Faisal	11.41 mgd
Other Authority	
DHA	43.48 mgd
Other District	
Total Demand	534.25 mgd
F/P	
NEK Old	25 mgd
NEK New	100 mgd
COD	200 mgd
K-III	100 mgd
Central	130 mgd
Total Production	555 mgd
Remainded Production	20.75 mgd

Zone-East

Town	
10 Landhi	62.40 mgd
11 Korangi	68.30 mgd
17 Bin Qasim	155.34 mgd
18 Gadap (East)	14.53 mgd
Canttonment	
⑥ Korangi	5.97 mgd
Other Authority	
Other District	
Thatta (as Low Water)	
Total Demand	306.54 mgd
Grand Total of Demand	**1,187.05 mgd**
F/P	
Gharo	20 mgd
Pipri	100 mgd
East	260 mgd
Total Production	380 mgd
Grand Total of Production	**1,270 mgd**
Remainded Production	73.46 mgd



source: Karachi Strategic Development Plan 2020 (Final, August 2007)

Figure 77.1.1 Future Land Use in 2025

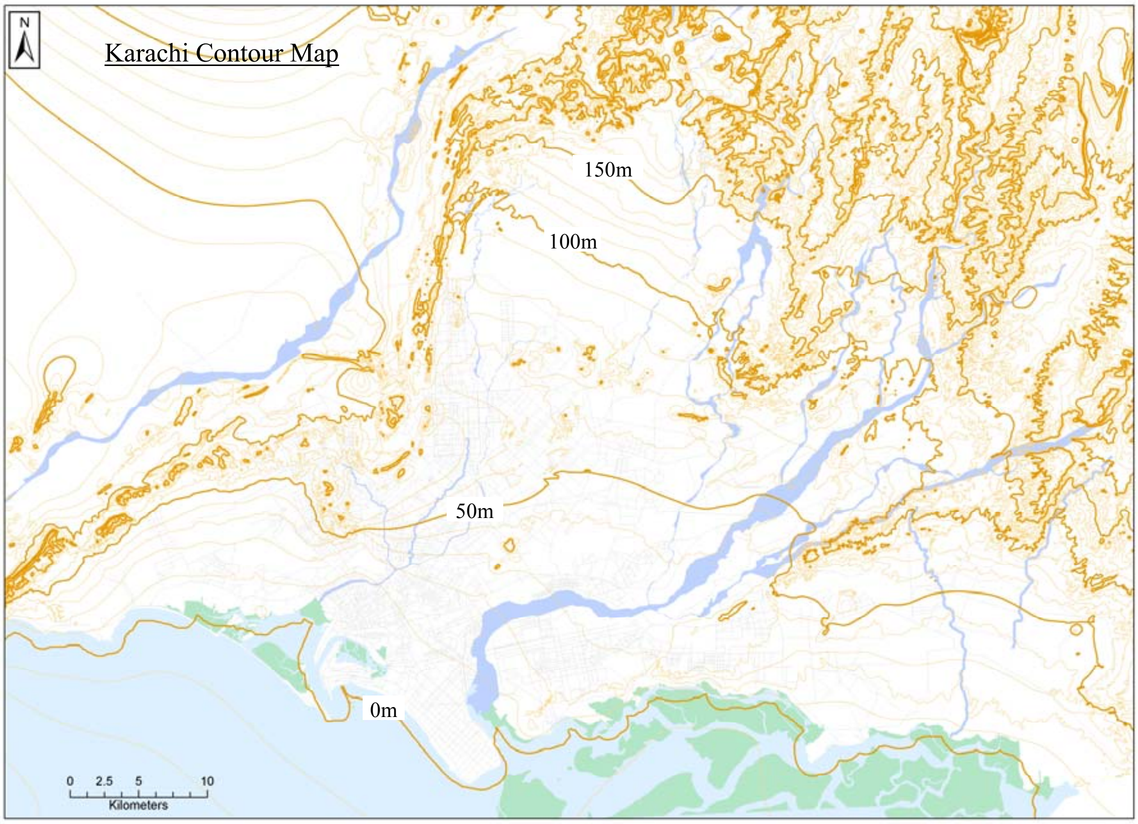


Figure 77.1.2 Karachi Contour Map

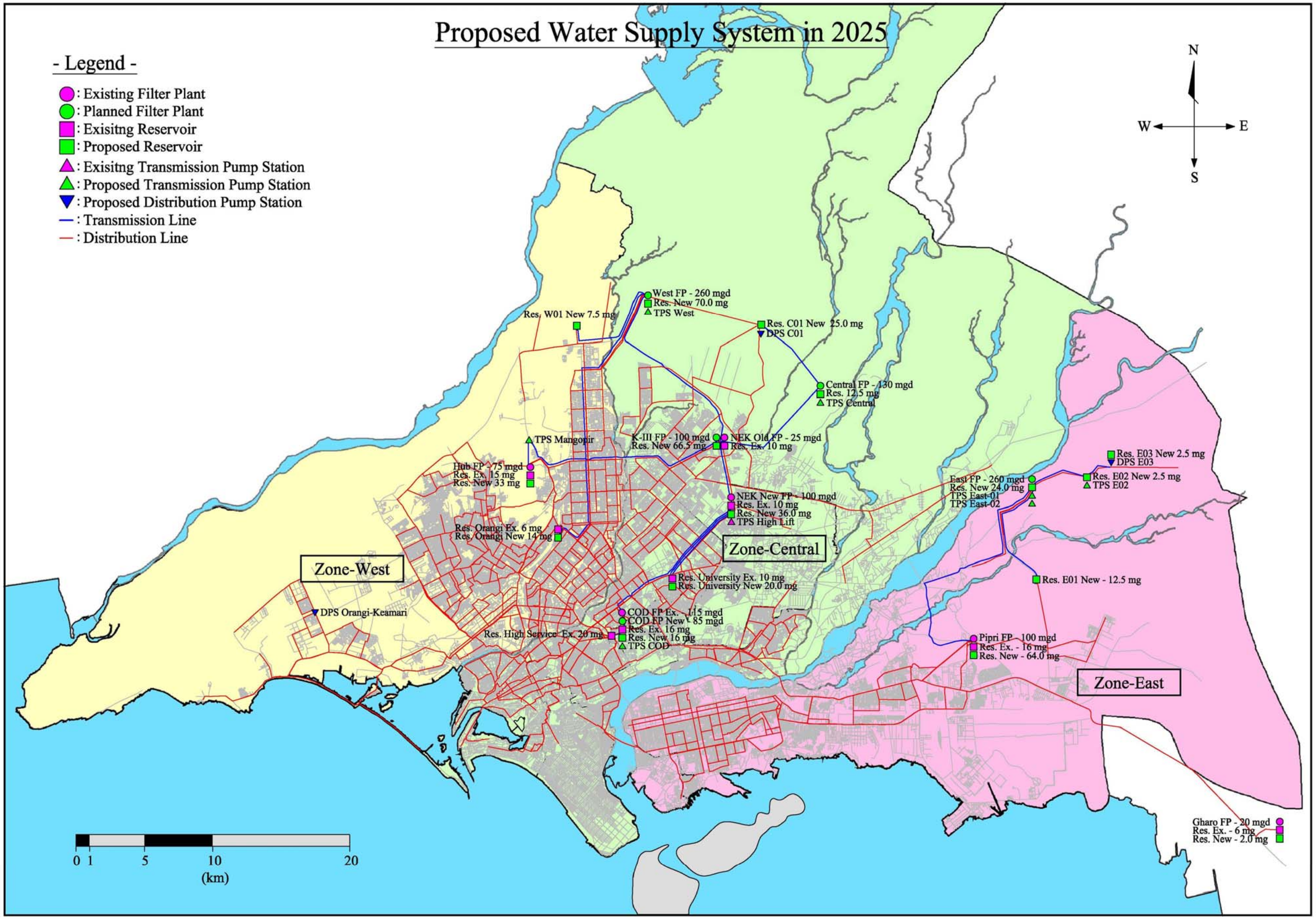


Figure 77.1.3 Proposed Water Supply System in 2025

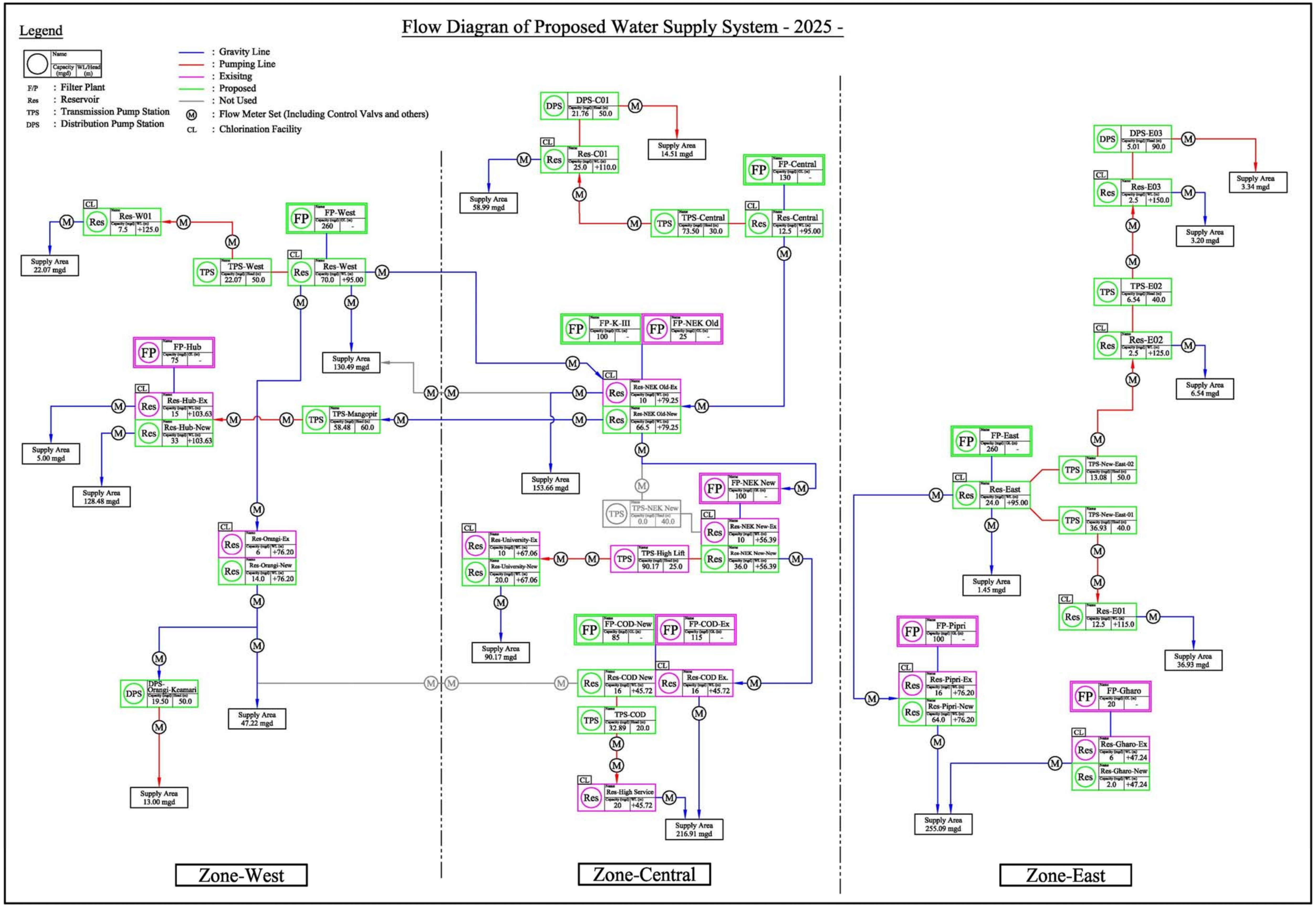


Figure 77.1.4 Flow Diagram of Proposed System in 2025

7.7.2 Network Analysis

(1) Conditions of Network Analysis

1) Formula for Hydraulic Calculation: Hazen-Williams Formula

There are a number of formulae available to calculate the velocity of flow (e.g. Hazen-Williams formula, Manning's formula, Darcy-Weisbach's formula and Colebrook-White formula). The Hazen-Williams formula is the best for situations involving pressure conduits. The formula is:

$$V = 0.84935\ C\ R^{0.63}\ I^{0.54}$$

For circular conduits, the formula is restated as

$$hf = 10.666\ C^{-1.85}\ D^{-4.87}\ Q^{1.85}\ L$$

Where,
- V = Velocity (m/s)
- C = Hazen-Williams coefficient
- R = Hydraulic Radius (m)
- I = Hydraulic Gradient, hf/L
- hf = Friction Head Loss (m)
- D = Diametre of Pipe (m)
- Q = Discharge (m^3/s)
- L = Pipe Length (m)

For confirmation, Darcy-Weisbach's formula with a friction factor of e=0.45mm which is calculated with Colebrook-White formula was also used for checking hydraulic analysis. There was no much difference between the results. Therefore, the Hazen-Williams formula has been adopted for this study.

2) azen-Williams Coefficient (C Value): 110 for all materials

The Hazen-Williams coefficient (C value) for new pipes made from cast iron, ductile iron or mild steel with cement mortar lining may be between 130 and 145. However, it is generally recommended that in the absence of specific data, a C value of 110 should be adopted. Therefore, a C value of 110 was adopted when designing the transmission and distribution system, including the existing pipelines.

3) ourly Peak Factor: 1.5

When designing the distribution system hourly demand fluctuations must be considered. For example, during the night people use less water, but in the morning and evening people use much more water. Because of absence of flow data for determining current hourly peak factor in Karachi, a peak factor of 1.5 was adopted referring to "Feasibility Study for future expansion of Karachi Water Supply System, December 1985". It is, however, difficult to review the time factor of 1.5 because water flow has not been measured properly.

4) inimum Dynamic Water Pressure: 10 m

A minimum pressure of 10 m in the distribution system has been adopted under peak flow conditions. This will provide sufficient pressure for 2 or 3 storey house.

5) etails of the Existing Water Supply System

It should be noted that since there is no recorded data or drawings of the existing transmission and distribution systems or details of the reservoirs, the modelling for the hydraulic analysis was prepared based on interviews with the KW&SB's engineers, for the followings system components:

- routes, materials and diametres of transmission and trunk distribution mains; and
- locations, capacities and water level of reservoirs.

(2) Results of Network Analysis

Appendix A77.1 shows the results of the analysis in detail.

7.7.3 Transmission Pumping Stations

Proposed transmission pump stations will deliver filtered water to distribution reservoirs through transmission mains for supplying water mainly to new developing area of three fringe towns, Keamari, Bin Qasim and Gadap. These areas are relatively high altitude area where is higher than the filtration plant or almost the same altitude as the filtration plant. The proposed pumping stations for the target year of 2025 including two existing pumping stations (Mangopir PS and High Lift PS) are shown in **Table 77.3.1**.

Table 77.3.1 Proposed Transmission Pumping Station in 2025

Type	Zone	Name	Q (mgd)			Pump Head (m)
			2016	2021	2025	
Transmission Pumping Station	West	TPS-W-Mangopir	40.98	52.53	58.48	60
		TPS-W-West	-	6.69	22.07	50
	Central	TPS-C-COD	26.06	29.76	32.89	20
		TPS-C-NEK New	18.65	0.00	0.00	40
		TPS-C-Central	24.41	47.48	73.50	30
		TPS-C-High_Lift	75.91	83.97	90.17	25
	East	TPS-E-East-01	-	28.67	36.93	40
		TPS-E-East-02	-	-	13.08	50
		TPS-E-E02	-	-	6.54	40

7.7.4 Water Transmission Mains

(1) Proposed Water Transmission Mains

The dimensions of proposed water transmission mains are listed in **Table 77.4.1**. **Figure 77.1.3** and **Figure 77.1.4** include the routes and flow diagram of the proposed filtered water transmission system respectively. Proposed filtered water transmission mains should not have any branches for distribution or bulk supply. Routes of transmission mains pass through mainly new developing area of three fringe towns, Keamari, Bin Qasim and Gadap. For future system, the existing water trunk mains except the trunk mains between NEK New F/P and University Reservoir and NEK Old and Mangopir P/S (NEK Hub Main) will not be used as the water transmission mains, but utilised for the trunk distribution mains. However, the water trunk mains between NEK New F/P and University Reservoir (about 16.7 km in total) are proposed to be rehabilitated and replaced, which are included in **Table 77.4.1**.

Table 77.4.1 Proposed Water Transmission Mains in 2025

Zone	Year	Dia. (in)	Length (m)
West	**2016**	72	141
		Sub-Total	141
	2021	36	20,364
		44	2,448
		Sub-Total	22,812
	2025	100	37,390
		Sub-Total	37,390
	Zone-Total		**60,343**
Central	**2016**	48	5,425
		56	11,348
		64	22,700
		88	9,275
		Sub-Total	48,748
	Zone-Total		**48,748**
East	**2021**	56	9,651
		100	20,364
		Sub-Total	30,015
	2025	24	2,078
		32	4,157
		Sub-Total	6,235
	Zone-Total		**36,250**
Total			**145,341**

(2) Water Management between Zones

Considering water demands in three zones, some water should be managed across zone boundaries as shown in **Figure 77.4.1**. Some water should be supplied from Zone Central to Zone West because Zone Central has enough supply capacity for its demand. On the other hand, there is no water exchange between Zone Central and Zone East.

Zone West	Zone Central	Zone East
Year 2016		
174 mgd ←	―	
Year 2021		
84 mgd ←	―	
Year 2025		
21 mgd ←	―	

Figure 77.4.1 Water Management between Zones

7.7.5 Distribution Reservoirs

(1) Proposed Distribution Reservoirs

Distribution reservoirs should have enough capacity to cope with water demand fluctuation in a day. In general peaks in water demand appear in the morning, at noon and in the evening. However, hourly demand fluctuation is difficult to accurately quantify because the metreing system does not exist in the current system. Based on engineering experiences, the capacity of distribution reservoir is proposed to be eight hours of daily demand.

Distribution reservoirs should be located at suitable place to supply water with enough pressure of minimum 10 kgf/cm^2 at the end of distribution network. To monitor and control the flow, flow metres and flow control valves should be installed at the outlet pipes at the reservoirs. And chlorination equipment should be installed in the all distribution reservoirs to increase the safety of water supply.

Proposed reservoirs for 2025 are listed in the **Table 77.5.1** and supply areas of each reservoir are shown in **Figure.77.5.1**.

Table 77.5.1 Proposed Distribution Reservoirs in 2025

Zone	Res	HWL	LWL	H	Req. Total V (mg)			Existing	Planned Total V (mg)			Planned New V (mg)		
		(+m)	(+m)	(m)	2016	2021	2025	(mg)	2016	2021	2025	2016	2021	2025
West	Hub	+103.63	+99.36	4.27	42.0	45.9	47.9	15.0	48.0	48.0	48.0	33.0	0.0	0.0
	Orangi	+76.20	+71.32	4.88	0.0	0.0	20.1	6.0	0.0	0.0	20.0	0.0	0.0	20.0
	West*	+95.00	+90.00	5.00	0.0	51.7	65.7	0.0	0.0	50.0	70.0	0.0	50.0	20.0
	W01*	+125.00	+120.00	5.00	0.0	2.3	7.4	0.0	0.0	2.5	7.5	0.0	2.5	5.0
	Mangopir PS**	+64.00	+61.00	3.00	0.9	1.1	1.2	0.0	1.5	1.5	1.5	1.5	0.0	0.0
Centarl	COD	+45.72	+40.23	5.49	32.0	32.0	32.0	16.0	32.0	32.0	32.0	16.0	0.0	0.0
	NEK Old	+79.25	+74.37	4.88	76.5	57.1	61.5	10.0	76.5	76.5	76.5	66.5	0.0	0.0
	NEK New	+56.39	+51.51	4.88	45.6	45.6	45.6	10.0	46.0	46.0	46.0	36.0	0.0	0.0
	University	+67.06	+62.18	4.88	25.4	28.0	30.1	10.0	30.0	30.0	30.0	20.0	0.0	0.0
	High Service	+45.72	+40.84	4.88	8.7	9.9	11.0	20.0	11.0	11.0	11.0	0.0	0.0	0.0
	Central*	+95.00	+90.00	5.00	11.4	11.9	12.4	0.0	12.5	12.5	12.5	12.5	0.0	0.0
	C01*	+110.00	+105.00	5.00	8.2	15.9	24.6	0.0	10.0	15.0	25.0	10.0	5.0	10.0
East	Gharo	+47.24	+45.72	1.52	6.7	6.7	6.7	6.0	8.0	8.0	8.0	2.0	0.0	0.0
	Pipri	+76.20	+71.32	4.88	33.3	66.8	78.5	16.0	35.0	70.0	80.0	19.0	35.0	10.0
	East*	+95.00	+90.00	5.00	0.0	11.9	23.2	0.0	0.0	12.0	24.0	0.0	12.0	12.0
	E01*	+115.00	+110.00	5.00	0.0	9.6	12.4	0.0	0.0	12.5	12.5	0.0	12.5	0.0
	E02*	+125.00	+120.00	5.00	0.0	0.0	2.4	0.0	0.0	0.0	2.5	0.0	0.0	2.5
	E03*	+150.00	+145.00	5.00	0.0	0.0	2.2	0.0	0.0	0.0	2.5	0.0	0.0	2.5

*: new reservoirs

**: suction well for PS

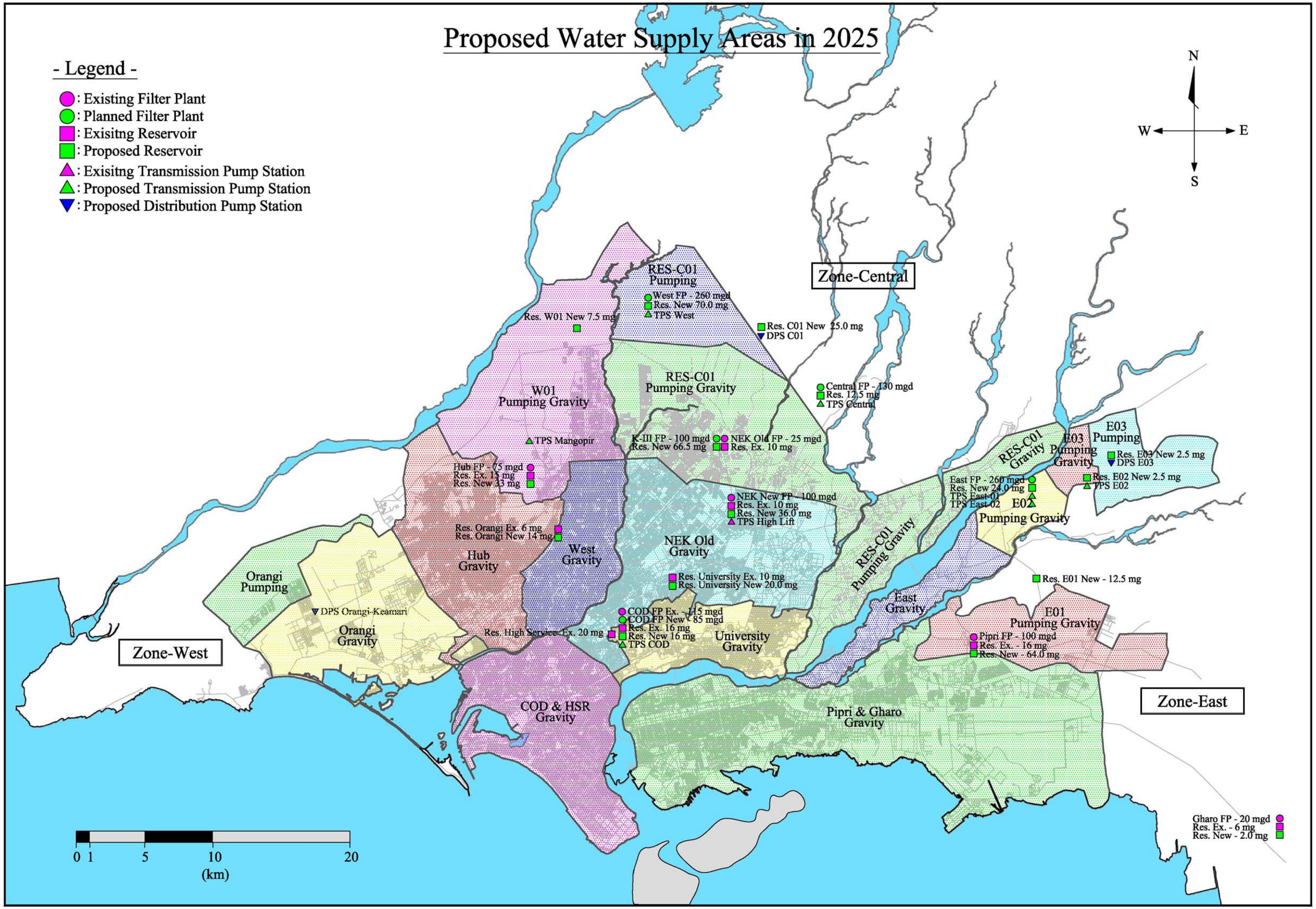


Figure 77.5.1 Proposed Supply Area from Each Reservoir in 2025

(2) Rehabilitation of the Existing Reservoirs

The Karachi Water Supply System has 16 existing distribution reservoirs including reservoirs at filtration plants, as listed in **Table 77.5.2**. Since the design life of the concrete structure is 50 years, this master plan proposes that 8 existing reservoirs constructed before 1975 will be rehabilitated by 2025. On the other hand, 4 reservoirs will be eliminated for future water supply system, since water from these reservoirs should be supplied by using distribution pumps. The area presently supplied from these reservoirs to be eliminated will be covered by other reservoirs by gravity. KW&SB are preparing to rehabilitate two reservoirs, High Service Reservoir and Orangi Reservoir. Especially, Orangi Reservoir is needed to be reconstruct at the existing site, since the existing reservoir has been destroyed.

Table 77.5.2 List of Existing Reservoirs

Name of Exiting Reservoirs	Construction Year*	Need for Rehabilitation	Elimination by 2025	Need for Expansion
Gharo F/P (Plant-1)	1942	×	-	×
Pipri F/P (Plant-1)	1968	×	-	×
Pipri F/P (Plant-2)	1971	×	-	
NEK Old F/P	1980	-	-	×
NEK New F/P	1998	-	-	×
COD F/P (Plant-1)	1962	×	-	×
COD F/P (Plant-2)	1971	×	-	
Hub F/P	1982	-	-	×
Unversity	1971	×	-	×
High Service	1945	×	-	-
Low Service	1942	-	×	-
Temple	1880	-	×	-
Currie	1896	-	×	-
Sydenham	1942	-	×	-
Orangi	1982	×	-	×
Kidney Hill	1978	-	-	-

*: information from KW&SB

7.7.6 Distribution Pumping Stations

In the areas where water can not be supplied by gravity flow, water should be supplied by pumping from distribution reservoirs. The capacity of distribution pumps is needed to be 1.5 times of daily demand considering the time factor of demand fluctuation.

Proposed distribution pumping stations will deliver water to customers who inhabit mainly at new developing area of three fringe towns, Keamari, Bin Qasim and Gadap. These areas are relatively high altitude area where is higher than the filtration plant or almost the same altitude as the filtration plant. The proposed pumping stations for the target year of 2025 are shown in **Table 77.6.1**.

Table 77.6.1 Proposed Distribution Pumping Station in 2025

Type	Zone	Name	Ave. Q (mgd)			Max. Q (mgd)			Pump Head (m)
			2016	2021	2025	2016	2021	2025	
Distribution Pumping Station	West	DPS-W-Orangi-Keamari	-	-	19.5	-	-	29.3	50
	Central	DPS-C-C01	-	-	21.76	-	-	32.6	50
	East	DPS-E-E03	-	-	5.01	-	-	7.5	90

On the other hand, a large number of the existing small size distribution pumping stations will be abandoned in the future system.

7.7.7 District Metre

In order to improve the efficiency of transmission and distribution system and to supply water equitably to the service area, it is necessary to understand how much water is flowed into which area. For that purpose, installation of flow metres (district metres) for transmission mains and trunk distribution mains is proposed mainly at the following locations. The number of flow metres required for the system in 2025 is listed in **Table 77.7.1**.

- Outlet of filtration plants, pumping stations and reservoirs
- Downstream of branch points of transmission and trunk distribution mains
- Boundary of towns

Table 77.7.1 Proposed District Flow Metres

Diameter (in)	Transmission Mains				Distribution Mains				Total
	West	Central	East	Sub-Total	West	Central	East	Sub-Total	
12				0		4	1	5	5
14				0	3	15	3	21	21
16				0	1		4	5	5
18				0	5	8	2	15	15
20				0		1		1	1
24			2	2	11	21	3	35	37
28				0	2	2		4	4
32			2	2	7	10	3	20	22
36	2			2	4	4	1	9	11
48		3		3	11	14	3	28	31
54				0	1	2		3	3
56		6	2	8	1	5	2	8	16
60				0		1		1	1
64		2		2		2		2	4
66				0	2	1		3	3
72	3			3	2	3	1	6	9
80				0		4		4	4
88		2		2	2	1	4	7	9
100	2		2	4	1	5		6	10
Total	**7**	**13**	**8**	**28**	**53**	**103**	**27**	**183**	**211**

7.8 DISTRUBUTION NETWORK AND SERVICE CONNECTION

7.8.1 Proposed Distribution Network and Service Connection

(1) Trunk Distribution Mains

The existing water trunk mains as listed in **Table 78.1.1** are proposed to be used as trunk distribution mains for future water supply system, except the trunk mains between NEK New F/P and University Reservoir and NEK Old and Mangopir P/S (NEK Hub Main) which will be used as the water transmission mains. At present the KW&SB use these water trunk mains mainly as transmission mains from filtration plants to reservoirs or trunk distribution mains. In future proposed system these water trunk mains will be mainly used as trunk distribution mains from reservoirs, since they already have many brunch connections.

In addition some large diametre's pipelines of the existing distribution pipes shown in **Table 78.1.2** will be used as the trunk distribution mains.

Table 78.1.1 Existing Water Trunk Mains

Diametre		Length
in	mm	(m)
12	300	5,720
15	375	4,266
18	450	36,106
24	600	72,268
32	800	27
33	825	77,235
36	900	15,311
40	1,000	2,644
42	1,050	2,631
48	1,200	88,113
54	1,350	39,667
64	1,600	6,112
66	1,650	30,960
72	1,800	13,693
84	2,100	10,409
Total		405,163

*Source: KW&SB

Table 78.1.2 Existing Distribution Pipes

Diametre		Length
in	mm	(km)
3	75	1,636.2
4	100	1,531.9
5	125	60.0
6	150	609.0
8	200	199.0
9	225	34.6
10	250	130.6
12	300	317.0
15	375	107.1
16	400	20.1
18	450	96.8
21	525	1.0
24	600	58.1
27	675	5.2
30	750	2.5
33	825	25.2
36	900	6.3
48	1,200	8.9
54	1,350	3.0
60	1,500	2.0
Total		4,854.4

*Source: KW&SB

The proportions of PRCC pipes used in the existing water trunk mains are more than 80 %. Therefore the study recommend that the existing trunk mains to be used as the trunk distribution mains are replaced with steel pipes or ductile cast iron pipes for future system. Because in general steel pipes and ductile cast iron pipes are widely used for pressured and treated water pipeline of large diametres (300 mm and more) in other countries. PRCC has disadvantages of workability, difficulty of field modifications due to differing site conditions and difficulty of repairs for leakages and damages.

Total length of trunk distribution mains required for future water supply system in 2025 is about 1,600 km as listed in **Tables 78.1.3** and **78.1.4** including about 685 km of the existing water trunk mains and parts of large diametres of distribution mains.

Table 78.1.3 Proposed Trunk Distribution Mains (1/2)

Zone	Supply Area	Type	Year	Dia. (in)	Length (m)
West	**HUB**	Replacement of Existing Pipeline	**2016**	14	11,321
				16	9,949
				18	15,563
				24	20,925
				32	26,626
				36	4,249
				48	25,265
				64	10,363
			Existing-Total		124,262
		Installation of Proposed Pipeline	**2016**	18	2,967
				24	5,078
				32	2,039
				36	4,014
				48	84
				Sub-Total	14,183
			2021	14	74,028
				16	2,908
				18	6,323
				24	4,558
				Sub-Total	87,817
			2025	14	27,673
				18	559
				28	1,407
				Sub-Total	29,639
			Proposed-Total		131,638
				Area-Total	**357,899**
	West	Installation of Proposed Pipeline	**2025**	14	91,484
				18	784
				24	1,585
				36	452
				48	2,318
				56	14
				72	753
				88	32,547
			Proposed-Total		129,937
				Area-Total	**129,937**
	W01	Installation of Proposed Pipeline	**2016**	14	10,091
				32	3,328
				Sub-Total	13,419
			2021	14	11,999
				18	2,620
				20	4,492
				24	5,683
				28	3,294
				Sub-Total	28,088
			Proposed-Total		41,507
				Area-Total	**41,507**
	NEK Old	Replacement of Existing Pipeline	**2016**	14	11,018
				16	4,965
				18	15,258
				24	16,513
				32	6,579
				48	25,716
				56	985
			Existing-Total		81,035
		Installation of Proposed Pipeline	**2016**	16	442
				18	2,870
				24	1,916
				28	89
				32	13
				36	3,121
				48	1,823
				56	3,829
				64	34
				72	2,198
				88	2,316
				100	1,763
			Proposed-Total		20,414
				Area-Total	**101,449**
	Orangi	Installation of Proposed Pipeline	**2025**	14	938
				18	3,291
				24	7,287
				28	10,887
				36	239
				88	8,093
			Proposed-Total		30,735
				Area-Total	**30,735**
	COD	Replacement of Existing Pipeline	**2016**	12	5,680
				14	2,395
				18	31,531
				24	21,316
				32	2,322
				36	11
				48	4,367
			Existing-Total		67,622
		Installation of Proposed Pipeline	**2016**	18	2,908
				24	1,984
				36	15,514
				48	5,946
				56	4,067
				Sub-Total	30,420
			2021	14	11,279
				16	6,771
				36	3,058
				Sub-Total	21,107
			Proposed-Total		51,527
				Area-Total	**119,149**

Zone	Supply Area	Type	Year	Dia. (in)	Length (m)
West		Replacement of Existing Pipeline		12	5,680
				14	24,735
				16	14,914
				18	62,353
				24	58,754
				32	35,527
				36	4,260
				48	55,348
				56	985
				64	10,363
			Exisitng Zone-Total		272,918
		Installation of Proposed Pipeline		14	227,491
				16	10,121
				18	22,322
				20	4,492
				24	28,091
				28	15,676
				32	5,379
				36	26,398
				48	10,171
				56	7,911
				64	34
				72	2,951
				88	42,957
				100	1,763
			Proposed Zone-Total		405,760
			Zone-Total		**678,678**
East	**Gharo**	Installation of Proposed Pipeline	**2016**	88	25,151
				-	-
			Proposed-Total		25,151
				Area-Total	
	Pipri	Replacement of Existing Pipeline	**2025**	12	5,769
				14	43,610
				18	12,410
				24	13,062
				32	26,203
				48	25,283
				56	18,791
				64	5,988
				72	2,220
			Existing-Total		153,335
		Installation of Proposed Pipeline	**2021**	14	8,312
				18	1,266
				24	4,373
				48	2,138
				56	2,639
				64	11,680
				72	9,714
				88	13,859
				Sub-Total	53,980
			2025	14	23,948
				18	444
				20	629
				28	1,239
				Sub-Total	26,259
			Proposed-Total		80,239
				Area-Total	**80,239**
	East	Installation of Proposed Pipeline	**2021**	14	8,903
				-	-
			Proposed-Total		8,903
				Area-Total	**8,903**
	E01	Installation of Proposed Pipeline	**2021**	14	1,815
				18	5,234
				32	3,616
				36	6,193
				56	4,923
			Proposed-Total		21,781
				Area-Total	**21,781**
	E02	Installation of Proposed Pipeline	**2025**	24	8,821
				-	-
			Proposed-Total		8,821
				Area-Total	**8,821**
	E03	Installation of Proposed Pipeline	**2025**	18	7,057
				-	-
			Proposed-Total		7,057
				Area-Total	**7,057**
		Replacement of Existing Pipeline		12	5,769
				14	43,610
				18	12,410
				24	13,062
				32	26,203
				48	25,283
				56	18,791
				64	5,988
				72	2,220
			Exisitng Zone-Total		153,335
		Installation of Proposed Pipeline		14	42,978
				18	14,001
				20	629
				24	13,194
				28	1,239
				32	3,616
				36	6,193
				48	2,138
				56	7,561
				64	11,680
				72	9,714
				88	39,010
			Proposed Zone-Total		151,951
			Zone-Total		**305,286**

Table 78.1.4 Proposed Trunk Distribution Mains (2/2)

Zone	Supply Area	Type	Year	Dia. (in)	Length (m)
Central	NEK Old	Replacement of Existing Pipeline	2021	14	2,116
				18	35,771
				24	8,064
				32	7,200
				36	12,170
				56	3,666
				64	4,177
			Existing-Total		73,164
		Installation of Proposed Pipeline	2016	18	12,457
				24	3,390
				32	9,033
				36	1,959
				48	1,747
				56	1,972
				72	2,193
				80	975
				100	17,994
				Sub-Total	51,720
			2021	14	20,284
				18	2,635
				24	2,477
				36	1,759
				48	8,429
				Sub-Total	35,584
			2025	14	23,841
				Sub-Total	23,841
			Proposed-Total		111,144
				Area-Total	184,309
	COD	Replacement of Existing Pipeline	2021	12	9,615
				14	10,029
				18	21,847
				20	2,579
				24	42,290
				28	4,423
				32	12,974
				36	1,915
				48	11,496
				56	4,806
				60	1,666
				64	4,662
				72	1,278
			Existing-Total		129,579
		Installation of Proposed Pipeline	2016	14	1,143
				16	1,750
				18	3,066
				24	4,970
				28	1,667
				36	2,082
				48	8,070
				56	4,912
				72	4,829
				80	6,840
				100	1,040
				Sub-Total	40,368
			2021	14	5,065
				16	2,006
				18	301
				24	2,277
				36	3,343
				Sub-Total	12,992
			2025	14	1,458
				Sub-Total	1,458
			Proposed-Total		54,817
				Area-Total	184,397
	University	Replacement of Existing Pipeline	2021	16	3,468
				18	5,980
				24	14,326
				32	6,873
				36	201
				48	9,114
			Existing-Total		39,962
		Installation of Proposed Pipeline	2016	18	3,818
				24	2,580
				28	713
				32	5,186
				36	3,928
				48	2,209
				56	4,773
				80	1,042
				88	8,054
				Sub-Total	32,302
			2021	14	8,310
				24	1,258
				28	959
				36	1,749
				Sub-Total	12,276
			2025	14	5,315
				18	1,170
				24	565
				Sub-Total	7,050
			Proposed-Total		51,628
				Area-Total	91,590
	HSR	Replacement of Existing Pipeline	2021	12	1,084
				14	5,092
				18	6,469
				24	3,657
				Sub-Total	16,302
		Installation of Proposed Pipeline	2016	14	1,388
				16	6,643
				18	4,591
				20	63
				24	3,003
				28	3,060
				32	4,161
				48	316
				Sub-Total	23,225
			Proposed-Total		23,225
				Area-Total	39,527

Zone	Supply Area	Type	Year	Dia. (in)	Length (m)
Central	C01	Installation of Proposed Pipeline	2016	18	17,207
				24	8,831
				28	3,267
				48	19,212
				56	3,623
				64	5,766
				Sub-Total	57,907
			2021	14	16,490
				18	4,507
				20	1,104
				24	3,140
				28	1,293
				32	8,309
				44	2,728
				Sub-Total	37,570
			2025	14	18,854
				36	8,619
				Sub-Total	27,473
			Proposed-Total		122,949
				Area-Total	122,949
		Replacement of Existing Pipeline		12	10,698
				14	17,237
				16	3,468
				18	70,066
				20	2,579
				24	68,337
				28	4,423
				32	27,047
				36	14,287
				48	20,610
				56	8,473
				60	1,666
				64	8,839
				72	1,278
		Exisitng Zone-Total			259,008
		Installation of Proposed Pipeline		14	102,147
				16	10,399
				18	49,751
				20	1,167
				24	32,490
				28	10,958
				32	26,689
				36	23,439
				44	2,728
				48	39,983
				56	15,279
				64	5,766
				72	7,021
				80	8,858
				88	8,054
				100	19,034
		Proposed Zone-Total			363,764
		Zone-Total			622,772
TOTAL		Replacement of Existing Pipeline		12	22,147
				14	85,581
				16	18,383
				18	144,828
				20	2,579
				24	140,154
				28	4,423
				32	88,776
				36	18,547
				48	101,240
				56	28,249
				60	1,666
				64	25,190
				72	3,498
		Exisitng Total			685,261
		Installation of Proposed Pipeline		14	372,616
				16	20,520
				18	86,074
				20	6,288
				24	73,775
				28	27,874
				32	35,684
				36	56,030
				44	2,728
				48	52,292
				56	30,751
				64	17,480
				72	19,686
				80	8,858
				88	90,021
				100	20,798
		Proposed Total			921,475
				12	22,147
				14	458,198
				16	38,903
				18	230,902
				20	8,867
				24	213,929
				28	32,297
				32	124,460
				36	74,577
				44	2,728
				48	153,532
				56	59,000
				60	1,666
				64	42,670
				72	23,185
				80	8,858
				88	90,021
				100	20,798
		Grand Total			1,606,736

(2) Distribution Network Main and Service Connection

The required length of the new distribution network main that will be installed when the supply area expands or improves was estimated from the length of the existing distribution network main and the existing number of domestic connections, giving a unit length of about 7.3 m per connection. This means 7.3 m of distribution network main is needed to provide one additional service connection. The number of domestic service connections was based on the increase in the population served.

The proposed length of distribution network mains were calculated by multiplying the number of service connections to be installed (which reflects the increase in population served) by the unit pipeline length per connection (which is 7.3 m as mentioned above). **Table 78.1.5** shows the proposed number of service connections and length of distribution network mains.

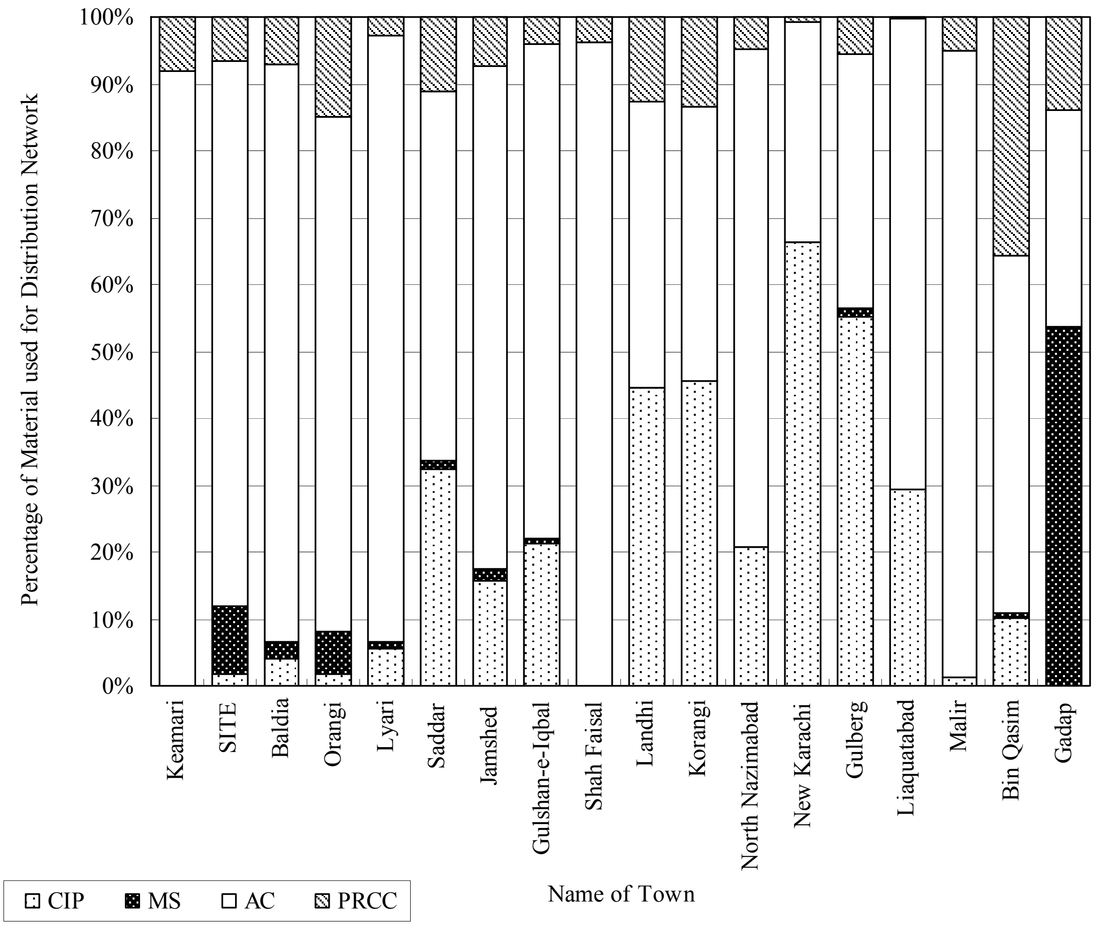
Table 78.1.5 Proposed Number of Service Connections and Length of Distribution Network Mains (incremental basis)

Year	2008	2009	2010	2011	2012	2013	2014
Distribution Network Main (km)	372.0	372.0	372.0	465.9	465.9	465.9	465.9
Number of Service Connection	66,525 (15,729)	66,525 (15,729)	66,525 (15,729)	83,322 (19,701)	83,322 (19,701)	83,322 (19,701)	83,322 (19,701)
Year	2015	2016	2017	2018	2019	2020	2021
Distribution Network Main (km)	465.9	459.5	459.5	459.5	459.5	459.5	459.5
Number of Service Connection	83,322 (19,701)	82,179 (19,430)	82,179 (19,430)	82,179 (19,430)	82,179 (19,430)	82,179 (19,430)	82,179 (19,430)
Year	2022	2023	2024	2025	Total		
Distribution Network Main (km)	459.5	459.5	459.5	459.5	8,040.6		
Number of Service Connection	82,179 (19,430)	82,179 (19,430)	82,179 (19,430)	82,179 (19,430)	1,437,976 (339,993)		

Note: Figures in parenthesis are number of non-domestic service connections.

7.8.2 Rehabilitation of Existing Distribution Network and Service Connection

For rehabilitation of the existing distribution system, the life span of the distribution network mains is estimated at about 50 years. Considering the present water supply service and materials used for distribution network mains as shown in **Figure 78.2.1**, however, it should be necessary to improve the entire present distribution network system. Material mainly used for the existing distribution system is AC pipe (about 65%). It is, therefore, proposed that the existing distribution network mains need to be improved / replaced by a distribution network improvement (DNI) town by town. On the other hand, service connections especially water meters need to be rehabilitated / replaced after at least 10 years because of those life times. It should be noted that even if new service connection is installed, water meter is not installed at area where DNI has not been implemented.



Source: Details of Length Size & Material of Existing Water Distribution Lines, Water Distribution Wing, KW&SB

Figure 78.2.1 Proportions of Materials for Distribution Network Mains

Concept of rehabilitation and replacement of the existing distribution network main and service connection are as follows.

- The existing distribution network mains will be intensively replaced by Distribution Network Improvement (DNI).
- At the same time water meters will be installed to all the existing service connections and service pipes branched from distribution network mains to customers will be also rehabilitated or replaced if necessary.
- Before the implementation of DNI water meters will not be installed not only to the existing connection but also to new connections.
- After the implementation of DNI water meters will be installed at the same time providing new service connections.
- For new residential areas to be developed especially at Keamari, Bin Qasim and Gadap Towns, water meters will be installed at the same time providing new service connections.

And the distribution network improvement (DNI) will may include;

- replacement and rehabilitation of the existing distribution network mains,
- installation of additional distribution network mains if necessary,

- replacement and rehabilitation of service pipes branched from distribution network main to customers,
- installation of water meters,
- replacement and rehabilitation of the existing trunk distribution mains (at present used as water trunk mains) for distribution network if necessary,
- construction of distribution reservoirs if necessary,
- installation of district/sub-district metres, and
- leakage control including leakage survey.

Table 78.2.1 and **Figure 78.2.2** show an implementation schedule of DNI. DNI of towns in zone west is prioritised and proposed to be implemented at stage I from 2012 to 2016 just after the completion of construction of proposed Central F/P (130 mgd). Prioritization of DNI is based on present water supply condition, service ratio, income level of customers and magunitude of the existing distribution network mains.

Table 78.2.1 Implementation Schedule of DNI

No.	Town	Implementation Schedule of DNI													
		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Stage		Stage I, Phase 2			Stage I, Phase 3		Stage II, Phase 2			Stage II, Phase 3		Stage III, Phase 2			
1	Keamari														
	Zone West														
	Zone Central														
2	SITE														
3	Baldia														
4	Orangi														
5	Lyari														
6	Saddar														
7	Jamshed														
8	Gulshan-e-Iqbal														
9	Shah Faisal														
10	Landhi														
11	Korangi														
12	North Nazimabad														
13	New Karachi														
14	Gulberg														
15	Liaquatabad														
16	Malir														
17	Bin Qasim														
18	Gadap														
	Zone West														
	Zone Central														
	Zone East														

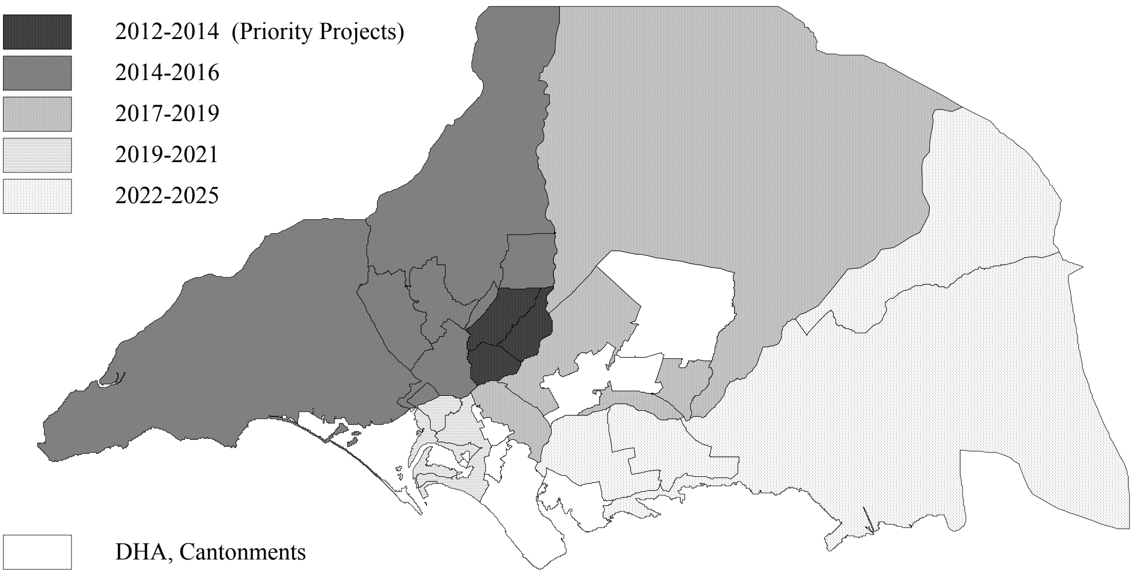


Figure 78.2.2 Implementation Schedule of DNI

Table 78.2.2 shows the number of service connections and length of distribution network mains which will be rehabilitated or replaced during DNI including installation of water meters to the existing service connections. Number of service connection includes the following two kinds of connections;

- existing connections as of 2005
- new connections from 2006 to the commencement of DNI, since before the DNI water meters will not be installed even to new connections

Table 78.2.2 Rehabilitation/Replacement of Service Connections and Distribution Network Mains by DNI (incremental basis)

Year	2008	2009	2010	2011	2012	2013	2014
Distribution Net-work Main (km)	-	-	-	-	273.9	547.9	570.5
Number of Service Connection	-	-	-	-	54,266 (13,060)	108,532 (26,119)	121,479 (26,705)
Year	2015	2016	2017	2018	2019	2020	2021
Distribution Net-work Main (km)	593.1	593.1	438.6	877.2	701.6	526.0	526.0
Number of Service Connection	134,426 (27,291)	134,426 (27,291)	115,170 (23,393)	230,340 (46,786)	179,773 (45,757)	129,206 (44,727)	129,206 (44,727)
Year	2022	2023	2024	2025	Total		
Distribution Net-work Main (km)	97.3	194.7	194.7	194.7	6,329.0		
Number of Service Connection	40,439 (8,164)	80,878 (16,329)	80,878 (16,329)	80,878 (16,329)	1,619,897 (383,006)		

Note: Figures in parenthesis are number of non-domestic service connections.

Table 78.2.3 shows the number of service connections which will be replaced after 10 years and length of distribution network mains which will be rehabilitated as the routine works including repairs of leakage.

Table 78.2.3 Rehabilitation/Replacement of Service Connections and Distribution Network Mains by other than DNI (incremental basis)

Year	2008	2009	2010	2011	2012	2013	2014
Distribution Net-work Mian (km)	69.9	77.4	84.8	92.2	87.1	96.4	91.9
Number of Water meter	-	-	-	-	-	-	-
Year	2015	2016	2017	2018	2019	2020	2021
Distribution Net-work Main (km)	123.2	132.5	156.9	166.1	170.4	214.7	223.9
Number of Water meter	-	26,612 (6,292)	26,612 (6,292)	26,612 (6,292)	26,612 (6,292)	26,612 (6,292)	37,734 (8,922)
Year	2022	2023	2024	2025	Total		
Distribution Net-work Main (km)	251.9	261.1	270.3	279.5	2,850.1		
Number of Water meter	95,637 (22,841)	149,903 (35,901)	174,411 (39,220)	187,358 (39,806)	778,103 (178,150)		

Note: Figures in parenthesis are number of non-domestic service connections.

7.9 SUMMARY OF PLANNING

Tables 79.1.1 and **79.1.2** present a summary of improvement works included in the master plan for the Karachi Water Supply System which are briefly itemised below. **Table 79.1.1** shows the components for bulk water supply system by stages and **Table 79.1.2** shows the components of retail water supply system by zones.

Stage I (2009-2016):

1. Development of Bulk Water Supply System (additional capacity of 130 mgd) including;
   a. Construction of Bulk Water Canal/Conduit (260 mgd),
   b. Construction of 2 Bulk Pumping Stations,
   c. Construction of 3 Filtration Plants of K-III (100 mgd), COD (85 mgd) and K-IV Central (130 mgd),
   d. Construction of 3 Transmission Pumping Stations,
   e. Expansion of Pump Capacity of 2 Transmission Pumping Stations,
   f. Installation of Transmission Mains of 32 km,
   g. Construction of 2 Distribution Reservoirs and
   h. Expansion of 7 Distribution Reservoirs.
2. Improvement of Existing Distribution Network System of Zone West (DNI)
   a. North Nazimabad, Gulberg, Liaquatabad (2012-2014)
   b. Keamari, SITE, Baldia, Orangi, New Karachi, Gadap (2014-2016)
3. Development of New Distribution Network System for New Residential Areas
4. Rehabilitation and Replacement of the Existing Water Supply System

Stage II (2014-2021):

1. Development of Bulk Water Supply System (additional capacity of 260 mgd) including;
   a. Construction of Bulk Water Canal/Conduit (260 mgd),
   b. Construction of 2 Bulk Pumping Stations,
   c. Construction of 2 Filtration Plants of K-IV West and K-IV East (130 mgd each),
   d. Construction of 2 Transmission Pumping Stations,
   e. Expansion of Pump Capacity of 4 Transmission Pumping Stations,
   f. Installation of Transmission Mains of 53 km,
   g. Construction of 4 Distribution Reservoirs and
   h. Expansion of 2 Distribution Reservoirs.
2. Improvement of Existing Distribution Network System of Zone Central (DNI)
   a. Jamshed, Gulshan-e-Iqbal, Shah Faisal, Malir, Gadap (2017-2019)
   b. Keamari, Lyari, Saddar (2019-2021)
3. Development of New Distribution Network System for New Residential Areas
4. Rehabilitation and Replacement of the Existing Water Supply System

Stage III (2019-2025):

1. Development of Bulk Water Supply System (additional capacity of 260 mgd) including;
   a. Construction of Bulk Water Canal/Conduit (260 mgd),
   b. Construction of 2 Bulk Pumping Stations,
   c. Construction of 2 Filtration Plants of K-IV West and K-IV East (130 mgd each),
   d. Construction of 2 Transmission Pumping Stations,
   e. Expansion of Pump Capacity of 6 Transmission Pumping Stations,
   f. Installation of Transmission Mains of 44 km,
   g. Construction of 2 Distribution Reservoirs,
   h. Expansion of 6 Distribution Reservoirs and
   i. Construction of 3 Distribution Pumping Stations.
2. Improvement of Existing Distribution Network System of Zone East (DNI)
   Landhi, Korangi, Bin Qasim, Gadap (2022-2025)

3. Development of New Distribution Network System for New Residential Areas
4. Rehabilitation and Replacement of the Existing Water Supply System

Table 79.1.1 Components of Bulk Water Supply System

Facility		Proposed				Rehabilitation / Replacement of Existing Facilities
	Stage	Stage I	Stage II	Stage III	Total	
	Target Year	2016	2021	2025		
	Construction	2009-2011	2014-2016	2019-2021		
Bulk Water Canal/Conduit		260 mgd	260 mgd	260 mgd	780 mgd	620 mgd
		K-IV	K-IV	K-IV	K-IV	GK, K-II, K-III, Hub
Bulk Pumping Station		2 P/Ss: 3.9MW, 7.1 MW	2 P/Ss: 7.8MW, 14.2 MW	2 P/Ss: 7.8MW, 14.2 MW	6 P/Ss	15 P/Ss
		K-IV	K-IV	K-IV	K-IV	Dhabeiji×6, Gharo×2, Pipri×3, NEK New×3, Hub×1,
Filtration Plant		3 F/Ps: 315 mgd	2 F/Ps: 260 mgd	2 F/Ps: 260 mgd	5 F/Ps: 835 mgd	6 F/Ps: 435 mgd
		K-III: 100 COD: 85 K-IV(C): 130	K-IV(W): 130 K-IV(E): 130	K-IV(W): 130 K-IV(E): 130	K-III: 100 COD: 85 K-IV(W): 260 K-IV(C): 130 K-IV(E): 260	Gharo: 20 Pipri: 100 COD: 115 NEK Old: 25 NEK New: 100 Hub: 75
Transmission Pumping Station		3 P/Ss (2 P/Ss)	2 nos. (4 P/Ss)	2 nos. (6 P/Ss)	7 P/Ss	2 P/Ss
		Central, COD, NEK New (Mangopir, High Lift)	West, East01 (Central, COD, Mangopir, High Lift)	East02, E02 (West, Central, East01, COD, Mangopir, High Lift)	West, Central, East01, East02, COD, NEK New, E02	Mangopir, High Lift
Transmission Main		32 km	53 km	44 km	129 km	17 km
Distribution Reservoir		2 nos. (7 nos.)	4 nos. (2 nos.)	2 nos. (6 nos.)	8 nos.	6 nos. (8 nos.)
		Central, C01 (Hub, COD, NEK Old, NEK New, Univ., Gharo, Pipri)	West, W01, East, E01 (C01, Pipri)	E02,E03 (Orangi, West, W01, C01, Pipri, East)	Central, C01, West, W01, East, E01, E02, E03	Gharo, Pipri, COD, Univ., High S., Orangi (Gharo, Pipri, COD, NEK Old, NEK New, Hub, Univ., Orangi)
Distribution Pumping Station		-	-	3 P/Ss	3 P/Ss	-

Note: Numbers in parenthesis are expansion of capacity.

Table 79.1.2 Components of Retail Water Supply System

Facility	Proposed				Rehabilitation/ Replacement			
Zone	West	Central	East	Total	West	Central	East	Total
Trunk Distribution Main (km)	406	364	152	922	273	259	153	685
Distribution Network Main (km)	2,539	3,152	2,349	8,041	3,751	4,208	1,220	9,179
by DNI	-	-	-	-	2,578	3,069	681	6,329
by other than DNI	-	-	-	-	1,173	1,139	539	2,850
Service Connection (×1,000)	454	564	420	1,438	1,119	900	378	2,398
by DNI	-	-	-		553	784	283	1,620
by other than DNI	-	-	-		566	116	95	778

CHAPTER 8

SEWERAGE MASTER PLAN

8 SEWERAGE MASTER PLAN

8.1 PLANNING FRAMEWORK

8.1.1 Basic Development Policies, Goals and Strategies

(1) Target Year

The target year of the Sewerage Master Plan is 2025 with phased implementation of sewerage projects. The first stage implementation will include priority projects following the adoption of the Master Plan.

(2) Sewerage Development Strategy

The goals of the Master Plan are betterment of living environment and water quality improvement in the Arabian Sea. In order to reach these goals, following strategies are recommended to adopt.

- To implement branch sewers as much as possible to reach better living environment.
- To use nallahs/drains as much as possible as sewage collectors not targeting complete separate system.
- To rehabilitate existing facilities to restore their original function and capacities.
- To treat all the collected sewage with the effluent BOD of less than 80 mg/l.
- To construct new facilities if capacities of rehabilitated/replaced existing facilities are not sufficient to collect and treat generated sewage.

(3) Selection of Service Area / Area of Sewerage Master Plan

The study area is the whole Karachi City consisting of 18 towns. In spite of the Study Area, the Master Plan is to cover only inner 15 towns because detailed information such as possible sites for sewage treatment plants, and actual locations of newly developing colonies in future are not clarified. Besides, it is envisaged that the unit implementation cost for outer 3 towns where there are few sewerage facilities is considerably high. Inner 15 towns are defined as the areas of Karachi City other than outer three towns of Keamari, Gadap and Bin Qasim and include urbanized areas in these three towns adjacent to parts of inner 15 towns. Outer three towns are defined as Keamari, Gadap and Bin Qasim Towns excluding urbanized areas as shown in **Table 81.1.1** and **Figure 81.1.1**.

Table 81.1.1 Towns Comprising Karachi City

			Relevant Towns /Cantonments
Inner 15 Towns **586 km^2**	Towns / Cantonments	Right Bank Side of Lyari River	SITE, Baldia, Orangi, North Nazimabad, New Karachi, Gulberg, Liaquatabad and Malir Towns
		Left Bank Side of Lyari River or Right bank Side of Malir River	Lyari, Saddar, Jamshed, Gulshan-e-Iqbal and Shah Faisal Towns
		Left bank Side of Malir River	Landhi and Korangi Towns
		Cantonments	Karachi, Clifton, Faisal, Malir and Karachi Creek Cantonments
	Other Urbanised Area		Urbanised areas adjacent to above towns in Keamari, Bin Qasim and Gadap Towns
Outer 3 Towns 2,366 km^2			Keamari, Bin Qasim and Gadap Towns (Except above mentioned areas)

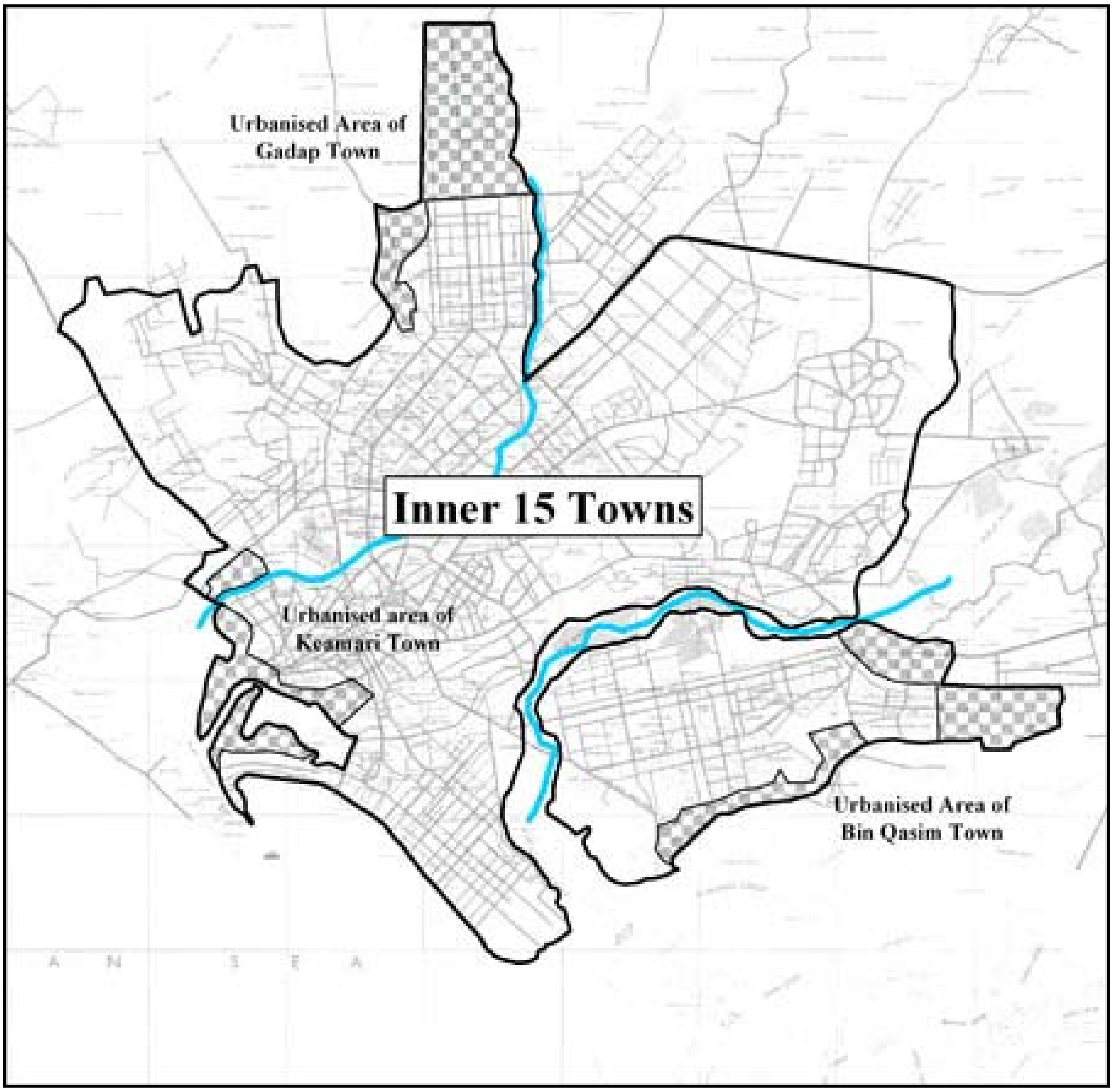


Figure 81.1.1 Schematic of Inner 15 Towns

As for outer three towns, supposing that a number of sewage treatment plants with the capacity of 4.4 mgd (20,000 m^3/d) for each will be constructed step by step taking the urban development in these three towns into account, the cost to implement 36 TPs (total capacity of 720,000 m^3/d to treat the generated sewage of 689,000 m^3/d) and sewers/pumping stations necessary to collect and convey the sewage in these three towns is estimated to be Rs. 85,300 Million. On the other hand, the cost is Rs. 105,300 Million for inner 15 towns. The latter is 23% larger than the former, but the unit cost for the inner 15 towns is Rs. 4,100 per capita which is one-third of the unit cost for the outer three towns of Rs. 12,300 per capita. EIRR (Economic internal return ratio) is calculated for both cases of the sewerage plan with outer three towns and without outer three towns, whose result is shown in **Table 81.1.2**. The EIRR without outer three towns and that with outer three towns are 6.7% and 3.8%, respectively. It is concluded that the sewerage plan without outer three towns is economically viable and hence it is recommended to implemen

Table 81.1.2 IRR of Sewerage Project

	Master Plan Area (km^2)	Population in Area (Person)	Total Base Cost (Million Rs.)	EIRR
Inner 15 towns only	586	25,582,000	105,300	6.7%
Inner 15 towns with Outer 3 towns	2,953	32,506,000	190,600	3.8%

Though sewerage implementation plan in these outer three towns is not included in the Master Plan, once water is supplied in these three towns, sewage is inevitably generated. Generated sewage will sure deteriorate the water environment as well as living environment unless some measures are taken to collect, convey and treat generated sewage. An option to solve the problem is to involve land/housing developers in sewerage facilities implementation and their operation and maintenance. It is recommended that the developers implement inner sewerage facilities such as branch sewers under KW&SB management at the time of land/housing development and add its cost on land/housing price. Concurrent implementation of road, water supply pipe, sewers and other underground structure can reduce the respective construction costs. Even in this case, KW&SB will be responsible for implementing and operating major sewerage facilities such as trunk sewers and sewage treatment plants.

(4) Collection System

1) Separate system will be adopted in principle.
2) Interception of nallahs before flowing into Arabian Sea to convey all the collected sewage to treatment plants
3) Nallahs and drainages are to be used as much as possible as trunk sewers.
4) Extension of Lyari Interceptor up to New Karachi
5) New installation of Malir Interceptors at both sides of Malir River

(5) Handling Non-domestic Sewage (including industrial wastewaters)

1) Industrial wastewaters comprise non-domestic sewage but are not estimated separately from other kinds of non-domestic sewage.
2) Non-domestic sewage generated in respective sewer districts is to flow into respective sewage treatment plants in principle, but toxic matters containing wastewaters are to be excluded unless these matters are removed beforehand.
3) Non-domestic sewage is supposed to have BOD concentration of 250 mg/l when flowing into sewerage facilities based on NEQS.
4) Factories are required to install pre-treatment facilities when and where necessary to meet the effluent standard stipulated in NEQS.

(6) Sewage treatment

1) The treatment level to meet the NEQS, namely effluent BOD of less than 80 mg/l
2) Either High Rate Trickling Filter or Waste Stabilization Pond System is adopted as treatment process in principle. Activated sludge process might be adopted only if the available land for the sewage treatment plant is too small to adopt these two processes.
3) Existing sewage treatment plants are rehabilitated to restore their original function and extended if necessary within respective site areas. New treatment plant(s) might be needed if the total capacities of extended treatment plants are not sufficient to treat the generated sewage in 2025, the target year of the Mater Plan.

8.1.2 Sewage Generation

(1) Future Population

Chapter 6 discusses town-wise future population that is shown in **Table 81.2.1** and population density is shown in **Table 81.2.2**.

Table 81.2.1 Town-wise Future Population

		Future Population (Person)				
		2006	2011	2016	2021	2025
1	Keamari					
	Urbanized Area 1	82,095	86,720	92,264	98,740	103,920
	Urbanized Area 2	208,096	216,048	225,580	236,714	245,622
	Urbanized Area 3	137,127	140,866	145,349	150,585	154,773
	Sub-Total	427,318	443,634	463,193	486,039	504,315
2	SITE	720,068	772,637	835,651	909,249	968,127
3	Baldia	643,782	784,294	952,723	1,149,444	1,306,821
4	Orangi	1,116,962	1,210,963	1,323,641	1,455,246	1,560,530
5	Lyari	925,708	938,854	954,611	973,016	987,740
6	Saddar	945,829	999,117	1,062,994	1,137,600	1,197,285
7	Jamshed	1,138,680	1,265,611	1,417,763	1,595,471	1,737,637
8	Gulshan-e-Iqbal	1,027,454	1,433,010	1,919,145	2,486,936	2,941,169
9	Shah Faisal	515,508	544,553	579,368	620,031	652,561
10	Landhi	1,056,812	1,287,471	1,563,960	1,886,890	2,145,234
11	Korangi	884,428	1,168,020	1,507,959	1,904,997	2,222,627
12	North Nazimabad	765,820	830,191	907,352	997,474	1,069,572
13	New Karachi	1,050,261	1,109,433	1,180,363	1,263,207	1,329,482
14	Gulberg	699,910	758,741	829,261	911,627	977,520
15	Liaquatabad	988,284	1,002,318	1,019,141	1,038,790	1,054,509
16	Malir	621,348	707,465	810,692	931,258	1,027,711
17	Bin Qasim					
	Urbanized Area 1	449,683	593,860	766,690	968,574	1,130,053
18	Gadap					
	Urbanized Area 1	135,765	143,415	152,584	163,293	171,860
	Urbanized Area 2	178,458	226,217	300,850	429,286	677,714
	Sub-Total	314,223	369,632	453,434	592,579	849,574
	Sub-Total	14,292,078	16,219,804	18,547,941	21,308,428	23,662,467
19	Cantonment					
	Karachi Cantonment	22,067	28,025	35,166	43,507	50,180
	Clifton Cantonnment	13,240	16,815	21,100	26,104	30,108
	Faisal Cantonment	130,931	166,281	208,654	258,144	297,737
	Malir Cantonment	276,083	350,622	439,970	544,327	627,812
	Korangi Creek Cantonment	48,058	61,031	76,585	94,751	109,282
	Sub-Total	490,379	622,774	781,475	966,833	1,115,119
20	Defence	396,252	482,737	586,407	707,490	804,356
	Sub-Total	886,631	1,105,511	1,367,882	1,674,323	1,919,475
	Total	15,178,709	17,325,315	19,915,823	22,982,751	25,581,942

	Future Population (Person)				
	2006	2011	2016	2021	2025
Inner 15 Towns and Urbanised	14,292,078	16,219,804	18,547,941	21,308,428	23,662,467
Cantonments	490,379	622,774	781,475	966,833	1,115,119
Defence	396,252	482,737	586,407	707,490	804,356
Total	15,178,709	17,325,315	19,915,823	22,982,751	25,581,942

Note:
(1) See **Section 6.1** for details about population projection
(2) Area of Keamari Town, Bin-Qasim Town and Gadap Town shows inhabitable one out of the total areas.
(3) ”Urbanised area” shows the areas of Keamari Town, Bin-Qasim Town and Gadap Town adjacent to inner 15 towns and to be sewered along with inner 15 towns. For the location of “Urbanised Area”, refer to **Figure 81.2.1**.

Table 81.2.2 Town-wise Area and Population Density

		Area (km^2)	Population Density (Person/ha)				
			2006	2011	2016	2021	2025
1	Keamari						
	Urbanized Area 1	2.5	328	347	369	395	416
	Urbanized Area 2	7.8	267	277	289	303	315
	Urbanized Area 3	3.9	352	361	373	386	397
2	SITE	25.4	283	304	329	358	381
3	Baldia	29.2	220	269	326	394	448
4	Orangi	23.5	475	515	563	619	664
5	Lyari	8.0	1,157	1,174	1,193	1,216	1,235
6	Saddar	24.1	392	415	441	472	497
7	Jamshed	23.4	487	541	606	682	743
8	Gulshan-e-Iqbal	53.7	191	267	357	463	548
9	Shah Faisal	11.7	441	465	495	530	558
10	Landhi	39.1	270	329	400	483	549
11	Korangi	41.5	213	281	363	459	536
12	North Nazimabad	16.7	459	497	543	597	640
13	New Karachi	20.5	512	541	576	616	649
14	Gulberg	13.8	507	550	601	661	708
15	Liaquatabad	10.9	907	920	935	953	967
16	Malir	17.8	349	397	455	523	577
17	Bin Qasim						
	Urbanized Area 1	21.1	213	281	363	459	536
18	Gadap						
	Urbanized Area 1	5.3	256	271	288	308	324
	Urbanized Area 2	20.9	85	108	144	205	324
19	Cantonment						
	Karachi Cantonment	5.7	39	49	62	76	88
	Clifton Cantonnment	3.4	39	49	62	77	89
	Faisal Cantonment	33.9	39	49	62	76	88
	Malir Cantonment	71.4	39	49	62	76	88
	Korangi Creek Cantonment	12.4	39	49	62	76	88
	Total	126.8	39	49	62	76	88
20	Defence	38.3	103	126	153	185	210
Overall		585.9	259	296	340	392	437

	Area (km^2)	Population Density (Person/ha)				
		2006	2011	2016	2021	2025
Inner 15 Towns and Urbanised Area	420.8	340	385	441	506	562
Cantonments	126.8	39	49	62	76	88
Defence	38.3	103	126	153	185	210
Overall	585.9	259	296	340	392	437

Note:
Population density in 2025
- Overall population density of 562 persons per hectare for inner 15 towns and urbanized parts of outer 3 towns
- Though the population density of Cantonment is not so high compared with other areas but its area is already sewered.
- Defence (DHA) currently has some areas to develop but they are expected to be developed and the population density will be 210 persons per hectare.

Figure 81.2.1 shows urbanised areas of outer 3 towns to be included in sewerage system in inner 15 towns.

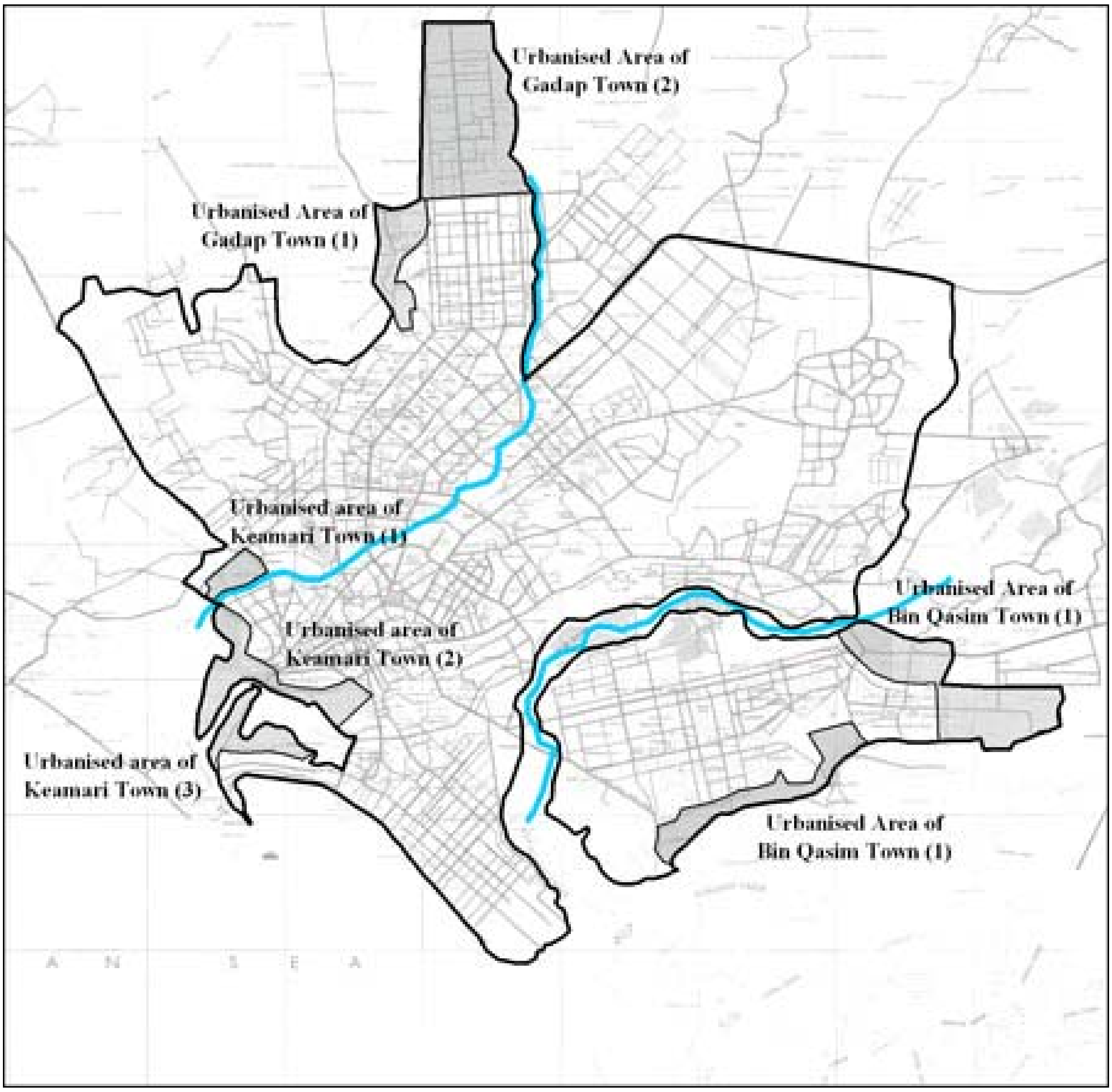


Figure 81.2.1 Urbanised Area of Outer 3 Towns

(2) Coverage Rate (or connection rate)

Present town-wise branch sewer coverage rate is assumed based on the estimated road lengths and interviews to KW&SB and it is summarized in **Table 81.2.3.**

Table 81.2.3 Town-wise Branch Sewer Coverage Rate

		Area (km^2)	Road Density (m/ha)	Road Length (km)	Existing Sewer Length (km)	Coverage Rate	Adopted Coverage Rate	Remarks
1	Keamari (Urbanised Area 1)	2.5	170	43	No data		25%	SITE
	Keamari (Urbanised Area 2)	7.8	170	133			70%	Saddar
	Keamari (Urbanised Area 3)	3.9	170	66			70%	Saddar
2	SITE	25.4	170	432	115.4	26.7%	25%	
3	Baldia	29.2	170	496	41.3	8.3%	10%	
4	Orangi	23.5	270	635	36.9	5.8%	10%	
5	Lyari	8.0	270	216	68.7	31.8%	40%	
6	Saddar	24.1	270	651	72.3	11.1%	70%	Jamshed
7	Jamshed	23.4	270	632	459.7	72.7%	70%	
8	Gulshan-e-Iqbal	53.7	170	913	164.0	18.0%	15%	
9	Shah Faisal	11.7	270	316	68.8	21.8%	20%	
10	Landhi	39.1	170	665	110.7	16.6%	20%	
11	Korangi	41.5	170	706	276.2	39.1%	50%	
12	North Nazimabad	16.7	270	451	396.9	88.0%	90%	
13	New Karachi	20.5	270	554	302.1	54.5%	50%	
14	Gulberg	13.8	270	373	487.1	130.6%	90%	
15	Liaquatabad	10.9	270	294	255.8	87.0%	90%	
16	Malir	17.8	270	481	146.1	30.4%	35%	
17	Bin Qasim (Urbanised Area 1)	21.1	170	359	No data		20%	Landhi
18	Gadap (Urbanised Area 1)	5.3	170	90	No data		50%	New Karachi
	Gadap (Urbanised Area 2)	20.9	170	355			10%	Orangi
19	Cantonment	126.8	90	1,141	No data		90%	
20	Defence	38.3	170	651	No data		30%	
	Total / Weighted average	585.9	182	10,653			48%	

Note:
(1) Road densities of 170 and 270 meters per hectare are estimated based on satellite images.
(2) Existing sewer length is obtained from respective engineers in charge.
(3) Since the coverage rate of Saddar town situated in the centre of Karachi City, 11%, is judged too low, and it is assumed to be the same as that of Jamshed town next to it.
(4) Little data is available on coverage rates of outer 3 towns, and it is assumed coverage rates of urbanised areas are supposed to be the same as those of respective neighbouring towns as described in Remarks.

Coverage rate is expected to be 100% by the target year of 2025 until which it is supposed to linearly increase. **Table 81.2.4** summarizes the trend of coverage rates of respective towns towards the target year of 2025. Present coverage rates of Cantonment and Defence are 90% and 30% and those in 2025 will be 100%, respectively.

House connections will be constructed gradually where branch sewers are implemented but flow rates to pumping stations and sewage treatment plants are estimated supposing that service connections will be completed where the area is sewered.

Table 81.2.4 Future Sewer Coverage Rate

		Area (km^2)	Futura Coverage Rate				
			2006	2011	2016	2021	2025
1	Keamari (Urbanised Area 1)	2.5	25%	45%	64%	84%	100%
	Keamari (Urbanised Area 2)	7.8	70%	78%	86%	94%	100%
	Keamari (Urbanised Area 3)	3.9	70%	78%	86%	94%	100%
2	SITE	25.4	25%	45%	64%	84%	100%
3	Baldia	29.2	10%	34%	57%	81%	100%
4	Orangi	23.5	10%	34%	57%	81%	100%
5	Lyari	8.0	40%	56%	72%	87%	100%
6	Saddar	24.1	70%	78%	86%	94%	100%
7	Jamshed	23.4	70%	78%	86%	94%	100%
8	Gulshan-e-Iqbal	53.7	15%	37%	60%	82%	100%
9	Shah Faisal	11.7	20%	41%	62%	83%	100%
10	Landhi	39.1	20%	41%	62%	83%	100%
11	Korangi	41.5	50%	63%	76%	89%	100%
12	North Nazimabad	16.7	90%	93%	100%	100%	100%
13	New Karachi	20.5	50%	63%	76%	89%	100%
14	Gulberg	13.8	90%	93%	100%	100%	100%
15	Liaquatabad	10.9	90%	93%	100%	100%	100%
16	Malir	17.8	35%	52%	69%	86%	100%
17	Bin Qasim (Urbanised Area 1)	21.1	20%	41%	62%	83%	100%
18	Gadap (Urbanised Area 1)	5.3	50%	63%	76%	89%	100%
	Gadap (Urbanised Area 2)	20.9	10%	34%	57%	81%	100%
19	Cantonment	126.8	90%	90%	90%	90%	100%
20	Defence	38.3	30%	30%	30%	65%	100%
	Weighted Average	585.9	48%	60%	72%	86%	100%

(3) Population in Sewerage Service Area

Town wise population in sewerage service area, or sewered population, is computed by multiplying the future population shown in **Table 81.2.1** and the future sewer coverage rate shown in **Table 81.2.4**, whose result is summarized in **Table 81.2.5**.

Table 81.2.5 Town-wise Future Population in Sewerage Service Area

		Future Population in Sewer Service Area (Person)				
		2006	2011	2016	2021	2025
1	Keamari					
	Urbanized Area 1	20,524	38,796	59,486	83,149	103,920
	Urbanized Area 2	145,667	168,290	193,524	221,764	245,622
	Urbanized Area 3	95,989	109,727	124,694	141,074	154,773
	Sub-Total	262,180	316,813	377,704	445,987	504,315
2	SITE	180,017	345,653	538,775	765,683	968,127
3	Baldia	64,378	264,183	546,562	931,655	1,306,821
4	Orangi	111,696	407,903	759,352	1,179,515	1,560,530
5	Lyari	370,283	523,782	683,301	850,109	987,740
6	Saddar	662,080	778,260	911,937	1,065,752	1,197,285
7	Jamshed	797,076	985,844	1,216,291	1,494,704	1,737,637
8	Gulshan-e-Iqbal	154,118	535,493	1,146,437	2,041,905	2,941,169
9	Shah Faisal	103,102	223,553	359,818	515,605	652,561
10	Landhi	211,362	528,541	971,301	1,569,098	2,145,234
11	Korangi	442,214	737,697	1,150,811	1,704,471	2,222,627
12	North Nazimabad	689,238	769,019	907,352	997,474	1,069,572
13	New Karachi	525,131	700,695	900,803	1,130,238	1,329,482
14	Gulberg	629,919	702,834	829,261	911,627	977,520
15	Liaquatabad	889,456	928,463	1,019,141	1,038,790	1,054,509
16	Malir	217,472	368,627	561,084	803,823	1,027,711
17	Bin Qasim					
	Urbanized Area 1	89,937	243,795	476,155	805,446	1,130,053
18	Gadap					
	Urbanized Area 1	67,883	90,578	116,446	146,104	171,860
	Urbanized Area 2	17,846	76,199	172,593	347,948	677,714
	Sub-Total	85,729	166,777	289,039	494,052	849,574
	Sub-Total	6,485,388	9,527,932	13,645,124	18,745,934	23,662,467
19	Cantonment					
	Karachi Cantonment	19,860	25,223	31,649	39,156	50,180
	Clifton Cantonnment	11,916	15,134	18,990	23,494	30,108
	Faisal Cantonment	117,838	149,653	187,789	232,330	297,737
	Malir Cantonment	248,475	315,560	395,973	489,894	627,812
	Korangi Creek Cantonment	43,252	54,928	68,927	85,276	109,282
	Sub-Total	441,341	560,498	703,328	870,150	1,115,119
20	Defence	118,876	144,821	175,922	459,869	804,356
	Sub-Total	560,217	705,319	879,250	1,330,019	1,919,475
	Total	7,045,605	10,233,251	14,524,374	20,075,953	25,581,942

	Future Population in Sewer Service Area (Person)				
	2006	2011	2016	2021	2025
Inner 15 Towns and Urbanised	6,485,388	9,527,932	13,645,124	18,745,934	23,662,467
Cantonments	441,341	560,498	703,328	870,150	1,115,119
Defence	118,876	144,821	175,922	459,869	804,356
Total	7,045,605	10,233,251	14,524,374	20,075,953	25,581,942

(4) Per Capita Domestic Water Consumption and Sewage Generation

Per capita water consumption discussed in **Chapter 6** is shown in **Table 81.2.6**.

Table 81.2.6 Per Capita Domestic Water Consumption

		Per Capita Domestic Water Consumption (lpcd)				
		2006	2011	2016	2021	2025
1	Keamari	64.64	64.69	68.85	78.20	85.45
2	SITE	67.50	67.55	71.89	81.65	89.22
3	Baldia	60.29	60.34	64.22	72.94	79.70
4	Orangi	60.29	60.34	64.22	72.94	79.70
5	Lyari	60.29	60.34	64.22	72.94	79.70
6	Saddar	85.80	85.87	91.38	103.80	113.42
7	Jamshed	76.84	76.90	81.84	92.96	101.57
8	Gulshan-e-Iqbal	83.90	83.97	89.36	101.50	110.91
9	Shah Faisal	73.02	73.07	77.77	88.33	96.52
10	Landhi	60.29	60.34	64.22	72.94	79.70
11	Korangi	60.29	60.34	64.22	72.94	79.70
12	North Nazimabad	81.29	81.35	86.58	98.34	107.46
13	New Karachi	60.29	60.34	64.22	72.94	79.70
14	Gulberg	79.42	79.48	84.59	96.08	104.98
15	Liaquatabad	74.18	74.23	79.00	89.73	98.05
16	Malir	65.12	65.17	69.36	78.78	86.08
17	Bin Qasim	66.51	66.56	70.83	80.45	87.91
18	Gadap	60.29	60.34	64.22	72.94	79.70
19	Cantonment	60.29	60.34	64.22	72.94	79.70
20	Defence	135.66	135.76	144.49	164.12	179.33

Note: See **Section 6.2** for detail.

Per capita sewage generation is calculated by multiplying per capita water consumption by return factor. The return factor for per capita water consumption is said to be in the range between 0.6 and 0.8, which is a common practice in Pakistan. The average of the range, 0.7, will be applied in the preparation of the Master Plan. The ratio of 0.7 is applied in Greater Karachi Sewerage Plan (S-III) prepared by KW&SB, too. The ratio will be adopted to non-domestic sewage as well.

No allowance for groundwater infiltration is considered because the groundwater table in Karachi City is generally lower than sewer depth.

Table 81.2.7 Return Factor and Allowance for Groundwater Infiltration

Item	Criteria
Return Factor to Water Consumption	0.7
Allowance for Groundwater Infiltration	No allowance

Domestic sewage generation is calculated by multiplying town-wise population in sewerage service area, per capita domestic water consumption and return factor shown in **Table 81.2.7**. Non-domestic sewage generation is calculated in the same manner. **Table 81.2.8** summarizes calculated domestic sewage generation and non-domestic sewage generation.

Table 81.2.8 Town-wise Sewage Generation

		Domestic Sewage (m^3/d)					Non Domestic Sewage (m^3/d)					Total (m^3/d)				
		2006	2011	2016	2021	2025	2006	2011	2016	2021	2025	2006	2011	2016	2021	2025
1	Keamari															
	Urbanized Area 1	929	1,757	2,867	4,552	6,216	295	679	1,166	1,703	2,143	1,224	2,436	4,033	6,255	8,359
	Urbanized Area 2	6,591	7,621	9,326	12,139	14,691	2,294	3,222	4,149	4,947	5,536	8,885	10,843	13,475	17,086	20,227
	Urbanized Area 3	4,343	4,969	6,009	7,722	9,257	1,381	1,933	2,484	2,951	3,277	5,724	6,902	8,493	10,673	12,534
	Sub-Total	11,863	14,347	18,202	24,413	30,164	3,970	5,834	7,799	9,601	10,956	15,833	20,181	26,001	34,014	41,120
2	SITE	8,505	16,343	27,111	43,764	60,463	9,170	17,363	26,964	39,469	49,864	17,675	33,706	54,075	83,233	110,327
3	Baldia	2,717	11,158	24,569	47,569	72,908	744	3,934	9,348	16,623	23,469	3,461	15,092	33,917	64,192	96,377
4	Orangi	4,714	17,229	34,134	60,224	87,062	958	3,623	6,977	11,507	15,474	5,672	20,852	41,111	71,731	102,536
5	Lyari	15,628	22,123	30,715	43,406	55,106	3,887	5,552	7,365	9,676	11,392	19,515	27,675	38,080	53,082	66,498
6	Saddar	39,765	46,778	58,334	77,436	95,055	63,800	72,487	83,514	100,283	112,409	103,565	119,265	141,848	177,719	207,464
7	Jamshed	42,874	53,068	69,678	97,262	123,548	9,282	12,792	16,996	22,041	25,957	52,156	65,860	86,674	119,303	149,505
8	Gulshan-e-Iqbal	9,052	31,474	71,713	145,080	228,339	5,310	17,961	38,066	70,319	101,609	14,362	49,435	109,779	215,399	329,948
9	Shah Faisal	5,270	11,435	19,587	31,881	44,088	4,453	9,549	15,349	22,702	28,744	9,723	20,984	34,936	54,583	72,832
10	Landhi	8,921	22,324	43,661	80,116	119,683	4,928	11,826	21,322	35,771	49,097	13,849	34,150	64,983	115,887	168,780
11	Korangi	18,664	31,159	51,730	87,028	124,001	12,659	19,983	30,284	46,458	60,725	31,323	51,142	82,014	133,486	184,726
12	North Nazimabad	39,221	43,794	54,991	68,667	80,453	8,341	9,372	11,240	13,120	14,300	47,562	53,166	66,231	81,787	94,753
13	New Karachi	22,164	29,596	40,492	57,708	74,172	4,825	6,541	8,593	11,432	13,658	26,989	36,137	49,085	69,140	87,830
14	Gulberg	35,020	39,104	49,101	61,312	71,836	7,600	8,661	10,478	12,211	13,297	42,620	47,765	59,579	73,523	85,133
15	Liaquatabad	46,183	48,245	56,359	65,250	72,376	10,173	10,468	11,520	12,467	12,864	56,356	58,713	67,879	77,717	85,240
16	Malir	9,914	16,817	27,242	44,330	61,929	17,944	28,463	41,705	61,368	78,269	27,858	45,280	68,947	105,698	140,198
17	Bin Qasim															
	Urbanized Area 1	4,187	11,358	23,609	45,361	69,540	8,027	21,122	40,663	70,607	98,789	12,214	32,480	64,272	115,968	168,329
18	Gadap															
	Urbanized Area 1	2,865	3,826	5,234	7,460	9,588	4,773	10,685	17,557	6,368	5,110	7,638	14,511	22,791	13,828	14,698
	Urbanized Area 2	753	3,218	7,758	17,766	37,810	251	4,793	19,563	13,738	20,150	1,004	8,011	27,321	31,504	57,960
	Sub-Total	3,618	7,044	12,992	25,226	47,398	5,024	15,478	37,120	20,106	25,260	8,642	22,522	50,112	45,332	72,658
	Sub-Total	328,280	473,396	714,220	1,106,033	1,518,121	181,095	281,009	425,303	585,761	746,133	509,375	754,405	1,139,523	1,691,794	2,264,254
19	Cantonment															
	Karachi Cantonment	838	1,065	1,423	1,999	2,800	1,133	1,408	1,752	2,231	2,858	1,971	2,473	3,175	4,230	5,658
	Clifton Cantonnment	503	639	854	1,200	1,680	680	845	1,051	1,339	1,715	1,183	1,484	1,905	2,539	3,395
	Faisal Cantonment	4,973	6,321	8,441	11,862	16,611	6,724	8,356	10,393	13,242	16,953	11,697	14,677	18,834	25,104	33,564
	Malir Cantonment	10,487	13,329	17,799	25,013	35,026	14,180	17,620	21,915	27,922	35,747	24,667	30,949	39,714	52,935	70,773
	Korangi Creek Cantonment	1,825	2,320	3,098	4,354	6,097	2,468	3,067	3,814	4,860	6,223	4,293	5,387	6,912	9,214	12,320
	Sub-Total	18,626	23,674	31,615	44,428	62,214	25,185	31,296	38,925	49,594	63,496	43,811	54,970	70,540	94,022	125,710
20	Defence	11,289	13,763	17,793	52,831	100,969	2,494	2,914	3,476	9,459	16,635	13,783	16,677	21,269	62,290	117,604
	Sub-Total	29,915	37,437	49,408	97,259	163,183	27,679	34,210	42,401	59,053	80,131	57,594	71,647	91,809	156,312	243,314
	Total	358,195	510,833	763,628	1,203,292	1,681,304	208,774	315,219	467,704	644,814	826,264	566,969	826,052	1,231,332	1,848,106	2,507,568

	Domestic Sewage (m^3/d)					Non Domestic Sewage (m^3/d)					Total (m^3/d)				
	2006	2011	2016	2021	2025	2006	2011	2016	2021	2025	2006	2011	2016	2021	2025
Inner 15 Towns and Urbanised	328,280	473,396	714,220	1,106,033	1,518,121	181,095	281,009	425,303	585,761	746,133	509,375	754,405	1,139,523	1,691,794	2,264,254
Cantonments	18,626	23,674	31,615	44,428	62,214	25,185	31,296	38,925	49,594	63,496	43,811	54,970	70,540	94,022	125,710
Defence	11,289	13,763	17,793	52,831	100,969	2,494	2,914	3,476	9,459	16,635	13,783	16,677	21,269	62,290	117,604
Total	358,195	510,833	763,628	1,203,292	1,681,304	208,774	315,219	467,704	644,814	826,264	566,969	826,052	1,231,332	1,848,106	2,507,568

Note: Non-domestic sewage generation is calculated by multiplying non-domestic consumption in service area of each town by the return factor

8.1.3 Quality of Sewage

(1) Quality of Domestic and Non-domestic Sewage

For existing three TPs, sewage generation in litre per capita per day (lpcd) and BOD generation in gram per capita per day (gmcd) are calculated using sewage flow (m^3/d) and influent BOD concentration (mg/l). Per capita sewage generation is obtained by dividing sewage flow by served population and BOD generation is obtained by multiplying influent BOD concentration by sewage generation. The result of the calculation is shown in **Table 81.3.1**. The average BOD generation is calculated to be 50 gmcd.

Table 81.3.1 Design Parametres in Existing Three Treatment Plants

	Treatment Capacity		Served Population	Sewage Generation (lpcd)	Design Influent BOD Concentration (mg/l)	BOD Generation per Capita-day (gmcd)
	(m^3/d)	(mgd)				
TP－1	232,000	51	1,600,000	145	385	56
TP－2	209,000	46	1,600,000	131	365	48
TP－3	245,000	54	2,000,000	123	385	47
Average						50

Source: KW&SB except BOD generation calculated by the Study Team.

Non-domestic sewage including industrial wastewaters is assumed to be treated within their premises to meet the NEQS, BOD of less than 250 mg/l, and discharged to public sewers.

(2) Quality of Domestic and Non-domestic Sewage

Table 81.3.2 shows town-wise BOD loading and **Table 81.3.3** shows overall BOD concentration. For design purpose, the BOD concentration of 600 mg/l in 2025, rounded over of 592 mg/l, will be applied.

For details about population, sewage generation and BOD generation of each town, refer to **Appendix A81.1.**

Table 81.3.2 Town-wise BOD Loading of Sewage

		Domestic Sewage (kg/d)					Non Domestic Sewage (kg/d)					Total (kg/d)				
		2006	2011	2016	2021	2025	2006	2011	2016	2021	2025	2006	2011	2016	2021	2025
1	Keamari															
	Urbanized Area 1	1,026	1,940	2,974	4,157	5,196	74	170	292	426	536	1,100	2,110	3,266	4,583	5,732
	Urbanized Area 2	7,283	8,415	9,676	11,088	12,281	574	806	1,037	1,237	1,384	7,857	9,221	10,713	12,325	13,665
	Urbanized Area 3	4,799	5,486	6,235	7,054	7,739	345	483	621	738	819	5,144	5,969	6,856	7,792	8,558
	Sub-Total	13,108	15,841	18,885	22,299	25,216	993	1,459	1,950	2,401	2,739	14,101	17,300	20,835	24,700	27,955
2	SITE	9,001	17,283	26,939	38,284	48,406	2,293	4,341	6,741	9,867	12,466	11,294	21,624	33,680	48,151	60,872
3	Baldia	3,219	13,209	27,328	46,583	65,341	186	984	2,337	4,156	5,867	3,405	14,193	29,665	50,739	71,208
4	Orangi	5,585	20,395	37,968	58,976	78,027	240	906	1,744	2,877	3,869	5,825	21,301	39,712	61,853	81,896
5	Lyari	18,514	26,189	34,165	42,505	49,387	972	1,388	1,841	2,419	2,848	19,486	27,577	36,006	44,924	52,235
6	Saddar	33,104	38,913	45,597	53,288	59,864	15,950	18,122	20,879	25,071	28,102	49,054	57,035	66,476	78,359	87,966
7	Jamshed	39,854	49,292	60,815	74,735	86,882	2,321	3,198	4,249	5,510	6,489	42,175	52,490	65,064	80,245	93,371
8	Gulshan-e-Iqbal	7,706	26,775	57,322	102,095	147,058	1,328	4,490	9,517	17,580	25,402	9,034	31,265	66,839	119,675	172,460
9	Shah Faisal	5,155	11,178	17,991	25,780	32,628	1,113	2,387	3,837	5,676	7,186	6,268	13,565	21,828	31,456	39,814
10	Landhi	10,568	26,427	48,565	78,455	107,262	1,232	2,957	5,331	8,943	12,274	11,800	29,384	53,896	87,398	119,536
11	Korangi	22,111	36,885	57,541	85,224	111,131	3,165	4,996	7,571	11,615	15,181	25,276	41,881	65,112	96,839	126,312
12	North Nazimabad	34,462	38,451	45,368	49,874	53,479	2,085	2,343	2,810	3,280	3,575	36,547	40,794	48,178	53,154	57,054
13	New Karachi	26,257	35,035	45,040	56,512	66,474	1,206	1,635	2,148	2,858	3,415	27,463	36,670	47,188	59,370	69,889
14	Gulberg	31,496	35,142	41,463	45,581	48,876	1,900	2,165	2,620	3,053	3,324	33,396	37,307	44,083	48,634	52,200
15	Liaquatabad	44,473	46,423	50,957	51,940	52,725	2,543	2,617	2,880	3,117	3,216	47,016	49,040	53,837	55,057	55,941
16	Malir	10,874	18,431	28,054	40,191	51,386	4,486	7,116	10,426	15,342	19,567	15,360	25,547	38,480	55,533	70,953
17	Bin Qasim															
	Urbanized Area 1	4,497	12,190	23,808	40,272	56,503	2,007	5,281	10,166	17,652	24,697	6,504	17,471	33,974	57,924	81,200
18	Gadap															
	Urbanized Area 1	3,394	4,529	5,822	7,305	8,593	1,193	2,671	4,389	1,592	1,278	4,587	7,200	10,211	8,897	9,871
	Urbanized Area 2	892	3,810	8,630	17,397	33,886	63	1,198	4,891	3,435	5,038	955	5,008	13,521	20,832	38,924
	Sub-Total	4,286	8,339	14,452	24,702	42,479	1,256	3,869	9,280	5,027	6,316	5,542	12,208	23,732	29,729	48,795
	Sub-Total	324,270	476,398	682,258	937,296	1,183,124	45,276	70,254	106,327	146,444	186,533	369,546	546,652	788,585	1,083,740	1,369,657
19	Cantonment															
	Karachi Cantonment	993	1,261	1,582	1,958	2,509	283	352	438	558	715	1,276	1,613	2,020	2,516	3,224
	Clifton Cantonnment	596	757	950	1,175	1,505	170	211	263	335	429	766	968	1,213	1,510	1,934
	Faisal Cantonment	5,892	7,483	9,389	11,617	14,887	1,681	2,089	2,598	3,311	4,238	7,573	9,572	11,987	14,928	19,125
	Malir Cantonment	12,424	15,778	19,799	24,495	31,391	3,545	4,405	5,479	6,981	8,937	15,969	20,183	25,278	31,476	40,328
	Korangi Creek Cantonment	2,163	2,746	3,446	4,264	5,464	617	767	954	1,215	1,556	2,780	3,513	4,400	5,479	7,020
	Sub-Total	22,068	28,025	35,166	43,509	55,756	6,296	7,824	9,732	12,400	15,875	28,364	35,849	44,898	55,909	71,631
20	Defence	5,944	7,241	8,796	22,993	40,218	624	729	869	2,365	4,159	6,568	7,970	9,665	25,358	44,377
	Sub-Total	28,012	35,266	43,962	66,502	95,974	6,920	8,553	10,601	14,765	20,034	34,932	43,819	54,563	81,267	116,008
	Total	352,282	511,664	726,220	1,003,798	1,279,098	52,196	78,807	116,928	161,209	206,567	404,478	590,471	843,148	1,165,007	1,485,665

	Domestic Sewage (m^3/d)					Non Domestic Sewage (m^3/d)					Total (m^3/d)				
	2006	2011	2016	2021	2025	2006	2011	2016	2021	2025	2006	2011	2016	2021	2025
Inner 15 Towns and Urbanised	324,270	476,398	682,258	937,296	1,183,124	45,276	70,254	106,327	146,444	186,533	369,546	546,652	788,585	1,083,740	1,369,657
Cantonments	22,068	28,025	35,166	43,509	55,756	6,296	7,824	9,732	12,400	15,875	28,364	35,849	44,898	55,909	71,631
Defence	5,944	7,241	8,796	22,993	40,218	624	729	869	2,365	4,159	6,568	7,970	9,665	25,358	44,377
Total	352,282	511,664	726,220	1,003,798	1,279,098	52,196	78,807	116,928	161,209	206,567	404,478	590,471	843,148	1,165,007	1,485,665

Note:
Per Capita BOD loading: 50 g/capita-d
BOD concentration of non-domestic sewage: 250 mg/l

Table 81.3.3 Quality of Sewage

		2006	2011	2016	2021	2025
Domestic	Quantity (m^3/d)	358,195	510,833	763,628	1,203,292	1,681,304
	BOD Loading (kg/d)	352,282	511,664	726,220	1,003,798	1,279,098
	BOD Concentration (mg/l)	983	1,002	951	834	761
Non Domestic	Quantity (m^3/d)	208,774	315,219	467,704	644,814	826,264
	BOD Loading (kg/d)	52,196	78,807	116,928	161,209	206,567
	BOD Concentration (mg/l)	250	250	250	250	250
Total	Quantity (m^3/d)	566,969	826,052	1,231,332	1,848,106	2,507,568
	BOD Loading (kg/d)	404,478	590,471	843,148	1,165,007	1,485,665
Overall BOD Concentration (mg/l)		713	715	685	630	592

8.1.4 Environmental Quality Standard

Revised National Environmental Quality Standards (NEQS), approved on December 28, 1999 by PEPC (Pakistan Environmental Protection Council), is the latest effluent standard discharged to public water bodies from industrial premises and others. "Effluent" includes treated effluent from sewage treatment plants. Relevant water qualities are shown in **Table 81.4.1**.

Table 81.4.1 Environmental Quality Standard

Parametre	Unit	Standards	
		Into Inland Water	Into Sea
BOD (5 days at 20 degrees C)	mg/l	80	80
COD	mg/l	150	400
Total Suspended Solids	mg/l	200	200
Faecal Coliforms	MPN/100ml	Not applicable	Not applicable

Source: PEPC (Pakistan Environmental Protection Council)

The standards imply that required treatment level is intermediate, not secondary, and that no disinfection is needed.

8.1.5 Design Criteria for Sewerage Facilities

(1) Sewer Network

There are no established design guidelines for sewerage planning in Pakistan. Instead, every consulting firm has its own guidelines for several parametres and applies them in preparing sewerage planning and facility design. Therefore, design criteria for the preliminary design of trunk/branch sewers in this Master Plan are mainly in accordance with Japanese criteria for sewerage facilities design taking the guidelines prepared by the local consulting firms into account. Criteria adopted for design of branch and trunk sewers are shown in **Table 81.5.1**.

Table 81.5.1 Design Criteria for Branch Sewer and Trunk Sewer

Item	Criteria
(1) Design flow	Peak flow (Maximum hourly sewage flow) Peak factor: 1.5
(2) Flow formula Gravity flow	Manning's formula $Q = A\times V$ $V = (1/n)\times R^{(2/3)}\times I^{(1/2)}$ Where Q: Flow rate (m^3/s) A: Flow section (m^2) V: Flow velocity (m/s) n: Roughness coefficient (Manning's n) Manning's n=0.015, for concrete pipe and box culvert R: Hydraulic radius (m) I: Gradient
(3) Depth of flow	Full depth for pipe 90% depth for box culvert
(4) Minimum Velocity	0.8 m/s
(5) Maximum Velocity	3.0 m/s
(6) Diameter of Sewer	Branch Sewer: 10" (254 mm) Sub-main Sewer: 12" to 36" (305 mm to 914 mm) Trunk Sewer: 42" (1000mm) or larger
(7) Pipe materials	Ready-made concrete pipe for gravity sewer Cast iron pipe for pressure main
(8) Diameter of ready-made concrete pipe	For branch sewer 10" (254 mm) For sub-main sewer 12", 15", 18", 24", 27", 33", 36" (305, 381, 457, 610, 686, 838 and 914 mm, respectively) For trunk sewer 42", 48", 54", 66", 72" and 84" (1070, 1220, 1370, 1680, 1830 and 2130 mm, respectively) Concrete pipes of these diameters are produced at a factory in Karachi. Box culvert will be adopted when large diameter of more than 84' is required

Branch sewers and dub-main sewers in the table are defined as ones that collect sewage from houses and other premises and convey the collected sewage to trunk sewers and nallahs/drains that flow into sewage treatment plants with diametres not exceeding around 1,000 mm.

(2) Pumping Station

Pumping stations relevant to trunk sewer line such as Clifton Pumping Station are considered in this Master Plan. Criteria adopted for preliminary design of these pumping stations are shown in **Table 81.5.2.**

Table 81.5.2 Design Criteria for Pumping Station

Item	Criteria
(1) Design flow	Peak flow (Maximum hourly sewage flow) Peak factor: 1.5
(2) Standby pump capacity	50 % of peak flow
(3) Screen facility	Bar screen, spacing of less than 20 mm
(4) Type of pump equipment	Conventional type (NOT submergible type) Pumps are supposed to be installed outside the sump because they are large scale ones.
(5) Constituent of pump equipment	A number of pumps of the same medium capacity will be installed for easier operation/maintenance and extension.
(6) Friction loss at pressure main	Hazen-Williams formula $h = 10.666 \times (Q/C)^{1.85} \times D^{-4.87} \times L$ Where h: Friction loss (m) Q: Flow rate (m^3/s) C: Velocity coefficient (110, for cast iron pipe) D: Pipe diametre (m) L: Pipe length (m)
(7) Specification of pump equipment a) Pump diametre b) Motor power	 $D = 146 \times (Q/V)^{0.5}$ Where D: Pump inlet/outlet diametre (mm) Q: Flow rate (m^3/m) V: Velocity (= 1.5-3.0 m/s) $P = (0.163 \times \gamma \times Q \times H / \eta) \times (1+\alpha)$ Where P: Motor Power (kW) γ: Specific Weight Q: Discharging flow (m^3/s) H: Pump head (m) η: Pump efficiency α: Allowance of motor power

(3) Sewage Treatment Plant

Three existing sewage treatment plants were designed so as to meet the effluent standard of BOD of less than 80 mg/l as stipulated by NEQS. The standard is not always met for the time being. It is needless to say that the current standard has to be met all the time at every sewage treatment plant to begin with until the target year of 2025. Next step might require more stringent effluent standard to restore the beautiful beaches of the Arabian Sea, which will be discussed in the course of the implementation of the Master Plan to propose.

As discussed in **Section 8.1.4**, the effluent standard stipulated by NEQS does not require secondary level for sewage treatment. Intermediate treatment level that gives effluent BOD concentration of less than 80 mg/l will be applied.

Three existing sewage treatment plants have applied either high rate trickling filter process (TP-1 and TP-2) or waste stabilization pond system consisting of anaerobic and facultative ponds (TP-3). When extension and/or replacement of existing plants is needed, the process currently applied will be applied in respective plants within the site area constraints taking the less energy consumption and treatment efficiency of these processes into account. Either of these two processes will be applied to new treatment plants to construct, if any, within the site availability.

Since the influent BOD concentration is calculated to be as high as 600 mg/l in the future, ordinary biological treatment processes need some pre-treatment. Anaerobic pond system is applied in TP-3 prior to facultative pond, but the system cannot be applied to other TPs taking its longer retention time of 1.4 days resulting in large site area requirement into account. Instead, Upflow Anaerobic Sludge Blanket (UASB) system is recommended as pre-treatment facility.

As for TP-1 and TP-2, the present high rate tricking filter facility will be rehabilitated and operated within its life span and treatment facilities will be extended as the sewage flow increases along with the addition of UASB to lower influent BOD. Either high rate trickling filter process or the waste stabilization pond system consisting of anaerobic and facultative ponds will be applied depending on sewage flow and site availability in new and extended treatment plants.

Anaerobic pond or UASB is expected to reduce influent BOD concentration of 600 mg/l to 300 mg/l or the removal efficiency of 50 %. The main part of treatment process of facultative pond or high rate trickling filter is expected to further reduce BOD concentration to 80 mg/l which meets the effluent quality standard stipulated in NEQS.

If the land allotted for a sewage treatment plant site is not large enough to adopt waste stabilization pond system or high rate trickling filter system, activated sludge process might be adopted following the UASB.

Table 81.5.3 summarizes influent/effluent qualities and treatment efficiencies on BOD basis of these processes.

Table 81.5.3 Influent and Effluent Qualities of Three Processes

Name of process	Influent BOD (mg/l) to the process	Effluent BOD (mg/l) to the process	BOD removal efficiency At the process (%)
UASB + High rate trickling filter			
UASB	600	300	50
High rate trickling filter	300	80	74
UASB + Activated Sludge Process			
UASB	600	300	50
Activated Sludge Process	300	80	74
Waste Stabilization Ponds			
Anaerobic pond	600	300	50
Facultative pond	300	80	74

The design criteria of waste stabilization pond, no matter whether it follows anaerobic pond or not, is not fully established and its design will follow the criteria applied to the existing TP-3. As for high rate trickling filter and relevant settling tanks, design guidelines of Japan are referred to in terms of hydraulic loading, BOD volumetric loading and overflow rate.

Table 81.5.4 summarizes design parametres of UASB, high rate trickling filter process (consisting of primary settling tank, trickling filter and secondary settling tank), anaerobic pond and facultative pond.

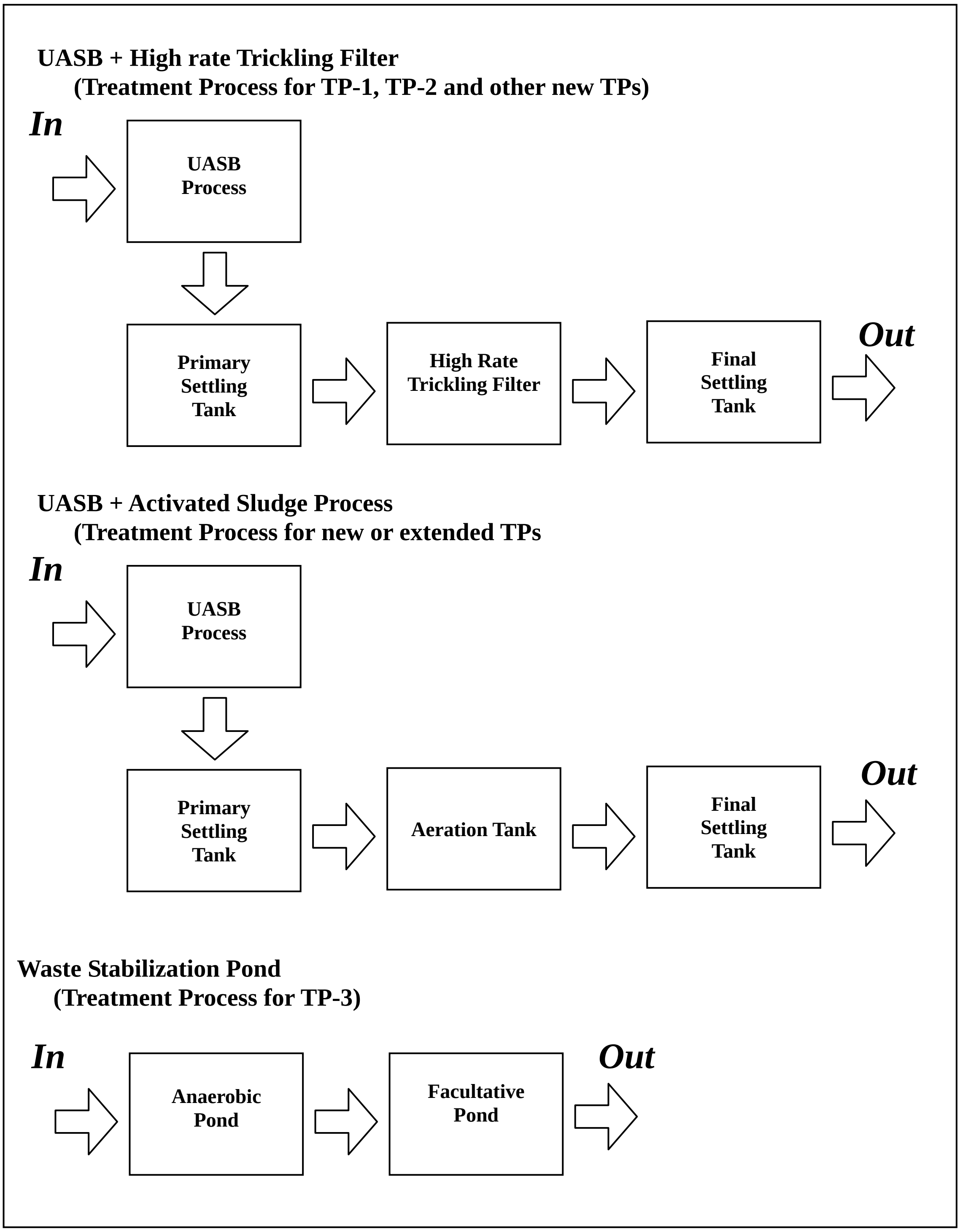


Figure 81.5.1 Schematic of Wastewater Treatment Processes

Table 81.5.4 Design Parametres of Unit Processes of Three Sewage Treatment Processes and Sludge Treatment Process

Name of unit process	Design parametre	Dimension and others
UASB + High Rate Trickling Filter		
UASB	Retention time of 10 hours	Effective water depth of 6 m
Primary settling tank	Overflow rate of 50 $m^3/m^2/d$	Tank diametre of less than 50 m
High rate tricking filter	Hydraulic loading of 15 $m^3/m^2/d$ BOD volumetric loading of 1.2 $kg/m^3/d$	Filter depth of 1.5 m Tank diametre of less than 45 m
Final settling tank	Overflow rate of 30 $m^3/m^2/d$	Tank diametre of less than 50 m
UASB + Activated Sludge Process		
UASB	Retention time of 10 hours	Effective water depth of 6 m
Primary settling tank	Overflow rate of 50 $m^3/m^2/d$	Tank diametre of less than 50 m
Aeration tank	BOD-SS loading of 0.54 kg/kg/d	Tank depth of 6 m
Final settling tank	Overflow rate of 30 $m^3/m^2/d$	Tank diametre of less than 50 m
Waste Stabilization Pond		
Anaerobic pond	Retention time of 1.4 days	Water depth of 2.5 m
Facultative pond	Retention time of 5.5 days	Water depth of 1.5 m
Sludge Treatment		
Sludge thickening tank	Solids loading of 90 $kg/m^2/d$	Retention time of 12 hours
Sludge drying bed	Sludge thickness of 20 cm	Retention time of 14 days
Belt press filter	Filtration rate of 140 kg/m/h	Belt width of 3 m

Based on the above mentioned parametres, the capacity of each of existing TP-1 and TP-2 is evaluated as 24.2 mgd (110,000 m^3/d). For the details about the evaluation, refer to **Appendix A81.2**.

(4) Sludge Disposal

Dewatered or dried sludge is partly sold and used as soil conditioner at present. The amount of sludge will sure increase in the future as the sewage generation increases and collection/treatment ratios increase. Taking the value of sludge as fertilizer and soil conditioner into account, it is recommended to sell dewatered sludge as much as possible. The possible profit obtained by selling sludge might lead to the reduction of operation and maintenance costs of sewage treatment plants. For expected sludge use/disposal site in the future, refer to **Appendix A81.3**.

8.2 ALTERNATIVE STUDY

8.2.1 General

Some alternatives are discussed for sewerage systems for inner 15 towns. The total sewage generation in inner 15 towns in 2025 is estimated to be 552 mgd (2,508,000 m^3/d). Compared with the future possible total capacities of three existing TPs of 102 mgd (465,000 m^3/d), around 450 mgd (2,043,000 m^3/d) of treatment capacity will be deficient. Sludge drying beds and unused lands occupy considerable parts of the site areas in TP-1 and TP-2 among three existing TPs. Making effective use of unused land and the conversion of drying beds to mechanical dewatering equipment will help enhance treatment capacities to a greater extent. Except for the site for TP-4 construction in Korangi Creek Cantonment area, little vacant land is available for TP construction within inner 15 towns.

KW&SB implemented an interceptor at the right bank side of Lyari River and the intercepted sewage is treated at TP-3. Lyari interceptor will be extended up to New Karachi Town in the near future. The plan to construct two new interceptors at the both bank sides of Malir River has been established and it is expected to be implemented in the near future.

Three alternatives for sewer district layout are investigated among which the most appropriate one will be selected as the Master Plan. Schematics of these three alternatives are shown in **Figures 82.1.1** to **82.1.3**, respectively. Sewer networks and magnitude of pumping stations and sewage treatment plants needed to implement respective alternatives are discussed below.

Three alternatives are first evaluated in qualitative terms, and costs for respective alternatives are compared and finally the most appropriate alternative is selected.
Alternatives are arranged taking the following prerequisites and constraints into account.

- Treatment level until 2025 targets effluent BOD concentration of 80 mg/l
- The concept of Lyari Interceptor extension and new installation of Malir Interceptor, proposed in S-III, will be duplicated in the Master Plan.
- Existing drains and nallahs are fully made use of as trunk sewers.
- TP-3 site has no room for extension, whereas both TP-1 and TP-2 sites have some extra space for their extension.
- The site of around 160 ha is assured for the construction of TP-4 in Korangi Creek Cantonment area.
- It is extremely difficult to obtain other sites for sewage treatment plant construction within inner 15 towns.

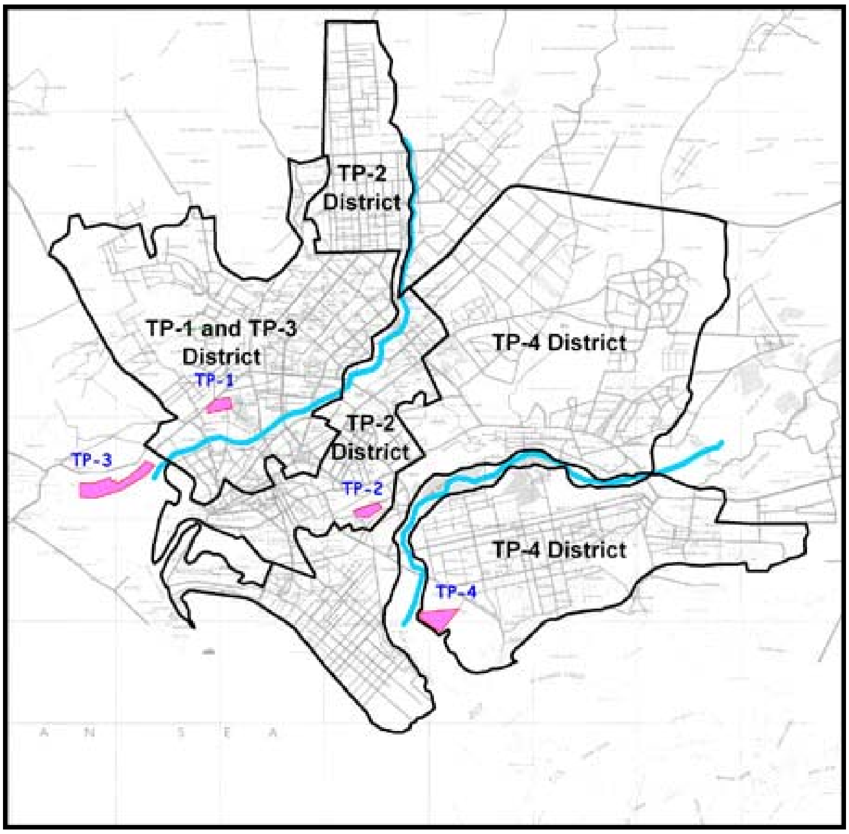


Figure 82.1.1 Schematic of Alternative 1

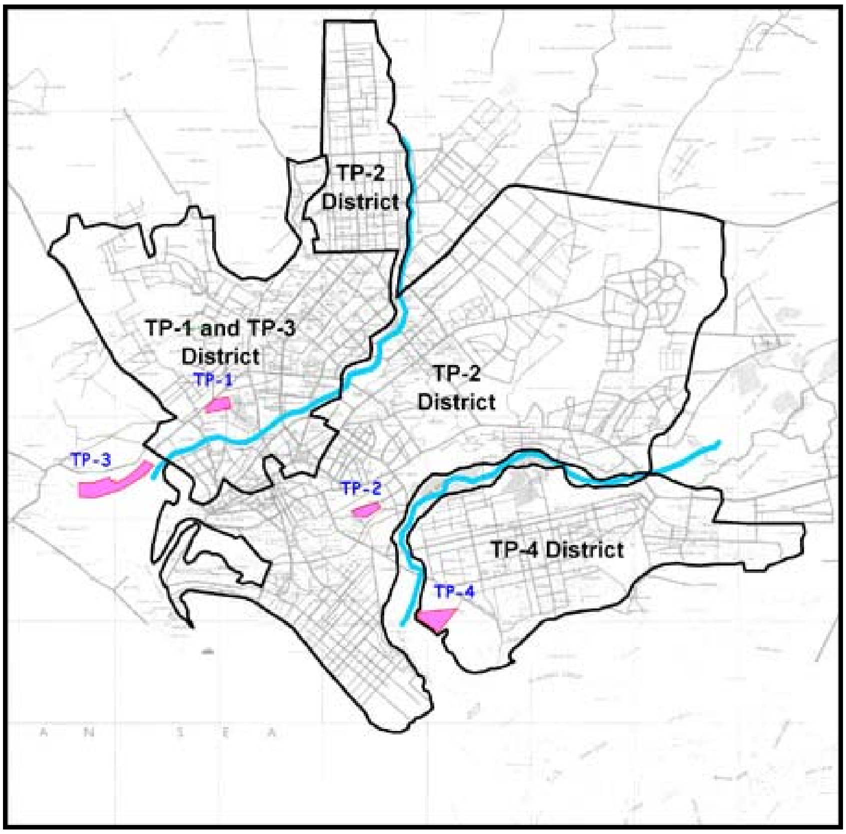


Figure 82.1.2 Schematic of Alternative 2

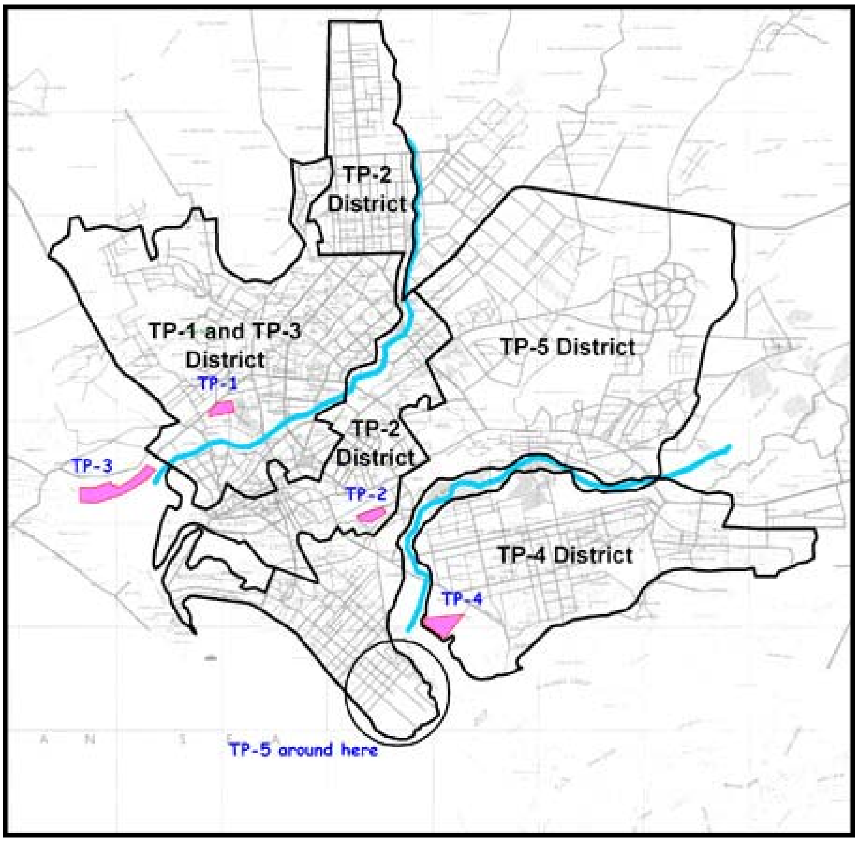


Figure 82.1.3 Schematic of Alternative 3

8.2.2 Description of Alternatives

(1) Alternative 1

Concept

- To cope with the increased amount of sewage through the replacement and extension of existing sewage treatment plants TP-1 and TP-2, and new installation of TP-4.
- To make use of natural configuration of land in which the city is divided by Lyari and Malir Rivers but to allow trunk sewers to cross the river if needed.

Layout

- TP-1 and TP-3 District at the right bank side of Lyari River in principle
- TP-2 District for the upstream area of the right bank side of Lyari River and the down stream area between Lyari and Malir Rivers
- TP-4 District at the upstream of the area between Lyari and Malir Rivers and at the left bank side of Malir River

Trunk Sewer

- Lyari interceptor at the right bank side of Lyari River extended to New Karachi to flow into TP-3
- Newly installed Malir Interceptor at the right bank side of the river flows into TP-4.
- Newly installed Malir Interceptor at the left bank side of the river flows into TP-4.

Pumping Station

- Existing four pumping stations of Jamila, Chakiwara, Clifton, Korangi and new pumping stations at left bank side of Lyari River, within Karachi Port area and at coast side of Bin Qasim Town (common for all the alternatives)

Sewage Treatment Plant

- To replace and extend TP-1 with the capacity of 110 mgd (500,000 m^3/d)
- To replace and extend TP-2 with the capacity of 108 mgd (490,000 m^3/d)
- The capacity of TP-3 will remain the same as the existing one of 54 mgd (245,000 m^3/d)
- To install new sewage treatment plant of TP-4 with the required capacity of 284 mgd (1,290,000 m^3/d)

(2) Alternative 2

Concept

- To cope with the increased amount of sewage through the replacement and extension of existing sewage treatment plants TP-1 and TP-2 including the adoption of area-efficient activated sludge process and new installation of TP-4
- No Malir River crossing

Layout

- TP-1 and TP-3 District: same as Alternative 1
- TP-2 District for the upstream area of the right bank side of Lyari River and the area between Lyari and Malir Rivers
- TP-4 District for the left bank side of Malir River.

Trunk Sewer

- Lyari Interceptor at the right bank side of Lyari River extended to New Karachi will flow into TP-3.
- Newly installed Malir Interceptor at the right bank side of the river flows into TP-2
- Newly installed Malir Interceptor at the left bank side of the river flows into TP-4

Pumping Station

- One new pumping station within DHA area and the other new one in Jamshed Town both connected to TP-2 in addition to common seven pumping stations mentioned in Alternative 1

Sewage Treatment Plant

- To replace and extend TP-1 with the required capacity of 110 mgd (500,000 m^3/d)
- To replace and extend TP-2 with the capacity of 273 mgd (1,240,000 m^3/d)
- TP-3 will remain the same with existing capacity of 54 mgd (245,000 m^3/d)
- To install new TP-4 with the required capacity of 119 mgd (540,000 m^3/d)

(3) Alternative 3

Concept

- To cope with the increased amount of sewage through the replacement and extension of existing sewage treatment plants TP-1 and TP-2, and new installation of TP-4 and TP-5.
- To make use of natural configuration of land in which the city is divided by Lyari and Malir Rivers

Layout

- TP-1 and TP-3 District: same as Alternative 1
- TP-2 District: same as Alternative 1

- TP-4 District for the left bank side of Malir River
- TP-5 District in the area between Lyari and Malir Rivers except TP-2 District area

Trunk Sewer
- Lyari Interceptor at the right bank side of Lyari River extended to New Karachi flows into TP-3.
- Newly installed Malir Interceptor at the right bank side of Malir River to TP-5
- Newly installed Malir Interceptor at the left bank side of Malir River flows into TP-4.

Pumping Station
- Same as Alternative 1

Sewage Treatment Plant
- To replace and extend TP-1 with the required capacity of 110 mgd (500,000 m^3/d)
- To replace and extend TP-2 with the required capacity of 108 mgd (490,000 m^3/d)
- TP-3 will remain the same with existing capacity of 54 mgd (245,000 m^3/d)
- To install new TP-4 with the required capacity of 119 mgd (540,000 m^3/d)
- To install new TP-5 with the required capacity of 167 mgd (760,000 m^3/d)

8.2.3 Comparison of Alternatives

Table 82.3.1 compares all the three alternatives. For details about NPV (Net Present Value) shown in the **Table 82.3.1**, refer to **Appendix A82.1**.

Table 82.3.1 Comparison of Alternatives

		Alternative 1 (RECOMMENDED)	Alternative 2 (TP-2 adopts ASP)	Alternative 3 (Additional TP in DHA area needed)
How to accept increased sewage		To replace and extend existing three sewage treatment plants, TPs-1, 2 and 3 To implement new sewage treatment plant TP-4 in Korangi Creek Cantonment area	To replace and extend existing three sewage treatment plants, TPs-1, 2 and 3 To implement new sewage treatment plant TP-4 in Korangi Creek Cantonment area	To replace and extend existing three sewage treatment plants, TPs-1, 2 and 3 To implement new sewage treatment plants of TP-4 in Korangi Cantonment and TP-5 in the south end of TP-5 District or in the other appropriate site.
Geographical considerations		Malir Interceptor (Right bank) crosses Malir River (TP-4 District) Sewage generated at a part of Lyari River left bank is diverted to TP-1 and TP-3 District crossing Lyari River as it is.	Malir Interceptor (Right bank) is connected to TP-2, not crossing Malir River Sewage generated at a part of Lyari River left bank is diverted to TP-1 and TP-3 District crossing Lyari River as it is.	Malir Interceptor (Right bank) goes to TP-5, not crossing Malir River Sewage generated at a part of Lyari River left bank side is diverted to TP-1 and TP-3 District crossing Lyari River as it is.
District Layout		TP-1 and TP-3 District: Right bank side of Lyari River except New Karachi and Gadap, and some part of left side bank of Lyari River (Catchment of two pumping stations of Jamila and Chakiwara) TP-2 District: New Karachi and Gadap in right bank side of Lyari River and a part of area between Lyari and Malir Rivers TP-4 District: Large part of area between Lyari and Malir Rivers and whole of the left bank of Malir River	TP-1 and TP-3 District: Same as Alternative 1 TP-2 District: New Karachi and Gadap in right bank side of Lyari River and whole of area between Lyari and Malir Rivers TP-4 District: Whole of the left bank of Malir River	TP-1 and TP-3 District: Same as Alternative 1 TP-2 District: Same as Alternative 1 TP-4 District: Whole of the left bank side of Malir River TP-5 District: Area between Lyari and Malir Rivers except area of TP-2 District
Schematic of District Layout		**Figure 82.3.1**	**Figure 82.3.2**	**Figure 82.3.2**
Trunk Sewers /Interceptors/ Pressure Main		Some trunk sewers to TP-1 Trunk sewer from New Karachi to TP-2 Pressure main from Clifton PS to TP-2 Lyari Interceptor (Right) to TP-3 Malir Interceptor (Right) to TP-4 crossing Malir River Malir Interceptor (Left) to TP-4	Some trunk sewers to TP-1 Trunk sewer from New Karachi to TP-2 Pressure main from Clifton PS to TP-2 Lyari Interceptor (Right) to TP-3 Malir Interceptor (Right) to TP-2 Malir Interceptor (Left) to TP-4	Some trunk sewers to TP-1 Trunk sewer from New Karachi to TP-2 Pressure main from Clifton PS to TP-2 Lyari Interceptor (Right) to TP-3 Malir Interceptor (Right) to TP-5 Malir Interceptor (Left) to TP-4
Pumping Stations		TP-1 and TP-3 District: Jamila PS, Chakiwara PS TP-2 District: Iqbal PS, Clifton PS (to TP-2) TP-4 District: Karachi Port PS, Korangi PS, Bin Qasim PS	Same seven pumping stations as Alternative 1 and two pumping stations of Jamshed and DHA Jamshed PS to lift up sewage of Malir Interceptor (Right) to TP-2 DHA PS to lift up sewage of DHA area to Clifton PS	Same seven pumping stations as Alternative 1
Sewage Treatment Plants		TP-1(Existing): Replace and extend to 110 mgd (500,000 m^3/d) TP-2 (Existing): Replace and extend to 108 mgd (490,000 m^3/d) TP-3 (Existing): 54 mgd (245,000 m^3/d) as it is TP-4 (New): Construct new 284 mgd (1,290,000 m^3/d) plant	TP-1(Existing): Replace and extend to 110 mgd (500,000 m^3/d) TP-2 (Existing): Replace and extend to 273 mgd (1,240,000 m^3/d) TP-3 (Existing): 54 mgd (245,000 m^3/d) as it is TP-4 (New): Construct new 119 mgd (540,000 m^3/d)	TP-1(Existing): Replace and extend to 110 mgd (500,000 m^3/d) TP-2 (Existing): Replace and extend to 108 mgd (490,000 m^3/d) TP-3 (Existing): 54 mgd (245,000 m^3/d) as it is TP-4 (New): Construct new 119 mgd (540,000 m^3/d) TP-5 (New): Construct new 167 mgd (750,000 m^3/d)
Evaluation	**General**	**Advantages:** Energy saving process such as HRTF and WSP is adoptable in all four TPs. However, mechanical dewatering is adopted fully in TP-1 and TP-2, and partly in TP-4 due to land constraints. Land acquisition for new sewage treatment plants is not required. **Disadvantages:** Additional stretch crossing Malir River for Malir Interceptor (right) is required to divert sewage to new sewage treatment plant TP-4 located at the opposite side of the River.	**Advantages:** No new trunk sewer crossing Malir Rivers is required. Land acquisition for new sewage treatments plant is not required. **Disadvantages:** More efficient process such as Activated Sludge Process with mechanical dewatering has to be adopted in sewage treatment plant TP-2; because the flow to TP-2 exceeds its maximum capacity of 119 mgd (540,000 m^3/d) if High Rate Trickling Filter is adopted. And additional pumping stations are necessary to lift up sewage of Malir Interceptor (Right)	**Advantages:** Energy saving process such as HRTF and WSP is adoptable in all five TPs. However, mechanical dewatering is adopted fully in TP-1, TP-2 and TP-5 due to land constraint. Amount of sludge to be mechanically dewatered is slightly larger than Alternative 1. **Disadvantages:** Land acquisition for new sewage treatment plant TP-5 located in high-class residential lots of DHA area will require cumbersome procedure as well as long time to settle.
	Environmental and Social Aspects	Land acquisition is needed for three new pumping stations (total area of 1.5 ha.)	Land acquisition is needed for five new pumping stations (total area of 2.5ha.) Number of affected people is larger than in case of Alternative 1. TP-2 adopting activated sludge process consumes lots of energy for its operation, which might lead to high risks of sewage flooding in case of power failure.	Land acquisition is needed for new TP-5 (75 ha) and three new pumping stations (total area of 1.5 ha). Number of affected people is largest among three alternatives.
	Net Present Value (NPV) of Construction and O&M Costs for 30 years	**NPV: Rs. 61,500 Million** Its total construction cost and O&M costs are nearly the same as those of Alternative 3. Hence, its NPV is nearly the same as that of Alternative 3.	**Rs. 69,500 Million** Its total construction cost and O&M cost are the highest among the three alternatives. Especially, construction cost and O&M cost of sewage treatment plant TP-2 which adopts activated sludge process and mechanical dewatering are very high.	**Rs.61,600 Million** Its total construction cost and O&M costs are nearly the same as those of Alternative 1. Hence, its NPV is nearly the same as that of Alternative 1.
Conclusion		Its NPV is nearly the same as that of Alternative 3. Energy intensive and high O&M skill requiring process such as activated sludge process is not adopted. Furthermore, no additional land is required. The alternative is judged technically, economically and environmentally viable and is **recommended**.	Activated sludge process consumes high energy and requires sophisticated operation skills. Power failure might cause health risks. Hence, the alternative is not viable from technical, environmental, social and economic view points.	Its NPV is nearly the same as that of Alternative 1, but land acquisition for new sewage treatment plant of TP-5 is inevitable, which needs long time and troublesome procedures and affects largest population. Hence, this alternative is not viable from technical, procedural, environmental and social view points.

8.2.4 Proposed Sewer District Arrangement

Among three Alternatives of 1, 2 and 3, Alternative 1 is judged to be the most viable one for the following reasons.

- y diverting some flow to TP-2, TP-1 can be extended within its site area.
- By diverting some flow to TP-4, TP-2 can be extended within its site area.
- No additional sewage treatment plant is needed except for TP-4 which is indispensable to treat the sewage at the left bank side of Malir River even if the plant does not receive the diverted flow from TP-2.
- The absence of large scale TP-2 with activated sludge process and related trunk sewers/pumping stations will lead to less construction and O&M costs

It is reviewed how to divert the sewage flow in order to solve the insufficient capacities of TPs taking the following points into account.

・To use existing sewers as much as possible
・To try not to divert the sewage flow generated in the areas where trunk sewers already exist.
・To use nallahs/drains as sewers in the areas of Malir Town, Shah Faisal Town, Malir Cantonment and Faisal Cantonment where there are no trunk sewers.
・To construct new interceptors to intercept the sewage collected through nallahs/drains.
・To construct a new sewage treatment plant, TP-4, at the left bank side of Malir River, according to the result of sewage flow diversion as well as to treat the sewage generated at the left bank side of Malir River.

The sewage is to be diverted as shown in **Table 82.4.1**. **Figure 82.4.1** shows the district arrangement.

Table 82.4.1 Outline of Sewage Diversion

Direction of Diversion	Description	Remarks
Crossing Lyari River	The sewage generated in the areas between Lyari and Malir Rivers, covered by Jamila and Chakiwara pumping stations, is currently diverted to the right bank side of Lyari River, which will continue to be applied. The diverted sewage will be treated at TP-3.	Arrow No.1 in **Figure 82.4.1**
	The sewage generated in New Karachi Town and a part of urbanised area of Gadap Town is conveyed by trunk sewers to the left bank side of Lyari River crossing the River. The diverted sewage will be treated at either TP-2.	Arrow No.2 in **Figure 82.4.1**
Crossing Malir River, From Right Bank Side To Left Bank Side	Malir Interceptor (right bank side) will cross Malir River and the intercepted sewage will be treated at new TP-4.	Arrow No.3 in **Figure 82.4.1**

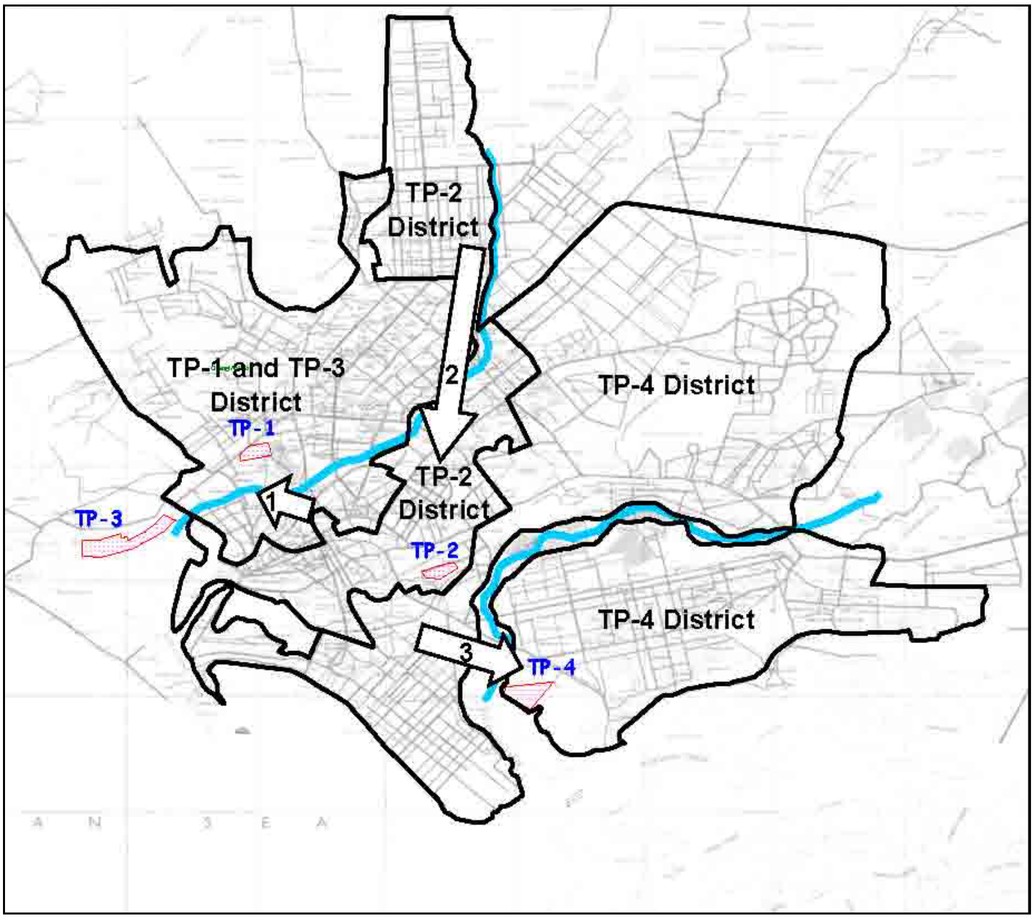


Figure 82.4.1 District Arrangement

New sewer district arrangement established based on above mentioned sewage flow diversion is outlined in **Tables 82.4.2** and **82.4.3**.

Table 82.4.2 Sewer District–wise Populations

	Population (person)				
	2006	2011	2016	2021	2025
TP-1 and TP-3 District	6,522,000	7,015,000	7,606,000	8,297,000	8,849,000
TP-2 District	2,980,000	3,353,000	3,817,000	4,401,000	5,013,000
TP-4 District	5,676,000	6,957,000	8,492,000	10,285,000	11,720,000
Total	15,178,000	17,325,000	19,915,000	22,983,000	25,582,000

	Population in Sewer Service Area (person)				
	2006	2011	2016	2021	2025
TP-1 and TP-3 District	3,314,000	4,435,000	5,906,000	7,458,000	8,849,000
TP-2 District	1,580,000	2,149,000	2,907,000	3,913,000	5,013,000
TP-4 District	2,150,000	3,648,000	5,710,000	8,704,000	11,720,000
Total	7,044,000	10,232,000	14,523,000	20,075,000	25,582,000

Table 82.4.3 Sewer District-wise Sewage Generation in Sewer Service Area

	Domestic Sewage (m^3/d)				
	2006	2011	2016	2021	2025
TP-1 and TP-3 District	172,000	223,800	311,500	439,400	563,500
TP-2 District	79,600	108,400	156,400	239,700	334,200
TP-4 District	106,600	178,600	295,700	524,300	783,600
Total	358,200	510,800	763,600	1,203,400	1,681,300

	Non Domestic Sewage (m^3/d)				
	2006	2011	2016	2021	2025
TP-1 and TP-3 District	58,900	85,800	121,000	145,800	173,800
TP-2 District	45,600	63,800	97,000	117,900	147,300
TP-4 District	104,300	165,700	249,700	381,000	505,200
Total	208,800	315,300	467,700	644,700	826,300

	Total (m^3/d)				
	2006	2011	2016	2021	2025
TP-1 and TP-3 District	230,900	309,600	432,500	585,200	737,300
TP-2 District	125,200	172,200	253,400	357,600	481,500
TP-4 District	210,900	344,300	545,400	905,300	1,288,800
Total	567,000	826,100	1,231,300	1,848,100	2,507,600

For details on population, sewage generation and BOD generation of each Sewer District, refer to **Appendix A82.2.**

8.3 PROPOSED MASTER PLAN

Figure 83.1.1 shows the overall layout of major sewerage facilities of proposed three sewer districts of TP-1/TP-3, TP-2 and TP-4.

8.3.1 TP-1 and TP-3 District

(1) General Description

The TP-1 and TP-3 District stretches both bank sides of Lyari River as shown in **Table 83.1.1** and **Figure 83.1.1**.

Table 83.1.1 Overview of TP-1 and TP-3 District

	Relevant Towns	Remarks
Right bank of Lyari River	Keamari, SITE, Baldia, Orangi, North Nazimabad, Gulberg, Liaquatabad, Gadap	
Left bank of Lyari River	Saddar, Jamshed	Jamila PS catchment, diverted by pressure
	Lyari, Saddar,	Chakiwara PS catchment, diverted by pressure

Note: Small urbanised parts of Keamari Town and Gadap Town will be included in this district

In TP-1 District, sewage is collected by piped sewers and flows into TP-1, while in TP-3 District the sewage is partly collected by piped sewers but flows into nallahs/drains on its way and finally flows into Lyari Interceptor that is connected to TP-3. These two sewer districts are difficult to geographically separate each other and are discussed together in this section.

The districts include all the towns except New Karachi Town and Gadap Town at the right bank side of Lyari River and drainage areas of two pumping stations of Jamila and Chakiwara. The sewerage system in the areas at the left bank side of the River has been planned together with that at the right bank side, whose concept will be followed in the formulation of the Master Plan.

The right bank side of Lyari River includes the industrial zone of SITE as well as the urbanized area having a large population. The drainage areas of Jamila and Chakiwara pumping stations consist of most densely populated areas in Karachi.

Lyari Interceptor was constructed to intercept nallahs/drains flowing into Lyari River. It currently functions as planned conveying intercepted sewage to TP-3. On the other hand, TP-1 receives the sewage collected by piped sewers. The basic concept how to collect and convey collected sewage in these two districts will remain the same in the formulation of the Master Plan.

Covered area, population and sewage generation of TP-1 and TP-3 District are shown in **Table 83.1.2**.

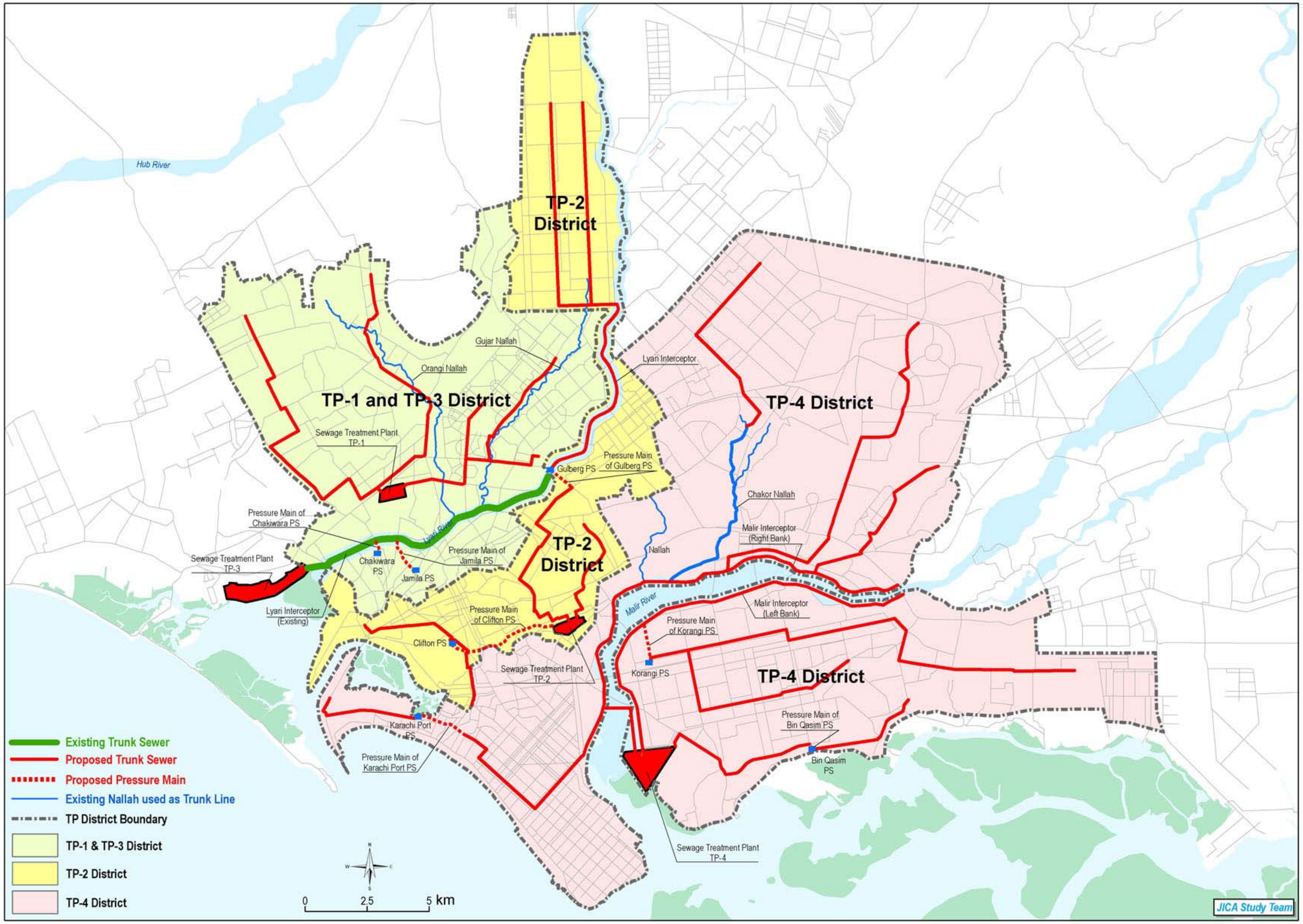


Figure 83.1.1 Layout of Major Sewerage Facilities of TP-1/TP-3, TP-2 and TP-4 Districts

Table 83.1.2 Design Basis of TP-1 and TP-3 District

	District Area (km^2)	Population	Sewage Generation (m^3/d)	Sewage Generation (mgd)
Right Bank Side of Lyari	125.4	7,078,000	585,700	128.9
Left Bank Side of Lyari	19.9	1,771,000	151,600	33.4
Total	145.3	8,849,000	737,300	162.3

(2) Trunk Sewer / Nallah, Drain

Existing two trunk sewers of 54” and 66” diameters are connected to TP-1 collecting the sewage generated in North Nazimabad, Gulberg and Liaquatabad Towns at the right bank side of the River. But, flow capacities of these two existing trunk sewers are not enough for future sewage flow. Therefore, new trunk sewers will be proposed in the Master Plan to relieve them.

Two new trunk sewers are planned in the Master Plan to collect the sewage generated in Orangi and Baldia Towns and convey the collected sewage to TP-1. The sewage generated in the district not covered by these new trunk sewers will flow into Lyari Interceptor via existing nallahs/drains and then finally flow into TP-3.

The existing Lyari Interceptor will be extended northeast to New Karachi Town. In the early stage, before 2021, existing Lyari Interceptor and its extended part convey sewage in New Karachi Town and a part of urbanised Gadap Town to TP-3. After 2021, the sewage should be diverted to the opposite side of Lyari River at the south end of extended part of Lyari Interceptor due to increased sewage generation. Therefore, New Karachi Town and the part of urbanised Gadap Town comprise TP-2 District as shown later. Gujjar Nallah, Orangi Nallah and other drains/nallahs will be intercepted by the Interceptor and the sewage flowing in these nallahs/drains will flow into TP-3. The additional flow from these nallahs/drains can be treated at TP-3 within its present capacity.

At present, TP-1 effluent is discharged to a nearby nallah, but it is needed to construct a pipeline or a channel exclusive for effluent discharge in the future when the flow to TP-1 increases. It is envisaged that the effluent discharge channel will be constructed at the time of first extension of the treatment facilities. The conduit will be double box culvert catering for 500,000 m^3/d of average daily flow with the dimension of 2 m by 2 m for each. It will be 2,100 meters long, be directed to the south passing near PS-s and finally flow into Lyari River.

Table 83.1.3 summarizes trunk sewers in TP-1 and TP-3 Districts.

Table 83.1.3 Outline of Trunk Sewers in TP-1 and TP-3 Districts

	Diameter / Size (inch / mm)	Length (m)	Remarks
A. New Trunk Sewer (Right bank side of Lyari River)			
Conduit	42” to 84”	26,300	
Box Culvert	1750mm x 1750mm x 2	11,300	
Sub-total		37,600	
B. New Trunk Sewer (Left bank side of Lyari River)			
Conduit	42” to 54”	5,200	
Sub-total		5,200	
C. Effluent Discharging Channel of TP-1			
Box Culvert	2000mm x 2000mm x 2	2,100	
Sub-total		2,100	
Total		44,900	

For flow calculation of trunk sewers, refer to **Appendix A83.1**.

(3) Branch Sewer and Sub-main Sewer

Table 83.1.4 shows length of branch sewers and sub-main sewers in these two sewer districts. Road length in each town is calculated by multiplying the area of each town by respective road densities. Supposing 97.5% of road length is the length of branch sewers and 4.5% of road length is the length of sub-main sewers, the lengths of branch sewers and sub-main sewers are calculated in each town. Taking coverage rates into account, lengths of existing branch sewers in each town are estimated. If the coverage rate is 80%, branch sewers corresponding to 20% have to be newly constructed. It is supposed that 20% of the existing branch sewers need rehabilitation.

Table 83.1.4 Outline of Branch and Sub-main Sewer of TP-1 and TP-3 District

		Right Bank of Lyari River	Left Bank of Lyari River	Total
Area (km^2)		125.4	19.9	145.3
Road Length (km)		2,762	537	3,299
Branch Sewer (km)	Total	2,693	524	3,217
	Existing	1,206	303	1,509
	Rehabilitation (20% of Existing)	241	61	302
	Newly Construct	1,487	221	1,708
Sub-main Sewer (km)	Newly Construct	124	24	148

(4) Pumping Station

1) Jamila Pumping Station

Existing Jamila Pumping Station is located in Saddar Town at the left bank side of Lyari River to convey sewage generated in a part of Saddar Town and Jamshed Town to Lyari Interceptor presently, and will be operated in 2025 as it is.

The required capacity of Jamila PS in 2025 is estimated to be 1.880 m^3/s (at peak) that exceeds the present capacity of 0.910 m^3/s and wet sump, pumps and motors have to be equipped as the flow increases. The existing equipment has been remarkably aged and needs to be replaced.

In 2025, target year of the Mater Plan, the collected sewage at this pumping station should be conveyed via a 1,200 mm diameter pressure main of 1,800 m long crossing Lyari River to Lyari Interceptor at the opposite side of Lyari River instead of existing aged pressure main.

Table 83.1.5 outlines Jamila PS.

Table 83.1.5 Outline of Jamila Pumping Station

	Design Flow	Description		
Jamila PS	1.880 m^3/s (112.8 m^3/m) (peak)	Pump	Capacity of Pump	42.3 m^3/m/unit
			Number (on duty)	3
			Number (standby)	1
			Total installed Capacity	169 m^3/m
		Generator	Capacity	500 kVA x 1
		Pressure Main	Diameter	1,200 mm
			Length	1,800 m

2) Chakiwara Pumping Station

Existing Chakiwara Pumping Station is located in Lyari Town at the left bank side of Lyari River to convey sewage generated in most of Lyari Town to Lyari Interceptor presently, and will be operated in 2025 as it is. The required capacity of Chakiwara PS in 2025 is estimated to be 0.752 m^3/s (at peak) that is smaller than the present capacity of 0.972 m^3/s, which means no extension is needed. However, the existing equipment has been remarkably aged and needs to be replaced.

In 2025, the collected sewage at this pumping station should be conveyed via an 800 mm diameter pressure main of 1,400 m long crossing Lyari River to Lyari Interceptor at the opposite side of Lyari River instead of existing aged pressure main.

Table 83.1.6 outlines Chakiwara PS.

Table 83.1.6 Outline of Chakiwara Pumping Station

	Design Flow	Description		
Chakiwara PS	0.752 m^3/s (45.1 m^3/m) (peak)	Pump	Capacity of Pump	16.9 $m^3/m/unit$
			Number (on duty)	3
			Number (standby)	1
			Total installed Capacity	68 m^3/m
		Generator	Capacity	200 kVA x 1
		Pressure Main	Diameter	800 mm
			Length	1,400 m

(5) Sewage Treatment Plant TP-1

The sewage generation in TP-1 and TP-3 District is estimated to be 162 mgd (737,300 m^3/d) in 2025. Since estimated flow into TP-3 through Lyari Interceptor in 2025 will be 54 mgd (241,900 m^3/d), the rest of the total sewage generation of 108 mgd (495,400 m^3/d) will be treated at TP-1.

It is envisaged that existing facilities of TP-1 will be rehabilitated and functional continuously until 2021. After 2021, these facilities will be demolished due to their life span expiration and construction of new facilities.

TP-1 occupies the site area of around 49 ha that enables the construction of the sewage treatment plant with the capacity of 110 mgd (500,000 m^3/d) within the present site area with mechanical dewatering.

1) Sewage and Sludge Treatment Processes

As discussed in **Section 8.1**, TP-1 will apply high rate trickling filter following UASB process as pre-treatment for reduction of high influent BOD concentration. Sludge will be thickened by gravity thickening tank then be mechanically dewatered due to land constraint for placement of drying beds.

2) Basic Conditions

The facilities of TP-1 are designed based on the basic conditions as shown in **Table 83.1.7**.

Table 83.1.7 Basic Conditions for TP-1

Item	Basic Conditions	
Location	SITE Town	
Area of Site	49 ha	
Design Sewage Flow	109 mgd (495,400 m^3/d)	
Treatment Capacity	Number of Trains: Capacity per Train: Total Capacity:	6 18.3 mgd/train (83,300 m^3/d/train) 110 mgd (500,000 m^3/d)
Design Sewage Quality	BOD	Influent: 600 mg/l Effluent: 80 mg/l
Effluent Discharge Point	Lyari River via a discharging channel	
Sewage Treatment	Lift pump + Screen/Grit chamber + UASB + Primary Settling Tank + High Rate Trickling Filter + Final Settling Tank	
Sludge Treatment	Gravity Thickening + Dewatering by Machine (100 %)	
Sludge Use/Disposal	Use and/or disposal at planned green area 15 km north of TP-1	

3) Sewage Treatment Facilities

The dimensions of main facilities of TP-1 are calculated based on the above conditions and are summarized in **Table 83.1.8** and layout of the proposed main facilities is shown in **Figure 83.1.2**.

Table 83.1.8 Summary of the Proposed Main Facilities of TP-1

Facilities	Specifications	Remarks
Pump Facility	Capacity of Pump: 96.8 m^3/m/unit	50% standby
	Number of pump (on duty): 6	
	Number of pump (standby): 2	
	Generator: 1,500 kVA x 2	
Screen Facility	Mechanical Screen	
UASB Reactor	100 m (W) × 78 m (L) × 6 m (D) × 6 tanks	
Primary Settling Tank	33 m in dia. × 2 tanks × 6 trains	
Trickling Filter	42 m in dia. × 6 tanks × 6 trains	High rate type
Final Settling Tank	43 m in dia. × 2 tanks × 6 trains	
Sludge Thickening Tank	18 m in dia. × 8 tanks	
Dewatering Machine	140 kg/m/h × (70 units + 8 units for standby)	Belt press filter (Belt Width: 3 m) 7 hour/day, 6 days/week

For process design for TP-1, refer to **Appendix A83.2**.

(6) Sewage Treatment Plant TP-3

The sewage flowing into TP-3 in 2025 is set forth to be 53 mgd (241,900 m^3/d), same as the existing one, because its site area has no room for its extension.

1) Sewage and Sludge Treatment Processes

As discussed in **Section 8.1**, sewage treatment plant TP-3 will apply Wastewater Stabilization Pond Process consisting of anaerobic ponds followed by facultative ponds, the same as the current one. Sludge will be suctioned from anaerobic ponds by pump and then be dried at drying beds, the same as the current one.

2) Basic Conditions

The facilities of TP-3 are designed based on the conditions as shown in **Table 83.1.9**.

Table 83.1.9 Basic Conditions for TP-3 Design

Item	Basic Conditions	
Location	At mouth of Lyari, Mauripur, Keamari Town	
Area of Site	221 ha	
Design Sewage Flow	53 mgd (241,900 m^3/d)	
Treatment Capacity	Number of Trains Capacity per Train: Total Capacity:	6 Vary with train 54 mgd (245,000 m^3/d)
Design Sewage Quality	BOD	Influent: 600 mg/l Effluent: 80 mg/l
Effluent Discharge Point	Arabian Sea (Swamp Area of Karachi Bay)	
Sewage Treatment	Lift pump + Screen/Grit chamber + Anaerobic Pond + Facultative Pond	
Sludge Treatment	Drying Beds (8.2 ha)	
Sludge Use/Disposal	Use and/or disposal at planned green area 15 km northwest of TP-3	

3) Sewage Treatment Facilities

The dimensions of main facilities of TP-3 are calculated based on the above conditions and are summarized in **Table 83.1.10** and layout of the proposed main facilities is shown in **Figure 83.1.3**.

Table 83.1.10 Summary of the Proposed Main Facilities of TP-3

Facilities	Specifications	Remarks
Main Pump Facility	Capacity of Pump: 127.0 m^3/m/unit	50 % standby
	Number of pump (on duty): 3	
	Number of pump (standby): 1	
	Generator: 1,375 kVA x 1	
Screen Facility	Mechanical Screen	
Secondary Pump Facility	Capacity of Pump: 14.0 m^3/m	50% standby
	Number of pump (on duty): 12	
	Number of pump (standby): 6	
	Generator: 1,375 kVA x 1	
Anaerobic Pond	150 m (W) × 150 m (L) × 2.5 m (D) × 6 trains	
Facultative Pond	150 m (W) × 1,150 m (L) × 1.5 m (D) × 6 trains	Weighted average length
Drying Beds	10.4 ha 140 m (W) × 120 m (L) × 2 beds 180 m (W) × 270 m (L) × 1 bed 180 m (W) × 120 m (L) × 1 bed	

For process design for TP-3, refer to **Appendix A83.2**.

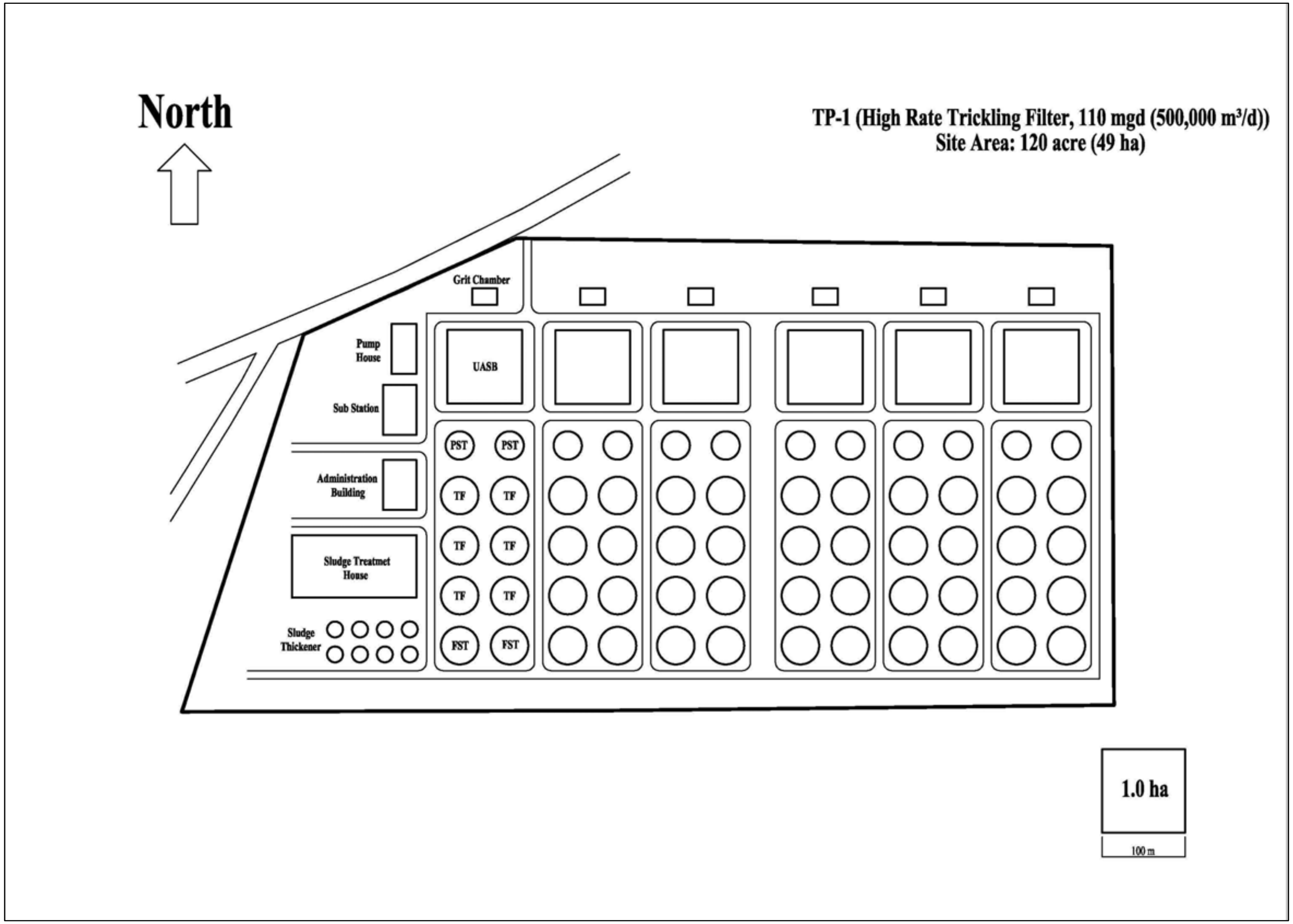


Figure 83.1.2 General Plan of Sewage Treatment Plant TP-1

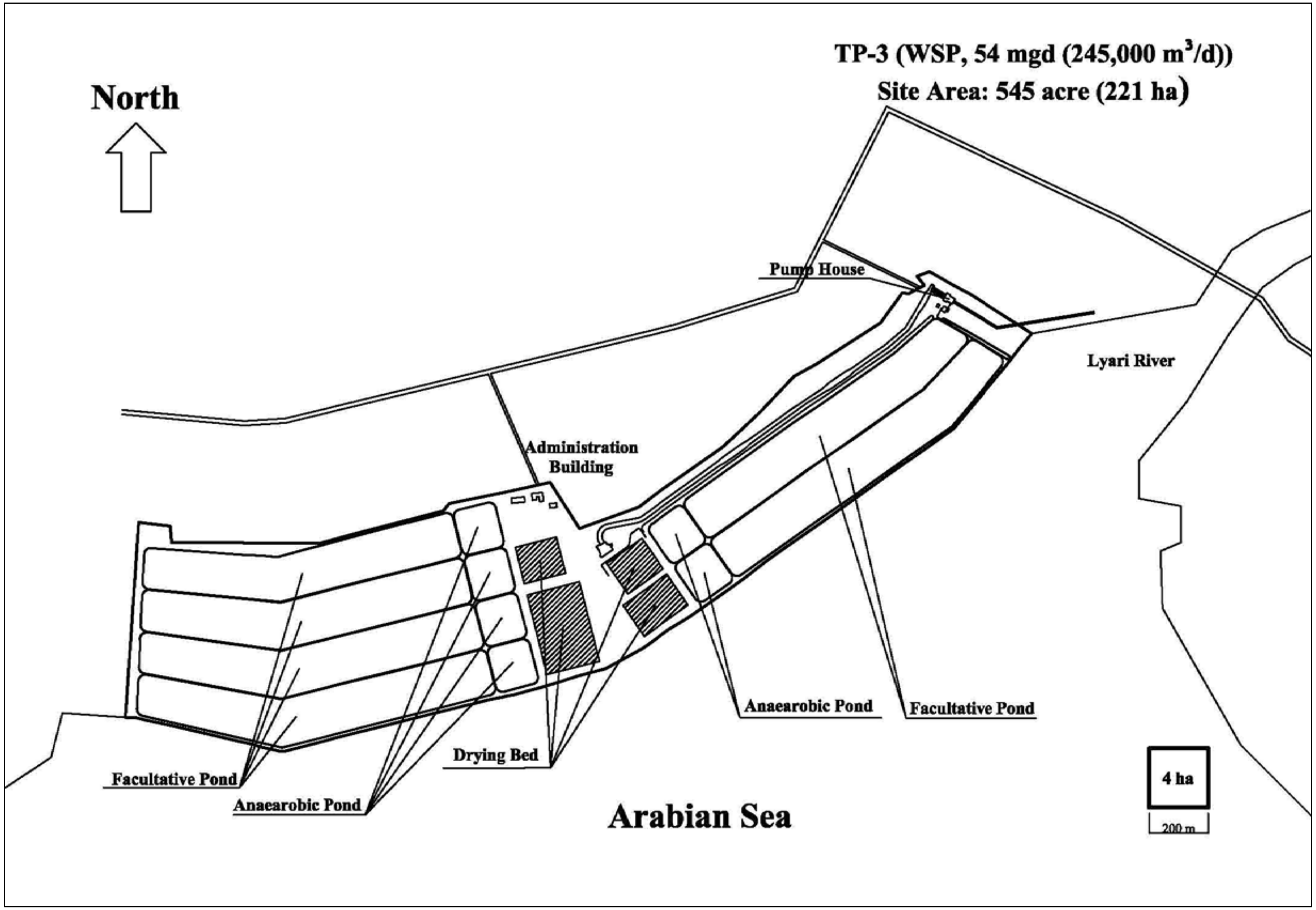


Figure 83.1.3 General Plan of Sewage Treatment Plant TP-3

8.3.2 TP-2 District

(1) General Description

The TP-2 District stretches both bank sides of Lyari River as well as TP-1 and TP-3 District as shown in **Table 83.2.1** and **Figure 83.1.1**.

Table 83.2.1 Overview of TP-2 District

	Relevant Towns	Remarks
Right bank of Lyari River	New Karachi, Gulberg, Gadap	
Left bank of Lyari River	Gulshan-e-Iqbal, Jamshed,	
	Keamari, Saddar, Karachi Cantonment	Clifton PS catchment

Note: Small urbanised parts of Keamari Town and Gadap Town will be included in this district.

The sewage generation in TP-2 District in 2025 will amount to 106 mgd (481,500 m^3/d). Its capacity is 108 mgd (490,000 m^3/d). Covered area, population and sewage generation of TP-2 District are shown in **Table 83.2.2.**

Table 83.2.2 Design Basis of TP-2 District

	District Area (km^2)	Population	Sewage Generation (m^3/d)	Sewage Generation (mgd)
Right Bank Side of Lyari	41.4	2,007,000	145,800	32.1
Left Bank Side of Lyari	59.0	3,006,000	335,700	73.9
Total	100.4	5,013,000	481,500	106.0

(2) Sewer Network / Nallah, Drain

The sewage generated in New Karachi, Gadap, Gulshan-e-Iqbal and Jamshed Town flows into TP-2 through extended stretch of Lyari Interceptor, then lifted up at Iqbal PS to new trunk sewers discharging TP-2, while the sewage generated in Keamari Town, Saddar Town and Karachi Cantonment flows to Clifton pumping station where the sewage is pumped to TP-2.

Nallahs in Saddar Town currently flowing into Arabian Sea will be intercepted and the intercepted sewage will flow into Clifton Pumping Station. Clifton Pumping Station will convey sewage to TP-2 through pressure main.

At present, TP-2 effluent is discharged to a nearby nallah, but it is needed to construct a pipeline or a channel exclusive for effluent discharge in the future when the flow to TP-2 increases. It is envisaged that the effluent discharge channel will be constructed at the time of first extension of the treatment facilities. The conduit is double box culvert catering for 490,000 m^3/d of average daily flow with the dimension of 2 m by 2 m for each. It will be 3,600 metres long, be directed to the southeast and finally flow into Malir River.

Table 83.2.3 summarizes trunk sewers in TP-2 District.

Table 83.2.3 Outline of Trunk Sewers of TP-2 District

	Diameter / Size (inch / mm)	Length (m)	Remarks
A. Lyari Interceptor (Extension)			
Conduit	84”	9,300	
Sub-total		9,300	
B. New Trunk Sewer (Right bank side of Lyari River)			
Conduit	42” to 66”	16,300	
Sub-total		16,300	
C. New Trunk Sewer (Left bank side of Lyari River)			
Conduit	42” to 66”	14,900	
Box Culvert	3000 x 2000 x 1 and 4000 x 2000 x 1	7,200	
Sub-total		22,100	
D. Effluent Discharging Channel of TP-2			
Box Culvert	2000 x 2000 x 2	3,600	
Sub-total		3,600	
Total		51,300	

For flow calculation of trunk sewers, refer to **Appendix A83.1**.

(3) Branch Sewer and Sub-main Sewer

Table 83.2.4 summarizes branch sewers in TP-2 District. Road length in each town is calculated by multiplying the area of each town by respective road densities. Supposing 97.5% of road length is the length of branch sewers and 4.5% of road length is the length of sub-main sewers, the lengths of branch sewers and sub-main sewers are calculated in each town. Taking coverage rates into account, lengths of existing branch sewers in each town are estimated. If the coverage rate is 80%, branch sewers corresponding to 20% have to be newly constructed. It is supposed that 20% of the existing branch sewers need rehabilitation.

Table 83.2.4 Outline of Branch and Sub-main Sewer of TP-2 District

		Right Bank of Lyari River	Left Bank of Lyari River	Total
Area (km^2)		41.4	59.0	100.4
Road Length (km)		909	1,211	2,120
Branch Sewer (km)	Total	886	1,181	2,067
	Existing	304	664	968
	Rehabilitation (20% of Existing)	61	133	194
	Newly Construct	582	517	1,099
Sub-main Sewer (km)	Newly Construct	41	55	96

(4) Pumping Station

1) Gulberg Pumping Station

Proposed Gulberg Pumping Station should be located near right bank of Lyari River to lift up sewage generated in New Karachi Town and Gadap Town to connection outfall via a 1500 mm diameter pressure main of 1,200 m long. **Table 83.2.5** outlines proposed Iqbal Pumping Station.

Table 83.2.5 Outline of Gulberg Pumping Station

	Design Flow	Description		
Gulberg PS	2.844 m^3/s (170.6 m^3/m) (peak)	Pump	Capacity of Pump	42.7 m^3/m/unit
			Number (on duty)	4
			Number (standby)	2
			Total installed Capacity	256 m^3/m
		Generator	Capacity	750 kVA x 2
		Pressure Main	Diameter	1,500 mm
			Length	1,200 m

2) Clifton Pumping Station

Existing Clifton Pumping Station is located in Saddar Town to convey sewage generated in Saddar Town and Keamari Town. Clifton pumping station is judged to have the sufficient capacity but some rehabilitation is necessary. Also, the pressure main to TP-2 is old and not pressure resistant. It has to be replaced to pressurize the design flow to TP-2 as originally planned.

Design flows to lift by these pumping stations, calculated capacities, requirement of pumps and pressure main for these pumping stations are presented in **Table 83.2.6**.

Table 83.2.6 Outline of Clifton Pumping Station

	Design Flow	Description		
Clifton PS	1.796 m^3/s (107.7 m^3/m) (peak)	Pump	Capacity of Pump	26.9 m^3/m/unit
			Number (on duty)	4
			Number (standby)	2
			Total installed Capacity	162 m^3/m
		Generator	Capacity	500 kVA x 2
		Pressure Main	Diameter	1,200 mm
			Length	4,800 m

(5) Sewage Treatment Plant TP-2

The amount of sewage flowing into TP-2 in 2025 will be 106 mgd (481,500 m^3/d).

It is envisaged that existing facilities of TP-2 will be rehabilitated and functional continuously until 2022. After 2022, these facilities will be demolished due to their life span expiration and new facilities will be constructed.

TP-2 occupies the site area of around 49 ha that enables the construction of the sewage treatment plant with the capacity of 108 mgd (490,000 m^3/d) within the present site area with mechanical dewatering.

1) Sewage and Sludge Treatment Processes

As discussed in **Section 8.1**, TP-2 will apply high rate trickling filter following UASB process as pre-treatment facility to lower high influent BOD concentration. Sludge will be thickened by gravity then be dewatered by machines.

2) Basic Conditions

The facilities of TP-2 are designed based on the conditions as shown in **Table 83.2.7**.

Table 83.2.7 Basic Conditions for TP-2

Item	Basic Conditions	
Location	Jamshed Town	
Area of Site	49 ha	
Design Sewage Flow	106 mgd (482,000 m^3/d)	
Treatment Capacity	Number of Trains: Capacity per Train: Total Capacity:	8 13.5 mgd/train (61,250 m^3/d/train) 108 mgd (490,000 m^3/d)
Design Sewage Quality	BOD	Influent: 600 mg/l Effluent: 80 mg/l
Effluent Discharge Point	Malir River via a discharging channel	
Sewage Treatment	Lift pump + Screen/Grit chamber + UASB + Primary Settling Tank + High Rate Trickling Filter + Final Settling tank	
Sludge Treatment	Gravity Thickening + Dewatering by Machine (100%)	
Sludge Use/Disposal	Use and/or disposal at planned green area 25 km east-northeast of TP-2	

3) Sewage Treatment Facilities

The dimensions of main facilities of TP-2 are calculated based on the above conditions and are summarized in **Table 83.2.8** and layout of the proposed main facilities is shown in **Figure 83.2.1**.

Table 83.2.8 Summary of the Proposed Main Facilities of TP-2

Facilities	Specifications	Remarks
Pump Facility	Capacity of Pump: 98.5 m^3/m/unit	50% standby
	Number of pump (on duty): 4	
	Number of pump (standby): 2	
	Generator: 1,000 kVA x 2	
Screen Facility	Mechanical Screen	
UASB Reactor	80 m (W) × 71 m (L) × 6 m (D) × 8 tanks	
Primary Settling Tank	28 m in dia. × 2 tanks × 8 trains	
Trickling Filter	36 m in dia. × 6 tanks × 8 trains	High rate type
Final Settling Tank	37 m in dia. × 2 tanks × 8 trains	
Sludge Thickening Tank	18 m in dia. × 8 tanks	
Dewatering Machine	140 kg/m/hr × (68 units + 7 units for standby)	Belt press filter (Belt Width: 3 m) 7 hour/day, 6 days/week

For process design for TP-2, refer to **Appendix A83.2**.

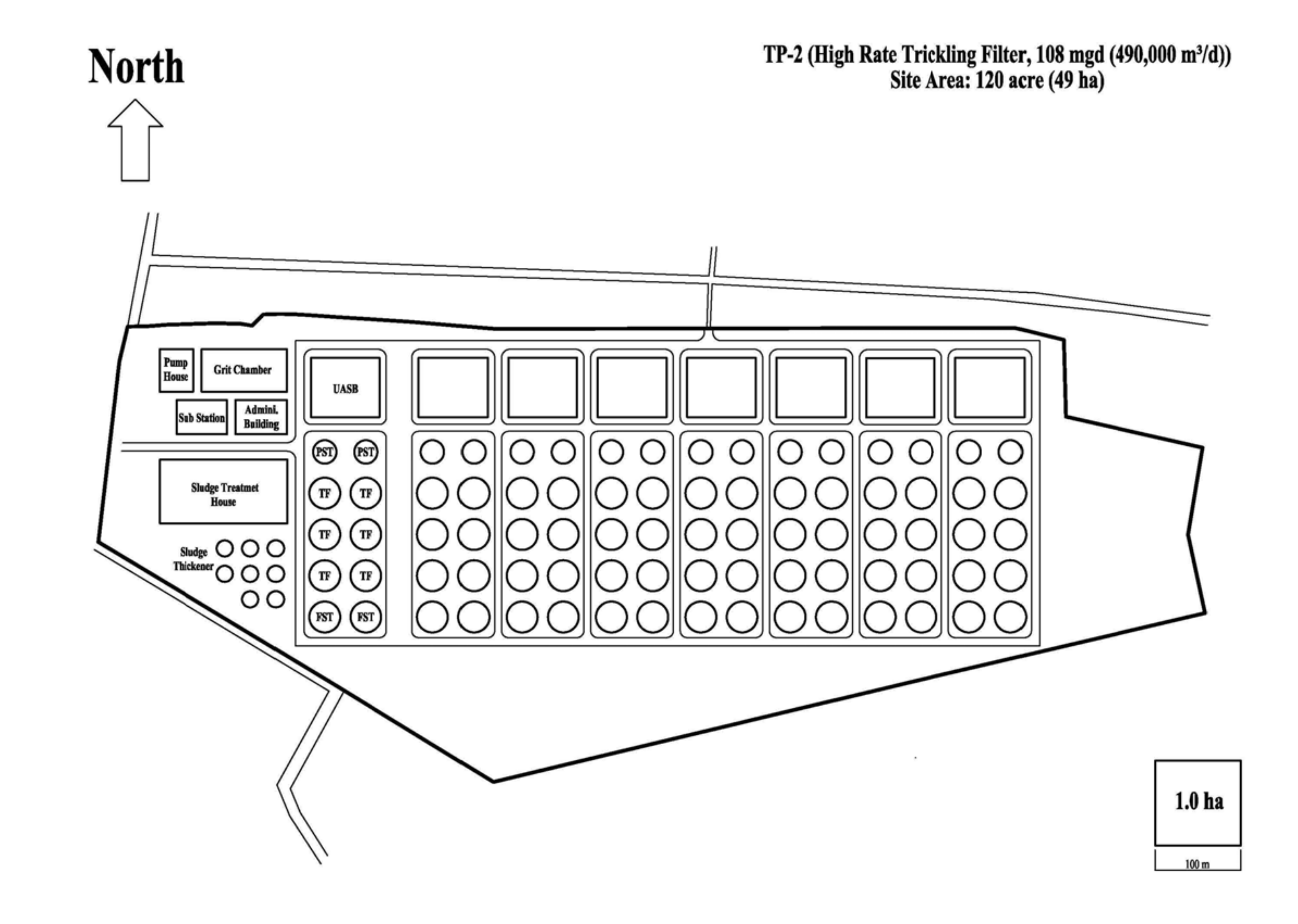


Figure 83.2.1 General Plan of Sewage Treatment Plant TP-2

8.3.3 TP-4 District

(1) General Description

The TP-4 District stretches both bank sides of Malir River as shown in **Table 83.3.1** and **Figure 83.1.1**.

Table 83.3.1 Overview of TP-4 District

	Relevant Towns	Remarks
Right bank of Malir River	Keamari, Saddar, Clifton Cantonment	Karachi Port PS catchment
	Jamshed, Gulshan-e-Iqbal, Shah Faisal, Malir, Faisal Cantonment, Malir Cantonment	
Left bank of Malir River	Landhi, Korangi, Korangi Creek Cantonment	Korangi PS catchment
	Bin Qasim	Bin Qasim PS catchment

Note: Small urbanised parts of Keamari Town and Bin Qasim Town will be included in this district

The sewage generation in TP-4 District will be 284 mgd (1,288,800 m^3/d) in 2025. Its capacity is 284 mgd (1,290,000 m^3/d).

Covered area, population and sewage generation of TP-4 District are shown in **Table 83.3.2**.

Table 83.3.2 Design Basis of TP-4 District

	District Area (km^2)	Population	Sewage Generation (m^3/d)	Sewage Generation (mgd)
Right Bank Side of Malir	226.1	6,113,000	754,600	166.0
Left Bank Side of Malir	114.1	5,607,000	534,200	117.5
Total	340.2	11,720,000	1,288,800	283.5

(2) Sewer Network / Nallah, Drain

The sewage generated at the upper stream of right bank side of Malir River will flow into Malir Interceptor (right bank side) through Chakor Nallah and other nallahs/drains, cross Malir River and finally flow into TP-4 located at the left bank side of the River. At the same time, the sewage generated at the downstream of right bank side of Malir River flows into Malir Interceptor (right bank side) just before crossing Malir River. Some of the sewage generated in Keamari Town (Karachi Port area) will be lifted up at Karachi Port PS.

Out of the sewage generated at the left bank side of the River, the sewage generated in the northern part of the area will flow into TP-4 through Malir Interceptor (left bank side). The sewage generated in the central part of the area will reach Korangi pumping station where it will be pressurized to Malir Interceptor (left bank side). The sewage generated in the southern part of the area will flow into TP-4 through new trunk sewer and Bin Qasim PS.

Table 83.3.3 summarizes trunk sewers.

Table 83.3.3 Outline of Trunk Sewers of TP-4 District

	Diameter / Size (inch / mm)	Length (m)	Remarks
A. Malir Interceptor (Right bank side)			
Conduit	42" to 66"	7,000	
Box Culvert	2750 x 2000 x 1 to 3500 x 3000 x 2	13,300	
Sub-total		20,300	
B. New Trunk Sewer (Right bank side of Malir River)			
Conduit	42" to 84"	40,000	
Box Culvert	2500 x 2000 x 1 to 3500 x 3000 x 1	6,700	
Sub-total		46,700	
C. Malir Interceptor (Left bank side)			
Conduit	66" to 72"	10,600	
Box Culvert	3500 x 3000 x 1	6,200	
Sub-total		16,800	
D. New Trunk Sewer (Left bank side of Malir River)			
Conduit	422 to 84"	40,400	
Box Culvert	3500 x 2000 x 1	1,600	
Sub-total		42,000	
Total		125,800	

For flow calculation of trunk sewers, refer to **Appendix A83.1**.

(3) Branch Sewer and Sub-main Sewer

Table 83.3.4 outlines branch and sub-main sewers in TP-4 district. Road length in each town is calculated by multiplying the area of each town by respective road densities. Supposing 97.5% of road length is the length of branch sewers and 4.5% of road length is the length of sub-main sewers, the lengths of branch sewers and sub-main sewers are calculated in each town. Taking coverage rates into account, lengths of existing branch sewers in each town are estimated. If the coverage rate is 80%, branch sewers corresponding to 20% have to be newly constructed. It is supposed that 20% of the existing branch sewers need rehabilitation.

Table 83.3.4 Outline of Branch and Sub-main Sewer of TP-4 District

		Right Bank of Malir River	Left Bank of Malir River	Total
Area (km^2)		226.1	114.1	340.2
Road Length (km)		3,390	1,841	5,231
Branch Sewer (km)	Total	3,305	1,795	5,100
	Existing	1,626	641	2,267
	Rehabilitation (20% of Existing)	325	128	453
	Newly Construct	1,679	1,154	2,833
Sub-main Sewer (km)	Newly Construct	153	83	236

(4) Pumping Station

1) Korangi Pumping Station

Existing Korangi Pumping Station located at north-western part of Korangi Town discharges the sewage generated in parts of Korangi Town and Landhi Town into Malir River at present. Its role will be converted to relay pumping station by the target year of 2025 that will pressurize the sewage to Malir Interceptor (left bank side).

The required capacity of Korangi PS in 2025 is estimated to be 4.817 m^3/s (at peak) that exceeds the present capacity of 0.809 m^3/s and wet sump, pumps and motors have to be equipped as the flow increases. The existing equipment has been remarkably aged and needs to be replaced.

In 2025, the collected sewage at this pumping station should be conveyed via a 2,000 mm diameter pressure main of 1,700 m long to Lyari Interceptor (left bank side).
Table 83.3.5 outlines Korangi Pumping Station

Table 83.3.5 Outline of Korangi Pumping Station

	Design Flow	Description		
Korangi PS	4.817 m^3/s (289.0 m^3/m) (peak)	Pump	Capacity of Pump	72.2 m^3/m/unit
			Number (on duty)	4
			Number (standby)	2
			Total installed Capacity	433 m^3/m
		Generator	Capacity	750 kVA x 2
		Pressure Main	Diameter	2,000 mm
			Length	1,700 m

2) Bin Qasim Pumping Station

Bin Qasim Pumping Station is the one planned in the Master Plan. Bin Qasim Trunk Sewer, also planned in the master Plan along the southern coast of the District, is so long that it will need to lift the sewage before it reaches TP-4.

Design flows considered for these pumping stations, calculated capacities, requirement of pumps and pressure main for these pumping stations are presented in **Table 83.3.6**.

Table 83.3.6 Outline of Bin Qasim Pumping Station

	Design Flow	Description		
Bin Qasim PS	0.999 m^3/s (59.9 m^3/m) (peak)	Pump	Capacity of Pump	22.5 m^3/m/unit
			Number (on duty)	3
			Number (standby)	1
			Total installed Capacity	90 m^3/m
		Generator	Capacity	500 kVA x 1
		Pressure Main	Diameter	900 mm
			Length	400 m

3) Karachi Port Pumping Station

Karachi Port Pumping Station is the one planned in the Master Plan. The sewage of Karachi Port lowland area will be lifted up at this pumping station to the outfall in DHA residential area.

Design flows considered for these pumping stations, calculated capacities, requirement of pumps and pressure main for these pumping stations are presented in **Table 83.3.7**.

Table 83.3.7 Outline of Karachi Port Pumping Station

	Design Flow	Description		
Karachi Port PS	1.106 m^3/s (66.3 m^3/m) (peak)	Pump	Capacity of Pump	24.9 $m^3/m/unit$
			Number (on duty)	3
			Number (standby)	1
			Total installed Capacity	99 m^3/m
		Generator	Capacity	500 kVA x 1
		Pressure Main	Diameter	1,000 mm
			Length	2,200 m

(5) Sewage Treatment Plant TP-4

TP-4 is a new sewage treatment plant to include in the Master Plan. It will be located at the western bank side of Malir River within Korangi Creek Cantonment. Its site area is around 168 ha. The amount of sewage flowing into TP-4 is estimated to be 1,288,800 m^3/d (284 mgd)

1) Sewage and Sludge Treatment Process

As discussed in **Section 8.1**, TP-4 will apply high rate trickling filter following UASB process as pre-treatment for reduction of high influent BOD concentration. Sludge will be thickened by gravity then be dried at drying beds or dewatered by machine due to land constraint.

2) Basic Conditions

The facilities of TP-4 are designed based on the conditions as shown in **Table 83.3.8**.

Table 83.3.8 Basic Conditions for TP-4

Item	Basic Conditions	
Location	Korangi Creek Cantonment area	
Area of Site	168 ha	
Design Sewage Flow	284 mgd (1,289,000 m^3/d)	
Treatment Capacity	Number of Trains: Capacity per Train: Total Capacity:	16 17.7 mgd/train (80,625 m^3/d/trian) 284 mgd (1,290,000 m^3/d)
Design Sewage Quality	BOD	Influent: 600 mg/l, Effluent: 80 mg/l
Discharge Point	Malir River	
Sewage Treatment	Lift pump + Screen/Grit chamber + UASB + Primary Settling Tank + High Rate Trickling Filter + Final Settling Tank	
Sludge Treatment	Gravity Thickening + Drying Beds (26%) or Dewatering by Machine (74%)	
Sludge Use/Disposal	Use and/or disposal at planned green area 25 km northeast of TP-4	

3) Sewage Treatment Facilities

The dimensions of main facilities of TP-4 are calculated based on the above conditions and are summarized in **Table 82.3.9** and layout of the proposed main facilities is shown in **Figure 83.3.1.**

Table 82.3.9 Summary of the Proposed Main Facilities of TP-44

Facilities	Specifications	Remarks
Pump Facility	Capacity of Pump: 111.9 m^3/m/unit	50% standby
	Number of pump (on duty): 12	
	Number of pump (standby): 6	
	Generator: 2,000 kVA x 4	
Screen Facility	Mechanical Screen	
UASB Reactor	90m (W) × 83m (L) × 6m (D) × 16 tanks	
Primary Settling Tank	33 m in dia. × 2 tanks × 16 trains	
Trickling Filter	42 m in dia. × 6 tanks × 16 trains	High rate type
Final Settling Tank	42 m in dia. × 2 tanks × 16 trains	
Sludge Thickening Tank	18 m in dia. × 20 tanks	
Sludge Drying Beds	Effective area: 27.5 ha	
Dewatering Machine	140 kg/m/hr × (136 units + 14 units for standby)	Belt press filter (Belt Width: 3 m) 7 hour/day, 6 days/week
Sludge Use/Disposal	Use and/or disposal at the planned green area 25 km northeast of TP-4	

For process design of TP-4, refer to **Appendix A83.2**.

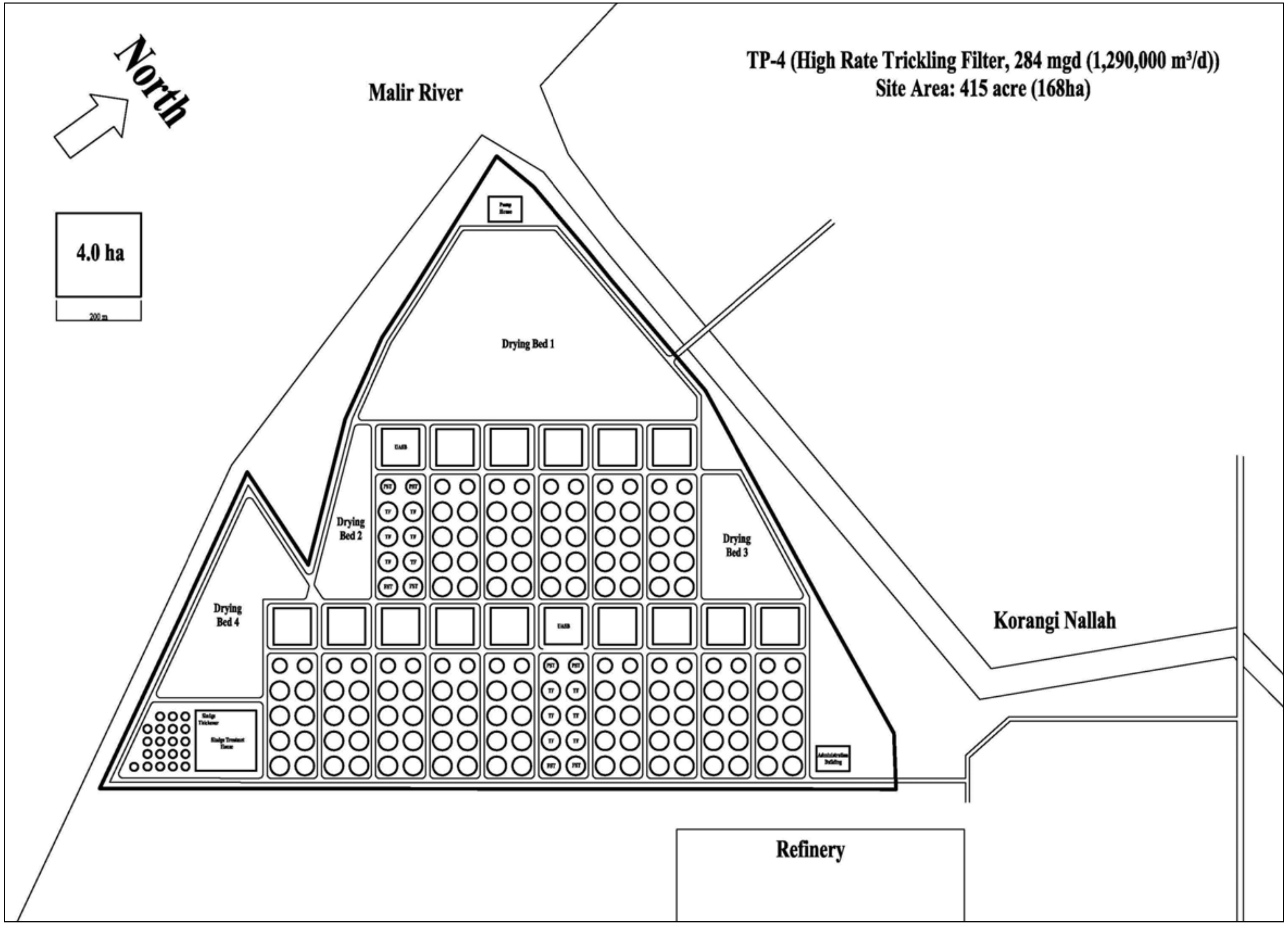


Figure 83.3.1 General Plan of Sewage Treatment Plant TP-4

CHAPTER 9

IMPROVEMENT OF MANAGEMENT SYSTEM

9 IMPROVEMENT OF MANAGEMENT SYSTEM

9.1 INSTITUTIONAL REFORM

Considering the size of the city, population density and the complex nature of its mandated responsibilities, KW&SB has made significant strides in the water and sanitation arena. However, much is still to be done and the role of KW&SB is changing. KW&SB's changing role has been brought about by new priorities set at National and Provincial level with the introduction of new Water, Sanitation and Environmental Policies, Development and Devolution Plans resulting in a major shift in thinking and policy towards a decentralised, people centric and demand responsive approach. This paradigm shift incorporates the principles of:

- Adoption of demand responsive approaches based on involvement, empowerment and full participation in decision making by user groups and beneficiaries
- O&M responsibility by users (beneficiary groups including local bodies, CCB's)
- Shifting the role of government from direct service delivery to that of planning, policy formulation, monitoring and evaluation and partial financial support

The reforms also call for substantial institutional development with regard to services, enhancement of technical and managerial capacity, appropriate forms of public-private partnership, private sector participation, use of information systems etc., to achieve sustainability. Additionally, pricing mechanisms to discourage excessive water use, reduction of leakage and UFW, reuse and recycling of sewage, rainwater harvesting etc; as well as a customer centric approach are advocated.

A diagnostic of the key issues affecting KW&SB are presented in **Table 91.1.1**. These were considered during the 'organisation review' conducted during the first and second phases of the JICA Study and have therefore influenced the recommendations, models and strategies in the Master Plan.

Based on the above, it will be necessary for KW&SB to take a more holistic view of the 'water business' in Karachi and to consider the interactions and influences of the various stakeholders that impact KW&SB's operation. These will determine the key 'business drivers' that will need to be developed to ensure that KW&SB meet business and service objectives now and in the future. The aspects described above, therefore, will provide the impetus for reforms.

Based on the above, a summary of the 'key issues' affecting KW&SB can be presented pictorially in **Figure 91.1.1**.

Table 91.1.1 Key Issues Requiring Intervention

Business Activity	Key Issues
Institutional Arrangements	Insufficient sector agency coordination/cooperation Insufficient community coordination/involvement Lack of an 'Integrated Water Resource Management' (IWRM) approach
Utility Management	Lack of adequate regulation (Water Bye Laws) Lack of monitoring/enforcement of existing regulation Insufficient capacity (HR/management expertise) Lack of capacity (IS/IT/workflow systems) Lack of strategy, policy, process development Lack of Process and Performance Management (example UFW reduction, energy and process chemicals efficiency, plant utilisation, labour efficiency, billing/revenue efficiency etc.) Insufficient project management skills and tools for control
Community Participation/Management	Community participation not an accepted approach No formal structural arrangements for dealing with user/beneficiary groups such as NGO's, CCB's
Spatial Planning and Demographic	Fast growth of population – demand outstrips supply Poor compliance with mandated supply coverage
Resources	Insufficient funds/financing to meet current/future demands for services Lack of project and financial control measures Tariffs not based on full cost recovery Poor billing/revenue practices and performance Insufficient pricing mechanisms to regulate/conserve water Lack of sustainable practices/care for the environment/regulatory enforcement
Political Interference	Lack of financial and management autonomy Political influence on infrastructure projects and priorities and day-to-day management activities
Socio-Economics	Low and irregular incomes of a large part of the customer base, resulting in low capacity to pay for services Debt/disconnection policy not addressing underlying problems
Communication, Information and Education	Limited communications, consultation, involvement and public relations activities Lack of awareness campaigns/outreach programmes Low public enlightenment to report problems, water use efficiency and bill settlement (especially Local Bodies)
Operation & Maintenance and Service Provision	Contaminated/depleting (usable/accessible) water sources Low service levels/insufficient water supply and lack of sanitation services, insufficient infrastructure to meet demand Poor quality of water delivered High levels of leakage and NRW Lack of O&M strategy and planning Lack of planned preventative maintenance and supply chain management

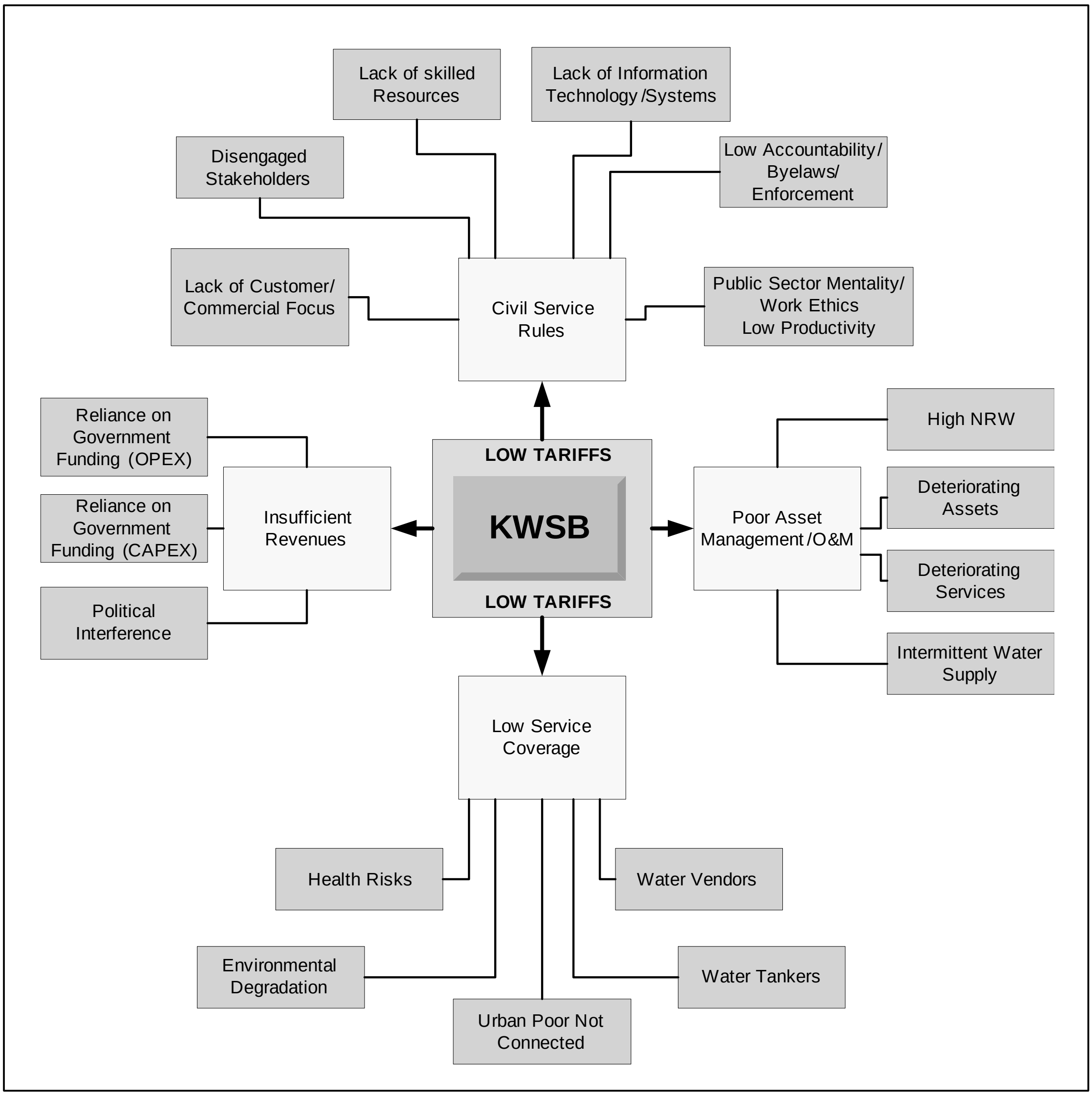


Figure 91.1.1 Problems in a 'Nutshell'

9.1.1 Strengths and Weaknesses of Current Institutional Arrangements

Based on the foregoing and on discussions with senior GOS officials and KW&SB staff as well as a review of documentation relating to current organisation arrangements, practices and procedures, the following organisation strengths and weaknesses have been identified.

Strengths

KW&SB's workforce and management are technically competent and capable of delivering operational and service improvements. Staff are generally well experienced and exhibit a degree of personal motivation despite obvious constraints brought about by limitations in organisational development, customer and operational systems and budgets. Managers are generally enthusiastic about the organisation and many have significant experience within the sector. Staff members are loyal to the organisation and many are knowledgeable about the processes in which they are involved. Financial support continues to be provided to KW&SB from the GOS despite disappointing operational and commercial performance.

Weaknesses

Potential weaknesses with recommendations for mitigation are detailed in **Table 91.1.2**.

Table 91.1.2 Organisational Weakness with Recommendations for Mitigation

Symptom	Recommendations for Mitigation
Lack of clearly defined strategic intent and how this links into individual, team and departmental performance.	Review the strategic intent, vision and mission statement and share these with the entire workforce. This includes the need to prepare and share a KW&SB-wide Corporate Business Plan. Performance targets should be set and measures put in place so that individual and departmental performance supports corporate objectives.
Lack of clearly defined Corporate Strategies.	Define corporate needs and prepare/share strategies with entire workforce. This includes the need for a strategy for asset planning/asset management and development/ asset acquisition; HRD, Customer Services development, etc.
Lack of clearly defined corporate policies and departmental business plans.	Define and share company wide and departmental policies and business plans with appropriate strategies and objectives to enable future improvements.
Lack of clearly defined Business Strategies (operations, customer, commercial, systems, people etc.)	Define departmental strategies, set and agree goals, key performance indicators, measures and action plans for continuous improvement.
There are no clearly defined mechanisms for 'performance managing' the business	Set up a system of performance management that establishes goals and measures for individuals, teams, departments and KW&SB as a whole. This should be a dynamic system that should change as the organisation develops over time.
The use of technology for future development of the business is not well understood or defined.	Prepare IT/Systems strategies that will meet the future corporate business and operational needs.
There are skill gaps in the organisation – human resource development, performance management, regulatory compliance, customer services, communications, corporate and strategic planning, risk management, contingency planning, systems development, community relations and health and safety.	Identify the gaps, train and/or recruit skilled personnel to fill them.
There is no effective job management or work planning system.	Introduce a Job Management System to give better control and information.
Systems for asset management/maintenance are not standardised across functions or departments and the use of computer software or systems to aid asset management/maintenance are not established.	Introduce appropriate technology for the effective management and maintenance of company assets.
Business critical processes are not well defined or 'owned'. For example, Agency Coordination/Government Liaison, Regulatory Compliance, Customer Services, Commercial management, Systems Development, HRD, H&S, Water Quality Management, Supply Chain Management, Operations & Maintenance Management etc.	Define, map and disseminate process routines. Assign key processes to owners or champions. Define and share key policies, strategies and procedures within each process area.
Work routines are generally not recorded to agreed quality standards and a process for sharing best practice is not established.	Codify work practices capturing best practice. Set up training and procedures to ensure the routines are adhered to. Encourage sharing of best practice on a formal basis by service level agreements across process boundaries.
Management information is inadequate and KW&SB struggles to provide any meaningful data to assist with the management of the organisation.	Establish the needs, design and introduce a meaningful MIS. Train staff in the use of the system.
KW&SB have aspirations to improve customer	All employees should be encouraged to 'think customer',

Symptom	Recommendations for Mitigation
services, however, does not demonstrate a commitment to being a customer service driven organisation.	internal and external. Structures need to be geared towards providing customer focus. Recording rather than solving complaints is not enough. Training on customer awareness and customer care should be provided to all existing and new employees.
Customer communication routes require development, including customer feedback.	Develop and agree a customer communications strategy to ensure customers are aware of services, performance against standards and opportunities for feedback. This will enable KW&SB to tailor services to meet changing customer perceptions.
Indications are that KW&SB are not fully utilising Human Resources in terms of efficiency levels as well as numbers of staff employed.	Implement new policies and procedures for staff appraisals, training, development and transfers. Introduce a system of 'succession planning' to ensure the organisation is 'equipped' with competent future leaders.
KW&SB has an aging workforce many of whom have worked for the organisation for many years. Ability to transfer knowledge is being lost.	The age profile will adjust if older employees are released and a programme of recruiting graduates and technicians is introduced. Ensure routines are in place for capture and transfer of knowledge. Ensure a system of equitable career progression based on ability to do the job as well as seniority.
Communications within KW&SB could be improved. There appears to be no mechanism for corporate messages to be cascaded throughout the organisation or for employees to give feedback.	Introduce a fully integrated communication strategy, including written communications, management and team meetings, toolbox talks etc. Feed back loops must be introduced to ensure the views of the workforce are known.
The culture within KW&SB is reactive rather than proactive.	Improve the planning processes and encourage managers and employees to consider the longer term and encourage initiatives for change.
H&S is not well understood or managed.	Assign responsibility for and set up a central H&S support function to ensure compliance with legislation and best practice. Ensure safe systems of work are introduced and that staff are well trained.

Whilst there appears to be a significant number of issues requiring consideration, with the right support from KW&SB's senior management team, each issue creates an opportunity for improvement and therefore, the aspects described above provides the 'imperative for change'.
Based on the above, a summary of the 'key solutions' can be presented pictorially in **Figure 91.1.2**.

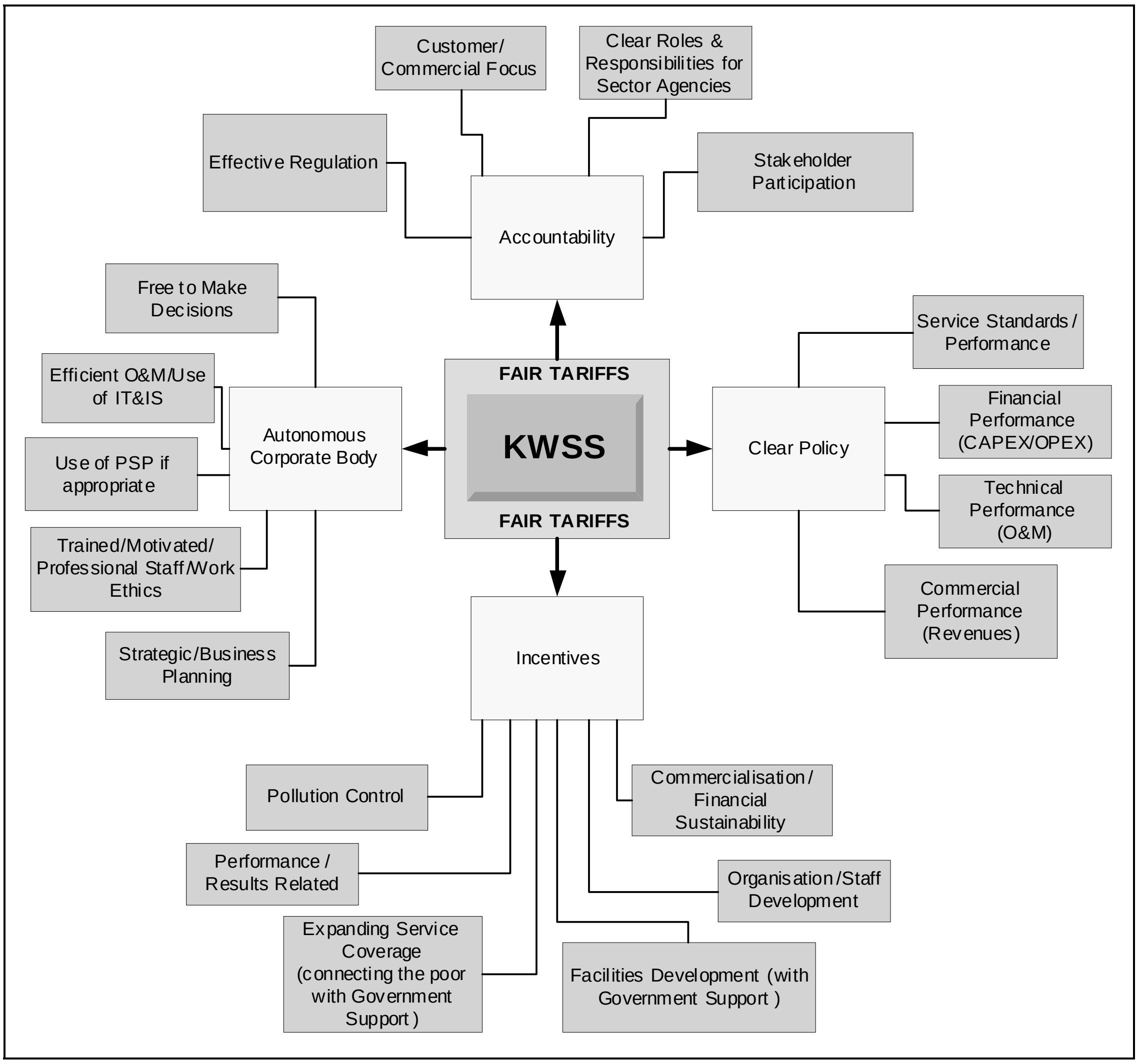


Figure 91.1.2 Solutions in a 'Nutshell'

9.1.2 Formulation of a Long - Term Improvement Plan

Based on discussions it is evident that KW&SB are seeking to become a professional, well-managed, financially autonomous institution which enjoys the high trust and confidence of customers. As a market-based enterprise, KW&SB will want to be responsive to customer demands and have a competent, dynamic and motivated staff. Achieving this will require that strategies are in place for "institutional reforms" as well as "infrastructure improvements".

On this basis, the Master Plan clearly focuses on three distinct aspects:

a) Water supply systems development; concentrating on improving existing water distribution networks (DNI: Distribution Network Improvement)
b) Sewage treatment and sewerage systems development; concentrating on improving and extending existing facilities) and,
c) Institutional reforms; It is this aspect that forms the basis of this section

9.1.3 The Imperative for Change

Based on the organisation review conducted during phases 1 and 2 of the study, it is evident that a 'business as usual' approach is not sustainable. This view is shared by others, including the GOS, KW&SB, and JICA, as well as the WSP and ADB (who have had interaction with KW&SB and CDGK regarding reforms).

The following key sector issues prevail in Karachi:

- Management arrangements for the water and sewerage sector are fragmented
- There is weak cooperation among sector agencies
- The sector is not financially self-sufficient
- There is strong resistance to raising tariffs
- Accounting rules and financial management processes are not consistent with good commercial practice
- There is insufficient focus on asset management/O&M
- There is a lack of customer and commercial focus
- Performance is constrained by civil service rules and work ethics
- There is a lack of strategic and business planning
- There is a lack of regulation and accountability

Based on the above it is clear that KW&SB must embark on a 'change management' or 'reforms programme' that **transforms** the organisation into a customer responsive, professional and commercially viable business. This calls for:

- Institutional and capacity building interventions to develop new skills, competencies, management arrangements, and new ways of working (improved processes and procedures for running the 'business')
- Business and commercial skills, strategic and business planning, with a clear focus on performance management and long term sustainability
- Involvement and consultation with users/communities with a clear focus on customer service provision and access to services for all
- Separation of roles and responsibilities ensuring that 'policy', 'ownership', 'service provision' and 'regulation' are clearly defined and understood

In this context, commercialisation does not equal private sector participation or privatisation. This view has been reinforced quite clearly during discussions held with senior level KW&SB and GOS officials. Rather, it involves implementing 'sound' business principles and practices at all levels of sector management and service delivery.

9.1.4 Reform Examples

There are a number of reform examples in Pakistan, however, little of this relates to the water sector. Reforms with respect to privatisation, deregulation and liberalisation is not a new concept; the government has been pursuing these options enthusiastically since the late 1980's with mixed success. Early on (in the cement sector) it became evident that due to the lack of competition, privatisation created monopolistic practices in terms of price hiking or price fixing by forming cartels which forced the government to create a national Monopoly Control Authority (MCA).

In the electricity sector, private power generators were allowed to start projects in the late 1980's and early 1990's before the National Electric Power Regulatory Authority (NEPRA) was in place. Apart from the banking sector which appears to be well regulated, it would appear that regulatory bodies of other industry sectors [the Pakistan Telecommunications Authority (PTA), the Oil and Gas Regulatory Authority (OGRA) and the Pakistan Electronic Media Regulatory Authority (PEMRA)], are inadequately funded or resourced or have insufficient powers and capabilities to effectively protect customer interests.

Despite various constraints the Sui Southern Gas Company Limited (SSGS) appears to be a 'shining example' of successful corporatisation in Sindh. SSGS was floated as a Limited Company with 70% ownership by the government and operates (profitably) under commercial principles free from civil service rules and regulations but in compliance with relevant Pakistan Company Law. Whilst they have a representational (imposed government officials) as well as a skills based board, the 'Chief Executive & Managing Director' is able to plan, run and control the organisation on sound commercial principles without undue 'interference' although understandably there will be influence in strategic decisions by the government. We are advocating corporatisation for KW&SB in an attempt to allow them sufficient autonomy to operate under commercial principles, however, this will not work unless effective regulation is in place that clearly defines the roles and responsibilities of the various 'actors'.

In service delivery, as well as in education, health, water/sewerage provision and solid waste management, it would appear that the government are doing little to ensure regulation in a systematic manner. In the water/sewerage sector, therefore, it would appear at least for the time being, that the sector will continue to be effectively 'self regulating' despite the current arrangements of policy pronouncement (water, sanitation and environmental policies), and limited resources and powers afforded to sector agencies such as the Pakistan Environmental Council, the Pakistan Environmental Protection Agency and the Sindh Environmental Protection Agency.

The examples of international practice are shown in **Appendix A91.1**. It is not intended to be an exhaustive list or suggestion of 'best practice', but is intended to illustrate some of the options for institutional reforms already implemented in other parts of the world.

9.1.5 Reform Options

During the Phase 2 stage, the JICA Study team evaluated the four reform options as depicted in **Figure 91.5.1**. After careful evaluation of advantages and disadvantages of each reform option, Option II-A was finally recommended by the JICA Study in its Interim Report dated July 2007. **Table 91.5.1** provides and analysis of some of the key advantages and disadvantages of the four options.

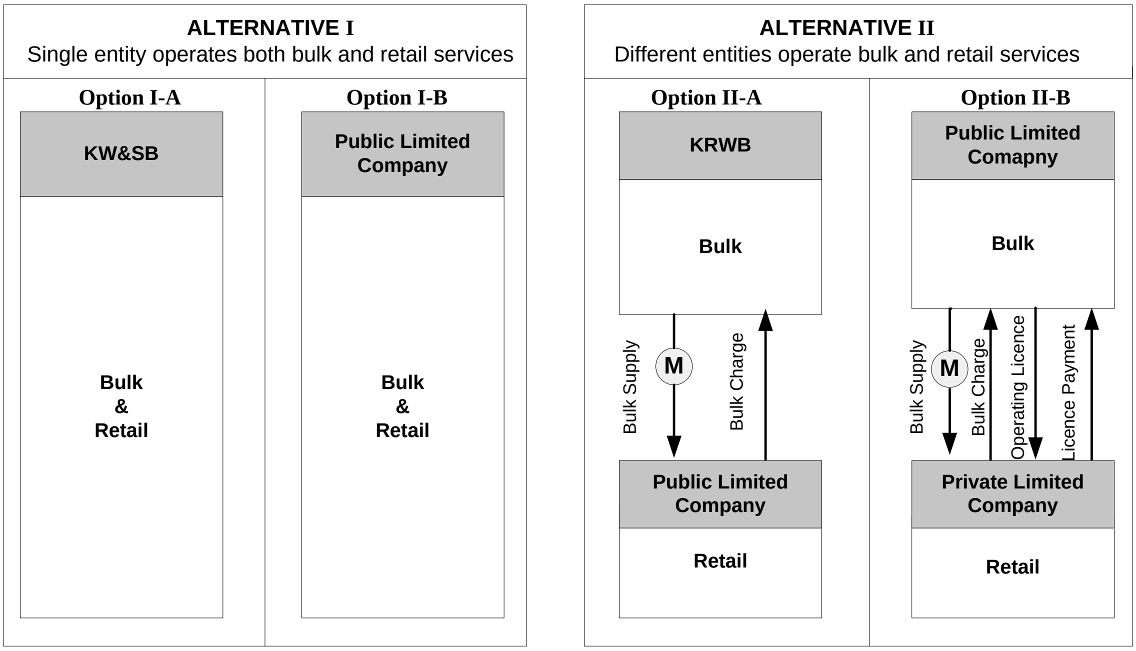


Figure 91.5.1 Alternative Reform Options

Table 91.5.1 Advantages/Disadvantages Associated with Each Reform Option

Reform Option	Advantage	Disadvantage
I-A: Internal Reforms. Bulk and retail services with single entity	▪ Politically less contentious ▪ Less resistance to change from staff ▪ Provides opportunity for business process improvements ▪ Provides opportunity for institutional and capacity building improvements ▪ Improved services through zoning	▪ Lack of role separation ▪ Political interference in day to day operations ▪ KW&SB not free to make management/investment decisions ▪ Reliance on Government subsidies ▪ Politicised tariffs ▪ Lack of managerial/technical/commercial skills ▪ Bulk and retail services with same entity ▪ Institutional strengthening and capacity building interventions take time and may have limited success
I-B: Bulk and retail services with single entity. Corporatised bulk supplier with retail services through zonal Business Units	▪ Separation of roles with clear lines of responsibility for policy, regulation and service provision ▪ Corporate body free to manage on commercial principles ▪ Business units introduces internal competition	▪ Corporatisation may be contentious with staff and/or government ▪ Corporatisation requires a new ordinance and 'articles of association' ▪ Bulk and retail services with same entity ▪ Complicates tariffs and subsidies in balancing the need for full cost recovery in retail services as well as a contribution to recovery of bulk supply assets, whilst ensuring affordability for all for 'essential use'
II-A: Bulk and retail split. Retail services through zonal Corporate Entities	▪ Provides opportunity for business process improvements ▪ Provides opportunity for institutional and capacity building improvements ▪ Improved services through zoning ▪ Separation of roles for policy,	▪ Corporatisation of retail services may be contentious with staff and/or government ▪ Corporatisation requires a new ordinance and 'articles of association'

Reform Option	Advantage	Disadvantage
	regulation and service provision ▪ Bulk and retail services with different entities ▪ Corporatised service providers free to operate within license agreement ▪ Corporatised entities introduces external competition ▪ Financial sustainability for retail service providers working to commercial principles based on full cost recover for improved services	
II-B: Bulk and retail split. Retail services through zonal Private Utilities	▪ Bulk and retail services with different entities ▪ Private utilities free to manage within license agreement ▪ Private utilities introduces external competition ▪ Financial sustainability for retail service providers working to commercial principles based on full cost recover for improved services	▪ Limited separation of roles with policy setting, laws and regulations retained by the Public Authority ▪ Public Authority set-up ties in CDGK with day to day operations ▪ Privatisation of retail services may be contentious with staff and/or government

Option II-A envisages that in the long run the responsibility for providing retail services (water supply and sewerage) would be transferred from KW&SB to 'corporatised' entities on a zone-by-zone basis. Once this process has been completed, KW&SB would be responsible for the management and operation of only the regional bulk water supply system, and, as such, it would need to be renamed , for example, as 'Karachi Regional Water Board (KRWB) as shown in **Figure 91.5.2**. It is envisaged that water supply and sewerage services in Karachi at that time would be managed and operated by three independent public limited companies established in each of the three independent retail service zones. These companies will implement Distribution Network Improvements (DNI) to substantially improve the quality of water supply and sewerage services in their respective retail service zones. Option II-A is described in more details in **Section 9.1.6**.

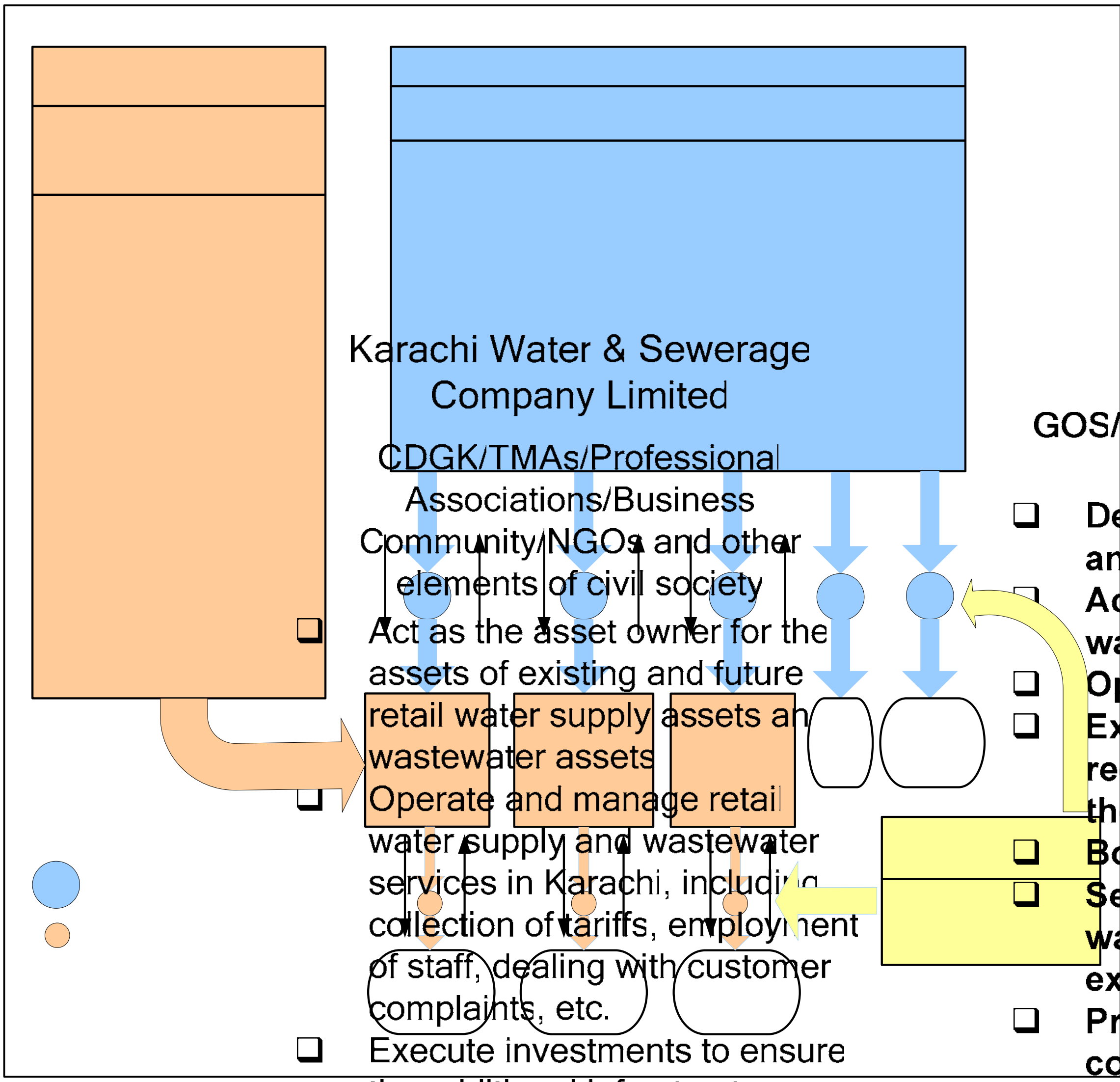


Figure 91.5.2 Details of Option II-A

9.1.6 Institutional Reforms Suggested by JICA Study

In the past, large capital investment works were implemented mostly for the purpose of developing large bulk supply schemes to bring water from distant water sources to Karachi. This has created a huge backlog of replacement, reinforcement and extension in the water distribution system. As a result, many water distribution pipes in the system have already been undersized and deteriorated, and the current levels of leakage and non-revenue water in the distribution system are unacceptably high. In most parts of the urban areas, residents are obliged to spend money on ground-level water reservoirs, suction/booster pumps, roof-top storage tanks, and water filters, and even then water must be boiled prior to drinking. While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high. Many households are compelled to use secondary sources of water such as shallow wells or tanker supplies just to meet their basic needs. In the light of the poor water supply situation, many residents in Karachi have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges.

It is only if customers are satisfied with the quality of the service they receive that they find themselves willing to pay for the service. The water awareness survey conducted as part of the

JICA study indicated that many households were willing to pay higher charges for a reliable supply of good quality water. With regard to the actual supply of water, the clear targets for the improved quality of the service can be summarized as follows:

- ◦ satisfy the customers' water demands so that they no longer need to utilize secondary sources (such as shallow wells and tanker supplies)
- ◦ water should be of a potable standard (this would make filtering and boiling of water unnecessary) and be aesthetically pleasing
- ◦ water should be supplied at an adequate pressure (this would make the use of suction/booster pumps and roof-top storage tanks unnecessary)
- ◦ water should be available on a 24-hour continuous basis to keep the supply system always full of water and under pressure to avoid both contamination and excessive air entrainment (this would make the use of ground-level water reservoirs unnecessary)

These improvements can only be attained through the implementation of distribution network improvements (DNI). DNI will embrace the rehabilitation of water trunk mains and distribution network and the refurbishment of service connections including installation of revenue metres. Where necessary, it will also include improvements to the existing sewerage system. Since DNI would require huge investments and more than 10 years to complete it across all areas of Karachi, it can only be implemented on an area-by-area basis in a progressive way. In the short to medium term, the costs associated with DNI will have to be recovered from the tariffs charged to customers. It is therefore recommended that customers in areas where DNI has already been completed (and receiving an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis) would pay a water charge that is some multiple of the current level of water charges, whereas customers in areas where DNI has not been completed (and continuously receiving the current level of service with intermittent supply) would continue to pay the current level of water charges. This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby to implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

KW&SB has suffered severely from political interference. On the other hand, local governments such as GOS, CDGK, TMAs, and UCs have legitimate roles in the shaping of policies for water and sanitation sector in the region, including the adjustment of tariffs. The source of the problem is that KW&SB has been expected to act both as the local governments' agent in developing and delivering these policies and as the operator of services with managerial and technical functions. This promotes a culture of interference in the day-to-day management of services and in the technical execution of projects. To address this problem it is proposed that policy and representative functions should be separated from the operation of services. It is obvious that any new institutional arrangements have to provide the service operator with a much greater degree of insulation from political interference.

Any attempt to implement institutional reforms is likely to fail if it is not accompanied by a discernible improvement in the quality of the service (through implementation of DNI). Similarly, DNI will not be able to produce satisfactory results if it is implemented within the existing institutional framework (without institutional reforms). Thus, institutional reform and DNI (improvements in service quality) are the two inseparably intertwined elements that will need to be implemented simultaneously. Implementing only one of theses two is likely to fail.

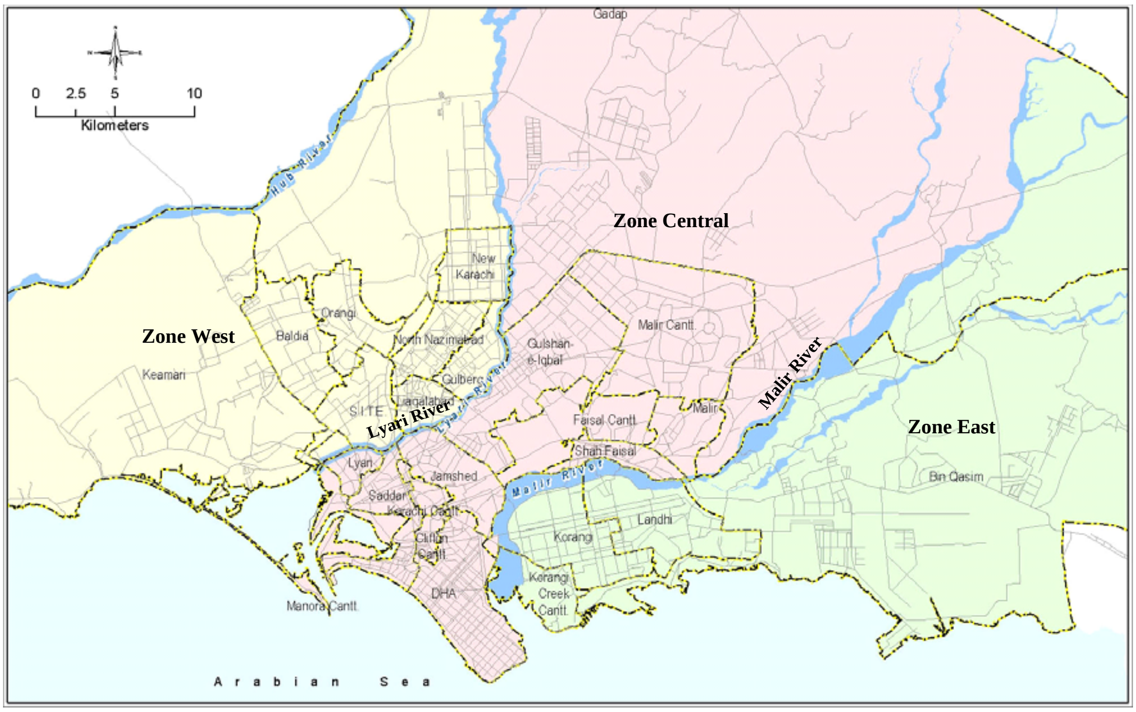


Figure 91.6.1 Three Independent Retail Service Zones

JICA Study proposes that the Karachi city be divided into three independent retail service zones by the Lyari and Malir Rivers (see **Figure 91.6.1**), and that in the long run the responsibilities for providing retail services (water supply and sewerage services) should gradually be transferred from KW&SB to 'corporatised' retail entities on a zone-by-zone basis as shown in **Figure 91.6.2**. The first stage of this reform process will take place in Zone West in early 2011 whilst at this point in time KW&SB will still retain responsibilities for bulk supply from the Kinjhar Lake to Karachi and for operation of retail services within Zone Central and Zone East. The Zone West retail entity will make improvements to the retail services within the Zone West through implementation of DNI in the zone.

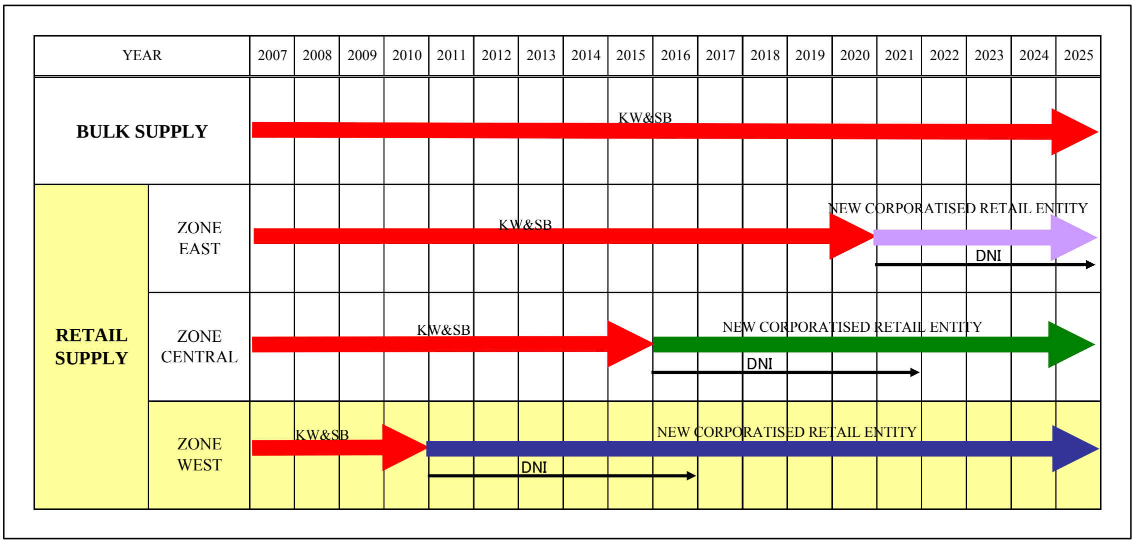


Figure 91.6.2 Transfer of Responsibility for Retail Services

Being an independent corporatised organisation, the Zone West retail entity would be able to perform free from civil service rules and develop its own rules and work ethics for how it does business. They will include rules for hiring and firing workers, adjusting wage structures, adopting performance-related payments and disciplining workers for poor performance or offering rewards and promotions based on good performance.

The Zone West retail entity would be established as a 'Public Limited Company (PLC)' under the provisions of the Companies Ordinance 1984. The PLC will purchase treated water from KW&SB in bulk and distribute it to all retail and bulk customers (both residential and non-residential) within Zone West. They will also be accountable for collection, transportation and treatment of sewage generated in Zone West. The PLC would take responsibility for all financial and technical aspects of the operation and management of water supply and sewerage services within Zone West including the collection of tariffs, employment of staff, dealing with customer complaints, etc. The scope of retail service that will be managed by the new service provider is broadly described as follows:

(i) Purchase bulk treated water from KW&SB and distribute it to all residential and non-residential customers in Zone West including large users such as industries, governmental institutions/organizations, cantonments, commercial entities (hotels, restaurants, hospitals, etc.) currently on a bulk supply arrangement with KW&SB

(ii) Collect sewage generated in Zone West (and also sewage transferred by KW&SB from outside Zone West) and ensure that sewage is properly treated before being discharged into natural water bodies.

(iii) Operate and maintain water supply and sewerage system within Zone West, which among others include the following infrastructure.

    (Water Supply)
    - Water Trunk Mains
    - Trunk Distribution Mains
    - Distribution Network Mains
    - Distribution Pumping Stations
    - Service Connections

    (Sewerage)
    - Service Connections
    - Sewage Collection Network
    - Trunk Sewers and Interceptors
    - Sewage Pumping Stations
    - Sewage Treatment Plants

(iv) Make extensions and improvements to the existing water supply and sewerage system in Zone West

(v) Collect water supply and sewerage charges from customers to recover the reasonable costs of providing services that are prudently and efficiently incurred

(vi) Enhance public hygiene and the preservation of the environment by supplying safe water that complies with the recommendations of the WHO Guidelines for Drinking Water and by ensuring that sewage is treated properly to such an extent that effluents from treatment plants comply with the requirements of the NEQS.

It is suggested that the majority of the PLC's shares would initially be held by CDGK and TMA's that fall within Zone West. As such, the reform is in line with the on-going process of "Devolution". Other stakeholders in Zone West such as large industries, cantonments, organizations representing civil society, private companies and a trust representing the interests of the company's employees would gradually be included as part of the shareholders as the financial performance of the PLC improves in future.

The objective of the PLC would be to undertake the operation of water supply and sewerage services in Zone West in accordance with high commercial and professional standards and without external interference in the day-to-day management of the services. There would be no political representation on the Board of the PLC and the articles of association and shareholders' agreement would specify that members of the Board should be selected on the basis of their commercial, professional, managerial and/or technical qualifications and experience.

JICA Study proposes that an independent Regulatory Board (RB) should be formed for economic and technical regulation of water supply and sewerage services in Zone West (see **Figure 91.6.3**). The RB should have the obligation to ensure that the new retail entity in Zone West is able to recover the reasonable financial and economic costs of providing water supply and sewerage services in Zone West. For this purpose, it will define a formula for setting tariffs that reflect the reasonable costs of providing the services to ensure that expenditures are prudently and efficiently incurred. It will also ensure that the formula is properly applied and implemented. The GOS and other local governments will have the power to intervene to limit tariff increases for reasons of regional policy but will be required to compensate the retail entity in such cases. The RB would be responsible for ensuring that the poor and lower income groups are protected from any unacceptable distributional impacts of tariff increases that might fall on them. Where services are provided free of charge the retail entity must be compensated by the relevant local body responsible for social welfare services. The Zone West retail entity would pay a regulatory charge from out of its gross water supply and sewerage revenues to cover the costs of the Regulatory Board.

The RB would monitor the performance of the Zone West retail entity against the prescribed service standards and will also act as 'Ombudsman' in dealing with customer complaints and related issues of customer service. It would also be responsible for setting out and enforcing 'Water Supply and Sewerage Services Regulations' which define clearly the statutory rights and obligations of both the Zone West retail entity and its customers in delivering and receiving the services.

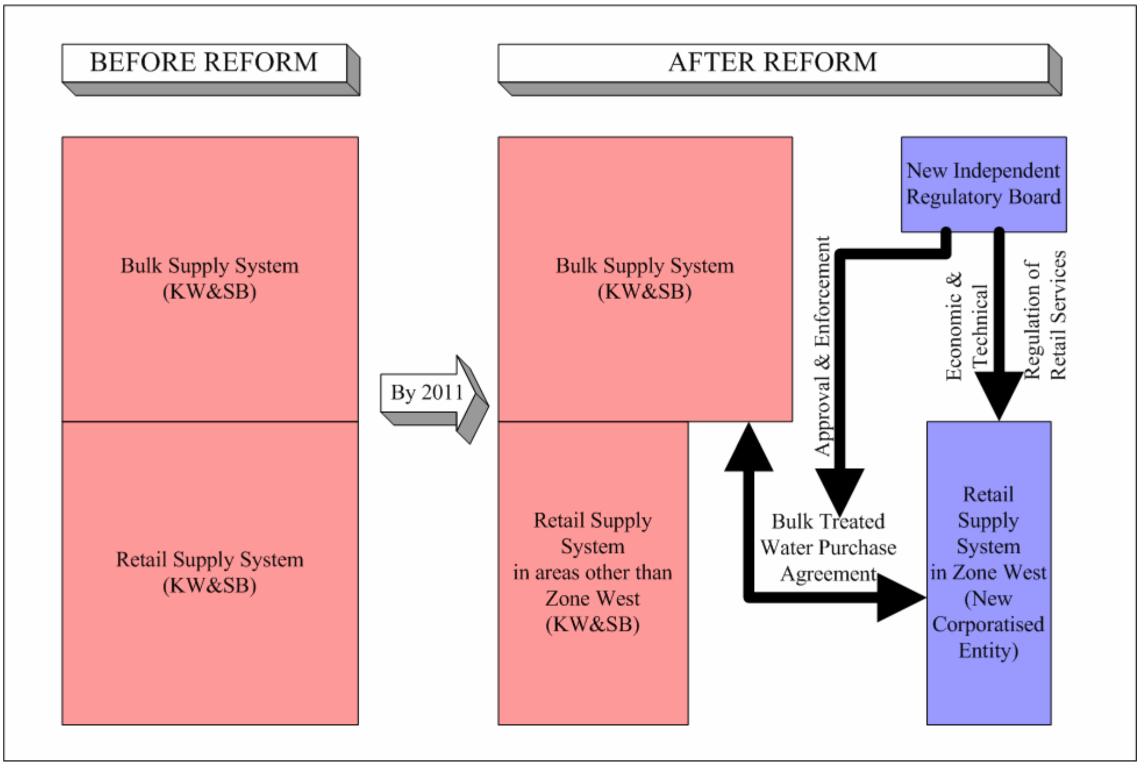


Figure 91.6.3 Institutional Reform Suggested by JICA Study

It should be noted that the 'JICA Study Team' are primarily concerned with the identification of possible reform options and therefore has sought to provide an outline of suggested reforms in principle at this stage. It is expected that detailed studies related to the suggested reforms will be carried out jointly by the Water and Sanitation Program (WSP) and the ADB assisted 'Karachi Mega City Sustainable Development Program (KMCSDP)'.

In order to put this reform (corporatisation) into effect, separate studies will need to be conducted:

- To draft amendments to relevant laws, ordinances and/or regulations that are necessary to enable KW&SB to relinquish responsibility for provision of retail services (water supply and sewerage) in Zone West
- To draft articles of association and shareholders agreement of the Zone West retail entity
- To develop a tariff structure which would be applied in areas where DNI has already been completed, and which, while providing adequate protection for the poor and a strong incentive for efficient use of water, ensure that the Zone West retail entity is able to recover the reasonable costs of providing the services including debt service on loans borrowed for financing DNI.
- To establish a mechanism for the transfer of KW&SB's employees currently engaged in provision of retail services in Zone West to the Zone West retail entity, including transfer of employees' pension rights, severance funds, etc.
- To establish a mechanism to determine the condition of retail assets and for the valuation and transfer of retail assets to the Zone West retail entity
- To establish a mechanism for dealing with the liabilities and receivables associated with the retail assets and customer base transferred to the Zone West retail entity
- To establish an independent Regulatory Board for economic and technical regulation of the water supply and sewerage services
- To draft 'Bulk Treated Water Purchase Agreement' between KW&SB and the Zone West retail entity

It is expected that the reform process would be put into effect through the 'Reform Committees' that have already been established under WSP's initiatives, which would take responsibility for ensuring the progressive implementation of reforms in close coordination with the Local Support Unit (LSU)-CDGK of the ADB assisted KMCSDP.

9.2 IMPROVEMENT OF FINANCIAL MANAGEMENT SYSTEM

A situation assessment of the current financial management practices and performance was carried out during the first phase of the study. Shortfalls were identified through the analysis of financial information and the diagnosis of financial statements. An outline of the key findings with recommendations for improvement can be summarised as follows:

9.2.1 Electricity Charges

Electricity charges are the largest expenditure item among direct costs of water supply and sewerage system operated by KW&SB. It accounted for Rs.1.64 billion or 57% of the total direct operating cost in the fiscal year 2004-05. Thus, this charge is the most serious component to lift water production cost. As a matter of fact, it is an essential cost for KW&SB to convey water source from Indus River. Therefore, the electricity expense is a key issue for KW&SB to reduce the total expenditure. KW&SB is using three kinds of energy sources for power machines in pump stations and plants. They are electricity, city gas and diesel. Among them, the electric power is the overwhelming expenses, because of its convenience. KW&SB is purchasing energy as power source at the following average prices at present.

Table 92.1.1 Comparison of Energy Sources in Unit Prices at KW&SB

Energy Source	Average Purchasing Price	Price per MMBTU	Price per 1000kcal
Electricity	Rs 6.04 per kWh	Rs 1,770	Rs 7.02
City Gas	Rs 10.70 per m^3	Rs 325	Rs 1.29
Diesel	Rs 37.70 per litre	Rs 1,040	Rs 4.13

Remark: Energy contents were set as 860 kcal/kWh of electricity, 8,300 kcal/m^3 of gas and 9,130kcal/l of diesel.

As shown in **Table 92.1.1**, the price of electricity is the highest of Rs.1,770 per MMBTU among the above energy sources. Gas is only Rs.325 per MMBTU or 18% of electricity. Diesel, however, is Rs.1,040 per MMBTU or 59% of electricity, so it is not cheap enough as energy source. Although the gas cost is much cheaper than electricity, it usually costs more to convert into power because of comparatively expensive power-driven machines by gas in general. It is said that natural gas is regarded as promising energy source in the country. It might be a good opportunity to utilise natural gas for power source in KW&SB.

In addition, KW&SB puts forth an effort to search useful new energy sources in Karachi. In developed countries, electricity bulk users procure electric power from neighbouring large factories which generate superabundant power based on excess generation capacity. That utilisation creates another social order issue in power market. It might be necessary to prepare relevant laws.

Natural energy sources are quite attractive energy sources in all countries. In particular, solar energy, wind power, hydro-power, etc. are considered as important and useful energy sources. Some of utilisation technology, however, is still under development and so its installation costs much as compared with existing fossil energy utilisation in general. In the long run, the agencies concerned can consider and discuss the possibility of natural energy utilisation, referring the natural climate conditions in Karachi.

9.2.2 Financial Charges

Financial charge is also serious component for high water production cost. It accounted for Rs.1.18 billion, which was the second largest expense in the expenditure items in the fiscal year 2004-05. Moreover, a part of interests within due time was not included in the financial charge and carried forward to the following year. That is reckoned in “accrued financial charges” in the B/S of the current year. In 2004-05, this amount was as follows: Rs.170 million as accrued financial charges of long-term foreign loans and Rs.1,063 million as that of short-term foreign loans, although the latter charges must be paid within a year. Eventually, the total financial charges aggregated to Rs.2,416 million at the end of the fiscal year. This would obviously be proof of heavy burden for financial management.

In order to avoid this condition, KW&SB has to procure high grant-element loans from donor countries as official development assistance (ODA). Incidentally, the ODA loan is defined as its grant element is more than 25%. For example, a grant element of the loan number SF-1001Pak by ADB was calculated at 27%, so it is narrowly classified as ODA loan. Since that of the loan number of PK-P40 by JBIC was calculated at 52%, it is also perceived as ODA. On the other hand, the loan number of 1987 by IDA was calculated at minus 4.8%, it might not be considered as ODA loan. In addition to interest charges, every loan lender levies some other charges like commitment charges and service charges.

Table 92.2.1 Grant Element of Agreed Loans

Loan Number	Lending Agency	Amount of Loan (million)	Interest Rate (%)	Repayment Period (Yrs)	Grace Period (Yrs)	Grant Element*1
1987-Pak	IDA	SDR 163.5	11.0	25.0	5	-4.8%
SF-1001Pak	ADB	SDR 39.9	7.0	35.0	10	26.8%
PK-P40	JBIC	¥10,300.0	2.6	20.5	5	51.9%

Remark: The details of the loans above and other loans are tabulated in **Table 35.2.2**.
Note: *1 Discounted at 10%.

Yet, KW&SB can not receive ODAs directly from donors as bi-lateral from foreign countries or multi-lateral loans from international financial organisations. In general, it receives ODA loans through the federal government as two-step loan. Therefore, the federal government is only one agency to contact for negotiation with foreign donors.

Pakistan has already borrowed considerable amount of loans from various countries and organisations. As a result, its debt-service ratio (DSR), a kind of country risk assessment factor of financing, has been at almost the serious level. As shown in **Table 92.2.2**, the DSRs for the recent five years were in the neighbourhood of 20% which is the critical level.

Table 92.2.2 Debt Service Ratio

Item	2000	2001	2002	2003	2004
Debt Service	2,854	2,995	2,850	3,040	4,285
Export of Goods & Service	11,312	12,164	15,943	18,980	20,242
DSR	25.2%	24.6%	17.9%	16.0%	21.2%

(Unit: US$ Million in lines 2 & 3)
Source: Global Development Finance, Country Tables 2006, March 2006, World Bank

9.2.3 Compensation of Labour

Compensation for workers of KW&SB is also an essential cost component for operation of water supply and sewerage services. It accounted for Rs.874 million or 30% of the direct expenditure in 2004-05. In the same year, the number of workers in KW&SB was recorded as 8,180 in total. Among them, around 4,600 workers are engaged in water supply services. Since KW&SB supplied 351 mgd of water in the same year, the number of employees over daily water supplied was calculated as 13.1 persons per one million gallon per day. This figure indicates almost double the average rate in Japan. Thus, this cost item must still have plenty of room for improvement and cost saving through enhancement of labour productivity.

In order to enhance labour productivity, KW&SB should standardise their daily routine of operation and maintenance (O&M) and sales activities. The close investigation of the present daily routine works and the in-depth analysis of their works would need to be conducted. The analysis results must be reflected to a work manual as standard work steps. The respective section chiefs must manage thoroughly their workers in conformity with the standard work schedule.

9.2.4 Accumulated Deficit

The profit and loss (P/L) table as of the end of 2004-05 indicated the accumulated deficit of Rs.10.4 billion. It is around four times of the annual sales in the same fiscal year. This was a result of the accumulation of deficits during the recent four years. During these years, KW&SB recorded a constant ordinary loss of more than Rs.2 billion. In other words, KW&SB has spent almost double the amount of its sales.

Moreover, the balance sheet (B/S) shows the accumulated financial charges in both the long-term and short-term foreign loans. Their figures were Rs.10.3 billion and Rs.3.0 billion, respectively. Their total comes to Rs.13.3 billion as of the end of 2004-05. This amount is more than the accumulated deficit and nearly equal to the outstanding of the principal (Rs.14.5 billion of the long-term foreign loans) in the same year. This is obviously another accumulated deficit. KW&SB might be able to get rid of some portions of these huge deficits by means of making disposition of hidden assets, such as undervalued real estates or securities. Although the B/S does not indicate these hidden assets, it could be potential financial sources if any are available.

9.2.5 Capitalisation

Water supply and sewerage service is one of process industry. The characteristics of process industry are of a high capital intensity of production, so the industries pour enormous sums into plant and equipment. Accordingly, they have large equity capital for investment. The capital adequacy ratio, i.e., equity capital over the sum of equity and liabilities, of Japanese water supply enterprises is around 53% as an average of 49 water supply enterprises serving more than 300,000 consumers.

In the case of KW&SB in the year 2004-05, its capital adequacy ratio was around 10% only. If the grant-in-aid is added into the equity, the capital would increase to Rs.17.5 billion, so the ratio is calculated at 47%. However, these capitals were withdrawn to be allocated to the accumulated deficit of Rs.10.4 billion. These grants were given mainly by GOS in recent years. In the year 2004-05 particularly, the “Greater 100 MGD Water Supply Project (K-III)” contributed the major grant portion to KW&SB. The insufficient equity obliges KW&SB to resort to external financial sources like loans and debts. It makes KW&SB to impede its management safety. It would be necessary to substantially increase its equity capital instead of increasing long-term debts.

9.2.6 Cost Recovery

The huge deficits in recent years mainly come from small operating revenue and large operating expenditure. In the year 2004-05, the total revenue was Rs.2,653 million, comprising Rs.2,232 million from water supply service and Rs.421 million from sewerage service. On the other hand, the total expenditure was Rs.3,896 million for operation, comprising Rs.3,069 million for water supply operation, Rs.537 million for sewerage operation and Rs.290 million for administration. In addition, the current financial charges were Rs.1,183 million. Furthermore, the accrued financial charges in the B/S were Rs.1,233 million as outstanding financial charges in the same year.

In 2004-05, the volume of water distributed to consumers was estimated at 128.1 billion. The volume of sewage collected was estimated at 89.7 billion gallons per annum. On the basis of these data, their unit values are calculated as shown in **Table 92.6.1** below. The common costs, which do not belong to operation activities, distributed proportional to the respective total expenditures.

Table 92.6.1 Unit Prices and Unit Costs of Water and Sewerage: 2004/05

Unit Value	Water	Sewerage
Unit Price	17.4	4.7
Unit Cost		
Unit Cost Based on Operation Expenditures	26.4	6.6
Unit Cost Based on Common Expenditures*1	16.0	4.0
Unit Cost	42.4	10.6

Remark: Including current and accrued financial charges

As shown in the table, the unit prices of both water and sewerage were 66% and 71% of unit costs based on operation expenditures. They were also down to 41% and 44% of unit costs based on the total expenditures. The difference between unit price and cost was quite large. It would not be impossible for KW&SB to improve their financial management without rectifying this situation. Moreover, approximately 20% of the sale revenue became to the accrued income and is reckoned up to account receivable, named as debtors (consumer's balance). This is another serious problem for the financial management.

From the point of financial management, cost recovery is the most fundamental policy for business enterprise. The cost recovery policy is an important principal for solving the financial problems and warrants further investigation.

9.2.7 Building a Sound Basis for Financial Management

Based on the above it is evident that a number of fundamental changes are necessary to improve the financial performance and thus the financial sustainability of KW&SB.

Assuming the principle of corporatisation, KW&SB will need to develop further financial management and control skills and expertise to manage the organisation on sound commercial principles. Accordingly, KW&SB will need to develop business planning practices as well as new, sound accounting and budgeting procedures and formats to ensure effective financial management, control and sustainability. This will include the need for sound computerised financial application software and computer systems; a 'Financial Information System' (FIS). Where financial staff are placed at operational sites or 'town offices', systems will need to be 'networked' to ensure access to and security of finances and financial information. KW&SB will need to invest in this as well as other systems to improve financial as well as operational performance. Taking SSGC as an example, they have invested heavily in "ORACLE Enterprise Resource Planning"; a systems suite that integrates application across all business processes including finance, human resources, operations, project planning, etc.

An asset revaluation exercise will also have to be undertaken to establish a complete list and value of current assets for effective planning and depreciation. Based on the above, it is likely that intensive staff training will be required to raise the level of financial management and control throughout all levels of the organization, including technical, field and accounting staff.

KW&SB will also need to develop and use a number of relevant key financial performance indicators to monitor performance at the centre as well as within the zonal "business units" or "service provider organisations" depending on how the organisation is reformed in future.

9.2.8 The Need for Financial Self-sufficiency

Financial self-sufficiency will afford KW&SB:

- Freedom in financial management with discretion to decide how to use the funds generated from services provided. KW&SB will have to work within the limits of the constraints of financial capacity that revenues bring
- Incentives to improve overall financial performance through efficiency savings (reducing operational expenditure through optimisation of business and operational processes)
- Incentives to increase revenues through improved service delivery and customer services (improving commercial billing and revenue practices and focussing on the reduction of NRW)

9.2.9 Achieving Financial Self-sufficiency

It is recognised that the provision of water and sanitation services has both socio-economic and financial dimensions; however, whilst these may be essential services for all regardless of social and financial standing, service providers will need sufficient financial incentive through cost recovery mechanisms (tariffs and revenues) to sustain a viable business.

In the long term, financial self-sufficiency means that revenues received (mainly from water and sanitation services sales) are able to cover the direct and indirect operating expenses, indirect costs, debt service and capital expenditure.

KW&SB's aim will be to achieve financial self-sufficiency in the future; not least, because this will afford them 'independence' from government influence and 'interference' in day to day operations. Corporatisation will be a good way to achieve this through affording the organisation more freedom for financial management. As discussed previously, this will bring with it the prerequisite for effective regulation to be in place.

9.2.10 Use of Financial Indicators

In future KW&SB's FIS will need to be capable of providing managers with timely and vital financial information relevant to their responsibilities within the organisation. This can be provided either by 'cost centre', functional department or 'business unit'. Relevant financial reports and key performance indicators and/or 'financial ratios' will also need to be measured and tracked to provide internal information as well as satisfy external reporting needs.

One of the major purpose of compiling the financial statements; Balance Sheet, Income Statement, and Cash Flow Statement, is to assess the financial condition of KW&SB. More emphasis should be placed on financial performance through the analysis of financial indicators. These are calculated from the information contained within the financial statements and are designed to show the relationship between various components of the entity's financial statements.

There are a number of useful indicators such as; Liquidity ('current ratio', 'gearing ratio'), Profitability ('operating ratio', 'return on assets', 'unit production costs', 'unit price'), Solvency ('debt to equity ratio'), Efficiency ('NRW ratio', 'facility utilisation ratio') Productivity ('staff per 1000 connections' 'Accounted for Water per employee'), Current Asset Management Capability ('collection efficiency', 'accounts receivable turnover ratio') etc. KW&SB will need to focus on performance measurement in this way in order to measure financial performance and to enable comparison with other organisations (benchmarking). This will enable KW&SB to not only track performance but will provide a 'tool' for performance improvements generally by tackling the areas of concern identified by the various indicators.

9.3 REDUCTION OF NON−REVENUE WATER

9.3.1 General

It is important to have a clear understanding of the internationally recognised definition of Non-Revenue Water (NRW) which is comprised of several components as shown in the following **Table 93.1.1**.

Table 93.1.1 Definition of Non-revenue Water

<table>
<tr><td rowspan="9">System Input Volume</td><td rowspan="4">Authorised Consumption</td><td rowspan="2">Billed Authorised Consumption</td><td>Billed Metreed Consumption (including water exported)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Un metreed Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorised Consumption</td><td>Unbilled Metreed Consumption</td><td rowspan="7">Non-revenue Water (NRW)</td></tr>
<tr><td>Unbilled Un metreed Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="2">Apparent Losses</td><td>Unauthorised Consumption</td></tr>
<tr><td>Metreing Inaccuracies</td></tr>
<tr><td rowspan="3">Real Losses (UFW)</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility’s Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metreing</td></tr>
</table>

Source: IWA “Best Practice” Water Balance and Terminology

As can be seen, water losses are divided into Real and Apparent Losses and Real Losses represent Unaccounted for Water (UFW). When combined with Unbilled Authorised Consumption (metreed & un-metreed) this equates to the total Non-revenue Water (NRW), that is water put into the system for which no payment is received.

There is often confusion and disagreement on UFW/NRW percentages because of lack of understanding of the definitions. For example, in the Mott McDonald Draft final Report Executive Summary dated April 1996; overall “leakage” in the trunk, secondary and tertiary mains was estimated to be 30% of system input. This is not the total UFW (water loss) which must include leakage/overflows from storage tanks, unauthorised consumption and metreing inaccuracies.

In the absence of system-input metreing and retail supply metreing the UFW percentage can only be a reasonable estimate, based on the Mott McDonald detailed analysis of pipeline losses and adjusted for the deterioration of the system over 10 years and for unauthorised consumption, and metreing inaccuracies. This report uses a reasonable estimate of 35% for UFW.

The following sections examine each component, review the relevant laws and regulations, examine the management system, and develop an Action Plan for reduction of NRW.

9.3.2 Reduction of Leakage in Trunk Mains

There are over 200 km of trunk water mains varying in diametre from 18” to 72”, the most widely used material being pre-stressed reinforced cement concrete (PRCC) pipes. In 1996 it was assessed that 40% of the overall pipelines leakage occurred in the trunk main system. Lack of metreing prevented accurate measurements but leakage results were obtained from extensive investigations by consultants.

From the inception of the K-III scheme to augment supplies by 100 mgd it was planned to maximize the benefits by reducing trunk main water losses. In May 2006 a contract was entered into between KW&SB and M/s MM Pakistan (Pvt.) Ltd. for Engineering Services for "Rehabilitation & Strengthening of Water Supply System under KIII Project"

The scope of works includes developing system mapping and a database in map form to show comprehensive details of the water system and to develop an equitable water distribution plan for Karachi. The physical works relate to trunk mains and reservoirs and are divided into two groups:

- Group A: System rehabilitation with extensive repairs to leaking joints including strengthening of the water supply system and rehabilitation work related to reservoirs
- Group B: Installation of flow measuring metres and flow control valves to regulate the water supply system. This includes flow metres at outlets to water treatment works, reservoirs, bulk water pumping stations and distribution pumping stations

The project contains 10 contract packages, 4 of which will shortly be awarded. These contracts are for strengthening of joints externally/internally on weak segments of trunk mains, replacement of part of old Dhadeji PRCC rising main, providing a new gravity main to Orangi town and Rehabilitation of University Reservoir. As of May 2007, 5 more contracts were awaiting KW&SB approval prior to inviting tenders. The last contract under preparation is for flow metres, pressure reducing and other control valves.

The System Mapping & Data Base work has commenced for the production of digital maps (scale 1:2000) to show full details of KW&SB's water supply facilities. The project which will rehabilitate about 50km of trunk mains and 2 reservoirs, provide a system data base and, as an extra, provide a new gravity main for additional water supplies to Orangi town, is expected to last about another 15 months at an estimated cost of Rs 2.2 billion. These rehabilitation works should reduce leakage and result in a reduction of UFW.

9.3.3 Reduction of Leakage in the Distribution System

The water distribution network comprises about 4,850 km of pipelines of which about 65% is asbestos cement pipes and 26% cast iron. Much of the system is old and in very poor condition. KW&SB regulate supplies to sub-zones by opening and closing feeder valves from the trunk mains and regulating the hours of operation of distribution pumping stations. Almost all "retail" (un-metreed) consumers (consumers other than bulk metreed supplies) are subjected to intermittent water supply.

Leakage within the secondary mains between the trunk mains and the distribution system is estimated to be 20% with the remaining 40% of overall pipeline losses occurring in the distribution system. There is no overall specific strategy, plan or department to deal with leakage; this task falls to the SEs of the 18 towns, under the direction of the appropriate Zone CE.

Substantial water losses and leakage occur due to the following:

- An aging network lacking maintenance and repair
- No planned leakage control system
- Poor workmanship and materials used for pipe and joint repairs. It is said that lack of funds prevents the purchase of spare pipe, repair collars etc. The current practice of using rubber tubing and cement rendered plastic for repairs has become the accepted norm of KW&SB.
- Poor workmanship and materials for connections carried out by the consumer (rarely the declared registered plumber) which are largely unsupervised by KW&SB staff
- Household water systems comprising ground and overhead tanks and an electric pump usually directly connected to the distribution pipe cause large losses due to leakage and

overflows which go unchecked because there is no volume charge

To reinforce this view we quote from the ADB "DRAFT Karachi Sustainable Mega City Water & Wastewater Roadmap", May 2007, as follows:
"The KW&SB distribution system is in very poor condition. It suffers from high leakage, contamination, and provides an average of only 3 hours supply per day. The distribution pipes and service connections are dilapidated and leak heavily. This is the biggest technical problem faced by the KW&SB. Considerable investment is needed to rehabilitate the distribution system and bring it to a level where it can provide potable 24/7 water supply. This investment will involve data gathering and pilot implementation of technical solutions, replacement and rehabilitation of distribution mains and service connections, implementation of District Metreing Areas (DMAs), and customer metreing to monitor the situation."

ADB will support improvements to the distribution system in accordance with the following:

- A rolling program of Distribution Network Improvements (DNI) on a zone-by-zone basis designed to significantly reduce system losses and progressively move towards achieving 24/7 supply.
- Improving the water distribution system is an immediate investment need. Distribution System Data Gathering and Pilot Improvements projects would lay the basis for future distribution improvement projects. This would involve investments in information gathering equipment such as bulk and customer metres and trialling distribution improvements (for instance, pressurizing a small zone for 24 hours and doing a rapid leak detection and repair program)."

It is understood that this project could be implemented as an extension to the current Rehabilitation & Strengthening of Water Supply System under KIII Project.

9.3.4 Reduction of Apparent Losses

(1) Unauthorised Consumption

While there are no reliable figures, and there is little information on this matter there are thought to be many illegal connections. Many services are known to have more than one connection to tap pipelines to maximise the time they have water. It is also known that illegal connections have been made to the trunk/secondary mains system as these pipelines are always full. Supplies to large Katchi Abadis are generally poor due to the distance from the distribution system and very long, above ground, illegal connections to the nearest pipeline are clearly visible.

Little is done to disconnect illegal connections. The law is rarely, if ever, enforced by those charged with these duties and there is known to be a degree of political and other interference.

(2) Metreing Inaccuracies

Due to the fact that about 1 million "retail" consumers are not metreed, inaccuracies in metres and metre reading is confined to about 5,000 bulk metreed connections. These bulk metres are located on the off takes from trunk or secondary mains which are pressurised 24 hours a day and it is said that metres generally record accurately. Any recording problems may be resolved by the metre workshop department which is equipped to repair and calibrate these bulk supply metres.

9.3.5 Laws and Regulations Relating to NRW

The Laws governing KW&SB appear to be unclear to a number of stakeholders. The Karachi Water & Sewerage Board Act of 24th April 1996 provides for the establishment of a Board for supply of water and disposal of sewerage in the Karachi Division.

The Managing Director (Chief Executive of the Board) is appointed by government (government being defined as the Government of Sindh). The powers of the Board include the following in relation to NRW:

1) Sanction in the manner on payment of fees as may be prescribed by regulations
    a) Water connections.
    b) Water supply to tankers.
    c) Sewerage connection.
2) Levy, collect or recover rates, charges or fees for water supply and sewerage services, including arrears thereof.
3) Have the power to reduce, suspend or disconnect the water supply in the event of contravention of the provisions of this Act or regulations.
4) Have the power to impose surcharge, not exceeding double the amount due, if rates, charges or fees for water supply or sewerage service or the arrears thereof are not paid within the time fixed by the Board.
5) Make regulations with the approval of the Government.
6) Regulate, control or inspect water connections, sewer lines and service lines including internal fittings.
7) Prepare and submit to Government schedule of water and sewerage tariff, rates, charges or fees to be levied by it.
8) Government shall, sanction with or without modification schedule of water and sewerage tariff, rates, charges or fees to be levied for the supply of water and maintenance of sewerage service within ninety days of its submission
9) Government may give aid or make grant to the Board.
10) The Board shall be responsible for bulk production of potable water and its distribution in accordance with the provision of this Act.
11) Subject to the provision of this act and the rules of Board, with the approval of the Government, make regulations for carrying out the purposes of this Act.
12) In particular and without prejudice to the generality of the foregoing powers, such regulations may provide for:
    a) Procedure for applying for water and sewerage connections including payment of fees for making application in this behalf.
    b) Regulation, control or inspection of private houses, water connections, service lines including internal fittings.
    c) Procedures for levying collecting rates, fees or charges for water supply and sewerage service and imposing surcharge in case of any default made in payment thereof.

The Sindh Local Government Ordinance 2001 devolved political power and decentralised administrative and financial authority to local government, in this case the CDGK comprising 18 Town Municipal Administrations and 178 Union Councils. KW&SB are administered through an Executive District Office (EDO) of CDGK. There is provision in the Ordinance for further decentralisation to towns in a city district. The definition of government in this Ordinance is again the GOS.

Hence Regulations are made by the Board of KW&SB with the approval of the Government of Sindh (GOS), for example the Revised Schedule for Water Supply & Sewerage Services published in the Sindh Government Gazette 1st October 2001 (Tariff)

In 2006, in terms of clause 6 (i) (c) of the KW&SB Act of 1996 the Chairman issued New Connection & Service Charges. This clause allows the chairman to act on behalf of the Board in any emergency for ratification by the Board at its next meeting. Presumably this clause was used because the Board never meets.

It appears therefore that in the devolution process KW&SB are a "Water & Sanitation Agency" functioning under CDGK. The Chairman is the CDGK Nazim with an MD acting as the Chief Executive of the Board. The composition of the Board was changed post devolution and presumably the Chairman, MD and all other board members were appointed by GOS. It is not known why the Board has ceased to function since 2001. It is not known if regulations were ever issued under the act to state when the board should meet, but failing such regulation the Chairman shall direct when meetings are held.

Whereas the board has powers on management of the system, water and sewerage tariff, rates, charges or fees to be levied for the supply of water and maintenance of sewerage service must be sanctioned by GOS.

There is a certain degree of confusion as to the responsibilities of KW&SB following the devolution from GOS to CDGK. Due to the involvement of TMA Nazims at ground roots level there are those who think water and sewerage services are a function of the TMAs. In the JICA Study Team Water Awareness Survey only 30% of Katchi Abadi residents were aware that KW&SB is the service provider.

Regarding Regulations, the items for which these are required are listed in the 1996 Act, and have been produced by KW&SB with approval by GOS as necessary (for example, the revised tariff was published in the Sindh Government Gazette). However, new regulations governing Water Connections and Connection Services, produced by internal memorandum in 2006 were not published although it is said that they were discussed with other stakeholders. Regulations regarding disconnection for non-payment are shown on the reverse side of the monthly bill. It would appear that By Laws have not been produced or revised for decades.

9.3.6 Distribution Network Improvement (DNI)

It is the considered opinion of this JICA Study Team that a substantial improvement to water service quality can be achieved by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. This view is shared by ADB in its Draft Karachi Sustainable Mega City Water & Wastewater Roadmap, May 2007.

Pilot projects are planned for Distribution Network Improvement (DNI) and KW&SB have accepted this principle as the way forward. It is also interesting to note that about 85% of households interviewed in the Water Awareness Survey support the introduction of domestic water meters. For the implementation of DNI's, efficient systems need to be developed for the reduction of non-revenue water including the reduction of physical water losses (UFW) which together with other initiatives will reduce overall NRW, these include:

- Proper repair to leakage points using appropriate materials and developing a skilled labour force and/or replacing pipes that are beyond repair
- Proper installation of new connections, water meters, accurate metre reading, calibration, repair and replacement of metres
- Water loss monitoring, identification of leaks and repair
- An accurate customer database and an efficient and effective billing and collection system
- A Consumers Service Centre for information as well as complaint resolution

- Elimination of illegal and unauthorised connections
- Efficient water use

9.3.7 Management System

The current management system for the reduction of UFW is weak and there is a need for strengthening the management system with the aim of reducing the amount of non-revenue water through water losses. This must be looked at in the overall context of the introduction of corporate reforms in the proposed ADB study as part of ADB's technical assistance for capacity building within CDGK, linked to future loans for the Karachi Mega City Development Project.

The ADB study is a follow on from the findings of the World Bank and Swiss Development Corporation for evolving a long term corporate strategy for KW&SB for structural changes, management accountability and organisational changes to eventually achieve full cost recovery whilst meeting the needs of customers and other stakeholders.

Management reform requires strengthening of the management system and is linked to institutional reforms to improve service provision by KW&SB. At a World Bank sponsored workshop held in February 2005 the core message was "fixing water and sanitation service delivery is not about fixing the pipes – it is about fixing the institutions that fix those pipes".

KW&SB has already embarked on a number of reforms and two additional vice chairmen have recently been appointed to facilitate and expedite the overall working and ongoing process of reform in KW&SB. There are many areas to be tackled and consideration has not yet been given to the reduction of real and apparent water losses (UFW).

The response by KW&SB to the problem of water losses, and in particular leakage, has been poor over the years. With the disbanding of the Distribution and Leakage Units there is no centralised system to control the work that should be carried out at Town level where lack of human and financial resources compounds an already bad situation.

The workshop referred to above noted the following:

- Technical staff lack professional knowledge and skill
- Lack of capability of staff below Assistant Executive Engineer (AEE)
- There is a need for a Resource Facility to train technical manpower below AEE (operational efficiency would assist in reducing NRW resulting from leakage).

A new NRW department will require an improved performance of the personnel at head office and zone level as KW&SB moves to a commercially oriented and competent organisation. In addition to capacity building and training, new staff and/or graduate trainees with appropriate qualifications will be required where expertise is limited.

The responsibility for water losses must ultimately be assigned to the "asset owners", i.e. the managers and operators of the network at zone level, with overall responsibility being assigned to a dedicated NRW department which will take responsibility for the reduction of water losses (and revenue losses).

9.3.8 Action Plan for Reduction of NRW

The current contracts to rehabilitate and strengthen the trunk mains (K-III project) to reduce water losses (UFW) should improve availability of water and provide a platform for further improvement to the trunk main system. Management of water losses will be improved if

KW&SB involve themselves in these projects. Furthermore, ADB have an interest in trunk mains and according to the "DRAFT Karachi Sustainable Mega City Water & Wastewater Roadmap" dated May 2007, ADB state that the K-III project is only being utilised to 40% of its capacity of 100 mgd. Current KW&SB works will bring an additional 40 mgd on stream and ADB will support the transmission expansion to bring the final 20 mgd to the KW&SB's customers at an estimated cost of Rs 1.2 billion (US$ 20 million) in their First Tranche Subprojects. The works comprise:

- Provision of approximately 20 km of 48" dia. and 36" dia. water transmission main from Pipri Treatment Plant to Korangi Industrial Area
- Provision of approximately 25 km of 36" dia. water transmission main from Pipri Treatment Plant to Malir Town

The Rehabilitation & Strengthening of Trunk Mains (K-III) project should be extended to cover the remaining 150 km of existing trunk mains to reduce water losses.

Regarding losses in the distribution system, as stated previously ADB are also interested in this urgent matter which requires considerable investment over a long period of time. Recently, a Local Support Unit (LSU) was established within CDGK to execute services and works included under the project. In February 2007 an Invitation for Expression of Interest (EOI) was advertised for a "Study on Water Balance and Equitable Distribution in Karachi". The study is to be completed in four months and the components comprise:

- Evaluating total inflows into the system and to each town in Karachi; actual and billed consumption; water losses and its components, preparing a water balance strategy
- Assessing problems in the distribution network within towns, including pressure and quality problems, and an equitable and efficient distribution system for Karachi in the short and medium term
- Recommending possible investment interventions based on the final analyses

This study will pave the way for future distribution improvement projects. A Distribution Network Improvement (DNI) Programme is included in the ADB first tranche subprojects leading to a rolling programme of DNI improvement on a zone by zone basis to significantly reduce losses and progressively move towards a 24 hour supply.

With regard to leakage within the distribution system, at connections and from household water systems, the DNI pilot projects will provide a platform to launch an overall NRW reduction plan. The pilot projects will provide data, experience and knowledge to develop a NRW unit thereby strengthening management capacity to reduce and control water losses and refine revenue collection systems. At zone level the DNI pilot projects will provide the opportunity to:

- Transfer knowledge and technology through training and active participation of KW&SB staff in the pilot projects
- Carry out training to broaden the understanding of the components of NRW and how to mitigate their effects
- Carry out training on the use of leak detection equipment

Illegal connections must be reduced; they should first be traced and listed by the zonal staff. Action should then be taken in accordance with the regulations; the connection legalised; checked for compliance; and placed on the register. This will become a serious issue when domestic consumers are metreed, and the law must be strictly enforced on defaulters.

The more serious transgression of connecting to secondary and trunk mains should be met with the full force of the law as a lesson to those involved in this mal-practice. Politics must not be allowed to interfere.

With the onset of universal metreing, a new facility will be required for the calibration, repair and replacement of domestic metres in addition to a modernised bulk metre facility requiring capacity building in this area.
The law relating to KW&SB as the Water & Sanitation Authority under CDGK should be revisited to ensure compatibility between the 1996 Act and the Sindh Government Ordinance of 2001. The public need to be made aware of the powers and duties of KW&SB and its relationship to TMAs in the context of service provision.

Regulations need to be simplified and reproduced in book form for water connection service charges, sanctioning of water connections, payment default etc. all in accordance with item 12) in **Section 9.3.5** above. The internal memoranda relating to service charges and connections, although described as “simplified” and “consumer friendly” are both 10 pages in length with a bewildering array of instructions and number of copies to KW&SB personnel.

In addition Regulations need to be modernised and extended, particularly in view of the intended metreing of retail consumers, to cover:

- Ownership of service connection pipe and responsibility for metre maintenance
- Materials & workmanship for service connections (including pipe tapping)
- Location and installation of water meters
- Metre reading, disconnection policy, metre repair and testing
- Procedures for KW&SB inspection & approval of new service connections
- KW&SB rights to oblige consumers not to waste water

The By Laws need to be examined for compliance with all other laws and regulations particularly the GOS Ordinance 2001 and the regulations issued in 2006, and re-written as necessary.

A significant increase in the availability of water could be achieved by replacing and refurbishing the distribution network, resulting in cost effective use of existing bulk water. Universal metreing, efficient and effective billing would rationalise water usage, so too would reducing the number of illegal connections. However, regardless of the overall increase in availability of water to consumers by these initiatives, major new sources need to be developed in parallel.

Timescales for the short term, medium term and long term goals for the reduction of NRW are given in the following **Figure 93.8.1.**

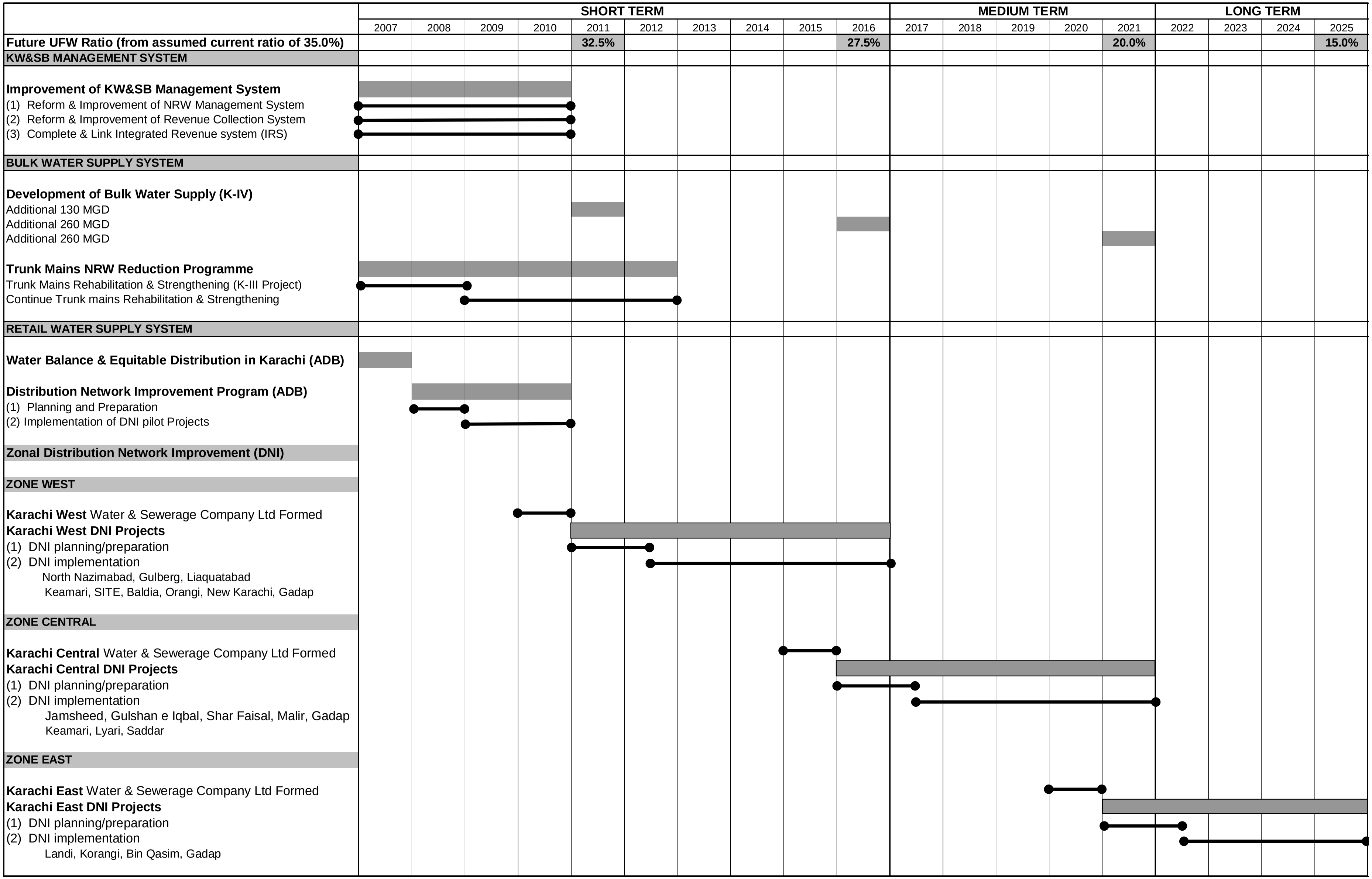


Figure 93.8.1 Timescales for Reduction of NRW

9.4 IMPROVEMENT OF REVENUE COLLECTION SYSTEM

9.4.1 General

The key to a successful water & sewerage service provider is to have the capacity to manage an efficient revenue collection system. Without adequate financial resources, water & sewerage service providers have little chance of sustaining proper operation and maintenance and expand for the future. In the case of KW&SB it has had major problems in its revenue collection system to finance O&M, with poor revenue recovery and mounting arrears. To review this situation all of the components of non-revenue water relating to authorised consumption are examined in this section. These are then related to plans for the improvement of the management system and subsequently the improvement of revenue collection.

9.4.2 Unbilled Authorised Consumption (Metreed)

KW&SB does not at present use domestic metreing. Metreed supplies (referred to as bulk supplies) are confined to government departments, large industrial complexes and other large consumers including housing development areas with their own distribution systems, commercial high rise buildings, hotels etc.

At the end of 2006, KW&SB restructured the metre consumer cell placing it under the supervision of the Superintendent Engineer (SE) Bulk Water Supply together with the metre workshop department. Engineers and revenue officers were allocated to the new structure which also splits the industrial consumers into two zones. This is part of the recent KW&SB initiative to reform the organisation.

The SE would deal with administrative matters whilst technical matters would still be referred directly to the Chief Revenue Officer (CRO). This change has had little or no effect on improving billing and collection.

Bulk supplies are extremely important in terms of revenue since bulk supplies should generate about 1.5 times the revenue for water and sewerage charges of the “retail” domestic consumers. It is therefore extremely important that the approximately 5,000 connections record accurately, are read accurately, billed monthly and monitored closely in regard to payment. The accuracy of the data base for the register of bulk consumers is not known, but this would be an easy task for KW&SB to verify and upgrade as necessary.

The bulk metreed supply department has a staff of 73 of which 25 are assigned to metre reading and bill delivery (average of about 200 metre readings/bill deliveries per person per month). There are no reported problems with metres which are said to be generally accurate, repaired, calibrated or replaced as necessary subject to the availability of replacement metres.

9.4.3 Unbilled Authorised Consumption (Un-metreed)

The un-metreed or “retail” category forms the majority of KW&SB consumers. KW&SB charge a monthly rate for domestic consumers in accordance with the size of the property. It is estimated that approximately 90% of households have a piped water connection (Socio Economic Survey Report-2005, Karachi City Profile V-1.0 / January 25 2006).

However, this does not imply that this number of connections is actually registered on the KW&SB data base. Considering the number of registered household connections which total about 1 million, it seems likely that many households with a piped water connection are not registered with KW&SB, even allowing for the bulk supplies to housing areas in DHA and cantonments.

It had been anticipated that the number of retail consumers on the data base would rise to 1.2 million by June 2007 after the introduction of the computerised integrated revenue system but this has not materialised. Clearly, KW&SB must commence a programme to update the register.

Another important factor in this category is bill delivery. There is anecdotal evidence to suggest that bill delivery may be a major problem. Complaints registered in the IRS centre contain a high number referring to non-delivery of the monthly bill. Considering the fact that only those consumers willing to pay the bill will complain a large problem is indicated.

It is to be noted that the monthly bill deliveries to "retail" consumers is carried out by the same number of personnel who previously delivered the bills annually. The revenue section has a staff of about 900, including bill deliverers, but the actual number of personnel delivering bills is not known. Bill delivery in some areas, particularly in Kachi Abadis is sometimes assisted by staff from the TMAs.

Regarding poor bill deliveries, in the large Katchi Abadis it is thought that up to 20% of bills being printed and sent for distribution are simply not being delivered. This is said to be due mainly to confusion of addresses in the Katchi Abadis (gas, electricity and town registration use different reference numbers). Also many bills are simply ignored because the recipients are illiterate.

9.4.4 Unbilled Authorised Consumption (Tankers)

A recent study by KW&SB states that prior to 1999 KW&SB was responsible for the operation of hydrants for road tanker supplies. When the Hub source failed the tanker service was transferred to the Pakistan Rangers as part of the "Water Crises Management". Pakistan Rangers would now prefer the operation to be taken over by KW&SB.

These tankers are a common sight in Karachi with an estimated 13,750 to 15,390 trips per day adding to the traffic volume delivering an estimated 15-20 mgd daily with a value of about Rs. 1 million/day according to KW&SB. It is estimated that about 25% of tanker deliveries are gratis, and there is a list showing the areas supplied and the approximate number of tanker trips. However, the criteria for selecting consumers for gratis tanker water supply are not clear.

This has been a very large source of authorised consumption for many years from which no revenue is derived and KW&SB are aware that a tanker "mafia" exists conniving with groups in both the private sector and staff of KW&SB to create artificial shortages and enhance profits at the expense of the consumers. In addition it is known that there are illegal tankers and hydrants. Hydrant supplies to tankers were not metreed and revenue was lost by the operation of both legal and illegal tankers.

Water Tankers are currently still operated under the control of the Rangers from the existing hydrants but a completely new arrangement is being implemented and planned to be in operation by the end of June 2007. Under the new arrangement, Tanker supplies will be under the control of the City Nazim who has assigned Tanker operations to the Town Nazims for O&M by the TMAs. The rationale is that the Town Nazims are aware of the needs for tanker supplies through the UC Nazims.

The 1996 Act sanctions KW&SB on payment of fees for water supply to tankers which should be prescribed by regulations. Revenue should therefore accrue to KW&SB. However this system of operation by TMAs has been adopted and is allowed under GOS legal notification

No.SOVIII/KW&SB/2(41)/2002 whereby The KW&SB Act of 1996 may be amended to ensure the smooth implementation of the Sindh Local Government Ordinance, and CDGK may assign work to the TMAs. Whereas it would be preferable for KW&SB to run this operation, this system has been adopted. The intended arrangement is:

- KW&SB finance the construction of metreed hydrants
- TMAs pay the full cost of operation & maintenance of the hydrants
- TMAs appoint Tanker operators by a tender process
- Tanker operators will charge domestic and commercial customers for delivery
- At the discretion of the TMAs, water will be provided free of charge to the poor and needy who lack a piped water supply

New metreed hydrants have been constructed by KW&SB; hydrants have been completed in 15 towns (except SITE, Baldia, Orangi). These 15 towns should be operational by 15th June, and deliveries will be made within the town borders.

The 3 towns of SITE, Baldia and Orangi have the highest ratios of Katchi Abadis which have very poor piped water supplies. Large water tanks located in the towns are filled from the tankers and water is collected by bucket or hand pump. There are about 35 locations where water can be drawn free of charge.

Hydrants can not be located in these towns and all three towns will be supplied by a hydrant located close to the Hub Filtration Plant, which should be in service by the end of June 2007.

It remains to be seen how successful this operation will be under the new arrangement, but it seems unlikely that KW&SB will derive any direct revenue from tanker supplies. At least this service will be metreed, more accurate figures of water supplied will be known, and there is an opportunity to reduce malpractice.

9.4.5 Non-payment of Billed Authorised Consumption

Billed Authorised Consumption is supposed to represent the total revenue of KW&SB for the provision of water & sewerage services. However, much of the revenue remains uncollected because of non-payment of bills, further aggravating the amount of non-revenue water. The KW&SB bill has charges for water, sewerage, conservancy and fire. The revenue for water & sewerage services is retained by KW&SB but the other charges are passed on to the TMAs. The collection situation is examined below:

(1) Metreed Consumption (Bulk Water)

As stated previously metreed supplies are confined to government departments, large industrial complexes and other large consumers including housing development areas with their own distribution systems, commercial high rise buildings, hotels etc. The extent of commercial losses due to incorrect billing or an incomplete database is not known.

However, Information is now being made available to the Revenue Department of KW&SB through the IRS/MIS system and results from May 2007 are summarised in **Table 94.5.1**.

Table 94.5.1 Monthly Billing & Collection for Bulk Consumers (May 2007)

	No. of Bills	Water Amount × Rs 1,000	Sewerage Amount × Rs 1,000	Arrears Water & Sewerage (Rs × 1,000)
Billed	4,995	194,474	48,730	7,395,644
Collected	2,067	72,928	21,745	N/A
Percentage	41.4%	37.5%	44.6%	N/A

Source: KW&SB Revenue Department

As can be seen, the collection rate for the month of May 2007 is unacceptably low considering the generally good supply conditions in the bulk supply system and the consumers' ability to pay. When the full year figures become available after June a more accurate assessment should be made.

The Revenue Department of KW&SB analyse all non-residential details and a list of consumers with arrears of more than Rs 50,000 goes to the Deputy Zonal Directors for action.

Clearly the full benefits of the recently introduced Integrated Revenue System, which rapidly provides accurate information on payment of current bills and arrears will not be realised until KW&SB institutes an integrated approach to act on the information provided and a monitoring system to assess the effectiveness of their efforts.

KW&SB are aware that a good collection rate from bulk consumers would go a long way towards eventual O&M cost recovery. According to figures supplied by KW&SB to ADB if all of the bulk water consumption was billed and collected it could generate an additional Rs 1.5 billion per annum.

(2) Un-metreed Consumption (Retail Water)

A similar situation to the bulk supply exists for retail water in that non-payment of bills is a common occurrence. To illustrate this point a summary of the May 2007 monthly billing figures is given in **Table 94.5.2**.

Table 94.5.2 Monthly Billing & Collection for Town Retail Consumers (May 2007)

	No. of Bills	Monthly Water Amount x Rs 1,000	Monthly Sewerage Amount x Rs 1,000	Water Arrears Amount x Rs 1,000	Sewerage Arrears Amount x Rs 1,000
Zone I					
Billed	176,358	8,327	2,815	53,581	16,650
Collected	24,125	1,337	484	2,528	1,019
Percentage	13.7%	16.1%	17.2%	4.7%	6.1%
Zone II (A)					
Billed	178,386	17,894	5,241	53,581	16,650
Collected	26,452	4,105	1,216	2,528	1,020
Percentage	14.8%	22.9%	23.2%	4.7%	6.1%
Zone II (B)					
Billed	274,306	23,006	7,104	99,037	29,417
Collected	88,658	9,673	3,074	9,306	2,866
Percentage	32.3%	42.0%	43.3%	9.4%	9.7%
Zone III					
Billed	333,778	18,709	6,291	95,493	29,019
Collected	88,109	6,079	2,092	7,729	2,914
Percentage	26.4%	32.5%	33.3%	8.1%	10.0%
Total					
Billed	962,828	67,936	21,451	301,692	91,736
Collected	227,344	21,194	6,866	22,091	7,819
Percentage	23.6%	31.2%	32.0%	7.3%	8.5%

Source: KW&SB Revenue Department

An analysis of the these monthly results shows that overall a mere 23.6% of the bills printed and

delivered to the KW&SB offices for distribution to the consumers were actually paid; 31.2% of the monthly water billing was recovered (32% for sewerage) and 6.7% of the arrears were paid (8.2% for sewerage).
It had been hoped that a combination of monthly billing introduced for "retail" consumers in July 2006 with the inclusion in the bill of 5% of arrears and the imposition of a 10% surcharge on unpaid amounts would lead to a rapid improvement in the collection rate. Although there were some early gains when the monthly billing system was introduced there has been no significant improvement.

However the reason for non-payment of bills is not simply a matter of introducing a computerised monthly billing system. The system of bill delivery to the consumers does not work efficiently, the level of service is so poor that consumers see no reason to pay, and disconnection of supply and other punishments have proved unworkable.

There was little or no evidence of a problem of affordability in the Water Awareness Survey, clearly a major problem is willingness to pay. Much depends on the quality of service as illustrated by the Leakage Survey in Landhi Town where there is a very poor supply (only 8% of consumers pay their May 2007 bill). Another fact emerging from the Water Awareness Survey is that 60% of those questioned on none payment said simply that they did not receive a bill. The new complaints management system has a high proportion of complaints that the bill was not received.

In addition, more than half of the retail consumers interviewed said that they are not satisfied with the quantity & quality of water, and the billing & information system. 75% are not satisfied with the way KW&SB handle complaints and 70% do not trust KW&SB officials.

9.4.6 Billing & Collection System

In June 2006 KW&SB awarded a 5 year contract to Millennium Systems & Consultants (Pvt) Ltd. (MSCL) for the printing of bills and other services at a cost of Rs 4 per bill comprising:

- Printing of Consumers monthly Bills for both retail and bulk
- Develop & Implement application software for billing related complaints management
- Develop & Implement application software for billing related MIS
- Data Entry of changes in billing Database
- Correlate KW&SB Billing Database with Citibank
- Establish a Billing Complaints Centre at premises provided by KW&SB
- Establish a Software Development Centre for developing application software for KW&SB

The Integrated Revenue System (IRS) has been implemented in two phases:

- Printing of all bills on a monthly basis. This phase was completed in August 2006 for the printing of the July 2006 bills
- Implementation of Billing System, Complaint Management System (CMS), Collection System and other support systems. Implementation of the sub-systems commenced in December 2006

The MSCL facility is located in the recently refurbished Revenue Secretariat in the KW&SB office complex at 9th mile Karsaz, Shara-e-Faisal which also services the newly established Consumers Service Centre (CSC), the CRO and his supporting departments, and the Bulk Transmission departments concerned with billing & collection of bulk metreed supplies. MSCL have a staff of 26 including 10 for the two shift telephone complaints centre currently open from 0900 hrs to 2200 hrs.

Bills are produced monthly for about 1 million retail (domestic un-metreed) consumers and about 5,000 bulk metreed consumers. The bills are for water, sewerage, conservancy and fire and include 5% of the arrears for payment each month with a surcharge of 10% for non-payment. Monthly bills are printed at a separate facility, boxed for collection by KW&SB staff for distribution from the KW&SB Town offices. Bulk consumer bills are delivered by the metre readers, retails bills are delivered by revenue staff at the town offices. There is known to be a problem with bill delivery due to confusion over addresses and lack of personnel.

MSCL have established the Software Development Centre and printing of monthly bills has been fully developed by MSCL together with data entry for changes in the data base; the development and implementation of application software for billing related MIS and billing related complaints management. The current extent of the IRS-MIS system is shown in **Table 94.6.1**.

Table 94.6.1 IRS-MIS Reports

Billing System Reports		
Retail		
	Demand Reports	
		Zone/Town/UC/Quarterly Demand Report
		Monthly Retail Demand Analysis
	Collection Reports	
		Town/Quarter collection Reports
		Town Collection through Banks/NADRA
		Town wise Collection (Current+Arrears)
		Yearly/Monthly/Town wise Collection Report
		Break up of collection for Incentive Purposes
	Printing Reports	
		Bill Printing Volume Statistics
		Date wise Duplicate/Special bills Printing Report
	Town/UC Consumer Performance Report	
	Employee with Greater than 1 consumer ID	
Bulk		
	Demand Reports	
		Town/Sector wise Demand Report
	Collection Reports	
		Town/Sector wise Bulk collection Report
		Yearly/monthly Sector wise collection
	Bill Printing Reports	
		Bill Printing Volume Statistics
		Date wise Duplicate/Specials bills Printing Report
	Town/Sector wise Consumer Performance Reports	
		Date wise
		Month wise
Payment		
	Bank Banch wise Collection	
	Town wise Demand v/s Collection	
	Processing Data wise Collection	
		Retail Payments
		Bulk Payments

The payment system is very high-tech and includes payment through mobile 'phones, credit cards and cheques but also caters for the 65% of population who don't have bank accounts with cash payments at banks or conveniently located NADRA kiosks. The aim was to increase the number of registered retail consumers to 1.2 million by the end of the first year of operation (June 2007), but this has not materialised.

Payment may be made through 550 branches of 9 banks, all payments being consolidated daily through Citibank who pass the information on to MSCL on CD with about a 2 day time lag. An immediate improvement would be for the 9 banks to send the information directly to the IRS centre. In November 2006, KW&SB signed an accord with NADRA for payment of bills through their system of Kiosks. Currently this service is available at 66 kiosks and will be extended to all 178 UCs in the future. All bills include the sum of Rs 8 to cover the bank charges. This needs to be looked at with inclusion of payments through NADRA.

The Billing Complaints Centre, run and staffed by MSCL, is fully operational and now receives 150-200 calls per day since the telephone number was printed on the front of the January 2007 bills. Complaints are not confined to billing but to any aspect of KW&SB's service provision. Billing complaints are normally resolved very quickly at the centre. For all types of complaints, MSCL has developed the software in close cooperation with the revenue staff of KW&SB. The Complaint Management System includes a tracking system to complaint resolution. None bill related complaints are handled by the zone directors. The CMS reports are shown in **Table 94.6.2**.

Table 94.6.2 IRS-MIS Complaints Management System (CMS) Reports

Complaints Management System Reports
Complaints Registered as of "Date"
Status wise Complaints
By Town
By Department
By Action Owner
By complaint type
Analysis by Complaint Status
Complaint Type Aging Analysis of Open complaints

A review of the current Aging Analysis shows that 4,190 (70%) out of 5,979 complaints had not been resolved after one month.

KW&SB has recently set up 7 Customer Service Centres which receive a CD of the monthly bills and can produce duplicate bills for consumers who do not receive their bill. The IRS in the MSCL facility is connected to the CSC in the building to provide data for the printing of duplicate bills. The CMS is also connected but not being used.

9.4.7 Consumers Service Centres

A Consumers Service Centre (CSC) has been opened in the Revenue Secretariat at the KW&SB main office complex at 9th mile Karzas. As stated above it is able to produce duplicate bills for consumers who have not received their bill. About 1,000 persons per month currently use this service and there is a NADRA kiosk in the office for payment of the bill.

The centre also receives and registers complaints, including about 25 complaints per day passed on from the MD's secretariat located in an adjacent building. All these complaints are written up in an Inward Register, transferred to the computer for printed summaries to go to the Chairman, Vice Chairman, Additional Vice Chairmen and the MD of KW&SB. The Executive Engineers at the 18 towns are contacted for complaint resolution which is tracked.

In addition to this CSC at the KW&SB Main Office on 9th Mile Karsaz, there are 6 other Consumers Service Centres using the same complaints system and can issue duplicate bills. These are located at:

- Jamsheed (Located in the Tax Office)
- Gulshan e Iqbal (Located in the office of the Deputy director Taxes)
- North Nazimabad (Located in the Tax Office)
- Liaquatabad (Located in the KMC Supermarket)

- New Karachi town (Located in the Office of the Town Nazim)
- Gulshan e Iqbal (Located at the KW&SB Head Office)

All offices can issue duplicate bills and register complaints for transmission to the relevant Town offices. The offices computer hardware is old and needs to be replaced. The 5 offices in Jamsheed, Gulshan e Iqbal, North Nazimabad, Liaquatabad, and New Karachi town are located in the Revenue Office of the KW&SB Town offices. These "tax" offices are remote from the Town SE's offices.

A Request for Proposals (RFP) has been prepared to link the 7 CSCs to the IRS centre. IT equipment needs to be procured and connectivity between the CSCs and the IRS central system through LAN/WAN at the Revenue Secretariat. The RFP may be used for inviting proposals for procurement of the required IT equipment and Networking Services. This will enable all the centres to be linked by computer to the Integrated Revenue System (IRS) at the KW&SB Revenue Secretariat which will enable the monthly billing data to be received direct. In addition the complaints procedure will be computerised for integration in the central Complaint Management System (CMS) which will include a tracking system up to complaint resolution.

Recently CDGK commenced a project to set up Call Centres at the KW&SB Revenue Secretariat and at the KW&SB offices in all 18 Towns. These Call Centres are intended to handle complaints on all matters related to CDGK, not just water & sewerage. It is not intended to link this complaints system to CMS developed by MSCL. A transmission mast has been erected and a networking box installed at the KW&SB Secretariat, and computers, printers, scanners and UPSs are to be installed at all Towns. Clearly there is need to review this project at least with regard to linking the KW&SB related complaints to the CMS which is already operational.

9.4.8 Management System

Improvement of the management system for billing & revenue collection is a vital and urgent task. KW&SB has major problems in its revenue collection system to finance O&M, with poor revenue recovery and mounting arrears

Recent interventions appear to have had limited success in terms of improved revenue collection. Despite changes to the management of the bulk supply the payment of bills and revenue collection remains unacceptably low. The split to 5 administrative zones does not show any significant change to the revenue stream, and the full benefits of the recently introduced Integrated Revenue System (IRS) and Complaints Management System (CMS) will not be realised until KW&SB institutes an integrated approach to act on the information provided and a monitoring system to assess the effectiveness of their efforts.

The imminent management changes to the water tanker service must be closely monitored and its success or otherwise evaluated. Currently it would appear that tanker water will remain as non-revenue water, estimated to be 3% of supply, which appears to be a lost opportunity for NRW reduction and increase in revenue.

KW&SB would be well advised to urgently add the following to its internal reforms:

- Review and revise the bill delivery system
- Update the Register of Consumers

KW&SB is a typical bureaucratic government entity, with antiquated IT equipment, and a long serving staff steeped in tradition, inward rather than outward looking, constrained by civil service rules and regulations and subjected to both internal and external political pressure. Due to poor information and planning KW&SB has been unable to stay in tune with its customer base, control water and revenue losses and respond rapidly to customer requests and complaints. Clearly institutional and management improvements must be made if revenue collection is to improve. An integrated improvement programme would develop an agreed institutional arrangement for KW&SB to operate along commercial lines together with reorganisation into area based management zones. For the Revenue Section this will require a change of mindset in the existing long serving staff, the introduction of professionals in finance and administration, and staff training in IT.

With the introduction of the latest technology and data management (IRS-MIS) KW&SB must not miss the opportunity to train its own revenue staff for strengthening of its management capacity. Strengthening is also required for the new CSCs requiring both IT skills training and training for dealing with complaint management. The 6 CSC offices should be linked to the IRS and CMS system at the KW&SB IRS centre. To this end, a Request for Proposals (RFP) is given in **Appendix A94.1**.

The introduction of the CDGK Call Centres for complaints on all aspects of CDGKs operations is a welcome addition. However, there is currently no intended connection to the KW&SB complaints management system. Integrated systems linked to the IRS-MIS are highly desirable and this connection should be explored. This is likely to be covered by the forthcoming ADB study of the "IT Platform for Asset Maintenance and Operations Management".

The need for education of consumers and dialogue with other stakeholders including NGO's, business and community leaders etc. has long been an outstanding issue. If KW&SB is to become an autonomous commercially oriented service provider there will be a need for management strengthening to establish an effective communications unit for improved communication and responsiveness to customer needs from senior management through its Public Relations Department and the newly established CSCs.

9.5 ESTABLISHMENT OF SUSTAINABLE DATA MANAGEMENT

A Geographic Information System (GIS) is generally defined as a computer based technology used to collect, store, manipulate, analyse and display geographically referenced data. GIS links spatial data to non-spatial attribute data. One of the main strengths of GIS is the capability to overlay information in different thematic layers, revealing complex spatial relationships between physical, social, and economic variables.

GIS has wide applicability in a municipality, utility, or government agencies. In developed countries, water and wastewater utilities are increasingly adopting GIS to perform day-to-day operations, maintenance, data management and customer service. Utilities can also use GIS for demand analysis, facility expansion planning, and network design based on hydraulic modelling and infrastructure management. KW&SB should develop its own GIS system according to their requirements.

9.5.1 GIS for Asset / Facility Management

Considering the existing problems in the water supply and sewerage facility operation and maintenance in Karachi, GIS applications for asset/facility management is the most important and basic requirements of the GIS development for KW&SB. GIS-based asset/facility management will increase the efficiency of renewal, expansion and disposal of the facilities as well as operation and maintenance.

In Karachi, many Katchi Abadis are located along the major rivers, Nalas, railway lines and other natural drainage networks. Many of KW&SB reserved lands are located in these areas and encroached illegally. KW&SB's networks of water supply and sewerage face similar situation of illegal connection and tapping of water supplies resulting in substantial system losses. The Land & Estate Department of KW&SB intends to develop a GIS-based asset management system for the management of KW&SB lands and encroachments.

Automated facility management based on GIS usually manipulates and manages facility information (spatial locations and facility attribute data) and provide a comprehensive inventory process for pipelines, structures, and other manmade improvements. Facility management is an essential base of operation, maintenance, customer service, management of pipeline construction and future expansion planning in water and wastewater services. A GIS-based facility management system could also locate underground utilities correctly for new construction projects to significantly reduce construction change orders, construction costs and incidence.

Usually GIS-based facility management systems use a simplified representation of actual objects (e.g. a road can be represented as a line): it lacks the graphical design functionality of CAD. However, GIS can be supplemented by linking to as-built CAD drawings to provide its users with more accurate and detailed information as needed (e.g. for engineering purposes).

9.5.2 Ongoing Facility Mapping for the Study

At the beginning of this JICA Study, it was quite difficult to understand the configuration of the main water supply pipelines and sewers in Karachi because facilities maps consisting all the existing main water supply pipes or sewers of the 18 towns are not available with KW&SB. In most cases, only superintending engineers, who are managing each town's water supply and sewerage system or the bulk water supply system, keep facility maps/sketches of their areas in hard copy of different scales and styles. Therefore, prior to the preparation of the Master Plan, it was required to collect facility maps from KW&SB's offices of each town and to put the collected information onto the same base map to understand the existing water supply and sewerage systems in Karachi.

Facility mapping can be done in many ways. Base map and mapping software to be used vary depending on the required accuracy of mapping and applications of mapped products. For the preparation of the Master Plan, GIS-based mapping with high accuracy is unnecessary. Instead, CAD-based or simple mapping software-based facility mapping on a general city guide map of Karachi could be used for the purpose. However, JICA Study Team adopted GIS-based facility mapping using high resolution Quick Bird satellite imageries (0.6m resolution) for build-up areas and SPOT imageries (2.5m resolution) for surrounding rural areas as the foundation of its base map to achieve the following objectives:

1) To prepare accurate maps of existing major facilities for the planning of future facility improvements.
2) To support the sampling area selection and random sampling within the selected areas in the household survey (see **Section 4.2** Water Awareness Survey) with high resolution satellite imageries.
3) To provide KW&SB a basis for their future GIS development

JICA Study Team has already carried out the GIS-based facility mapping in the following steps using 'ESRI's ArcGIS' software.

1) Evaluation of required base map
2) Acquisition of high resolution satellite imageries
3) Image processing and geo-referencing of the satellite imageries to use them as the foundation of base map

4) Digitisation of basic topographic futures such as roads and rivers from the satellite imageries as part of the base map.
5) Collection of existing facility maps and drawings from KW&SB's offices.
6) Scanning of the collected maps and drawings
7) Digitisation of the scanned maps and drawings into GIS layers
8) Rectification of the digitised information with the help of KW&SB's engineers using the satellite imageries.

In Karachi, many of main water supply pipelines and sewers had not been properly mapped with scale even as hard copy facility maps before the Study. Understandings of many facilities' locations stayed only in KW&SB's engineers' minds. The high resolution satellite imageries of 0.6m resolution was required as medium to extract the knowledge of the engineers on the existing pipelines and to locate them properly onto a map. These imageries had successfully helped KW&SB engineers of the 18 towns to locate their facilities in GIS. The facility locations digitised from the scanned maps were also rectified by a number of KW&SB engineers using high resolution satellite imageries. By November 2007, the JICA Study team have completed digitisation and rectification processes on the following information and infrastructure.

a) topographic information such as roads, rivers, canals, railways
b) administrative boundaries of CDGK, 18 TMAs and 178 UCs
c) the entire Bulk Water Supply System from the Kinjhar Lake to Karachi
d) 405 km trunk distribution pipes
e) 643 km distribution mains 10 inches and larger in diametre
f) 325 km trunk sewers 18 inches and larger in diametre
g) water distribution pumping stations
h) sewage treatment plants and pumping stations

The facility maps created using the GIS software have been used by the JICA Study team for the analysis of existing systems and the planning of future development as well as for the presentations of the Master Plan.

9.5.3 Future GIS Development in KW&SB

Establishment of GIS department within KW&SB has been discussed with KW&SB. One of the concerns is the sustainability of the GIS system after completion of the JICA Study. Since September 2007, JICA Study team have been providing on-the-job training for 2 officials nominated by KW&SB. These officials have been seconded to the JICA Study Team on a full time basis and have been working on the digitisation of small diametre distribution mains on a town-by-town basis under the guidance of the JICA Study team. They will be able to continue the work even after completion of the JICA Study. In the meantime, the JICA Study team have suggested that KW&SB should establish a 'GIS Department' and develop its GIS system on a stage-by-stage basis corresponding to the changes in the actual needs. The stage-by-stage development is proposed to avoid over-investments in early stages.

It is recommended that initially KW&SB should use the GIS system only for producing facility maps. It is strongly recommended that KW&SB should build up its GIS system using the same base map as has been used by the JICA Study Team. Otherwise, KW&SB will waste resources and will also face great difficulties in reconciling spatial data accuracy and consistency of collected data.

The management of the GIS system requires the continuous updates of facility data. In order to maintain the sustainability of the GIS system, it is recommended that KW&SB should not contract out the management of the GIS system to local consultants.

The stage-by-stage development of the GIS and GIS Department in KW&SB includes four stages, Preparation Stage, Initial Stage, Transitional Stage and Advanced Stage. Preparation Stage of KW&SB's GIS is already ongoing within the JICA Study team. After handing over of the GIS by the JICA Study team, KW&SB should proceed with the rest of stages by itself.

The tasks involved in each stage are presented below. In Transitional Stage, it is recommended that KW&SB should review this stage-by-stage GIS development plan considering changes in GIS requirements, the technical maturity of in-house GIS staff, and the availability of financial resources.

1) Preparation Stage (with JICA Study team): 2006-2007
   - Base map development from the satellite imageries and existing maps (roads, rivers, town boundaries, UC boundaries, etc.)
   - Creation of contour map
   - Mapping of existing major facilities (main water lines, sewers, pumping stations)
   - Mapping of planned facilities

2) Initial Stage (start with few KW&SB's in-house GIS staff): 2008-2010
   - Enhancement of base map accuracy and location adjustment of entered data
   - Entering existing water distribution pipes and sewers of small diametres
   - Deciding the attribute data to be collected for each type of facilities
   - Entering attribute data to the digitised water supply and sewer lines and other facilities
   - Defining topology of water supply and sewer lines as networks
   - Entering KW&SB's reserved lands including location of water reservoirs and distribution pumping stations.
   - Entering the information regarding encroachment on the KW&SB's reserved lands.

3) Transitional Stage (with standard GIS functions): 2011-2014
   - Update and improvement of existing facility data through extensive field surveys
   - Recording leakages and repair works for facility improvement
   - Land management for legal process regarding encroachment on KW&SB's lands
   - Trial development of consumer database and detailed distribution network for the distribution network improvement pilot project
   - Review of the GIS development plan

4) Advanced Stage (with specialized GIS software or program customisation): 2015-2025
   - Updating of facility GIS data and linking as-built drawings to the GIS
   - Development of costumer database using digitised housing plots to improve revenue collection and complain handling
   - Application of GIS for water distribution control, etc.
   - Maximizing the use of the established GIS for effective facility management and revenue collection.

It is envisaged that the high resolution imageries along with the GIS data developed will be transferred from the JICA Study team to KW&SB. The least-required resources for Initial Stage of the GIS Development within KW&SB are shown in **Table 95.3.1**.

Table 95.3.1 Human Resources, Software, Hardware Required for Initial Stage

Category	Items	Number	Required Experience, Specifications, etc.
Human Resources	GIS Manager	1	experience with GIS development planning, facility management, image processing, etc.
	GIS Operator	2	experience with geo-referencing and digitisation, etc.
	Office Assistant/System Technician	1	management of appointments with engineers, maintenance of the system, etc.
Hardware	High Performance PC	1	for image processing, etc. (3.2GHz dual core processor, 4GB RAM, Two SCSI HDs of 146GB, Graphic Card of 256MB)
	Middle Performance PC	2	for Digitisation, etc. (2.8GHz CPU, 1.5GB RAM, SATA HD of 200GB, Graphic Card of 256MB)
	Low Performance PC	1	for distraction work, etc.
	Colour Printer	1	A3 size ink jet
Software	ESRI ArcInfo	1	for geo-referencing and spatial analysis, etc.
	ESRI ArcView	2	for digitisation, inquiring and printing
	ERDAS Imagine	1	for image processing
	Standard Software	4	MS Windows, MS Office, Norton Anti Virus

During Initial Stage, KW&SB will need only two or three qualified in-house staff who could possibly be fulfilled from local GIS specialists having experiences with JICA Study team to ensure smooth transfer of the GIS data and required skills to KW&SB. Large-scale fieldwork, such as facility location data collection using GPS, can be outsourced to local consultants. However, once in-house GIS staff understands basics of GIS development, field works can be directly managed by in-house GIS staff by hiring field surveyors and providing them with necessary equipment such as GPS. Direct management by in-house GIS staff is more preferable in terms of capacity development and reducing expenses.

Large size scanner and plotter are also required for map digitisation and printing. In Initial Stage, however, KW&SB may use local printing shops for the scanning and printing of large size maps and drawings.

The absolute horizontal accuracy of the base map prepared by the JICA Study team is about 20 m in urban areas (Map scale of 1:40,000) and more than 20 m in the surrounding rural areas. In Initial Stage, the accuracy of the base map would have to be enhanced by re-rectifying the satellite imageries with accurate ground control points. For facility management, the base map will need to have about 1m of horizontal accuracy (Map scale of 1:1200). Considering DGPS available from survey companies in Karachi and the potential of the acquired 0.6m high resolution satellite imagery, the horizontal accuracy of 1m is achievable.

The locations of facilities already entered into the GIS need to be adjusted once the accuracy of the base map is enhanced. The accuracy enhancement has to be done before digitising distribution pipelines and sewer of small sizes because small pipes are normally laid in narrow streets where post location adjustment is very difficult.

The largest task in Initial Stage is the digitisation of small water distribution and sewerage pipes. First, the drawings or sketches of the small pipes have to be collected from KW&SB's town offices for digitisation. Then, the location and attributes of the digitised pipelines have to be rectified with KW&SB's engineers or felid workers on satellite imageries as already done for larger size pipelines during Preparation Stage. This is a continuous work and may take many years to complete in case of a large city like Karachi.

The proposed DNI pilot project should include the development of trial GIS-based customer database covering the relatively small target areas of the pilot project. It would be important to examine the effectiveness and feasibility of customer database development at this stage before going into full-scale development of GIS-based customer database in Advanced Stage of GIS development. The feasibility of integrating the GIS-based customer database and the linking to the KW&SB's billing system should also be explored in this stage.

Advanced Stage requires software development to enhance the utilization of entered facility and customer data. For example, ESRI's ArcFM is the software specialized in facility management, which can be used for the KW&SB's GIS. Standard ArcGIS software is also covering various functions which can be used for facility management or other GIS applications for water supply and sewerage. Moreover, latest ArcGIS support program-interface customisation using Visual Basic, which is a user friendly program language. Since off-the-shelf GIS software is developing very fast, it is important to re-evaluate required GIS software and software customisation before going into Advanced Stage.

9.6 IMPROVEMENT OF CUSTOMER SERVICES

KW&SB do not have a clear customer mandate describing the levels of services to be provided and the responsibilities of customers to pay bills, settle arrears and to comply with regulations with respect to illegal connections, tampering with supplies, etc.

KW&SB does not conduct regular customer surveys to ensure that all customers who receive a supply are registered on the billing database. Whilst there is evidence of illegal connections and 'stealing' of water on a large scale, audits are not systematically conducted. Opinion surveys are not used to improve service shortfalls.

Currently monthly billing is practiced (previously annually). In an attempt to increase revenues, current bills include a portion of outstanding arrears and an interest charge for outstanding debt. This is a good approach to revenue management as monthly billing makes the charges more affordable and allows customers to budget their outgoings; however, it remains to be seen to what extent this approach has on reducing receivables and improving collection rates.

Current legislation allows KW&SB to set tariffs and charges with approval from Government, however, it would appear that the current tariff has remained largely unchanged since 1998. Based on initial analysis it is evident that this is not based on 'full cost recovery' and therefore coupled with the current poor billing and revenue recovery performance, revenues are not sufficient to fund KW&SB's operation.

Apart from 'bulk' (metreed) customers, there is no metreing of consumption and therefore the opportunity to base charges on actual consumption is being missed. Metreing is accepted as the most appropriate method of charging and allows charging mechanisms to limit water wastage through applying block tariff pricing, with increased charges for consumption beyond essential use. This would also allow a fair system of subsidy/cross subsidy for those less able to pay.

KW&SB has segregated responsibility for the management and billing of bulk supplies from retail supply billing. The 'bulk metre unit' (reporting to CE (BT)) is responsible for metre reading and metre maintenance and has indirect responsibility for bulk billing ('key accounts') which has been established as a separate unit under the CRO. The 'key accounts' team has subdivided responsibility into customer groups such as 'commercial', 'industrial' and 'Local Bodies' to ensure regular and prompt payment. This warrants future consideration and investment in order to improve collection rates; for example, the key accounts group should be in regular and close liaison with key customers with respect to technical matters as well as commercial matters.

The practice of billing or ‘taxing’ customers who do not have a water supply or sewerage connection or those that are not officially registered but receive a supply needs clarification. It is estimated that 70-80% of customers in certain categories either do not pay or have large arrears, not least the bulk customers, a number of which are government organisations. This is currently being tackled by KW&SB, however, the issue of ensuring 100% billing is a larger issues that warrants further investment and study.

Due to lack of training in the customer services arena staff are not well placed to provide improved services, as the required ‘skill sets’ are not well developed. This is becoming increasingly pressing as KW&SB have now established 7 “Consumer Service Centres” (CSC) with a plan to increase this to 100 centres, as well as contracting out telephone complaints handling for which KW&SB should be setting and monitoring service and performance standards.

KW&SB does not have a ‘Customer Service Strategy’ or service policy in place. Consequently, customer service practices and standards vary within and across Regions and are highly dependent on local management attitudes towards customer service provision. KW&SB will therefore need to consider introduction of a strategy that clearly details the organisation’s strategic intent with regard to customer services. This should state short and long term service aspirations and service standards to be applied across the customer base.

Responsibility for key customer activities is fragmented, for example, contact management; head of the CSC at the 9th Mile complex reports to the MD, whilst the new contact centre operated by ‘Millennium Consultants’ reports to the CRO via Director (Billing). The current set-up does not allow for clear ownership of the whole process from initial contact through to satisfactory resolution. There are no documented procedures relating to contact management and complaints statistics or analysis is not used as a means of eliminating route causes of problems.

9.6.1 Effective Provision and Management of Customer Services

Effective provision of customer services will require that KW&SB is organised in such a way that focuses on service delivery. Viewed as a ‘key process’, customer services will be an ‘enabler’ to business success through integration with other key corporate processes such as operations and other support activities including finance, systems, HR management, strategic and business planning etc. Accordingly, rather than looking at improving services in isolation, KW&SB will need to consider a more holistic approach as depicted in **Figure 96.1.1**.

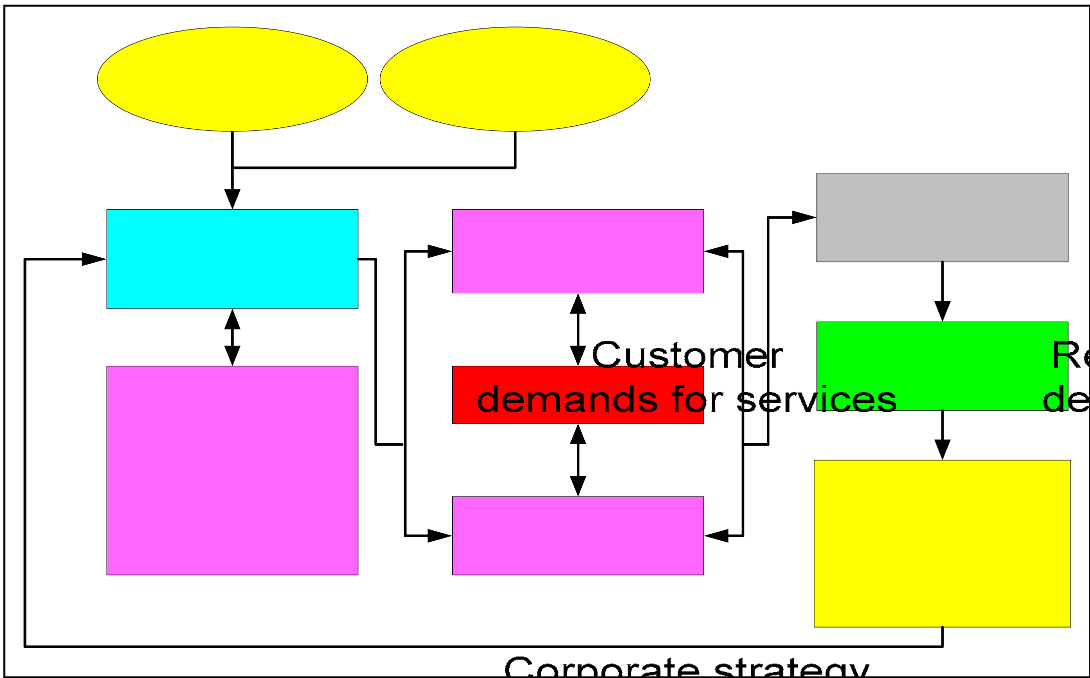


Figure 96.1.1 Customer Model

Based on the recent drive to improve revenue collection it is evident that KW&SB have recognised the paramount importance that good customer service practices has on the success of the organisation. Control of the revenue stream is vital to long-term financial sustainability and proper, responsible control of revenue through accurate metreing and billing followed by responsive collection will ensure that KW&SB's financial position is sufficiently healthy to sustain growth and investment in future. In addition, timely response to customer service inquiries and requests (as well as complaints handling) is essential in building public confidence and support of the utility's management.

In order to highlight the importance of "Customer Services" and ensure that it receives the highest priority across the business, KW&SB will need to consider implementing a 'Customer Focus Programme'. The programme would be designed to focus on all 'customer facing activities' including contact management, billing and revenue collection, metre reading and metre management as well as customer and community relations.

This program will need to detail the agreed service standards to be applied by KW&SB (built around customer needs and values) and should seek to integrate the functional and process areas as shown in **Figure 96.1.2**. A fundamental part of this program involves consulting with customers to ensure they are provided with the opportunity for feedback and a say in how services are provided. KW&SB should continue therefore with the plan to establish further CSC's or 'Walk in Centres' (one in each town as a minimum).

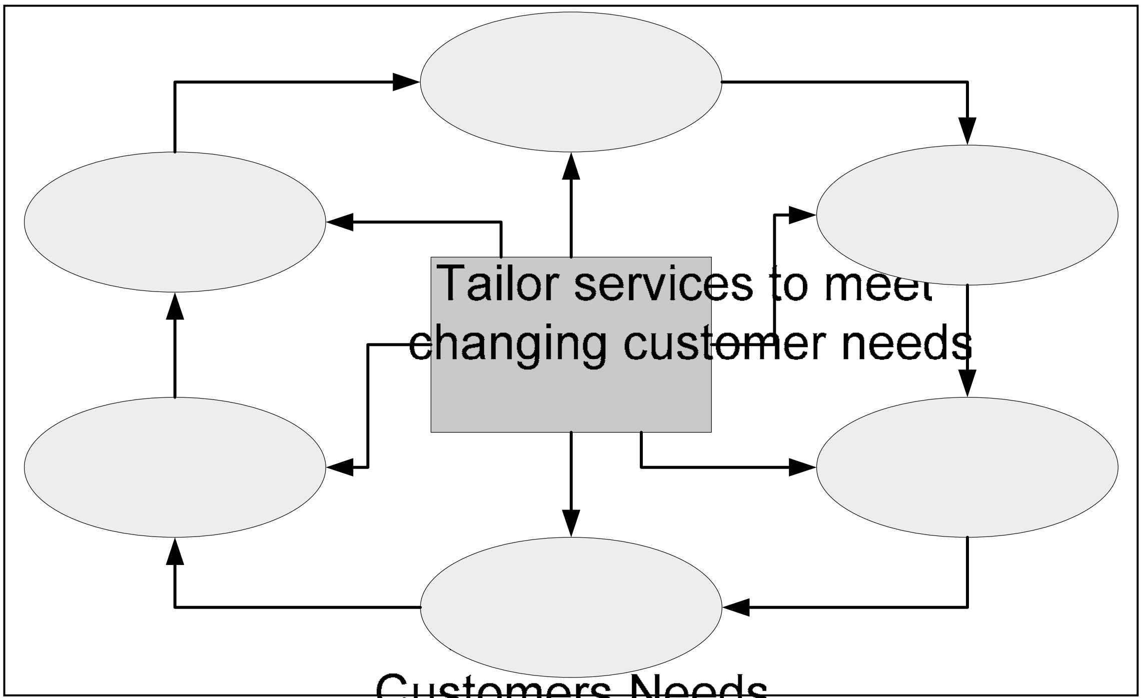


Figure 96.1.2 Customer Focus Programme

9.6.2 Organisation Design

KW&SB recognises that people are key to their success and that creating the right culture is fundamental to delivering service excellence. In this respect, customer service training should be provided to all staff. Recruiting, developing, and retaining the right people with the skills and behaviours to deliver excellent customer service will also be an essential part of enhancing customer satisfaction. A customer culture, vision and values will need to be developed that is visible in the work environment. Staff will need to be supported with quality procedures and the 'tools to do the job'.

Organizational Model

KW&SB's goal will be to provide a seamless service from 'source to tap'. This can be achieved by centralising the key customer processes, managed at 'the centre' without losing sight of the importance of local service provision within the Regions. KW&SB should therefore maintain a network of regional Walk in Centres with clear accountability to the Centre.

The Key functions at the centre would be as follows:

- Customer Relations - call centre, special accounts, customer correspondence, and complaints management
- Metre Services - metre testing and calibration, large metre replacement, planning and coordination of new metre installations, planning and coordination of metre replacement program
- Revenue Management - account administration, planning and coordination of metre reading, bill review and adjustment, payment processing, credit management, legal, contract management (3rd party service providers), and revenue maximization
- Performance and Planning – analysis of management information, performance management reporting, business plan development, monitoring of business plan delivery, coordination and communication of change activity

The Walk in Centres should offer local customer contact and payment facilities; although much of this activity will be centralized over time as business processes and customer behaviours change. Field based staff involved in metre reading, metre installation, metre replacement, investigation of high bill complaints, and turning on/off customer supplies would also be located in the regions, although the work planning and scheduling associated with these activities would be managed from the Centre.

9.6.3 Commercial and Customer Contact System

KW&SB are relying on third parties to provide customer database management, bill printing and some contact management (complaints handling) activities. In order to maintain 'ownership' of customer data, KW&SB should ensure that customer systems are developed that ensure sound financial performance whilst at the same time provide staff with the information they need to provide excellent service. In future, this will require the continued development of the systems provided by MSCL to ensure full integration of customer related activities that will provide staff with reliable, efficient, and instantaneous access to customer accounts, water system status, and other resources for ensuring customer satisfaction.

(1) Revenue Management

Whilst billing services are being provided by MSCL, KW&SB will want to ensure that customers are provided with clear, accurate bills in the most efficient and cost-effective way available. As such KW&SB will need to ensure that existing outsourcing/service provision arrangements are closely monitored in accordance with the contract to ensure compliance with performance standards.

a) Billing

The billing system is one of the key business systems as it covers the process from metreing through to collection, and provides supporting information on previous queries, details of payment history etc. KW&SB (through MSCL where appropriate) will want to ensure that data held within the billing system is both accurate and up-to-date so as to facilitate correct billing and therefore should ensure that:

- Any changes to billing practices are introduced in a controlled, progressive manner with a clear plan of action with regard to communication and training to ensure that employees and customers alike are aware of new and/or amended policies and procedures
- Clear, concise bills that are easy to read and understand are designed with customer input to help reduce customer inquiries/complaints and prevent delays in bill payment
- "Right first time" bills are produced, minimizing cancellations and unnecessary customer contacts thereby reducing the need for debt recovery
- Procedures to ensure that changes of property ownership are completed with both ends of the chain captured to verify dates of ownership to minimize the "moved in yesterday" syndrome
- Periodic cross-referencing of the customer database is conducted with third party databases to identify customer gaps
- Metre readers and other field staff are encouraged (incentivised) to report potential illegal connections and other sources of unbilled usage via a dedicated internal hot-line.
- Fieldwork turn-around times are managed to minimise accounts awaiting work completion
- Key Account Liaison staff monitor high-volume commercial accounts, and other key accounts, and provide personalised services to these customers; focussing on additional revenue generation and water meter accuracy

b) Revenue Collection

KW&SB will want to maximise revenues at optimum cost and with a minimum of bad debt write-off. This will require development of a robust credit management policy and procedures which are clearly documented and communicated to all employees and customers, and which are applied without exception.

KW&SB (through third party arrangements for revenue collection where appropriate) will want to ensure:

- A pro-active approach to collection by actively chase outstanding debt
- Prioritised actions and interventions are taken based on materiality e.g. bill value
- All collection activities are carried out in a fair and reasonable manner
- Flexible payment terms are offered to those less able to pay
- Collection/credit management processes are reviewed regularly to identify potential improvements and enhancements
- Introduction of new payment options where of benefit to both customers and the business
- Bill payment strategies that actively promote cost-effective and convenient payment methods, such as automated bank drafts, payment at ATM's etc.
- That customer payments are processed and deposited without unnecessary delay
- The Call Centre and the Walk in Centres which will provide one of the main opportunities for influencing customer behaviour are provided with scripts and processes to ensure opportunities for managing credit risk are handled on a consistent basis

(2) Contact Management

KW&SB's goal will be to provide customers with a courteous, informed, and prompt response to their enquiries. The resolution of customers' problems at first contact will be key to achieving this objective and will require that staff (through MSCL where appropriate) have the proper tools, training, and management systems and programs to help them serve customers.

Customer-facing staff should have rapid access to all information necessary to resolve enquiries in a timely fashion, and to the complete satisfaction of the customer wherever possible. All customer contacts should be logged to ensure that a complete record of contacts is available for future reference and analysis. Customer Service staff should work closely with Field Service personnel across the entire operational area to enable customer's problems to be investigated and rectified promptly.

Currently MSCL try to resolve billing queries at first point of contact and record/pass on operational complaints for resolution by KW&SB staff. Further training is required to ensure that both billing and operational enquiries can be resolved at 'first point of contact'.

Contact management training can be provided effectively through developing and introducing a reference or training manual. The manual would contain all relevant procedures, details of policies relating to billing and collection/operational matters, and also key facts sheets with information about subjects such as water quality, current rates, water conservation, as well as answers to frequently asked questions. The manual should be regularly updated and supplemented with daily briefings on planned water supply interruptions, construction projects, or other activities that could impact customers. This could be provided as an "electronic bulletin board" on the current application developed and used by MSCL in the call centre.

a) Complaints Management

KW&SB will need to adopt a focused, pro-active approach to complaints handling. To ensure that procedures are followed, timescales are met, and that standards of response are satisfactory, responsibility for complaint management should be assigned to dedicated teams who are trained to handle, track, progress chase, and monitor complaints.

All complaints should be recorded and coded as such to allow accurate information to be produced about the volume and nature of complaints received, and about response times to resolve them. This information should be used for the purposes of monitoring performance against the agreed standards and also for identifying trends in complaint volumes/types.

b) Call Centres

KW&SB will need to consider a number of call centre options available to them. Best practice suggests a single call centre acting as a 'single point of contact' on a 24-hour, 365-day basis is most effective for the consistent handling of both routine and emergency contacts. However, this requires major investment in and integration of systems. For ease of contact, there will be just one Customer Service telephone number that would be publicised widely.

Robust communication links, supported by efficient and effective systems, will need to be developed to facilitate the "one-stop shop" concept and to ensure that, as far as possible, customers experience a seamless service.

Customers will be able to contact the Call Centre to query and settle bills, make payment arrangements, and secure connection or termination of services. They will also be able to report operational problems and request advice or assistance on technical matters.

c) Walk in Centres

KW&SB should push ahead with the strategy to introduce 'Walk in Centres' at each of the 18 towns. KW&SB (through MSCL) are currently putting together plans to provide systems and communications links at 7 office locations. Walk in Centres should provide customers with the opportunity to interact with KW&SB face to face in convenient locations and in this way will play a key role within local communities as information and service providers.

Customers should be able to visit the Centres to set up contracts for water/sewerage services, pay their bills, resolve any questions about their accounts, request technical assistance, register complaints, and pick up information leaflets.

d) Customer Correspondence

Customers should be able to contact KW&SB by letter, fax, and email, with all correspondence logged on the system. KW&SB may wish to consider establishing a central Customer Correspondence team to ensure that incoming Customer Services mail is correctly sorted, logged, and distributed. Where appropriate they will investigate and respond to customer enquiries and complaints direct. If investigation or action is required by other departments, the correspondence team will track and monitor progress to ensure a prompt and full response to the customer. A key part of the Correspondence Team's activity will be to monitor and analyse customer correspondence on a regular basis to identify and eliminate problems, highlight potential areas for improvement, and reduce unnecessary contacts.

9.6.4 Customer Relations

KW&SB will need to develop a "Communications Strategy" that addresses the need to provide customers with clear concise information about services, for example; routine day to day operational information such as advance notification of interruptions to supply, or public education information, such as advice on water conservation.

The strategy may include the development of a range of customer information leaflets available at the Walk in Centres or distributed with the bills as part of specific awareness campaigns focusing on topical issues. For example; an annual or semi-annual customer newsletter could be used to provide information about KW&SB's progress, about new services, and about forthcoming events. It could also contain articles on water related topics, such as advice about water conservation, water hygiene practices etc.

With the view of improving awareness and company image, KW&SB could also consider a regular programme of "open services", 'road shows', talks and presentations to the general public, community groups and businesses. Additionally as part of KW&SB's website strategy, customers should be able to obtain basic billing and operational information, for example, a guide to rates, what to do if you spot a leak, advice on saving water, etc.

(1) Interruptions to Service

On occasions interruptions to services will be necessary to allow improvements to the network. KW&SB should aim to provide customers with a minimum of 24 to 48 hours notice of any planned interruption to the service. In the event of unplanned interruptions; as a result of a burst pipe for example, KW&SB should aim to inform customers and relevant stakeholders as soon as possible of the loss of supply and advise them on when services will be restored. This notification could take any of the following forms depending on the extent of the problem and the number of customers affected: hand-delivered notice, verbal notice from Field Service personnel, loud-hailed message, radio broadcast etc.

(2) Public Education and Outreach Programme

The cornerstone of the 'Communications Strategy' should be a "Public Outreach Programme" that would focus on the following four main areas of interest:

- Role and responsibilities of KW&SB: what services are provided, processes involved in supplying potable water and treating sewage, cost of providing water and sewerage services and standards to be met in terms of service delivery, water quality, etc.
- Customer Service/Billing and Collection: how to enquire or complain, what are the current rates, how is the bill calculated, how are metres read, what payment methods/payment plans are available, what happens if you don't pay, etc.
- Water quality: how safe is the water to drink, how can you prevent contamination of the supply, how to get the quality tested, etc.
- Water conservation: why conserve water (financial and environmental benefits), how to save water in the home, water management in buildings (urinal controls, cistern displacement devices, grey water recycling in schools, offices, etc)

(3) Customer feedback and consultation

KW&SB will want to maximise the use of customer feedback and consult with customers about current and future standards of service. In this way KW&SB would be able to monitor actual performance, measure the effectiveness of any changes implemented, and anticipate future requirements. In addition, consulting with customers will help KW&SB to establish a direct relationship with customers and to demonstrate that customers' opinions are valued. Not all customers have the same level of expectations and requirements. Customer surveys will help KW&SB to identify and prioritise the elements and levels of service required by different customer types.

KW&SB may want to consider establishing "Regional Citizens Advisory Councils" composed of a cross section of the customer base. Establishing an ongoing dialogue with customers will be of benefit and the creation of Citizens Advisory Councils will provide useful forums for sharing information and ideas, create an atmosphere of openness, and ensure that KW&SB remain focused on customer issues.

The Councils would be made up of volunteer customers who would meet with KW&SB

representatives on a regular basis to discuss customer-related issues/initiatives. For example, the Councils could review new/revised customer literature, advise on proposed service improvements, provide a customer perspective on future legislative or policy changes, etc. Working in partnership with different sectors of the community in this way will undoubtedly help KW&SB to identify how they can offer further assistance or respond more appropriately to their needs, thereby enhancing customer satisfaction.

KW&SB may also wish to consider introducing customer suggestion boxes that will be posted at the Walk in Centres. Similarly an electronic suggestion box could be linked to KW&SB website so that those customers with access to the Internet could email their suggestions for service improvements.

9.7 REVIEW OF LAWS AND REGULATIONS

9.7.1 The Legislative and Administrative Framework

According to the Constitution of Pakistan, water is a Provincial subject and the responsibility for water related issues rests with the Ministry of Water and Power (MWP). Within the Ministry, exists the 'Water Wing' (WAPDA) to discharge its water related responsibilities. For water related matters, the MWP coordinates efforts primarily between WAPDA, the Indus River System Authority (IRSA), the Federal Food Commission (FFC), as well as other Federal Ministries and Provincial Irrigation and Agriculture Departments amongst others.

The relevant legislation in force includes the WAPDA Act, 1958; The Environmental Protection Act (EPA), 1997 and the IRSA Act, 1992 amongst others; whilst at a more local level the Sindh Local Government Ordnance (SLGO), 2001 and the KW&SB Act, 1996 run in parallel. Whilst the SLGO, 2001 gives general powers for the provision of water and sanitation services, the KW&SB Act, 1996, provides a more detailed account of specific technical and administrative responsibilities and powers vested in KW&SB as an 'autonomous' body. Also in force are the KW&SB APT Rules, 1987, the KW&SB Efficiency and Discipline Rules, 1987 and the KW&SB Delegation of Powers, 1991 amongst others. Some of these will have been superseded following devolution as the Government of Sindh (GOS) have issued a number of rules and regulations for local government departments. These include 'Local Fund Budget Rules, 2001'; 'TMA/UA, APT Rules, 2001'; 'Contract Rules, 2001', 'TMA Rules of Business, 2002', 'Conduct of Business Rules, 2001' amongst others.

More recently the Government of Pakistan (GOP) have issued the 'National Environmental Policy, 2005'; the 'National Drinking Water Policy, 2006' and the draft 'National Sanitation Policy, 2006. In response to national policy, the GOS have issued the draft 'Sindh Water Supply Policy, 2006' and the draft 'Solid Waste & Sanitation Policy, 2006'. With the advent of these recent policies it may be prudent for the GOS to consider introduction of a unified provincial 'Water Law' that seeks to eliminate the overlaps and anomalies by combining, clarifying and simplifying the plethora of existing Acts. Whilst the policies act as 'guiding principles', the water laws would need to clearly define roles and responsibilities for all 'actors' involved to ensure an 'integrated approach' to water resource management (IWRM), including the standards required for the supply of safe drinking water and disposal of waste water with due care for the environment.

Devolution of water and sanitation services (W&SS) from the Provincial Government of Sindh to the City District Government of Karachi (CDGK) was enacted as a result of the Sindh Local Government Ordnance (SLGO), 2001. This was effected by setting up a 'Water & Sanitation Department' (CDGK) headed by an 'Executive District Officer' (EDO). Along with other 'departmental heads' (responsible for provision of services such as Health, Education, Agriculture, Transport, etc.,) the 'EDO Water & Sanitation' is responsible to the CDGK and the people of Karachi via a system of Town Municipal Administration (TMA) and Union Councils (UC's). Due to the size of the city and considering the "essential services" nature of W&SS, it was decided to retain KW&SB as the 'executing agency' for W&SS. As such the KW&SB Act, 1996 was not revoked when the SLGO, 2001 came into force. To maintain effective W&SS at a local level, KW&SB have recently re-organised its Divisional offices in line with the 18 Towns and within 3 hydraulic zones. The current KW&SB organisation structure with key functional responsibilities is shown at **Chapter 9** of progress report No.1.

In accordance with SLGO, 2001; of which Sections 52 and 182 are particularly relevant, KW&SB are responsible for water and sanitation (drainage, sewerage and sewage treatment) services for Karachi. KW&SB are also responsible for bulk supply of water to various agencies including 'Cantonments', such as the Defence Housing Authority (DHA), the Sindh Industrial Trading Estate (SITE), the Karachi Port Trust (KPT) and other major organisations/agencies. These organisations/agencies are responsible for onward distribution of water and collection/disposal of sewage. There has been much discussion regarding KW&SB taking ownership of the water and sanitation infrastructure within these areas and for provision of services, however, due to poor asset condition, this is yet to be agreed.

Working alongside KW&SB is the 'Sindh Katchi Abadis Authority' (SKAA), various Non-Governmental Organisations (NGO's) and 'City Community Boards' (CCB's) with the aim of improving W&SS and ensuring that all areas and communities throughout Karachi are represented. The idea of CCB's or 'beneficiary groups' taking an active role in the O&M of local schemes has been slow 'getting off the ground'.

Responsibility for compliance with 'drinking water standards', safe disposal of sewage and for compliance with environmental legislation/standards is placed on KW&SB, however, the fragmented nature and responsibility for W&SS provision as described above does not 'sit well' with this. KW&SB currently follow and are subject to compliance with the World Health Organisation (WHO), 1971 International Drinking Water Standards and the EPA Standards, for water quality and effluent quality, however, due to lack of effective independent monitoring or 'policing', KW&SB are effectively 'self regulating'.

Whilst KW&SB constitute an autonomous body, in carrying out its duties, KW&SB interact with a number of CDGK departments having either advisory, political, administrative or sanctioning powers over their financial and operational activities. In this event, KW&SB have little 'autonomous freedom' and therefore, essentially continue to operate as an executing agency with a number of financial and operational constraints placed on them coupled with a high level of political interference in day to day operations at local (Town and Council) level. KW&SB is governed by a board of directors of which the M.D KW&SB is a member and the City Nazim is the Chairman. Other board members include representation from private industry as well as government bodies. It is understood that whilst formal board meeting are conducted infrequently, The M.D consults on a regular basis with the Chairman of the board and other related CDGK and GOS departments regarding approval/processing of major development projects, approval of budgets, funding, financing, loan repayment, tariff adjustments, water quality/effluent standards compliance etc.

In conclusion, overall, there is sufficient legislation and policy pronouncement already in place, however, the motivation, coordination, resources, participation of beneficiaries and institutional capacity to effectively implement them appear to be sorely missing. Additionally, there would appear to be overlaps and lack of clarity in responsibilities for interrelated agencies and a lot of the legislation is very prescriptive and 'over-specified' which enforces strict bureaucratic routines and stifles the development of new ways of working. Therefore, with the concept of making KW&SB more ‘accountable’, there is a need for new legislation (or Water Byelaws) that more clearly defines what KW&SB can and cannot do in relation to fulfilling their constituted responsibilities for the provision of water and sanitation services. This will include raising finances, cost recovery mechanisms (tariff setting), service standards, management of human resources, asset O&M, asset creation/disposal etc.

9.7.2 The Need for Consolidated and Appropriate Water Byelaws

The formulation of a new and appropriate ‘Water Law’ or ‘Water Byelaws’, to compliment current legislation is required. This warrants a more detailed study and analysis which could be taken up by ADB as part of their ongoing support to the GOS. In principle, the outline is provided in **Table 97.2.1** as a guideline for implementation of a consolidated and appropriate water law or byelaws which highlights the key requirements to be considered:

Table 97.2.1 Guidelines for New Water Byelaws

CHAPTER	SECTION	AREA TO BE COVERED
DEFINITIONS & INTERPRETATIONS		Definitions and interpretations
BYELAWS & LEVELS OF SERVICE	APPLICATION OF BYELAWS AND LEVELS OF SERVICE	Application of byelaws and levels of service
	TARIFFS, RATES AND CHARGES	Prescribed tariffs and charges for services Determination of tariffs Subsidies
	APPLICATION for SERVICES	Application for water services Application for sewerage services Special arrangements for services
	PAYMENT	Payment of deposits Payment for services provided
	ACCOUNTS	Account queries Appeals against findings of authority Arrears Payment plans
	TERMINATION AND LIMITATION OF USE	Limitation/purposes of use Discontinuation of services Interruption of services Restoration of services
	GENERAL PROVISIONS	Responsibility to comply with byelaws Unauthorised use of services Compliance with notices and documents Power of entry and inspection Damage to water supply schemes Pollution of water supply schemes Liabilities and compensation Offences and penalties
WATER SUPPLY SERVICES	CONNECTION TO WATER SUPPLY SCHEME	Provision of connection pipe Location of connection pipe Water connection for single property Water connection for multiple users Interconnection between premises Disconnection of connection pipe
	COMMUNAL WATER SERVICES	Access to stand post/spot sources
	TEMPORARY SUPPLIES	Emergency supplies Hydrant supplies Tanker supplies
	STANDARDS AND CONDITIONS OF SUPPLY	Quantity, quality and pressure General conditions of supply
	MEASUREMENT OF SERVICES	Measuring the quantity of water supplied Estimated consumption Defective measurement devices Customer side water losses

CHAPTER	SECTION	AREA TO BE COVERED
	INSTALLATIONS	Approval of installations Provision and maintenance of installations Authorised material specifications
	POLLUTION, RESTRICTIONS AND WASTEFUL USE	Responsibilities for preventing contamination Water restrictions imposed from time to time Water conservation methods Water quality sampling and testing
SEWERAGE SERVICES	STANDARDS & GENERAL PROVISIONS	Standards Objections to discharge to sewer network
	ON-SITE SANITATION	Application for infrastructure Service charges
	SEWAGE DISPOSAL	Provision of connecting sewer Connection to sewers Connections for single property Connections for multiple users Interconnection between premises
	INDUSTRIAL EFFLUENT	Application for disposal of industrial effluent Unauthorised discharges Quality standards Consequences of non-compliance
	QUANTITY OF DISCHARGE	Basis of measurement of domestic discharge Basis of measurement of industrial discharge
	INSTALLATIONS	Drains in streets or public places Construction standards by authority or approved provider Maintenance of facilities Pre-treatment facilities Protection from floodwater ingress

9.8 HUMAN RESOURCE DEVELOPMENT

9.8.1 Gaining Consensus on Human Resource Management and Development Needs

A senior management strategic workshop was held on 06 February 2007 with the aim of involving KW&SB in the development of the institutional aspects of the Master Plan, specifically with respect to ‘Human Resource Management’ (HRM) and ‘Human Resource Development’ (HRD) activities. The aim of the workshop was to enable a forum where senior KW&SB managers could express ideas and concerns in an open and honest environment with the idea of developing new ways of working that would transform KW&SB into a customer focused efficient and commercially sustainable professional Organisation.

The key findings as described below have influenced the development of the Master Plan.

(1) Consensus of HRM needs

- A professional HRM set-up should be established that sets policy and guidance for good HRM practices and procedures. This cannot be devolved to departmental managers
- Promotions should be based on performance and merit as well as the ability to do the job. This should include skills, ‘values and behaviours’, experience and qualifications as well as seniority
- Job transfers should be based on merit and the need to develop skills for the good of the individual and organisation alike. Avoid political appointments
- Investment in office facilities and equipment such as computers, desks and even stationary is required for staff to feel valued, part of the organisation, and motivated to work in a ‘business like’ environment
- If staff are officiating higher graded roles for extended periods they should be promoted and rewarded accordingly

- Managers should be free to take ‘ownership’ of problems and to make decisions based on delegated powers and authority without the need to refer even minor decisions to superiors. Managers should be ‘free to manage’ without fear of retribution to eliminate the current feeling of low moral and low esteem. Enthusiasm and creativity is being ‘stifled’ by the current management style and approach
- Job evaluation and job design should go hand in hand with rewards and recognition based on job size, responsibility for budgets, staff, resources etc.

(2) Consensus of HRD needs

- Professional in-house training facilities with organized training based on individual as well as departmental needs should be established with sufficient funds for effective operation. Induction training and vocational training are just as important as technical and on the job training.
- Learn from good practices in other well run organizations; scholarships, study tours and other methods could be used to build staff knowledge and capacity
- Career and succession planning should be based on organisation as well as individual needs. Staff should be supported in developing training needs for career progression and promotions should be based on ‘the best person for the job’ principle
- Job descriptions with clear roles and responsibilities are required so that staff are aware of what is expected of them and how their performance will be measured
- A professional, open and honest ‘performance appraisal system’ should be introduced that clearly defines goals, targets, training and development needs to improve individual performance

9.8.2 HRM and HRD Situation Assessment

A situation assessment of HRM and HRD aspects was conducted during the first phase of the JICA study. This can be summarised as follows:

The organisation does not have well defined policies or procedures in place for manpower planning, recruitment, performance management/improvement, motivation, succession planning, human resource development or training amongst other key activities.

Like other government establishments, KW&SB are bound by various civil service rules and regulation ‘imposed’ from time to time. This has influenced the current civil service ‘values and behaviours’ and is largely the cause of low morale and lack of motivation and enthusiasm prevalent throughout the organisation. Many employees have long service with KW&SB, turnover of staff has been negligible (apart from retirement) and recruitment has effectively been put on hold for the past few years. The practice of promoting staff based almost entirely on seniority rather than on ‘ability to do the job’ does little to encourage the development of sustainable policies and processes for improved performance. At the same time valuable experience and knowledge is being lost as routines are not in place to capture and transfer knowledge.

The current policy of internal transfers and promotions from within the organisation and no external recruitment (until most recently, whereby graduate engineers are currently being recruited) despite some obvious skill gaps is becoming more and more evident, not least due to the need to introduce new systems and technologies etc. to improve business, commercial and operational performance.

The current organisational structure is a traditional functional hierarchy. It does not provide the most efficient or effective way of organising the business. The present arrangement reinforces functional ‘silo’ mentality where each department or function invariably operates in isolation to other departments with little coordination or teamwork across processes or lines of responsibility. This type of set-up potentially exacerbates bureaucracy, inhibits information flow and communications, prevents the sharing of best practice and stifles teamwork, creativity and initiative.

Due to the need for Systems and Process improvements, most of the functional departments within KW&SB are ‘reactive’ in nature with little time to assume a more ‘pro-active’ approach. The current set-up does not encourage communication and as a result the sharing of ideas and learning is limited. When operating through functional lines of control, it is difficult to prevent inefficient practices developing as each department tends to be ‘inward looking’. This type of functional arrangement can often result in employees not being aware of ‘wider’ corporate issues.

KW&SB’s low level of automation, particularly in the administrative field has led to labour intensive manual practices involving a large number of employees performing clerical, administrative or menial tasks compared to those performing skilled or technical/managerial tasks.

The industrial relations climate is poor which means that change initiatives are often stifled due to union opposition or intransigence. As water is highly politicised, local councillors and political parties are reluctant to ‘rock the boat’ or upset the ‘steady state’ by introducing or forcing through radical changes or reforms. This limits KW&SB’s ability to initiate change within their own organisation, which in turn stifles initiative and enthusiasm for change.

(1) Process ownership

There is no central coordinating role at policy level dealing with HRM. Based on recent changes to the KW&SB organisation structure (June 2006), the Chief Administrative Officer (CAO) does not hold functional responsibility for HRD or Training activities. The CAO primarily holds administrative responsibility for HRM and Training activities. Responsibility for the Training function rests with the DMD (Planning & Design).

There is no longer a central coordinating role at policy level dealing with HRD. This has been devolved to the respective CE’s and CO’s to manage capacity building and enhancement of human resources within their areas of responsibility. KW&SB will need to take care that the lack of a central HRD Department with competent staff to deliver training and development activities, does not dilute their development efforts.

(2) Building Staff Capacity

Programmes for building staff capacity should be aimed at developing technical competencies, process competencies and managerial competencies to ensure efficient operation of all aspects of the business. Currently, apart from a variety of basic skills training courses, skills are developed by means of on-the-job training.

KW&SB can gain significant improvements in business and staff performance by enhancing and aligning skill levels with the stated needs of the business. This will require considerable investment in assessing competencies and tailoring training and development needs of each employee throughout the organisation to meet agreed individual, departmental and corporate objectives. This would lead to the need for introducing a “corporate training and development plan”, which will require continuous monitoring and development.

KW&SB do not have a formal training policy or documentation regarding the training and development needs of individuals or KW&SB as a whole. However, both internal and external training is provided as funds allow. It is recommended that all training in future is based on individual and departmental development needs and should be targeted and prioritised, rather than be made available to those who have time to attend.

The quality and success of training imparted is not measured or monitored. We recommend introduction of a system that measures the effectiveness of training delivered and the effects of training on the trainee's performance. Currently, KW&SB do not have a formal policy on career development or a career development and progression planning process, although criteria is well established for promotions and job transfers.

Little emphasis is given to training, development and promotional prospects of those lower down the organisation, for example clerical staff or labourers. The system of promoting to vacant positions based on seniority 'leaves them behind'. Equal emphasis and opportunities for further development and enhancement should be open to all employees. The ultimate aim of a career development programme is to enhance the future performance of the organisation itself through the development and advancement of its employees. It is recommended that individuals take responsibility for their own careers, by introduction of a training and development framework designed to allow all grades and disciplines equal opportunity for advancement.

(3) Managing Performance

KW&SB do not have a system in place for formally setting or communicating corporate, departmental or personal performance targets/key performance indicators and performance measures are not formally set or monitored. 'Job descriptions' are not widely used and therefore, key tasks and priorities and how these are measured are not always clearly understood. For KW&SB to be a successful service organisation, employees must know what is expected of them and to have the opportunity to learn new skills to improve their contribution to the 'Business'.

A system for sharing corporate objectives has not been developed and therefore, it is not clear how departmental or functional objectives are set and measured to ensure that these contribute to wider corporate goals. Similarly a system for sharing departmental objectives has not been developed and therefore it is not clear how individual's objectives contribute to wider departmental objectives.

The current system of 'rewards and recognition' (terms and conditions) does not relate to performance and therefore good performance goes largely 'unrecognised' and poor performance goes largely 'un-checked'.

No or little feedback is given to individuals regarding their performance; consequently, training or future development needs are not formally discussed, agreed or documented.

9.8.3 The Imperative for Change

The current reforms and commercialisation agenda is presenting a number of challenges to KW&SB, including the need to ensure that there are appropriate arrangements in place for effective human resources management and development with the idea of transforming KW&SB into a customer focused efficient and commercially sustainable professional organisation. It is recognized that this cannot be achieved by running the organisation on a 'business as usual' approach; a fundamental shift away from current business principles will require a new approach to human resource management (HRM) and human resource development (HRD).

(1) The Need for HR Policies

HR policies ensure that everyone is treated fairly and consistently and that their contributions to the success of KW&SB are appropriately recognised and rewarded. All employees should be fully aware of what is expected of them and what they, in return, should expect from KW&SB. HR Policies summarise the Organisation's responsibility to individuals and their responsibility to the Organisation.

<u>The Policies</u>

Detailed HR policies and procedures will need to be developed and preferably be contained in an "Employee Handbook", which would also require development. The HR policies/procedures should be readily accessible to all employees and KW&SB will need to take responsibility for facilitating understanding through training where appropriate.

a) Recruitment & Selection

KW&SB should have a non discriminatory policy to recruit and promote on merit as well as seniority, regardless of sex, pregnancy, trade union membership, sexual orientation, race, disability, age or religion. Wherever possible, existing employees should have an opportunity to apply for vacancy/promotion opportunities. KW&SB will need to clearly define recruitment and selection procedures/techniques which support this policy, and for training recruiters. All newly appointed employees should be integrated into their new role through a supervised induction programme and therefore be given appropriate support and guidance until they are fully competent to do the job.

b) Development and Training

Through performance management processes KW&SB will aims to ensure that all employees know what is expected of them and possess the necessary skills, knowledge, values and experience to achieve the highest level of performance of which they are capable. Wherever possible, KW&SB will undertake to provide development opportunities, such as study for qualifications, secondments, project work and undertaking other challenging roles.

c) Reward and Motivation

KW&SB's aim is to reward with fair and competitive salary and benefit packages. All elements of reward will need to be designed to support the achievement of desired behaviour, values and standards as well as high performance and continuous improvement/development. Reward procedures and mechanisms will need to be accessible and transparent. KW&SB will also recognise that pay/benefits are only one element of reward, and that personal development, recognition and celebration of achievement are also equally significant.

d) Equity, Diversity and Dignity at Work

KW&SB's employment policies will need to be based on the principles of equality and diversity, this being in the belief that the elimination of unfair discrimination in the workplace contributes to productivity and performance as it allows people's talents to be most effectively utilised. KW&SB will also need to commit to ensuring the dignity at work and fair treatment of all, and that procedures are in place for resolving any grievance or harassment issue which staff may have in connection with their employment.

e) Conduct and Capability

KW&SB will need to ensure that there is a strong management framework and key principles to support people at work. The purpose of the policy is to allow managers to deal effectively with staff and colleagues when their conduct, performance or attendance falls below acceptable standards. KW&SB will need to provide guidance and rules under which people can operate effectively, and through which the organisation can ensure compliance with relevant employment laws.

f) Job Security and Pensions

KW&SB will need to provide an equitable pension scheme for all employees. Where individuals are affected by changes to their role or their personal/health circumstances, all reasonable steps are taken to enable them to stay with the organisation. This may be through discussing possible solutions to enable them to continue in their role, adjusting working hours/patterns, or helping find a new role within or outside the Authority. As a responsible employer, there will also be a need to have in place policies which support a reasonable work-life balance. KW&SB should also aim to implement a 'Health and Safety Policy' which will set out the approach to managing 'Occupational Health and Safety' of all employees.

g) Communications, Information and Consultation

KW&SB should encourage an open and honest culture, and to ensure that all employees are regularly updated with what is happening in all areas of the business, and that consultation takes place as appropriate. Two way and face-to-face communication is essential, giving everyone the opportunity to ask questions and have a voice in decision making. KW&SB should also encourage a 'no-blame' culture, so that all can have their say without fear of reprisal or discrimination. Accordingly, KW&SB will need to put in place channels of communication (direct and indirect) and feedback, as well as making sure that communication is timely and inclusive. KW&SB will recognise and work with registered trade unions and put in place appropriate collective bargaining arrangements as necessary.

(2) The Need for Improved HRD Methods

The management of human resources is integral to business success. People are at the heart of the organisation and effective business, operations and customer services performance is closely linked to having a well-trained and committed work force in place. It is evident that the workforce and management in KW&SB are technically competent and capable of delivering the services required, however, there are opportunities for KW&SB to capitalise on these inherent skills by introducing more effective systems and strategies.

KW&SB will need to improve on their HRD approach in order to 'add value' to the training efforts currently provided, by **'professionalising'** the functioning of the Human Resource Department and by 'building' capacity of the staff engaged in delivering HRD and Training services. The HR Department will need to be developed to take a more proactive role by providing overall direction and strategy for HRD and Training activities and by providing support to 'line managers' responsible for the key business processes described earlier. This approach will ensure that line managers take a more active role in staff development issues whilst at the same time ensure that employee needs and expectations are adequately managed.

CHAPTER 10

PROJECT COST AND IMPLEMENTATION SCHEDULE OF MASTER PLAN

10 PROJECT COST AND IMPLEMENTATION SCHEDULE OF MASTER PLAN

10.1 BASIC CONDITIONS AND ASSUMPTIONS

Preliminary cost estimates are done for the proposed facilities/equipment described in Chapters 3 and 4. All the costs mentioned in this chapter are expressed in Pakistan Rupees as of 2007. Taxes and duties vary depending on the type of equipment or material and are included in the respective unit costs.

10.1.1 Construction Cost

The capital costs of the proposed water supply and sewerage projects were estimated based on the data and information provided in the following documents using the conditions and assumptions shown in **Table 101.1.1**.

a) JBIC-financed Karachi Water Supply Improvement Project – Contract Documents
b) K-III Project – Contract Documents
c) Tameer-e-Karachi Project – Trunk Mains Installation Contracts
d) K-IV Project, Greater Karachi Water Supply Scheme, Executive Summary May 2007
e) Greater Karachi Sewerage (S-III) Project – PC-1 Documents
f) Schedule of Rate, Government of Sindh, October 1, 2004
g) Catalogue prices of manufacturers and suppliers

Table 101.1.1 Conditions and Assumptions Used for Estimate

(a)	Base Cost	Current price in 2007
(b)	Engineering Fees	7.5% of (a)
(c)	Physical Contingency	5% of [(a) + (b) + land acquisition cost]
(d)	Price Contingency	1.5% of (c) for F/C component, 6.0% of (c) for L/C component
(e)	Project Administration	1.5% of (d)

10.1.2 Operation and Maintenance Cost

Operation costs comprise personnel costs, electricity costs, diesel fuel costs, chemical costs, sludge disposal costs (sewerage) and other. These costs were estimated based on the total pumping capacity in case of a pumping station and the total treatment capacity in case of a water treatment plant or a sewage treatment plant. Maintenance costs of mechanical and electrical equipments of pumping stations, water treatment plants and sewage treatment plants were calculated based on their construction costs. Maintenance costs of sewers were presumed to depend on the length.

10.1.3 Other Costs

The total cost of the Master Plan includes the following miscellaneous costs besides the direct construction costs or base costs.

(1) Engineering Fees

The engineering fees include the costs for detail design, assistance for tendering/tender evaluation to the contract awards and construction supervision. They are estimated to be 7.5% of the direct construction costs for both water supply and sewerage projects.

(2) Land Acquisition Cost

The land acquisition cost is needed to construct necessary facilities.

(3) Contingencies

The physical contingency is estimated to be 5% of the sum of the direct construction, engineering and land acquisition costs. The price contingency is calculated for the total of the direct construction, engineering, land acquisition costs and physical contingency supposing annual inflation rate of 1.5% for foreign portion and of 6% for local portion, respectively.

(4) Administration Costs

The administration cost is estimated to be 1.5% of the total of direct construction, engineering and land acquisition costs and physical/cost contingencies.

10.2 COST ESTIMATES

10.2.1 Water Supply Projects

(1) Initial Cost

A summary of the costs for the water supply components is presented in **Table 102.1.1.** Refer to **Appendix 102.1** for details of initial cost of water supply project.

Table 102.1.1 Cost Estimate for Water Supply Components

(Million Rs.)

		Total	Breakdown	
			F/C	L/C
(A)	Bulk Water Supply	72,641	60% 43,362	40% 29,279
(B)	Zone West	52,653	72% 37,691	28% 14,962
(C)	Zone Central	58,527	71% 41,803	29% 16,724
(D)	Zone East	30,252	71% 21,541	29% 8,711
Total Base Cost (TBC)		214,073	67% 144,397	33% 69,676
(E)	Engineering Fees	16,055	70% 11,238	30% 4,816
(F)	Land Acquisition	1,547	0% 0	100% 1,547
(G)	Physical Contingency	11,583	67% 7,781	33% 3,802
Sub-total (TBC+E+F+G)		243,257	67% 163,416	33% 79,841
(H)	Price Contingency	80,792	30% 24,052	70% 56,740
Sub-total (TBC+E+F+G+H)		324,049	58% 187,468	42% 136,581
(I)	Project Administration	4,861	0% 0	100% 4,861
Total Project Cost (TPC)		328,910	57% 187,468	43% 141,441

(2) Operation and Maintenance Cost

A summary of the operation and maintenance cost for the water supply components is presented **in Table 102.1.2.** Refer to **Appendix 102.2** for details of operation and maintenance cost of water supply project.

Table 102.1.2 Operation and Maintenance Cost of Water Supply Component

(Million Rs./year)

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Bulk Water Supply System (Common)																		
Operation Cost	991	991	991	991	1,437	1,503	1,503	1,503	1,503	2,070	2,211	2,351	2,492	2,524	2,777	2,918	3,059	3,200
Maintenance Cost	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Total	999	999	999	999	1,445	1,511	1,511	1,511	1,511	2,078	2,219	2,360	2,500	2,532	2,785	2,926	3,067	3,208
Bulk Water Supply System (Zone West)																		
Operation Cost	73	73	73	73	73	73	73	73	73	196	197	199	201	203	330	340	350	360
Maintenance Cost	4	4	4	4	8	8	8	8	8	21	21	21	21	21	35	35	35	35
Total	78	78	78	78	81	81	81	81	81	217	218	220	222	224	365	375	385	395
Bulk Water Supply System (Zone Central)																		
Operation Cost	310	310	310	310	627	646	665	683	702	706	711	715	720	724	739	750	761	772
Maintenance Cost	14	14	14	14	41	41	41	41	41	60	60	60	60	60	79	79	79	79
Total	324	324	324	324	668	687	705	724	742	766	770	775	779	784	817	828	839	850
Bulk Water Supply System (Zone East)																		
Operation Cost	354	355	355	355	355	355	355	355	355	481	486	492	497	503	636	646	655	665
Maintenance Cost	8	8	8	8	8	8	8	8	8	16	16	16	16	16	23	23	23	23
Total	362	364	364	364	364	364	364	364	364	497	502	508	513	519	660	669	679	688
Total																		
Operation Cost	1,727	1,729	1,729	1,729	2,493	2,578	2,596	2,615	2,633	3,452	3,605	3,758	3,911	3,954	4,483	4,654	4,825	4,996
Maintenance Cost	35	35	35	35	65	65	65	65	65	105	105	105	105	105	145	145	145	145
Total	1,762	1,764	1,764	1,764	2,557	2,643	2,661	2,680	2,698	3,557	3,710	3,862	4,015	4,058	4,627	4,799	4,970	5,141

10.2.2 Sewerage Projects

(1) Initial Cost

A summary of the costs for the sewerage components is presented in **Table 102.2.1**. Refer to **Appendix 102.3** for details of initial cost of sewerage project.

Table 102.2.1 Cost Estimate for Sewerage Components

(Million Rs.)

		Total	Breakdown	
			F/C	L/C
(A) Zone West				
	TP-1 and TP-3 District	24,002	44% 10,532	56% 13,470
	TP-2 District	4,122	21% 871	79% 3,251
	Sub Total	28,124	41% 11,403	59% 16,721
(B) Zone Central				
	TP-1 and TP-3 District	2,563	44% 1,117	56% 1,446
	TP-2 District	19,101	52% 9,911	48% 9,190
	TP-4 District	14,861	23% 3,395	77% 11,466
	Sub Total	36,525	39% 14,423	61% 22,102
(C) Zone East				
	TP-4 District	40,625	50% 20,147	50% 20,478
	Sub Total	40,625	50% 20,147	50% 20,478
Total Base Cost (TBC)		105,274	44% 45,973	56% 59,301
(D)	Engineering Fees	7,896	70% 5,527	30% 2,369
(E)	Land Acquisition	18	0% 0	100% 18
(F)	Physical Contingency	5,660	45% 2,575	55% 3,085
Sub-total (TBC+D+E+F)		0 118,848	45% 54,075	55% 64,773
(G)	Price Contingency	69,313	14% 9,477	86% 59,836
Sub-total (TBC+D+E+F+G)		188,161	34% 63,552	66% 124,609
(H)	Project Administration	2,823	0% 0	100% 2,823
Total Project Cost (TPC)		190,984	33% 63,552	67% 127,432

(2) Operation and Maintenance Cost

A summary of the operation and maintenance cost for the sewerage components is presented in **Table 102.2.2.** Refer to **Appendix 102.4** for details of operation and maintenance cost of sewerage project.

Table 102.2.2 Operation and Maintenance Cost of Sewerage Component

(Million Rs /year)

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Zone West																			
TP-1 and TP-3 District	Operation Cost	9	9	9	9	9	9	32	74	78	145	152	160	179	186	198	209	222	233
	Maintenance Cost	7	7	7	7	7	7	28	51	53	91	94	96	101	104	111	116	126	131
	Sub Total	16	16	16	16	16	16	60	124	131	236	246	256	280	290	308	325	348	364
TP-2 District	Operation Cost	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Maintenance Cost	0	0	0	0	2	2	6	11	12	16	16	16	16	19	21	24	26	28
	Sub Total	0	0	0	0	2	2	6	11	12	16	16	16	16	19	21	24	26	28
Sub Total	Operation Cost	9	9	9	9	9	9	32	74	78	145	152	160	179	186	198	209	222	233
	Maintenance Cost	7	7	7	7	9	9	34	62	65	108	110	113	117	123	132	139	152	159
	Sub Total	16	16	16	16	18	18	67	136	143	252	262	273	296	309	329	348	373	392
Zone Central																			
TP-1 and TP-3 District	Operation Cost	7	7	7	7	8	8	12	12	13	13	14	14	15	15	16	16	17	17
	Maintenance Cost	1	1	1	1	1	1	4	7	8	12	12	13	13	14	15	16	17	18
	Sub Total	8	9	9	9	9	9	16	20	20	25	26	27	28	29	30	32	34	35
TP-2 District	Operation Cost	0	0	0	0	0	0	0	0	0	0	0	0	166	193	214	234	255	277
	Maintenance Cost	0	0	0	0	0	0	0	0	0	0	0	0	44	52	57	65	68	76
	Sub Total	0	0	0	0	0	0	0	0	0	0	0	0	210	245	270	299	323	353
TP-4 District	Operation Cost	0	0	0	0	0	0	0	0	0	0	0	7	8	9	10	10	11	12
	Maintenance Cost	0	0	0	0	13	14	15	17	18	27	35	44	52	61	73	83	94	104
	Sub Total	0	0	0	0	13	14	15	17	18	27	35	50	60	70	82	94	105	116
Sub Total	Operation Cost	7	7	7	7	8	8	12	12	13	13	14	21	188	217	239	261	283	306
	Maintenance Cost	1	1	1	1	14	16	20	24	26	38	47	56	109	127	144	164	179	198
	Sub Total	8	9	9	9	22	23	32	36	38	51	61	77	297	344	383	425	462	504
Zone East																			
TP-4 District	Operation Cost	0	0	0	0	59	64	68	73	77	112	155	201	260	306	363	427	495	553
	Maintenance Cost	0	0	0	19	20	26	27	28	29	45	56	67	84	95	108	126	144	157
	Sub Total	0	0	0	19	78	90	95	100	105	156	211	268	344	402	471	553	638	711
Sub Total	Operation Cost	0	0	0	0	59	64	68	73	77	112	155	201	260	306	363	427	495	553
	Maintenance Cost	0	0	0	19	20	26	27	28	29	45	56	67	84	95	108	126	144	157
	Sub Total	0	0	0	19	78	90	95	100	105	156	211	268	344	402	471	553	638	711
Total																			
Total	Operation Cost	16	17	17	17	76	81	113	158	167	269	321	381	627	709	800	898	999	1,093
	Maintenance Cost	8	8	8	27	43	50	81	114	119	190	213	236	311	345	384	428	474	514
	Sub Total	25	25	25	44	118	131	193	272	286	460	534	617	937	1,054	1,183	1,326	1,473	1,607

Table 102.2.3 Zone-wise Initial Cost for Water Supply and Sewerage

		Total	Breakdown	
			F/C	L/C
(A) Bulk Water Supply				
	Bulk Water Supply		60%	40%
		72,641	43,362	29,279
(B) Zone West				
	Water Supply		72%	28%
		52,653	37,691	14,962
	Sewerage		41%	59%
		28,124	11,403	16,721
	Sub Total		61%	39%
		80,777	49,094	31,683
(C) Zone Central				
	Water Supply		71%	29%
		58,527	41,803	16,724
	Sewerage		39%	61%
		36,525	14,423	22,102
	Sub Total		59%	41%
		95,052	56,226	38,826
(D) Zone East				
	Water Supply		71%	29%
		30,252	21,541	8,711
	Sewerage		50%	50%
		40,625	20,147	20,478
	Sub Total		59%	41%
		70,877	41,688	29,189
Total Base Cost (TBC)				
	Water Supply		67%	33%
		214,073	144,397	69,676
	Sewerage		44%	56%
		105,274	45,973	59,301
	Sub Total		60%	40%
		319,347	190,370	128,977

10.3 IMPLEMENTATION AND DISBURSEMENT SCHEDULES

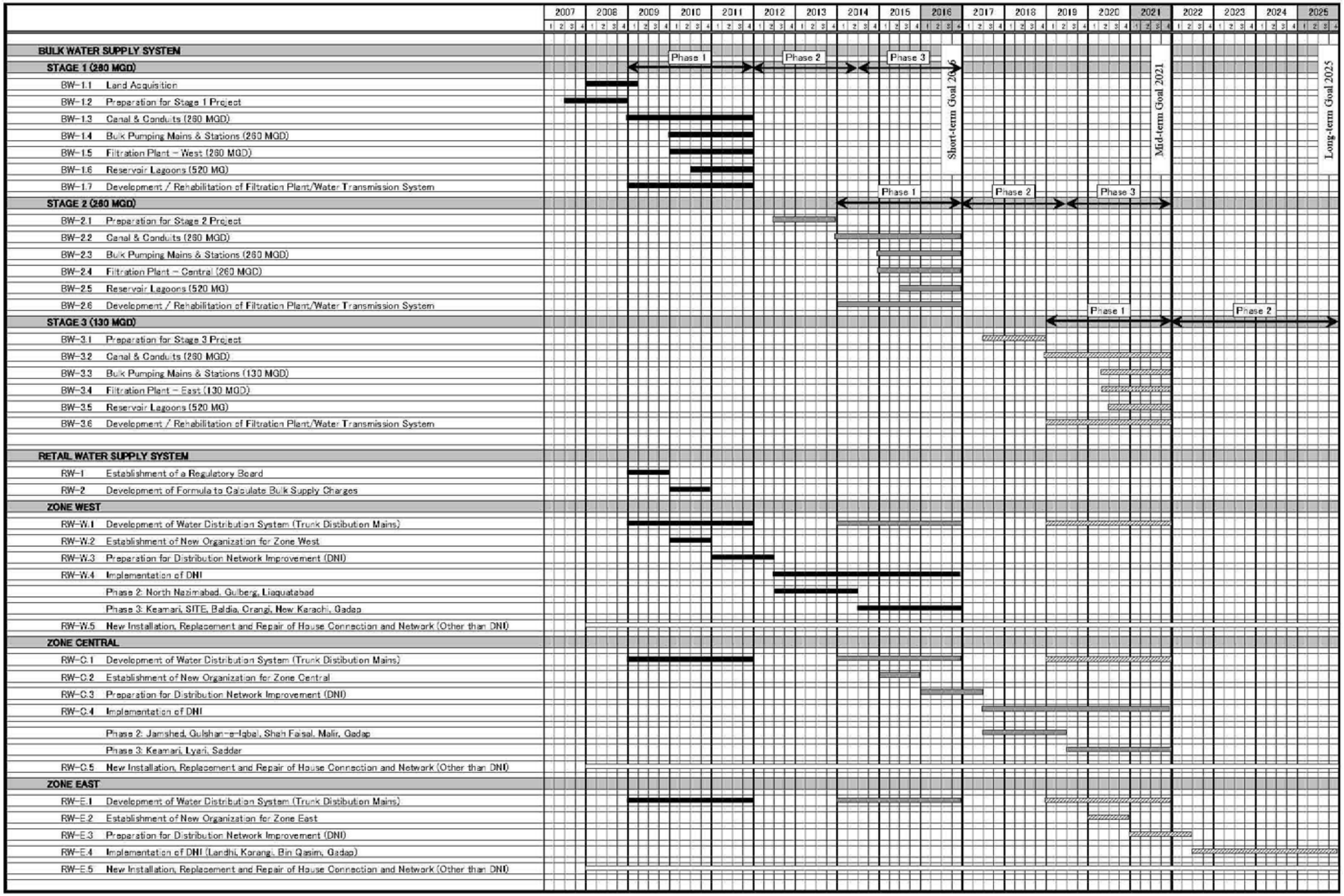
10.3.1 General

Proposed water supply and sewerage projects are implemented during the period between 2008 and 2025. These projects are allocated as follows. The whole implementation is divided into three stages, namely, Stage I (Target year: 2016), Stage II (Target Year: 2021) and Stage III (Target Year: 2025).

10.3.2 Water Supply Projects

A summary of implementation schedule of the water supply component is shown in **Table 103.2.1.**

Table 103.2.1 Implementation Schedule of Water Supply Projects



Stage I (Target Year: 2016)

1. **Development of Bulk Water Supply System (additional capacity of 130 mgd) including;**
   a. Construction of Bulk Water Canal/Conduit (260 mgd),
   b. Construction of 2 Bulk Pumping Stations,
   c. Construction of 3 Filtration Plants of K-III (100 mgd), COD (85 mgd) and K-IV Central (130 mgd),
   d. Construction of 3 Transmission Pumping Stations,
   e. Expansion of Pump Capacity of 2 Transmission Pumping Stations,
   f. Installation of Transmission Mains of 32 km,
   g. Construction of 2 Distribution Reservoirs and
   h. Expansion of 7 Distribution Reservoirs.
2. **Improvement of Existing Distribution Network System of Zone West (DNI**)
   a. North Nazimabad, Gulberg, Liaquatabad (2012-2014)
   b. Keamari, SITE, Baldia, Orangi, New Karachi, Gadap (2014-2016)
3. **Development of New Distribution Network System for New Residential Areas**
4. **Rehabilitation and Replacement of the Existing Water Supply System**

Stage II (Target Year: 2021)

1. **Development of Bulk Water Supply System (additional capacity of 260 mgd) including;**
   a. Construction of Bulk Water Canal/Conduit (260 mgd),
   b. Construction of 2 Bulk Pumping Stations,
   c. Construction of 2 Filtration Plants of K-IV West and K-IV East (130 mgd each),
   d. Construction of 2 Transmission Pumping Stations,
   e. Expansion of Pump Capacity of 4 Transmission Pumping Stations,
   f. Installation of Transmission Mains of 53 km,
   g. Construction of 4 Distribution Reservoirs and
   h. Expansion of 2 Distribution Reservoirs.
2. **Improvement of Existing Distribution Network System of Zone Central (DNI)**
   a. Jamshed, Gulshan-e-Iqbal, Shah Faisal, Malir, Gadap (2017-2019)
   b. Keamari, Lyari, Saddar (2019-2021)
3. **Development of New Distribution Network System for New Residential Areas**
4. **Rehabilitation and Replacement of the Existing Water Supply System**

Stage III (Target Year: 2025)

Zone West

1. **Development of Bulk Water Supply System (additional capacity of 260 mgd) including;**
   a. Construction of Bulk Water Canal/Conduit (260 mgd),
   b. Construction of 2 Bulk Pumping Stations,
   c. Construction of 2 Filtration Plants of K-IV West and K-IV East (130 mgd each),
   d. Construction of 2 Transmission Pumping Stations,
   e. Expansion of Pump Capacity of 6 Transmission Pumping Stations,
   f. Installation of Transmission Mains of 44 km,
   g. Construction of 2 Distribution Reservoirs,
   h. Expansion of 6 Distribution Reservoirs and
   i. Construction of 3 Distribution Pumping Stations.
2. **Improvement of Existing Distribution Network System of Zone East (DNI)**
   a. Landhi, Korangi, Bin Qasim, Gadap (2022-2025)
3. **Development of New Distribution Network System for New Residential Areas**
4. **Rehabilitation and Replacement of the Existing Water Supply System**

10.3.3 Sewerage Projects

A summary of implementation schedule of the sewerage component is shown in **Table 103.3.1**.

Table 103.3.1 Implementation Schedule of Sewerage Projects

		2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
		1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4	1 2 3 4
SEWERAGE COMPONENTS																				
ZONE WEST																				
TP-1 AND TP-3 DISTRICT																				
A-1	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																			
	New Branch Sewer / Small Pump																			
A-2	Trunk Sewer																			
	New Trunk Sewer (North Nazimabad, Gulberg and Liaquatabad)																			
	Other New Trunk Sewer																			
	New Effluent Discharging Channel of TP-1																			
A-3 (1)	Sewage Treatment Plant TP-1																			
	Rehabilitation of Existing Facility																			
	Extension of Facility																			
A-3 (2)	Sewage Treatment Plant TP-3																			
	Rehabilitation of Existing Facility																			
	Extension of Main Pump																			
TP-2 DISTRICT																				
A-4	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																			
	New Branch Sewer / Small Pump																			
A-5	Trunk Sewer																			
	Extension of Lyari Interceptor																			
	Other New Trunk Sewer																			
ZONE CENTRAL																				
TP-1 AND TP-3 DISTRICT																				
B-1	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																			
	New Branch Sewer / Small Pump																			
B-2	Trunk Sewer																			
	New Trunk Sewer																			
B-3	Pumping Station																			
	Rehabilitation of Jamila Pumping Station																			
	Rehabilitation of Chakiwara Pumping Station																			
TP-2 DISTRICT																				
B-4	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																			
	New Branch Sewer / Small Pump																			
B-5	Trunk Sewer																			
	New Trunk Sewer																			
	New Effluent Discharging Channel of TP-2																			
B-6	Pumping Station																			
	Gulberg Pumping Station (New)																			
	Rehabilitation of Clifton Pumping Station																			
B-7	Sewage Treatment Plant TP-2																			
	Rehabilitation of Existing Facility																			
	Extension of Facility																			
TP-4 DISTRICT																				
B-8	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																			
	New Branch Sewer / Small Pump																			
B-9	Trunk Sewer																			
	Malir Interceptor (Right Bank)																			
	Other New Trunk Sewer																			
B-10	Pumping Station																			
	Karachi Port Pumping Station (New)																			
ZONE EAST																				
TP-4 DISTRICT																				
C-1	Branch Sewer																			
	Replacement of Existing Branch Sewer / Small Pump																			
	New Branch Sewer / Small Pump																			
C-2	Trunk Sewer																			
	Malir Interceptor (Left Bank)																			
	Other New Trunk Sewer																			
C-3	Pumping Station																			
	Rehabilitation of Korangi Pumping Station																			
	Bin Qasim Pumping Station (New)																			
C-4	Sewage Treatment Plant TP-4																			
	Construction / Extension of Facility																			

Stage I (Target Year: 2016)

Zone West

TP-1 and TP-3 District

a. Construction and Rehabilitation of Branch Sewers
b. Construction of Trunk Sewer
c. Construction of Effluent Discharging Channel of TP-1
d. Rehabilitation of Sewage Treatment Plant TP-1 (24 mgd or 110,000 m^3/d)
e. Extension of Sewage Treatment Plant TP-1 (55 mgd or 250,000 m^3/d)
f. Rehabilitation of Sewage Treatment Plant TP-3 (54 mgd or 245,000 m^3/d)

TP-2 District

a. Construction and Rehabilitation of Branch Sewers
b. Extension of Lyari Interceptor
c. Construction of Trunk Sewer

Zone Central

TP-1 and TP-3 District

a. Construction of Branch Sewers

TP-2 District

a. Construction of Branch Sewers

TP-4 District

a. Construction of Branch Sewers
b. Construction of Malir Interceptor (Right Bank Side)

Zone East

TP-4 District

a. Construction of Branch Sewers
b. Construction of Malir Interceptor (Left Bank Side)
c. Construction of Sewage Treatment Plant TP-4 (107 mgd or 486,000 m^3/d)

Stage II (Target Year: 2021)

Zone West

TP-1 and TP-3 District

a. Construction of Branch Sewers
b. Construction of Trunk Sewers
c. Extension of Sewage Treatment Plant TP-1 (37 mgd or 167,000 m^3/d)
d. Extension of Main Pump of Sewage Treatment Plant TP-3

TP-2 District

a. Construction of Branch Sewers

Zone Central

TP-1 and TP-3 District

a. Construction and Rehabilitation of Branch Sewers
b. Construction of Trunk Sewer
c. Rehabilitation of Jamila Pumping Stations
d. Rehabilitation of Chakiwara Pumping Stations

TP-2 District

a. Construction and Rehabilitation of Branch Sewers
b. Construction of Trunk Sewer
c. Construction of Effluent Discharging Channel of TP-2
d. Construction of Gulberg Pumping Station
e. Rehabilitation of Clifton Pumping Station
f. Rehabilitation of Sewage Treatment Plant TP-2 (24 mgd or 110,000 m^3/d)
g. Extension of Sewage Treatment Plant TP-2 (94 mgd or 429,000 m^3/d)

TP-4 District

a. Construction and Rehabilitation of Branch Sewers
b. Construction of Trunk Sewer
c. Construction of Karachi Port Pumping Station

Zone East

TP-4 District

a. Construction of Branch Sewers
b. Construction of Trunk Sewer
c. Rehabilitation of Korangi Pumping Station
d. Extension of Sewage Treatment Plant TP-4 (125 mgd or 567,000 m^3/d)

Stage III (Target Year: 2025)

Zone West

TP-1 and TP-3 District

a. Construction of Branch Sewers
b. Construction of Trunk Sewer
c. Extension of Sewage Treatment Plant TP-1 (18 mgd or 83,000 m^3/d)

TP-2 District

a. Construction of Branch Sewers
b. Construction of Trunk Sewer

Zone Central

TP-1 and TP-3 District

a. Construction of Branch Sewers

TP-2 District

a. Construction of Branch Sewers
b. Extension of Sewage Treatment Plant TP-2 (13 mgd or 61,000 m^3/d)

TP-4 District

a. Construction of Branch Sewers

Zone East

TP-4 District

a. Construction and Rehabilitation of Branch Sewers
b. Construction of Trunk Sewer
c. Construction of Bin Qasim Pumping Station
d. Extension of Sewage Treatment Plant TP-4 (53 mgd or 243,000 m^3/d)

CHAPTER 11

EVALUATION OF MASTER PLAN AND SELECTION OF PRIORITY PROJECT

11 EVALUATION OF MASTER PLAN AND SELECTION OF PRIORITY PROJECT

11.1 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS OF MASTER PLAN

11.1.1 Purpose and Level of Considerations

(1) Purpose

The purpose of the Environmental and Social Considerations is to ensure that development options under consideration are environmentally and socially sound and sustainable and that the environmental consequences of the project are recognized early and taken into account in the project design. The procedure should follow the Pakistan Laws, and JICA's Guidelines for Environmental and Social Considerations are also taken into account.

The JICA Study Team is assisting the KW&SB to consider the environmental and social aspects of this study. The role of the JICA Study Team is to:

- Help the KW&SB implement the proper environmental and social considerations,
- Prepare an effective Master Plan and select priority project(s) which will not cause significant negative environmental or social impacts,
- Assist the KW&SB to consult with stakeholders when preparing the Master Plan and conducting the Feasibility Study to foster support for the projects,
- Ensure the positive information disclosure for accountability and promotion of participation of various stakeholders.

(2) Level of Consideration Required by JICA

The Preparatory Study (which was conducted by JICA in 2005) concluded that this study requires considerations of environmental and social assessment. The categorization is in accordance with JICA's Guidelines for Environmental and Social Considerations, which were revised in 2004. The assessment scoping conducted in the Preparatory Study, all the environmental items were evaluated as either B, C or D. Further, a significant improvement of water quality and public health is expected by the project. Therefore, this project is evaluated overall as "category B"[1] in the preliminary assessment. In Basic Study and Master Plan stages, KW&SB in cooperation with the Study Team has not found any reasons to change its category of B.

(3) Contents of Environmental and Social Considerations in Master Plan

The contents of environmental and social considerations in Master Plan are:

- Review the current environmental and social conditions in the project area based on the secondary data and simple field surveys,
- Choose the better plans by conducting alternative study (including zero option),
- Identify and predict the environmental impacts and prepare the mitigation measures.

11.1.2 Water Supply System

(1) Components of Water Supply System

The following tables show the components of the Master Plan for the Karachi water supply

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[1] Based on the JICA Guidelines, the proposed projects are classified into one of three categories: "A", "B" or "C". The project classified as Category "A" is likely to have significant adverse impacts, and the project classified as Category "B" is likely to have less adverse impacts than those of Category "A" project. The project classified as Category "C" is likely to have minimal or no adverse impacts.

system. The proposed facilities of upper 3 lines of the **Table 111.2.1** (bulk water canal/conduit, bulk pumping station, filtration plant) are proposed by KW&SB as K-IV project, Greater Karachi Water Supply Scheme (Executive Summary, May 2007).

Table 111.2.1 Components of Bulk Water Supply System

Facility	Proposed	Rehabilitation/ Replacement
Bulk Water Canal/Conduit	780 mgd	620 mgd
Bulk Pumping Station	6 P/Ss	15 P/Ss
Filtration Plant	5 F/Ps : 835 mgd	6 F/Ps: 435mgd
Transmission Pumping Station	7 P/Ss	2 P/Ss
Transmission Main	129 km	17 km
Distribution Reservoir	8 nos.	6 nos. (8 nos.)
Distribution Pumping Station	3 P/Ss	-

Note: the proposed facilities in upper 3 lines are proposed by KW&SB as K-IV project, Greater Karachi Water Supply Scheme (Executive Summary, May 2007)
Number in parenthesis is expansion of capacity

Table 111.2.2 Components of Retail Water Supply System

Facility	Proposed				Rehabilitation/ Replacement			
Zone	West	Central	East	Total	West	Central	East	Total
Trunk Distribution Main (km)	406	364	152	922	273	259	153	685
Distribution Network Main (km)	2,539	3,152	2,349	8,041	3,751	4,208	1,220	9,179
by DNI	-	-	-	-	2,578	3,069	681	6,329
by other than DNI	-	-	-	-	1,173	1,139	539	2,850
House Connection (×1,000)	454	564	420	1,438	1,119	900	378	2,398
by DNI	-	-	-		553	784	283	1,620
by other than DNI	-	-	-		566	116	95	778

The detail of the proposed water supply development plan is described in **Chapter 7** "Water Supply Master Plan".

(2) Analysis of Alternatives

a) Project Benefits and Positive Impacts

The main objectives of the water supply project are to improve the living condition, public health, standards of living and to encourage economic growth. Therefore, the project is expected to have the following benefits and positive impacts.

- Expanded water supply service areas,
- Increased amount of water distribution and continuous water supply,
- Improvement of water quality supplied,
- Reduced non-revenue water including water leakage,
- Increased economic activities (such as commercial and industrial), improved employment opportunities, and economic growth,
- Improvements to public health which will then result in higher economic activity and productivity,
- Increased local employment opportunities during the construction phase of the project, either as direct labour for construction or as provide services at the construction sites.

b) With/Without Project

With the project, the benefits and positive impacts mentioned above will be expected. If the project is not implemented, the situation could be as follows.

- Severe water shortage will be happen as the population in Karachi City is increasing in future,
- The leakage rate will remain high and the big amount of water will be wasted,
- The public health condition will become worse due to water shortage.

c) Alternative of Water Source

The alternatives of water sources are rivers, groundwater, desalination and reuse of treated effluent. There is very little and irregular precipitation in Karachi, it is therefore very difficult to use local surface water as a source of water supply in Karachi.

The Karachi District area comprises four basin areas, namely Malir River Basin, Gadap Basin, Lyari River Basin, and Hub River Basin. The groundwater exists in these basins and the aquifer is available in different depths of different strata. The groundwater is recharged manly by precipitation which falls in the watershed area of the basins. Since the major streams and nallahs are ephemeral in natures, most of the precipitation is lost through surface runoff.

The request for additional 1,200 cuses intake from the Indus River is already made by CDGK and KW&SB to Federal government and this will be most possible new water sources for Karachi water supply.

Desalination can be an option to obtain another water source, but its cost is huge. One desalination plant (3 mgd = 13,500 m^3/d) is under construction by DHA. The conclusion still remains effective even at present and most likely it will continue to remain valid in foreseeable future (see **Section 3.2.2**).

The treated effluent from TP-3 and Pakistan Still Mill treatment plant is used as plant watering and sprinkle water to golf course. The effluent with BOD_5 80 mg/l, which is the effluent standards of Pakistan, is not appropriate to use as water sources.

d) Alternative for Water Transmission System

In M/P, it is proposed to divide Karachi into three hydraulic zones each separated from the others by two major rivers i.e. Malir and Lyari Rivers. Within each zone, the alternatives for water transmission system are discussed (see **Appendixes A73.1 to A 73.4** for the detail). In each zone, three alternatives of distribution system are compared in terms of cost and difficulty in operation.

(3) Environmental and Social Impacts and Mitigation Measures

The scoping, full evaluation of potential significant impacts and the recommendation of mitigation measures are shown in **Appendix A111.6**. The following sections summarize the results of the environmental and social considerations related to the impact evaluation and recommended mitigation measures.

For the water supply system, K-IV project, Greater Karachi Water Supply Scheme (Executive Summary, May 2007) which includes the pumping stations, canal and conduits to bring raw water from Kinjar Lake to Karachi, reservoir lagoons and three water filtration plants is under the process of approval from the Federal Government. JICA Study Team proposes the implementation of necessary facilities from there three filtration plants to meet the water demand based on this K-IV project. Thus, the impact assessment has to be conducted for the facilities which JICA Study Team proposes. However, some recommendations are made for K-IV project and that is described in **Appendix A111.8**.

Table 111.2.3 Summary of Impact and Mitigation Measures for Water Supply System

No	Environmental Items	Adverse Impact	Duration	Proposed Mitigation Measures
1	Resettlement	8 new reservoirs and 8 expansion reservoirs are proposed in M/P and the land acquisition for these facilities are necessary.	Permanent	Minimization of resettlement is important. All 8 new reservoirs are proposed in arid and vacant area where is not used for any purpose. 5 reservoirs among 8 expansions are located away from the city and the enough space for expansion the facilities near existing locations. Land acquisition is necessary but no resettlement is occurred. 2 reservoirs named Orangi and High Service are not used at present. The Orangi requires some land for expansion but there is some space available and the capacity of high service is larger than the proposed capacity, the replacement will be done within the existing boundary. For COD and University reservoirs, some space in existing boundary and additional acuqisition of land will meet the requirement (see a. of this section).
2	Local economy such as employment and livelihood	Adverse affects on the living conditions of inhabitants by changes in land use due to the project.	Permanent	As most of the proposed reservoirs are located in arid and vacant area, no significant change is expected in local economy. If the site is private properties, sale of lands to KW&SB may bring profits to landoweners. The land should be acquired by following the Land Acquisition Act.
3	Land use and utilization of local resources	Land use will be changed by land acuqisition for new facilities.	Permanent	Change in land use is not significant as the site for new 4 reservoirs are selected in arid and vacant area.
4	Existing social infrastructures and services	Serious disruptions of vehicular traffice and pedestrian, traffic jams, bottlenetks, delays and incovinicences to general public will be expected.	Temporary	The impact is temporary (during construction phase) and in short duration. The anoucement before the construction, diversion of traffic, and construction of temporary roads will mitigate the impact.
5	Local conflict of interests	Water is supplied by water tanker which is operated by the Ranger to the households without house connection.	Permanent	The water supply facilities will be constructed step by step till 2025, the demand for tank-cars water supply will not decrease immediately. KW&SB have to consult with the Rangers.
6	Water rights and rights of common	There may be a possibility of adverse impact on the additional water right from the Indus River.	Permanent	No additional water intake from Indus river is required till 2025. (K-IV project which requires additional water intake is under request.)
7	Public health condition	During construction phase, the residents near reservoirs and trunk sewers will be affected due to deteriorated air and water quality, noise, etc. Some impacts may be expected on water quality of water bodies by increase of sewage.	Temporary Permanent	The effect will be temporary and their duration will not be long. Sprinkling water, prevention of soils from silting up the nallahs, maintenance of equipments will reduce the impacts. Sewerage system is proposed with water supply system, therefore the impact is negligible.
8	Landscape	Construction of reservoirs may influence landscape to some extent but it affects only close residents.	Permanent	This could be mitigated by the appropriate facility design. Plantation of trees in and around the facilities would also mitigate the impact.
9	Air pollution	Localized increase in dust due to excavation & earthwork, temporary increase in the levels of SO_2/NOx, from construction equipment and vehicles.	Temporary	Dust control through spinkling / washin of construction sites and access roads particularly in congested areas. Preventive maintenance of construction equipment and vehicles to meet emission standards will be necessary.
10	Waste	The spoil will be generated during installation of pipelines and development of reservoirs.	Temporary	The spoil should be disposed of in a proper manner at the disposal sites. The top soil removed during excavation should be separately stored to be used in green belts, buffer zones or spread over agricultural land.
11	Noise and vibration	Some noise and vibration may occur during construction due to construction work, transportation and heavy construction equipment.	Temporary	Noises and vibration will be intermittent and of short duration mostly during daytime. Equipment maintenance should be strengthened to keep them low noise and sound barriers should be installed if needed. There will be no permanent facility that creates noise / vibration.

a. Resettlement/Land Acquisition/Local Economy

The land for water supply facilities such as distribution reservoirs and pumping stations is needed.

Table 111.2.4 Required Land for Distribution Reservoirs

Name	Land	Name	Land	Name	Land
Zone west					
Hub	4.2 ha	Orangi	2.2 ha	West	7.6 ha
W01	0.6 ha				
Zone central					
COD	1.6 ha	NEK old	7.4 ha	NEK new	4.0 ha
University	2.2 ha	Central	1.4 ha	C01	2.7 ha
Zone east					
Gharo	0.7 ha	Pipri	7.2 ha	East	2.6 ha
E01	1.4 ha	E02	0.3 ha	E03	0.3 ha

Each location for distribution reservoirs are checked by the satellite image.

As most of the reservoirs are located in scattered area, land acquisition is necessary but involuntary resettlement might not happen.

The acquisition of private properties for public purposes including development projects in Pakistan is governed by the Land Acquisition Act 1894. It is comprised of 55 sections pertaining to area notification and surveys, acquisition, compensation and apportionment, awards and disputes resolution, penalties and exemptions. National Resettlement Policy was formulated in 2002 to ensure an equitable and uniform treatment of resettlement issues all over Pakistan. The Policy also aims to compensate for the loss of income to those who loses the communal property including common assets, productive assets, structures, other fixed assets, income and employment, community networks and services, pasture, water rights, public infrastructure like mosques, shrines, schools, graveyards etc. KW&SB and CDGK have to acquire the necessary land according to the laws and regulations.

b. Local Conflict of Interests

The areas where are not in the service area by any water supply or low service quality of water supply are watered by tank-cars which belongs to private sectors from 9 bases of Bowser Filling Stations in the city area. The operations and managements of these Bowser Filling Stations and tank-cars are under Rangers. As the water supply service area will be expanded by Master Plan, it will affect the sales by tank-cars of Rangers. However, as the water supply facilities will be constructed step by step till 2025, the demand for tank-cars water supply will not decrease immediately. KW&SB have to consult with them on this matter.

c. Air Pollution, Noise and Vibration, Traffic Disturbance

SPM (suspended particulate matter) would be the predominant pollutant affecting the air quality during the construction phase of reservoirs and pipelines. The soil of the project is likely to generate considerable quantities of dust, especially during dry conditions. Dust will be generated mainly during excavation along with transportation activities and open storage of fine earth materials. The impact is temporary during construction phase and dust control through sprinkling/washing the construction sites, use of dust collectors, preventive maintenance of construction equipment and vehicles will mitigate the impacts.

During construction period, noise and vibration will be generated due to movement of vehicles, and operation of light and heavy construction machineries (bull dozers, scrapers, concrete mixers, pumps, cranes etc.). Noise and vibration generated from sources mentioned above will be intermittent and of short duration mostly during daytime. Strengthening of equipment maintenance should be necessary and sound barriers should be installed if necessary.

Significant impacts are predicted to the surrounding traffic especially in congested areas by installation of pipelines along the main roads of the city, especially University Road, Mahghopir Road and Mirza Adam Khan Road. The impact is temporally but the attention should be paid in selection of the routes to bring construction materials. In addition to this, the schedule of installation of sewers should be informed in advance and relief road should be proposed to mitigate the impacts.

11.1.3 Sewerage System

(1) Components of Sewerage System

The proposed sewerage system in 2025 is shown in the table below.

Table 111.3.1 Proposed Sewerage System in 2025

	TP-1 (extension)	TP-3 (existing)	TP-2 (extension)	TP-4 (new)
District area (km^2)	145.3		100.4	340.2
Population	8,849,000		5,013,000	11,720,000
Branch Sewer Length (km)	3,300		2,120	5,230
Trunk Sewer Length (km)	46		48	121
Number of main Pumping Station	2 (Jamila, Chakiwara)		2 (Gulberg, Clifton)	3 (Korangi, Bin Qasim , Karachi Port)
Location of TP	SITE Town	Keamari Town	Jamshed Town	Korangi Creek Cantonment
TP Site area (ha)	49	221	49	168
Capacity (m^3/d) (mgd)	500,000 (110)	245,000 (54)	490,000 (108)	1,290,000 (284)
Influent BOD (mg/l)	600	600	600	600
Effulent BOD (mg/l)	80	80	80	80
Sewage Treatment Process	UASB + HRTF	Wastewater stabilization pond	UASB + HRTF	UASB + HRTF
Sludge Treatment Facilities	GT + MD	DB	GT + MD	GT + DB /+ MD
Treated Sewage Discharge Point	Lyari River	Arabian sea (swamp area of Karachi Bay)	Malir River	Malir River

Note: UASB for upflow anaerobic sludge blanket, HRTF for high rate trickling filter, GT for gravity thickening, DB for drying bed, MD for Mechanical dewatering,

The proposed sewerage system is detailed in **Chapter 8** "Sewerage Master Plan".

(2) Analysis of Alternatives

a. Project Benefits and Positive Impacts

The main objectives of the sewerage project are to improve the living environment, public health and hygiene, standards of living and to encourage economic growth. Therefore, the project is expected to have the following benefits and positive impacts.

- Improvement of the water quality of the rivers/sea by collection and treatment of sewage prior to its discharge to river/sea and improvement of the river/coastal water environment,
- Reduced risks of diseases by a proper collection, treatment and disposal of sewage, and enhancement of the human health,
- Improvement of sanitation conditions in the cities,
- Increased economic activities (such as commercial and industrial), improved employment opportunities, and economic growth,
- Improvements to public health which will then result in higher economic activity and productivity,
- Increased local employment opportunities during the construction and O/M phases of the project, either as direct labour for construction and O/M stages or as provided services at the sites.

b. With/Without Project

With the project, the benefits and positive impacts mentioned above will be expected. If the project is not implemented, the situation could be as follows.

- Untreated sewage will continuously contaminate receiving bodies such as nallah, rivers and sea,
- The public health condition will become worse due to continuous drain and river water contamination and the health risk will be increased,
- The sea/coastal water environment will get worse.

c. Alternative Study for Sewerage System

The three alternatives for sewerage system are studied from technical, economic, environmental and social view point (see **Section 8.2** “Alternative Study”).

Alternative 1 has technical advantage of adoption of energy saving process but the river crossing of the trunk sewer is necessary. Alternative 2 has the advantage that no river crossing of the sewer is necessary but more efficient process which requires higher energy consumption and sophisticated operation skills should be adopted and cost for construction and O&M becomes higher. Alternative 3 requires additional land acquisition for TP-5 (75 ha).

Comparing 3 alternatives, it is concluded that alternative 1 is recommended from technical, economical, environmental and social view-points.

(3) Environmental and Social Impacts and Mitigation Measures

The scoping, full evaluation of potential significant impacts and the recommendation of mitigation measures are shown in **Appendix A111.8**. The following sections summarize the results of the environmental and social considerations related to the impact evaluation and recommended mitigation measures.

Table 111.3.2 Summary of Impact and Mitigation Measures for Sewerage System

No	Environmental Items	Impact	Duration	Mitigation Measures
1	Resettlement	Treatment plants and pumping stations are proposed and land acquisition is necessary.	Permanent	Proposed site for TP-4 is vacant and KW&SB allegedly has already acquired. Sites for pumping stations are vacant land thus no resettlement may occurred.
2	Local economy such as employment and livelihood	Adverse affects on the living conditions of inhabitants by changes in land use due to the project.	Permanent	As proposed treatment plants and pumping stations are located in vacant area, no significant change is expected in local economy.
3	Land use and utilization of local resources	Land use will be changed by land acuqisition for new facilities.	Permanent	As proposed treatment plants and pumping stations are located in arid and vacant area, no significant change is expected in land use.
4	Existing social infrastructures and services	Considerable disruptions of vehicular traffice and pedestrian, traffic jams, bottlenetks, delays and incovinicences to general public will be expected.	Temporary	The impact is temporary (during construction phase) and in short duration. The announcement before the construction, diversion of traffic, and construction of temporary roads will mitigate the impact.
5	Public health condition	During construction phase, the residents near treatment plant and trunk sewers will be affected due to deteriorated air and water quality, noise, etc.	Temporary	The effect will be temporary and their duration will not be long. Sprinkling water, maintenance of equipments/machineries which is used for construction to reduce the air pollution will reduce the impacts.
6	Hydrological situation	The effluent from the treatment plants will be discharged into the rivers. 4 trunk sewers will be crossing either Malir or Lyari River.	Permanent	The present amount of effluent will increase by proposed Master Plan but the capacity of receiving body will be enough for the increased effluent. Two existing pressure mains are crossing the Lyari River. During dry season, the river flow is small and impact could be small.
7	Sea / coastal zone	The effluent from the sewage treatment plant will be dischaged to the sea.	Permanent	If the treatment plants are properly operated and maintained to meet the effluent standard, no significant adverse impact is expected.
8	Landscape	Treatment plant and pumping station might pose an unaesthetic sight but it affects only limited number of residents.	Permanent	This could be mitigated by the appropriate facility design. Treatment plant should be located away from the densely populated residential areas.
9	Air pollution	Localised increase in dust due to excavation & earthwork, temporary increase in the levels of SO_2/NOx, from construction equipment and vehicles	Temporary	Dust control through sprinkling /washing of construction sites and access roads particularly in congested areas Preventive maintenance of construction equipment and vehicles to meet emission standards.
10	Water pollution	Overflow of sewers and breakdown of treatment plant will lead to failure in meeting the requisite standards. Poor performance will affect the proposed reuse for irrigation, and also the receiving water body.	Permanent	Preventive maintenance of all components should be performed regularly. TP should be maintained properly and proper response plan must be prepared and all workers must be trained to tackle emergencies.
11	Soil pollution	If the sludge is disposed of to land, there may be some risk of soil contamination.	Permanent	The sludge should be disposed of in specified landfill site.
12	Waste	The debris will be generated during installation of sewers and TPs. Sewage treatment plants will generate the considerable sludge in the treatment process.	Temporary Permanent	The debris should be disposed of in a proper manner at the pre-identified disposal sites. The sludge from the sewage treatment plant should be disposed of in a specified landfill site with proper precaution or given for land application to farmers, if it can be handled properly by them.
13	Noise and vibration	Some noise and vibration may occur during construction due to heavy construction machineries.	Temporary	Noises and vibration will be intermittent and of short duration mostly during daytime. Equipment maintenance should be strengthened to keep them low noise and sound barriers should be installed if needed. There will be no permanent facility that creates noise / vibration.
14	Offensive odors	Odor may emit from the sewage treatment plants.	Permanent	Odor emission is unavoidable, but but it can be minimized by appropriate operation and maintenance. Setting of buffer zone might be an option to minimize odor problem.

a. Resettlement/Land Acquisition/Local Economy

The land for sewage treatment plant and pumping stations should be acquired.

Table 111.3.3 Required Land for Sewerage Facilities

Sr.	Name of Facility	Site	Required Land (ha)	Existing land use	Type of ownership
1	TP-1 (extension)	SITE town	0	Existing TP site	-
2	TP-2 (extension)	Jamshed town	0	Existing TP site	-
3	TP-4	Korangi Creek Cantonment	168	Vacant land	CDGK
4	Gulberg PS	Gulshan-e-Iqbal	0.5	Vacant land	N.A.
5	Bin Qasim PS	Bin Qasim	0.5	Vacant land	N.A.
6	Karachi Port PS	Keamari	0.5	Vacant land	N.A.

In sewerage scheme, TP-1 and TP-2 will be extended within the present site area, and no land acquisition is required. For TP-4, 168 ha of land is needed but it substantially belongs to KW&SB at present. The site is proposed by KW&SB in the report of "Greater Karachi Sewerage Plan (S-III)" and the Team has confirmed the location by site visit and satellite image. The area is vacant and the surrounding area is used as yard for some construction material and base for trucks. There are no houses at the proposed site and the resettlement problem will not occur (see **Figure A111.8.2** of **Appendix A111.8**).

For the three pumping stations (Gulberg, Bin Qasim, and Karachi Port), the required land is around 0.5 ha at largest and the vacant land will be available around the proposed area.

b. Disposal of Treated Sewage and Sludge from TP

The treated sewage from TPs is discharged into the Lyari or Malir River~~s~~ and finally into Arabian Sea. Some part of the treated sewage from TP-3 is conveyed to Pakistan Air Force and used as the plant watering. The treated sewage will meet the effluent standards of Pakistan and the discharge will not cause the adverse impacts on river and sea, on the contrary, it will contribute to improving the present water quality of water bodies.

However, localized deterioration of water quality at the effluent discharge points may occur infrequently during power failure if back-up generators are not operated. Preventive maintenance of facilities and sufficient stock of fuel and spare parts will mitigate the impacts.

Sludge is composed of by-products generated through the treatment of sewage. It contains both compounds of agricultural value (including organics, nitrogen, phosphorus and potassium, and to a lesser extent, calcium, sulphur and magnesium), and pollutants which usually consist of heavy metals, organic pollutants and pathogens. The characteristics of sludge depend on the original pollution load of the sewage and also on the technical characteristics of the wastewater and sludge treatment carried out.

If the influent does not contain high level of pollutants and the sludge is properly treated, sludge can be recycled to agriculture (landspreading), or landfilling. Currently, the sludge is dried at sludge drying beds in the existing TPs. The dried sludge is loaded to the trucks and provided to the farmers as soil conditioner free of charge. This will be applied to the new TP (TP-4). Some amount of sludge will be provided for development of green area proposed in the "Karachi Strategic Development Plan 2020". If the dried sludge is used and/or disposed of, it should be done in environmentally sound manner at appropriate location.

c. Air Pollution, Noise and Vibration, Traffic Disturbance

SPM (suspended particulate matter) would be the predominant pollutant affecting the air quality during the construction phase of treatment plants and sewers. The soil of the project area is likely to generate considerable quantities of dust, especially during dry condition. Dust will be generated mainly during excavation along with transportation activities and open storage of fine earth materials. The impact is temporary during construction phase and dust control through sprinkling/washing the construction sites, use of dust collectors, preventive maintenance of construction equipment and vehicles will mitigate the impacts.

During construction period, noise and vibration will be generated due to movement of vehicles and operation of light and heavy construction machineries (bull dozers, scrapers, concrete mixers, pumps, cranes etc.). Noise and vibration generated from sources mentioned above will be intermittent and short duration mostly during daytime. Strengthening of equipment maintenance should be necessary and sound barriers should be installed if necessary.

Significant impacts are predicted to the surrounding traffic especially in congested areas by installation of sewers along the main roads of the city. The impact is temporally but the attention should be paid in selection of the routes to bring construction materials. In addition to this, the schedule of installation of sewers should be informed in advance and relief road should be proposed to mitigate the impacts.

d. Effects of Odour from TPs

TPs will generally emit odour if they are not operated properly and the odour mainly comes from the sludge handling system such as sludge drying beds.

In the water awareness survey conducted in this Study, interviews were conducted to 100 residents around the existing three TPs to know their awareness of the TPs. In the interview, perception of seriousness of the odour from the TPs was asked as a question and its result is shown in the table below.

Table 111.3.4 Perception of Odour Problem from TPs (unit:%)

Level of seriousness of the odour	TP-1 (29 samples)	TP-2 (17 samples)	TP-3 (54 samples)	Area Average (100 samples)
No problem	83.0	65.0	88.0	79.0
Not very serious	10.2	14.7	0.0	7.1
Serious	6.8	11.2	6.0	8.6
Very serious	0.0	9.1	6.0	5.3

According to the results of interview, most of the respondents think the odour from TPs is not serious problem, however, some of the respondents have problem to some extent. The source of odour was not clear by the survey but the possible source may be the nallah where the garbage is accumulated and effluent from the TP become stagnant and the sludge drying beds within the TPs.

If the TPs are properly operated and maintained, the odour will not cause serious problem and the mitigation measure to locate the sludge drying beds away from the residential area as far as possible and setting buffer zone are effective to prevent odour problem.

11.2 ECONOMIC EVALUATION OF MASTER PLAN

11.2.1 Objectives of Economic Evaluation

In the national economy, there are various economic sectors, such as agriculture, industry, transportation, infrastructure, etc. In a sector, there are various sub-sectors. Infrastructure structure sector, for instance, includes water, sewerage, waste-disposal, electric power, city gas, telecommunication, etc. The projects of these sectors bring their products and services for the beneficiaries utilising human resources, natural resources, financial resources, etc.

In these projects, economic evaluation aims to select the most optimal plan in the fields of resources utilisation from the national economic point of view. In a procedure of the evaluation, the optimal solution is provided through the following analysis and studies: (i) economic analysis of cost and benefit, (ii) value evaluation through time preference applying a social discount rate; (iii) optimal valuation for utilised resources applying real values or shadow prices; and fairness of income distribution in fruits brought by economic development activities.

At present, water is a scarce resource in almost all countries and cities with growing population and with growing economic activities, like Karachi City. This scarcity makes water both a social and an economic good. Thus, the water related studies are being proposed as development, augmentation, rehabilitation and conservation projects. An economic analysis of the projects is useful for persons in charge to be aware of the actual economic value of scare water resources. From the point of economic view, therefore, an economic evaluation is an essential tool to assess whether the water projects are beneficial to utilization of scare water resources.

Water supply project is one of the most essential water schemes. Water is generally a location-specific resource and a non-tradable output. Furthermore, water markets are subject to imperfection. They are operated and maintained under the various imperfect conditions such as physical constraints, legal constraints, limitations in the development of water rights, high costs of investment in congestion, complex institutional structure, wide range of stakeholders' interests, cultural values, resources sustainability, etc.

Water is vital for human life, that is, a precious commodity. Water supply project generates significant benefits. On the other hand, water is still wasted on a large scale, and moreover consumed under a high incidence of unaccounted-for-water. These issues are improved in the formulation of water supply projects, in consideration of the characteristics in the planning site. Economies of scale in the projects are proposed as proper system in production, transmission and distribution water. The economic evaluation is conducted on the basis of the prepared scheme, from the economic point of view.

Sewerage project is also one of the essential water schemes. Sewerage scheme aims at disposing sewage safely, and at keeping natural water quality and urban environment by means of preventing from water contamination. Thus, its objectives are summarised as improvement of public health, prevention of sewage inundation, conservation of clear public water, utilisation of treated sewage water, creation of better water environment, etc. In order to carry out these objectives, sewerage system is formulated including sewer piping network, treatment plants and pumping stations. The economic evaluation is conducted as comparison with the cost of these facilities and the benefit of the expected effects from the system.

11.2.2 Evaluation Procedures

In this master plan study, an economic evaluation is conducted for the proposed master plan in both water supply and sewerage projects to verify the project viability from the economic point of view. The economic evaluation of the proposed project functions as a guideline of assessing their economic viability. The proposed project is evaluated through evaluation indices, which are calculated on the basis of costs and benefits of the project. The evaluation procedure is illustrated in **Figure 112.2.1**.

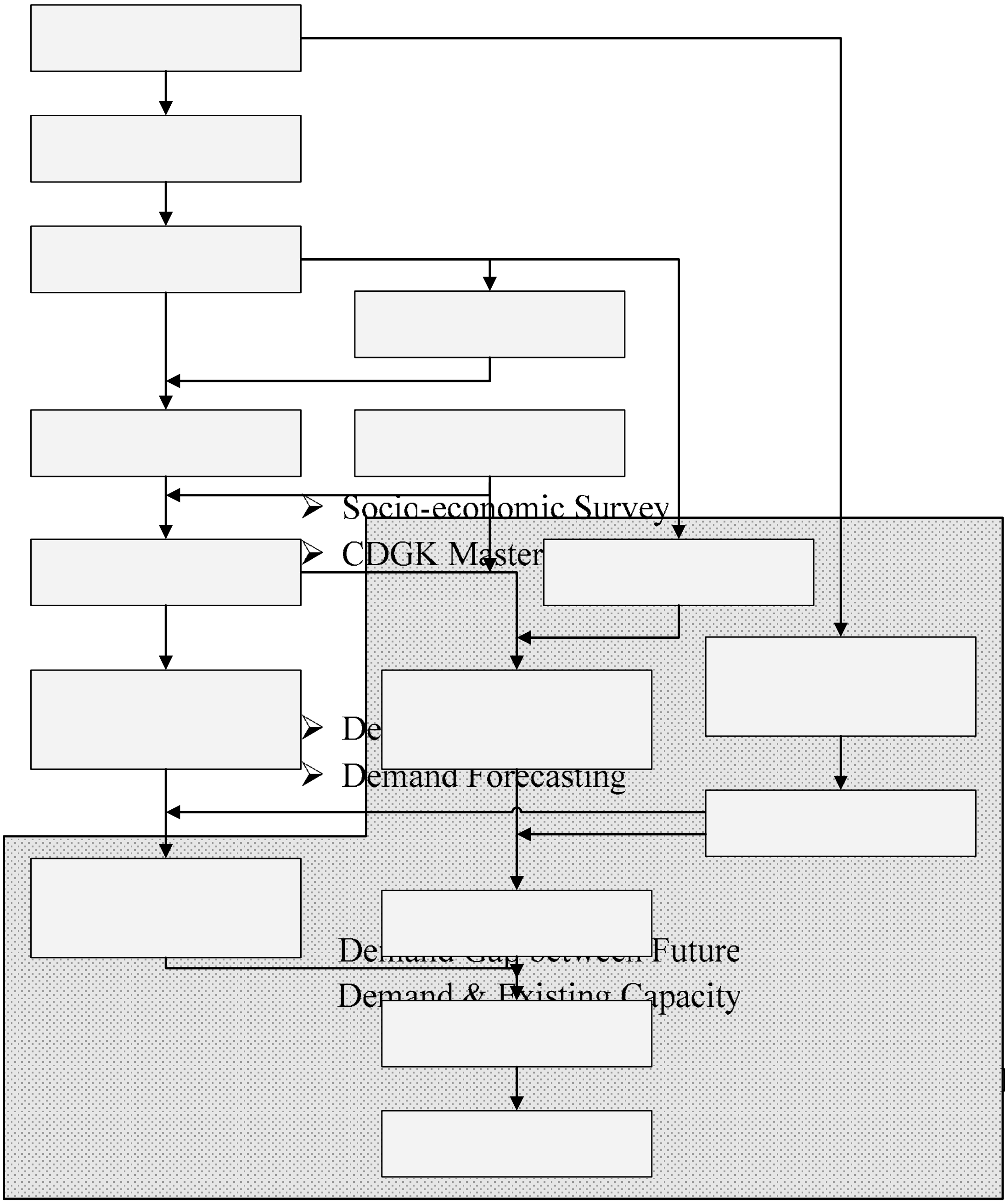


Figure 112.2.1 Flow Chart of Economic Evaluation Procedure in Master Plan Stage

The economic benefit is derived from the difference of net effect values brought about the socio-economic situations between with-project and without-project conditions in the areas influenced by the proposed project. The effect values under with-project condition are estimated as the effects accrued from the implementation of the proposed project. On the other hand, the effect values under without-project condition are estimated as the economic burden of present water supply and sewerage service level even in the future. The difference between these two values is accounted as the project net benefits of both water supply and sewerage system projects. The economic benefit is estimated in economic terms, of course.

The project cost of the proposed project is estimated by the engineers in charge in **Chapter 10**. The economic cost, however, differs from financial cost presented by the engineers in the sense of value judgment since the former is valued at real resource cost and the latter is resource cost valued at market prices. Thus, to estimate the economic costs of the proposed projects, the financial costs have to be converted through conceivable adjustment.

The economic evaluation is conducted in the following steps.

(1) Identification of Project Benefits

The project benefit is defined as a difference between with-project case and without-project case, as mentioned above. The project brings about some effects for beneficiaries in the project areas. On the other hand, the expected beneficiaries can not enjoy these effects in the future, unless the project is implemented. The difference between the two cases is identified as benefits of the project in the economic analysis. Thus, it is the first step for a project evaluator to identify the effects of the proposed project. For examples, water supply project is considered to bring the following effects: improvement of public health due to purified potable water, enhancement of amenity and well-being due to better accessibility to safe water sources and social effects related water supply like environmental improvement. In economic analysis, tangible benefits among various effects of the project are quantified as economic benefits in the evaluation work.

As a matter of course, a benefit accruing from the proposed project corresponds to a cost of constructed facilities presenting its effects of the project. On the other hand, a prior investment does not always correspond to positive benefit accruing at the same time, which is inevitable in infrastructure project in general. Thus, the prior investment should be regulated in an implementation planning and reduced as much as possible in its construction programme.

(2) Economic Value of Cost and Benefit

Economic evaluation of the project through economic analysis is made on the basis of economic costs and benefits. Hence, economic value or real value is derived from market (financial) value. The market value is usually distorted by transfer payments such as taxes and subsidies, especially in local currency portions. These transfer payments are transferred to the government which acts on behalf of the society. Then, they should not be treated as economic value. They must be eliminated from the market value of costs and benefit as a whole. It is clearly impracticable to trace procurement sources for all the project inputs, particularly in this master study stage. In actual procedure, the economic value is calculated in the following way in this study.

The foreign currency portions of the project costs are considered as real value in general, because they are evaluated in the international competitive market. On the other hand, the local currency portions include some transfer payments in general. Thus, the local currency portions of project costs are adjusted through applying a special conversion factor to the financial (market) costs.

(3) Evaluation Factors

The project evaluation is conducted in accordance with the conventional methodology that is commonly applied for evaluation of development project under finance of the World Bank and other international agencies such as ADB. Applying cost and benefit estimated in the above step, they are compared and condensed into evaluation factors. The factors are Economic Internal Rate of Return (EIRR) for a main index, and Net Present Value (NPV) and Benefit-Cost Ratio (B/C) for supplementary indices.

The EIRR is defined as a special rate of discount that settles the following conditions to the satisfaction.

1° The present value of cost is obtained through discounting the all costs incurred during the economic life of the proposed project at the special rate.

2° The present value of benefit is obtained through discounting the all benefits accruing from the project during the same lifetime at the special rate.

3° As a result, the present value of cost is equal to the present value of benefit.

In the case that this EIRR exceeds the social discount rate, the proposed project could be judged as viable economically in the national economy. The NPV shows the magnitude of project incremental benefit. The B/C indicates the gap between the project efficiency and the social discount rate.

11.2.3 Criteria and Preconditions

Economic evaluation of the proposed project is a guideline of assessing its economic viability. In order to carry out the project evaluation, it is necessary to set up several criteria, preconditions for estimation of economic value, and judgement of the proposed project. They are listed up as follows.

(1) Criteria for Estimation in Economic Value

1° Standard Conversion Factor

All the costs involved in every project component have to be measured in economic costs, i.e., real costs or "opportunity costs". As mentioned before, local market values are usually distorted by transfer payments such as taxes and subsidies. These payments have to be eliminated from the market values of cost and benefit. Then, the local currency portion of economic costs was estimated by mans of applying a special conversion factor to the financial costs. This rate is called as a standard conversion factor (SCF). In this study, it was estimated at 0.88, the details of which are shown in **Table A112.1.10** of **Appendix A112.1**.

2° Shadow Wage

Prevailing wages of skilled workers are considered to reflect an opportunity cost of labour, because the workers are usually shortage in the labour markets. Therefore, the shadow wage rate of skilled workers is set up as 1.0. On the other hand, unskilled workers are in excess in general, since the region including the project areas has excess workers in condition of unemployment and underemployment. Thus, the shadow wage rate of unskilled workers is assumed at 0.7 of legislated wage rate. This rate was applied in the other projects in Pakistan, for example, i.e., “Sehwan Barrage Complex Report, Oct. 1993, Government of Sindh”.

3° Land Value

Market price of land has peculiar characteristics as compared with other commodities, especially in urban areas. Land price should be evaluated on the basis of productivity of the land for productive plots such as crop cultivation and balance of supply and demand for non-productive land such as residential plots. On the other hand, land price is sometimes distorted by speculation in future escalation expectation and by social prestige. In this study, most lands which would be expropriated for transmission piping space, pump stations and distributing reservoirs are utilized for water distribution and sewer piping network. These lands are not utilized for productive activities at present and even in the future. Thus, the value of these lands will be evaluated at nothing from the economic viewpoint.

(2) Schedule and Evaluation Period

1° Base Year: Beginning of 2008. The JICA project is assumed also to start at the beginning of 2008.

2° Construction Period: The project implementation up to the target year 2025 is divided into the three stages. The construction works in the first stage is implemented between 2008 and 2016. The second stage continues until 2021. The third stage continues until 2025, and is completed by the target year 2025.

3° Disbursement Schedule: Uniform distribution of project costs during the construction period above

4° Economic Life: 30 years after the completion of the project

5° Evaluation Period: 30 years after the completion of the construction work (2008–2055)

(3) Other Criteria

1° Price Level Cost and benefit of the project were set at the beginning of 2007.

2° Exchange Rate: Rs.60.77 per US$1.00 and JP¥121.68 per US$1.00, then JP¥2.00 per Rs.1.00 at the end of January, 2007.
(Referred to International Financial Statistics, April 2007, IMF)

3° Social Discount Rate: 12% per annum
(Referred to Southern Punjab Basic Urban Services Project, August 2003, ADB, GOP)

4° Distribution of Benefit Accruing from Public Health Improvement:

Public health conditions are improved by social infrastructures like water supply, waste-disposal and sewerage. According to “Study on Economic Evaluation Methodology in Development Project” by JICA, affordability-to-pay for environmental sector services is set up a benchmark as follows: 4% of household’s disposable income for water supply service; 2% for waste disposal service; and 1% for sewerage service, referring to “Project appraisal manual, World Bank”. This means that the affordability-to-pay for these sectors is 7% of household disposable income, which is distributed as 57% for water supply; 29% for garbage disposal; and 14% for sewerage.

Pan-American Health Organization recommends that the tariff for water supply and sewerage services is within 5% of household income. It is distributed into 3.5% for water supply and 1.5% for sewerage, which is recalculated as 70% of the total payment and 30% for sewerage.

In general, willingness-to-pay for sewerage service is said to be lower than that for waste disposal. Once the sewerage system removes sewage from a service and its surroundings, its living condition becomes comfortable simply. On account of this, the users’ incentive to pay for the public sewerage service is lower than the waste disposal.

Considering these recommendations above, the benefit accruing from public health improvement is set to be distributed as 50% for water supply, 30% for waste disposal and 20% for sewerage in this study.

11.2.4 Water Supply Projects

(1) Economic Benefits

A) Benefits of Proposed Water Supply Project

One of main goals of water supply project is to improve public health and well-being. The people of low income class would receive the largest benefit from the project. In particular, the people in Katchi Abadis who are receiving little piped water because of insufficient water supply network system. They rely on water provided by water tanker or other suppliers and ground water though well system. Besides these basic benefits, the water supply project gives various advantages to the people and the regional economy in and around the project area. The following **Table 112.4.1** listed up the benefits accruing from water supply project.

Among these benefits in the table, benefits in lines with A and B are considered as direct benefit, which the proposed project directly brings about those benefits to the beneficiaries. Benefits in line with C are considered as indirect benefit. The proposed project generally has ripple effects on people or regional economy in relation to the project.

Table 112.4.1 Benefits Accruing from Proposed Water Supply Project

A. Improvement of Public Health	a. Elimination of poor quality water source in service areas
	b. Elimination of poor quality water source during stoppage of water supply during dry season
	c. Reduction of water borne diseases
	d. Reduction of medical expenses
B. Enhancement of Amenity and Well-being	a. Elimination of equipment for procuring water source and for distributing water to the respective taps through a piping network within household
	b. Time-savings associated with procuring water source
	c. Energy-savings associated with boiling water for disinfection
	d. Elimination of stoppage of water supply during dry season
	e. Reduction of absence from work because of water borne diseases
	f. Reduction of operation and maintenance expenses of existing water supply system
C. Social Issues Related to Water Supply	a. Conservation effects of water resources
	b. Effective use of alternative water resources
	c. Efficient operation of water supply equipment
	d. Stimulation of project investment to regional economy
	e. Prevention of urban disaster by means of fire hydrant
	f. Improvement of degree of freedom for urban planning
	g. Increase of land values

B) Quantifiable Direct Benefits

The benefits listed in the table above are furthermore classified into two categories. They are quantifiable or tangible, and non-quantifiable or intangible. To calculate evaluation indices for economic evaluation, only tangible benefits are quantified as project benefits. In this study, the following benefits are selected as tangible benefit, and they are bound into four components.

1°	Benefits of B.-a. to d.	Water source saving benefit for residents
2°	Benefits of A.-a. to d. and B.-e.	Public health improvement benefit for residents
3°	Benefit of B.-a.	Water source saving benefit for non-residential water consumers
4°	Benefits of B.-f.	Reduction of O&M expenses of existing water supply system

As mentioned before, the net benefit of water supply project is captured as a difference between with-project condition and without-project condition. Under the with-project condition, the beneficiaries within the project area can enjoy the effects of the proposed water supply project. Under without-project condition, on the other hand, the people have to get water sources by means of the present water procurement systems as discussed in the “Water Awareness Survey” conducted by the JICA study team in 2006. Then, the difference between the two cases is identified as project net benefit.

Benefits are identified in various phenomena as not only tangible benefits but also intangible ones. As classified in the previous section, the tangible benefits consist of two main categories, i.e., a) domestic water for domestic use and b) water for non-domestic use. In terms of domestic water, the benefit is composed of a sum of (i) water source saving benefit, (ii) public health improvement benefit. The benefit of non-domestic use is assumed as a sum of water source saving benefits of various non-domestic water consumers.

In addition, the operation and maintenance costs of the existing water supply system will not be necessary after the inauguration of the new system. These expenses are counted as a tangible benefit for the proposed project. In this study, the in-tangible benefits are considered as indirect benefits, which are not quantified in this study.

C) Estimate of Unit Economic Benefits

a) Benefits of Saving Domestic Water Procurement Costs

Under the without-project condition, the people coming into the project areas have to install the same water supply system in their house as the present residents utilise the water supply facilities for keeping their potable water. Under the with-project condition, however, they do not have to install the domestic water supply system in their house because of sufficient public water available from the new proposed system. This means that they can save the installation costs owing to the proposed project. These costs are identified as one of the project benefits.

The water source procurement ways and their composition in the present water supply conditions are categorised into four types in the project areas, referring to the “Karachi Master Plan 2020”. Their residential types are categorised as follows: Type 1 defined as a housing type of low income level, which was classified in “group of people in Katchi Abadis” in “Water Awareness Survey” conducted by the JICA study team in 2006; Type 2 defined as a type of meddle income level, classified in “Low and Lower Middle Income Group”; Type 3 defined as a type of upper middle income level, classified as “Upper Middle Income Group”; and Type 4 defined as a type of high income level, classified as “High Income Group”.

Table 112.4.2 shows the water procurement volumes by water source for the respective residential types. The data sources come from the “Water Awareness Survey”. The details of the procurement ways and their volume are explained in full in **Table A112.2.4** of **Appendix A112.2**.

Table 112.4.2 Present Water Procurement Sources and Volume: 2005

(Unit: litre/household/month)

Water Source	Type 1 Low Income Level	Type 2 Middle Income Level	Type 3 Upper Middle Income Level	Type 4 High Income Level
1° Bottled water	11	50	65	120
2° Piped water	9,201	15,406	23,227	27,932
3° Piped water (shared)	785	987	559	9
4° Water tanker	2,956	1,477	1,104	1,531
5° Water carried by seller	462	259	282	0
6° Public water storage	468	248	10	0
7° Well/bore	1,692	6,365	2,752	1,214
8° Others	11	11	7	0
Total	15,586	24,803	28,006	30,806
Total rounded	**15,600**	**24,800**	**28,000**	**30,800**

Their respective water costs were estimated in financial values applying their present prices in the market. The market prices were surveyed also in the "Water Awareness Survey". The water sources are summarised in the following procurement ways.

1° Water purchasing costs of bottled water, piped water and spot market water such as water tanker, donkey cart, public water storage, etc.
2° Energy of water boiling for making drinking water.
3° Water fetching from river, canal, pond, lake, etc.
4° Water tank system in their residence because of insufficient water pressure and backup for water shortage due to the present unreliable piped water system.

The results were summarized in **Table 112.4.3**. The detailed back data are tabulated in **Table A112.2.5** of **Appendix A112.2**.

Table 112.4.3 Monthly Operational Cost for Procurement of Water Sources

(Unit: Rs. /Household/month)

Water Source	Type 1	Type 2	Type 3	Type 4
1° Water Purchasing Cost	475	688	820	1,389
1) Bottled water	180	494	637	1,181
2) Piped water	38	63	91	107
3) Spot market water*1	256	131	92	101
2° Water Boiling for Drinking*2	31	28	27	19
3° Water Fetching Cost*3	23	23	23	0
Total	529	739	870	1,408

Note: *1 Water provided by tanker, donkey sellers, public storage, etc.
*2 Boiled with city gas supplied by Sui Gas supply system.
*3 Family member is assumed to work for water fetching.

Once the proposed project is introduced in the project area, the beneficiaries will be able to enjoy the project effects just after the completion of the project. They can eliminate these water procurement costs from their living costs, which are transferred to other economic activities in their lives.

These effects are estimated as a total of water source procurement costs. In addition, most of households install their water tank and pump system according to the survey results. Its cost comprises initial installation cost and daily operation and maintenance (O&M) cost. The installation costs are invested to construct the water tank and pumping system. The installation cost is annualized by means of capital recovery factor (CRF). As a result, the effects are summarized as shown in **Table 112.4.4**.

Incidentally, the CRF is calculated applying the formula below.

$$CRF = \frac{r}{1 - 1/(1+r)^n}$$

Where, *CRF* : Capital recovery factor
n : Economic life (years)
r : Discount rate (12%)

The factor is calculated at 0.134 with 20 years of tanks' economic life and at 0.177 with 10 years of pump's economic life. The detail information is also **Tables A112.2.2** to **A112.2.5** of **Appendix A112.2**.

Table 112.4.4 Annual Cost of Water Sources Procurement System

(Unit: Rs./Household/Year)

Water Source	Type 1	Type 2	Type 3	Type 4
1° Water Source Costs	6,343	8,862	10,435	16,386
2° Annual Cost of Domestic Water Tank System				
1) Domestic plumbing system	4,929	11,135	14,603	23,361
2) Well system	163	650	303	482
Total	11,435	20,648	25,341	40,744

Accordingly, the project effects are recalculated into unit water procurement cost under the present socio-economic conditions. The unit costs for the respective residential types are summarized in **Table 112.4.5**. The present unit costs in economic terms were calculated as Rs.245/1000 gallon or Rs.54/m^3 for Type 1, Rs.278/1000 gallon or Rs.61/m^3 for Type 2, Rs.302/1000 gallon or Rs.66/m^3 for Type 3, and Rs.441/1000 gallon or Rs.97/m^3 for Type 4. The people in the project area bear these costs for procurement of water sources under the without-project condition. The net project benefit of "saving water procurement cost" is a difference between these present water procurement costs and the future water cost served by the proposed water supply project. The beneficiaries in the project area can enjoy this net benefit from the proposed water supply system after the completion of the project.

Table 112.4.5 Average Unit Cost of Water Procurement

Water Source	Type 1	Type 2	Type 3	Type 4
1° Annual consumption (m^3/HH[*1])	187	298	336	370
2° Annual procurement cost (Rs./y)	11,435	20,648	25,341	40,744
3° Unit procurement cost (Rs./m^3)	61	67	75	110
4° Unit procurement cost in economic value[*2]				
(Rs./m^3)	54	61	66	97
(Rs./1000 gallon)	245	278	302	441

Note: *1 "HH" stands for household
*2 Applied 88% of the SCF.

b) Benefits from Public Health Improvement for Residents

The water supply system contributes to improve the people's living environment. The improved environment will contribute to decrease the occurrence of water borne diseases certainly. As a result, medical expenses will be reduced in the both sides of residents in the project area and health care institutions. In other words, the people can save their medical expenses due to less opportunities of medical examination and the society where the health care institutions exist in its territories can save medical treatment expenses. These savings are one of the economic benefits for the society and also for the nation. They can be utilised for other economic activities as economic surplus in the nation.

Once the people suffer from water borne diseases, they would have a medical examination from a doctor and/or take medicines to recover their health as soon as possible. In Pakistan, if they can get a medical certificate from a doctor, their salaries and/or wages could be guaranteed during their absence from their workplace. The employers have to pay their compensation without any productive activities. The savings of these losses due to their diseases, i.e., reduction of compensation and production losses can be identified as one of the economic benefits. They can be utilised for other purposes as financial surplus in the nation as well.

1) Saving of Household Medical Expenditures

According to the "Water Awareness Survey" of the JICA Study Team, the household expenditure for medical treatment of water borne diseases was reported as follows: Rs.298 per month by Type 1; Rs.249 per month by Type 2; Rs.306 per month by Type 3; and Rs.643 per month by Type 4. These expenditures were recalculated in economic terms, as shown in **Table 112.4.6**.

Table 112.4.6 Saving Value of Household Medical Expenditure

Water Source	Type 1	Type 2	Type 3	Type 4
1° Household expenditure for medical expenditure (Rs./month)	298	249	306	643
2° Annual expenditure in economic value*1 (Rs./year)	3,147	2,629	3,231	6,790

Note: *1 Applied 88% of the SCF.

2) Saving of Medical Treatment Expenses

In Karachi City, the public medical institutions such as hospitals, health centres and dispensaries treated around 5.9 million cases of outpatients and 0.24 million cases of inpatients in the year 2005, according to the statistics of Health Department, GOS. Since the total population of Karachi City is estimated at 15.1 million in 2005, the morbidity rate was calculated at 390 outpatients per 1,000 populations and 1,580 inpatients per 100,000 populations.

According to hospital list of Health Department GOS, there are 161 hospitals in Karachi City. They are segregated into public and private hospitals as follows: 21 hospitals with 4,400 beds in the public sector and 140 hospitals with 8,300 beds in the private sector. Thus, the number of hospitals of the private sector is around seven times more than that of the public sector. The number of beds of the private sector is nearly twice of the public sector. The morbidity rate mentioned in the previous paragraph was based on the public sector only. On the other hand, data regarding the number of patients in the private sector are not available. Then, the number of patients in the private sector is assumed to be the same as the public sector, considering the existing private medical institutions. Accordingly, the morbidity rate was counted as 780 outpatients per 1,000 populations and 3,160 inpatients per 100,000 populations in Karachi City.

The morbidity rate of water borne diseases is said to be 30% of the total morbidity rate covering all diseases, in general. In 2005, Civil Hospital Karachi recorded that the treated patients of water borne diseases accounted for 75,600 cases or 11% of the total number of patients (689,500 cases). Jinnah Postgraduate Medical Centre Karachi (Federal Hospital in Karachi City) treated 24,400 patients of water borne diseases to the total patients of 542,000, so the morbidity rate was calculated at 4.5%. Thus, the suffering rate of water borne diseases was variable in the respective hospitals. Moreover, some of sufferers may not get examined by a doctor in hospital. Hence, the morbidity rate of water borne diseases in medical institutions was conservatively assumed to be 10% of that of the all diseases. Accordingly, the morbidity rate was set as 78 outpatients per 1,000 populations and 316 inpatients per 100,000 populations.

In 2005-06, Civil Hospital Karachi received the annual budget of Rs.796 million for general hospital services. This amount was segregated into medical examination for all operation and treatment in the hospital on the basis of some suppositions. The hospital treated the total number of 938,600 outpatients and 308,400 inpatients in the same fiscal year. An average expense of medical examination was calculated as Rs.430 per outpatient and Rs.1,300/day per inpatient. An inpatient suffering from water borne diseases stays three to five days in a hospital for treatment and operation according to doctors in Health Department. Then, the average expense for inpatient was calculated at Rs.5,200 per hospitalisation for four-days staying on average.

On the other hand, a private hospital charges patients for the following average fees on medical treatments: Rs.1,000 to Rs.2,000 per outpatient's consultation and Rs.30,000 to Rs.45,000 per inpatient's hospitalisation for three to five days' staying, according to an interview survey. Considering these facts, the average expenses were set as Rs.970 per outpatient and Rs.21,400 per inpatient suffering from water borne diseases in this study. **Table 112.4.7** shows the summary of these expenses.

Table 112.4.7 Unit Cost of Medical Examination

Patient	Public Hospital	Private Hospital	Average Expense
Outpatient (Rs. per Visit)	430	1,000 to 2,000	970
Inpatient (Rs. per Hospitalisation)	5,200	30,000 to 45,000	21,400

Basic figures for estimation of benefit are summarised taking the discussion above in account. The expenses are converted into economic value applying the SCF.

For Outpatient:

Average annual number of visits to hospitals: 78 visits per 1,000 populations
Average amount of charges: Rs.970 per visit in market prices
Rs.854 per visit in economic value

For Inpatient:

Average annual number of visits to hospitals: 316 times per 100,000 populations
Average amount of charges: Rs.21,400 per hospitalisation in market prices
Rs.18,800 per hospitalisation in economic value

In addition, all patients have to use transportation like bus or taxi to visit the nearest hospital when they suffered from water borne diseases. It costs Rs.10 per ride for bus fare and Rs.15 per km for three-wheeled taxi (rikshaw). In Karachi City, a hospital covers around 94,000 populations on average, i.e., the total population of 15.12 million over 161 hospitals in 2005. The population density in Karachi City was 4,200 per km^2, so a hospital covers around 22 km^2. Supposing that this area were in a circle, its radius could be around 2.7 km. Thus, a patient would use transportation for around 1.5 km on average, i.e., almost a half of the radius. Then, the transportation costs are calculated at Rs.20 for a round-trip of bus or Rs.60 for a round-trip of taxi. Accordingly, an average fare for round-trip for hospital was set as Rs.40 per patient. It is converted to Rs.35.2 per patient in economic terms. The total visits for applying transportation were calculated at 8,116 visits per 100,000 population including both outpatients and inpatients. Then, the total transportation cost was calculated at Rs.285,700 per year per 100,000 populations in economic value.

3) Decrease of Absence from Work due to Illness

The people suffering from water borne diseases would generally see a doctor and have a medical examination as outpatients, or may be hospitalised as inpatient for several days in case of suffering from serious diseases. They have to be absent from their work and loose their working opportunities during these medical treatments. Then, the improvement of their living condition brings the reduction of the absence from their works, so the reduction of working losses is considered as economic benefit. This benefit is estimated using a period absent from work and an average income per capita. The average period of absence from work due to water borne diseases was 4 days, as discussed in the previous sub-section.

As of 2007, an average household income was calculated at Rs.12,700 per month. This average income was estimated applying the survey results in "Socio Economic Survey Report-2005 V1.0 (Table 11), Karachi Master Plan 2020, CDGK". Its income distribution was shown in **Table 112.4.8**. The original figures were based on 2004 price level. The figures were converted applying CPI of 120 between July 2004 and January 2007. The details are shown in **Table A112.2.1** of **Appendix A112.2**.

Table 112.4.8 Weighted Average Monthly Income of Household in Karachi City: 2007

Income Class		Percentage Distribution	Average Household Income (Rs./month)
Type 1	Low Income Class	72%	7,200
Type 2	Middle Income Class	20%	19,800
Type 3	Upper Middle Income Class	4%	30,600
Type 4	High Class	4%	55,000
Total/Average (Weighted Average)		100%	12,700

Source: Socio Economic Survey Report-2005 V1.0 (Table 11), Karachi Master Plan 2020, CDGK

A household size was reported as 7.0 persons on average, according to the survey report-2005 above. In "Water Awareness Survey" conducted by the JICA study team in 2006, however, an average household size was reported as 9.2 members. In the household, the number of income earner was reported as 2.1 members on average. Considering these facts, the income earners were set as 2 persons of 7 members in the household. Accordingly, an average income of workers was set as Rs.6,350 per capita per month, or Rs.212 per day. Accordingly, the unit benefit was calculated as follows.

<u>In case of Outpatient:</u>
Average annual number of visits to hospitals: 78 visits per 1,000 populations
Average losses of working wage: Rs.106 per visit in market value
Rs.93 per visit in economic value
(Assumed to spend a half day for examination and treatment)
<u>In case of Inpatient:</u>
Average annual number of visits to hospitals: 316 times per 100,000 populations
Average amount of charges: Rs.848 per hospitalisation in market value
Rs.746 per hospitalisation in economic value

c) Benefit from Improvement of Non-domestic Water Supply System

The water demand of non-domestic users in the tariff of the KW&SB in 2005 is classified into two categories, i.e., "No-domestic users" and "Bulk Supply". This water consumption was estimated at 140 billion gallon or 31 million m^3 per annum, or accounted for around 40% of the total demand. It is said that most of non-domestic users are covered by the piped water supply system of KW&SB at present.

Manufacturing industry is the largest water consumers among the non-domestic water consumers. The manufacturing sub-sector accounted for more than 40% of the total consumption of the non-domestic users. Thus, the water consumption characteristics of the manufacturing industry are assumed to be a leading industrial type of water consumption features in non-domestic users in this study.

The recent statistical data of manufacturing industry in Karachi City are not available. The Statistical Division of the government conducted the survey of manufacturing industry covering the whole country in the fiscal year 2000-01. The statistical data in Sindh Province were summarized in the survey report, which is the latest is information in this field. **Figure 112.4.1** shows the manufacturing output by major industrial type in the province. The number of manufacturing establishments reported to the government was 1,768 in the province. There were 1,218 establishments in Karachi City, accounting for around 70% of the provincial total.

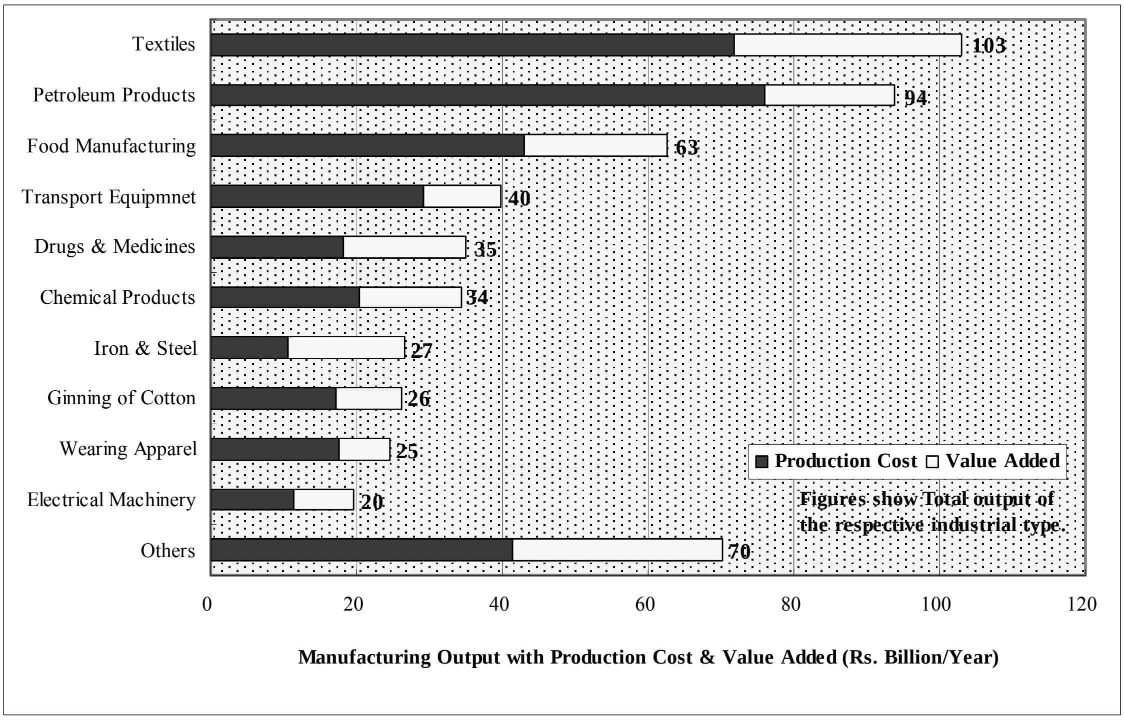


Figure 112.4.1 Manufacturing Output of Major Industrial Types in Sindh Province: 2000-01

The water consumption data of manufacturing establishment by industrial type were not available, either. Then, the water demand of manufacturing establishments was estimated as follows. The production and value added of the respective industrial types were derived from the said industrial statistics. A unit water demand of the respective industrial types was quoted from the Japanese survey report of "Unit Requirement for Location of Manufacturing Industry, Classified by Industrial Type, March 2006, Japan Industrial Location Centre". As a result, the overall water demand on average was calculated as 60,000 gallons per day per establishment, or 271m^3/day/establishment in Sindh Province in 2007. The details of this calculation were tabulated in **Table A112.2.7** of **Appendix A112.2**.

In industrial sector, most of establishments procure industrial water through the piped water supply system of KW&SB at present. They consume well water which accounts for at most 5% to 7% of the total consumption, according to a former member of "Karachi Chamber of Commerce and Industry". On the basis of this information, the procurement of water in an average manufacturing establishment was assumed as follows: The total water demand is procured mainly through the piped water supply system, 5% of which is pumped up from well. The well water is used for mainly emergency and back up for the piped water. The average water procurement cost of the average manufacturing establishment was estimated as Rs.31.4/1,000 gallon or Rs.6.9/m^3, as shown in **Table 112.4.9**. The details of this calculation were tabulated in **Table A112.2.8** of **Appendix A112.2**.

It is said that manufacturing establishments consumes more other water sources such as well water and tanker water than piped water. In this section, the rate of other water sources was set up as 5% to 7% of the total piped water consumption. Since there were not any clear data and information, this assumption was followed because this assumption is functioned to safe side for the project evaluation.

Table 112.4.9 Water Procurement Cost in Manufacturing Industry

Description	Total	Piped Water	Well Water	(Rs./1000gallon)
Daily consumption (m^3/day)	281	267	14	
Annual consumption (m^3/year)	102,515	97,390	5,126	
Cost of procurement (Rs.1,000/year)*1	804,938	373,238	431,700	
Unit procurement cost (Rs./m^3)	7.9			35.7
Unit cost in economic value (Rs./m^3)	6.9			31.4

Note: *1 The initial investment cost was estimated at Rs.2.49 million. Including an annualized the investment cost, the annual O&M cost was estimated at Rs.431,700 per year.

d) Reduction of Operation and Maintenance Expenses for Existing Water Supply System

In the case that the new water supply system in the project areas under with-project case, the present operation and maintenance expenses under without-project case are reduced just after the inauguration of the proposed project. Under without-project case, a part of O&M costs is already appropriated in "Saving Domestic Water Procurement Costs" as procurement cost of piped water. Then, this cost has to be subtracted from the total O&M cost. The net O&M cost is calculated at Rs.14/1000 gallon or Rs.3.1/m^3 in economic value.

The unit cost of Rs.14/1000 gallon or Rs.3.1/m^3 is calculated on the basis of KW&SB financial statement in the latest fiscal year 2004-05. It does not include depreciation and financial charges. In this study, this unit value is used for a unit benefit of O&M expense reduction.

e) Negative benefits

The proposed project presents a lot of economic benefits to the society, as mentioned above. At the same time, it makes some existing facilities unnecessary after inauguration of the project. These phenomena should be avoided as much as possible from the socio-economic point of view. In fact, however, some facilities have to be eliminated because of no necessity under with-project condition in a realistic manner. These facilities have to be counted as negative benefit in the economic evaluation.

In the proposed project, the following three items are considered to be unnecessary: (i) existing distribution pipes incompatible with the proposed system; (ii) existing domestic water supply system in domestic users for attaining a reliable backup covering up the insufficient public water supply system; and (iii) existing well system in non-domestic users for a reliable backup covering up the insufficient public water supply system.

1) Removal of existing distribution pipes

The existing piping network was designed to satisfy the requirements for the water demand of the planning target and of the planning/design standards of water supply system at the time. The present network becomes insufficient due to increasing population and improving living standard in accordance with economic growth. These distribution pipes would not always be compatible with the proposed piping network system from the viewpoint of not only piping capacity but also specification of pipes. These pipes become useless for the new system, so they can not be avoided to be taken away for installation of the new pipes.

In this study, the residual value of these useless pipes is assumed to be 20% of the new piping cost in the same area. Since the conditions of the existing pipes are of a variety of oldness, size and material of pipes, it would be impossible to valuate their residual valuate properly. Thus, the same rate of 20% of the new piping cost is assumed to be appropriated as negative benefit in the respective project areas. This negative benefit starts at the same time as the DNI begins.

2) Residual value of existing domestic water supply system in residence

As mentioned in **Section 11.2.4-(1)-C)-a)**, most of households install their water tank and pump system in their residence. They had to install the system to keep their safe living condition of water against unreliable water supply system by KW&SB. However, if the proposed project is completed in the project areas, the beneficiaries would not have to rely on the water tank and pump system since they can get safe water without stoppage for the whole day over. They do not have to maintain the tank and pump system after the inauguration of the project.

Yet, this useless water supply system in these beneficiaries is considered as social loss from the economic point of view. In this study, thus, the residual value of this system has to be included in the expected benefits as negative benefit. Their average values in economic value are estimated as follows: (i) Rs.14,900 for Type 1 residence; Rs.34,200 for Type 2 residence; Rs.43,600 for Type 3 residence; and Rs.88,900 for Type 4 residence. They are summarized in **Table 112.4.10**. The detail calculation is tabulated in **Table A112.2.9** of **Appendix A112.2**.

Table 112.4.10 Negative Benefit of Domestic Water Supply System by Residential Type

(Unit: Rs.)

Item	Type 1	Type 2	Type 3	Type 4
1° Initial Investment Cost	32,183	72,700	95,343	196,594
2° Residual Value in Market Prices*1	16,511	38,030	48,451	98,747
3° Negative Benefit in Economic Value	14,900	34,200	43,600	88,900

Note: Residual value was assumed as a half of the initial investment cost.

3) Residual value of existing water supply system in non-domestic user's facilities

Most of manufacturing establishments install their well system for a reliable backup to the insufficient public water supply system. In the same manner, most of non-domestic water users are also considered to install their well system. However, if the proposed project is implemented in their territory, they would not have to rely on the backup well system. Thus, these systems are also considered as negative benefit, as mentioned in the previous section.

The initial investment cost of well system in a factory was estimated at Rs.2.93 million for the economic life of 30 years, as calculated in **Section 11.2.4-(1)-C)-c)**. In the same manner as the domestic water system, the residual value is assumed to be a half of the initial value. It was calculated at Rs.1.47 million. Since the annual water consumption was calculated at 22,600 gallon or 0.10 million m^3 per year. The unit negative benefit is assumed to be calculated at Rs.65.0/1000 gallon or Rs.14.3/m^3 in the year in market prices, when the proposed project is inaugurated. It is converted to Rs.59.0/1000 gallon or Rs.13.0/m^3 in economic value. The detail calculation is tabulated in **Table A112.2.10** of **Appendix A112.2**.

D) Estimate of Overall Economic Benefits

The benefit of water supply project is basically calculated as a product of water volume consumed or the number of beneficiaries, and unit benefit. The unit benefits of the tangible benefits were already discussed in **Section 11.2.4-(1)-C)**. They are summarised in the following section.

a) Summaries of Unit Benefits

1) Benefits from Saving Costs of Domestic Water Procurement

The unit benefits were estimated in **Section 11.2.4-(1)-C)-a)**. They were quantified as unit value per water volume consumed, which were segregated into residential types. They are summarised as follows: Rs.245/1000 gallon or Rs.54/m^3 of Type 1; Rs.278/1000 gallon or Rs.61/m^3 of Type 2; Rs.302/1000 gallon or Rs.66/m^3 of Type 3; and Rs.441/1000 gallon or Rs.97/m^3 of type 4.

2) **Benefits from Public Health Improvement**

The unit benefits are composed of three categories: (i) saving of household medical expenditures; (ii) saving of medical treatment expenses; and (iii) decrease of absence from work due to illness. They were estimated in Section 8.2.4-(1)-C)-b). **Table 112.4.11** summarises the unit benefits from the public health improvement.

Table 112.4.11 Economic Unit Benefits from Public Health Improvement

Saving of Household Medical Expenditures (Unit: Rs./Household/Year)		
	1° Type 1	3,417
	2° Type 2	2,629
	3° Type 3	3,231
	4° Type 4	6,790
Saving of Medical Treatment Expenses		
	1° Outpatient (Rs.1000/Year/1,000 Population)	66.6
	2° Inpatient (Rs.1000/Year/100,000 Population)	5,951
	3° Transportation Costs (Rs.1000/Year/100,000 Population)	284.1
Decrease of Absence from Work due to Illness		
	1° Outpatient (Rs.1000/Year/1,000 Population)	7.3
	2° Inpatient (Rs.1000/Year/100,000 Population)	235.8

The benefits above are the total value brought by the elimination of the water bore diseases. As discussed in **Section 11.2.3-(3)-4°**, the benefit is distributed as 50% from water supply, 30% from waste disposal and 20% from sewerage. The unit benefit of the respective project schemes applies these components in the actual calculation of the total benefit of the project.

3) **Benefit from Improvement of Non-domestic Water Supply System**

The unit benefit was estimated in **Section 11.2.4-(1)-(C)-(c)**. It was quantified as unit value per consumed water volume. It was estimated at Rs.31.4/1,000 gallon or Rs.6.9/m^3 in economic value.

4) **Reduction of Operation and Maintenance Expenses for Existing Water Supply System**

The unit benefit was estimated in **Section 11.2.4-(1)-(C)-(d)**. It was quantified as unit value per served water volume. It was estimated at Rs.14/1,000 gallon or Rs.3.1/m^3 in economic value.

5) **Negative Benefits**

A. Removal of existing distribution pipes

The existing distribution pipes which become useless in the proposed project will be eliminated from underground. These pipes are valuated from their residual values. Their value was set as 20% of the new piping cost.

B. Residual value of existing domestic water supply system in residences

The existing domestic water supply facilities become useless just after the inauguration of the proposed project. This negative benefit is posted when the proposed project is inaugurated. These facilities are also valuated from their residual values. Their values were estimated as follows: Rs.14,900 of Type 1; Rs.34,200 of Type 2; Rs.43,600 of Type 3; and Rs.88,900 of Type 4.

C. Residual value of existing water supply system in non-domestic user's facilities

The existing well water supply facilities become useless just after the proposed project is inaugurated. These facilities are valuated from their residual values. It was quantified as unit value per consumed water volume. It was estimated at Rs.59/1000 gallon or Rs.13.0/m^3 in economic value.

b) Beneficiaries and Water Consumption

The number of beneficiaries is another key data to the quantification of economic benefits brought by the proposed project. **Table 112.4.12** summarises the number of beneficiaries and water consumption by the beneficiaries from the year 2012 when the economic benefits begin just after the project's inauguration to the target year 2025. It shows that a ratio of beneficiaries starts from 15% of the total residents in Karachi City in 2012. In the target year, the ratio will reach to 100%, so all residents can enjoy the healthy living environment in terms of water. The detail calculation of the beneficiaries and water consumption is tabulated in **Table A112.2.17** of **Appendix A112.2**.

Table 112.4.12 Beneficiaries and Water Consumption for Benefit Estimation: 2011 to 2025

Item	2012	2016	2021	2025
1° Beneficiaries (Population Base, Unit:1000)				
Total Population	20,155	23,585	28,541	32,506
Beneficiaries of Project	3,102	12,089	23,998	32,506
2° Beneficiaries (Household Base, Unit:1000)				
Number of Households	2,879	3,369	4,077	4,644
Beneficiaries of Project	433	1,727	3,428	4,644
3° Domestic Water Consumption of Beneficiaries (Unit: Million m^3/Year)				
Total Consumption	506	640	876	1,087
Consumption by Beneficiaries	81	329	737	1,087
4° Non-domestic Water Consumption of Beneficiaries (Unit: Million m^3/Year)				
Total Consumption	327	392	502	580
Consumption by Beneficiaries	50	201	422	580

c) Annual Economic Benefits

The economic benefit of water supply project is calculated as a product of water volume consumed by beneficiaries or the number of beneficiaries, and unit benefit. The total economic benefits were estimated at minus Rs.3.42 billion in 2012. The existing domestic water supply facilities of the beneficiaries' residences in the first implemented areas of the DNI become useless, because the improved water supply system can serve sufficient and safe water to the beneficiaries. This negative benefit is so large as compared with the positive benefit that the total benefit falls into negative in the first year. The total benefit in the following year, however, turns into positive and increased year by year. Its annual benefit becomes to Rs.74.64 billion in the target year 2025. **Table 112.4.13** shows the annual economic benefits between 2012 and 2025.

(2) Economic Costs

A) Capital Investment Costs

The estimate of the proposed project was already discussed in **Chapter 10**. The estimate was enumerated in market prices, what is called "financial value". The respective costs are composed of foreign portion and local portion. The foreign portion means the materials and services which are procured from the international markets because they are not available in the local products and services. The local portion means the materials and services which are available in the domestic markets because they are produced and provided by local industries and people. The local portion, thus, has to be converted into economic value applying the SCF. The price contingency is not included in the economic evaluation.

Table 112.4.13 Economic Benefit of Proposed Water Supply Project in Master Plan

(Unit: Rs. Billion)

Year	Domestic Saving Benefit					Non-domestic Saving Benefit	Medical Benefit						
							Family Expense				Medical Treatment	Absence from Work	Sub-total
	Type 1	Type 2	Type 3	Type 4	Sub-total		Type 1	Type 2	Type 3	Type 4			
2012	2.63	1.24	0.36	0.57	4.81	0.35	0.50	0.12	0.03	0.06	0.20	0.01	0.92
2013	4.28	2.02	0.58	0.93	7.81	0.56	0.81	0.19	0.05	0.09	0.32	0.02	1.48
2014	6.17	2.92	0.84	1.35	11.29	0.81	1.15	0.27	0.07	0.13	0.46	0.03	2.12
2015	8.37	3.96	1.15	1.85	15.33	1.10	1.55	0.36	0.10	0.18	0.62	0.05	2.86
2016	10.69	5.06	1.49	2.38	19.62	1.39	1.95	0.45	0.13	0.23	0.78	0.06	3.59
2017	12.75	6.03	1.79	2.86	23.43	1.64	2.27	0.53	0.15	0.26	0.91	0.07	4.18
2018	16.18	7.66	2.30	3.67	29.81	2.05	2.82	0.65	0.18	0.33	1.13	0.08	5.18
2019	19.15	9.07	2.75	4.38	35.35	2.40	3.26	0.76	0.21	0.38	1.30	0.10	6.00
2020	21.43	10.16	3.10	4.94	39.63	2.66	3.56	0.83	0.23	0.41	1.42	0.11	6.56
2021	23.81	11.29	3.48	5.54	44.11	2.92	3.87	0.90	0.25	0.45	1.55	0.12	7.13
2022	25.86	12.27	3.82	6.07	48.01	3.12	4.12	0.96	0.26	0.48	1.65	0.12	7.59
2023	28.69	13.62	4.28	6.79	53.37	3.40	4.48	1.04	0.29	0.52	1.79	0.13	8.25
2024	31.70	15.06	4.77	7.56	59.09	3.70	4.86	1.13	0.31	0.56	1.94	0.15	8.94
2025	34.90	16.59	5.30	8.40	65.19	4.01	5.24	1.22	0.34	0.61	2.10	0.16	9.65

Year	Reduction of O&M Expenses	Positive Benefit Total	Negative Benefit							Grand Total
			Distribution Piping	Domestic Water System				Non-domestic	Total	
				Type 1	Type 2	Type 3	Type 4			
2012	0.09	6.16	0.46	3.96	2.52	0.73	1.26	0.65	9.59	-3.42
2013	0.14	10.00	0.46	2.09	1.33	0.38	0.67	0.41	5.34	4.66
2014	0.21	14.43	0.49	2.17	1.38	0.40	0.69	0.47	5.60	8.83
2015	0.28	19.57	0.49	2.52	1.61	0.46	0.81	0.54	6.43	13.13
2016	0.36	24.96	0.48	2.68	1.71	0.49	0.86	0.55	6.75	18.20
2017	0.42	29.67	0.55	1.71	1.09	0.31	0.55	0.47	4.68	24.99
2018	0.53	37.58	0.55	3.80	2.42	0.69	1.21	0.79	9.45	28.12
2019	0.63	44.38	0.55	2.66	1.70	0.49	0.85	0.66	6.91	37.47
2020	0.70	49.55	0.56	1.37	0.87	0.25	0.44	0.48	3.97	45.58
2021	0.78	54.94	0.58	1.39	0.89	0.26	0.45	0.49	4.05	50.88
2022	0.84	59.56	0.59	0.75	0.48	0.14	0.24	0.38	2.58	56.98
2023	0.93	65.95	0.55	1.71	1.09	0.31	0.55	0.54	4.74	61.21
2024	1.02	72.75	0.55	1.83	1.17	0.34	0.59	0.56	5.03	67.72
2025	1.12	79.97	0.56	1.96	1.25	0.36	0.63	0.58	5.32	74.64

The existing water supply facilities are involved into the proposed project and used as a part of the proposed system. Their costs are valuated at Rs.25.6 billion in market value, which come from the fix assets' book value after written down depreciation at the end of the fiscal year 2005/06. These facilities are utilised as a part of the proposed project. In 2012, they are involved in the proposed project. Their value was assumed to increase at the rate of 3% per annum referring to the past records, so they were re-evaluated Rs.30.6 billion in 2012. Their economic value was re-calculated at Rs.27.0 billion.

The construction costs are annually disbursed in accordance with the implementation schedule. In these investment costs, the distribution piping network such as service pipes and water meter is completely improved to accord with the new water supply system standard. The beneficiaries can enjoy the new water supply condition with no time-restricted and no suspension of the water supply. **Table 112.4.14** shows the annual disbursement of direct construction cost and its related costs in market prices. The total figures of the project were estimated as Rs.329 billion by the target year 2025. The table also included the economic costs converted from the market prices. The total economic costs were calculated at Rs.237 billion.

B) Operation and Maintenance Costs

The operation and maintenance (O&M) cost is annually required during the economic life of the proposed project. The O&M cost starts in 2012, just the beginning year of the distribution network improvement in the stage-I. It was estimated at Rs.0.64 billion in 2012 in market prices. It was converted to Rs.0.49 billion in economic value. It increases year by year in accordance with the increment of the service areas until the target year 2025. Beyond 2025, it is set to keep the same O&M costs for the project target beneficiaries. The annual O&M costs of both financial and economic values are enumerated in **Table A112.2.19** of **Appendix A112.2**.

C) Replacement Costs

The electrical and mechanical equipment is considered that its economic life is 15 year in general. On the other hand, the other facilities such as buildings, piping network, and civil works are considered that their economic life is more than 30 years. Thus, the former equipment has to be replaced in every 15 years within the evaluation period. The first replacement cost starts in 2023, which is 15 year after the completion of the starting construction work.

The distribution network pipelines need to be improved or replaced to keep high efficiency of water conveyance. In addition, service connections including water meters need to be rehabilitated or replaced after 10 years because of their short life times. These costs are appropriated as replacement costs even after the target year 2025. These replacement costs are tabulated in **Table A112.2.20** of **Appendix A112.2**.

Table 112.4.14 Economic Investment Cost of Proposed Water Supply Project in Master Plan

Financial Value

(Unit: Rs. Billion)

Year	Direct Cost			Engineering			Land Acq.	Physical Contingency			Price Contingency			Administration	Total		
	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Local	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Local	Foreign	Local	Total
2008	1.13	0.46	1.59	0.08	0.04	0.12	1.55	0.06	0.10	0.16	0.02	0.13	0.15	0.05	1.29	2.33	3.62
2009	11.13	6.14	17.27	0.91	0.39	1.30	0.00	0.60	0.33	0.93	0.38	0.85	1.23	0.31	13.02	8.02	21.04
2010	11.14	6.15	17.29	0.91	0.39	1.30	0.00	0.60	0.33	0.93	0.58	1.31	1.89	0.32	13.23	8.50	21.73
2011	11.42	6.26	17.68	0.93	0.40	1.33	0.00	0.62	0.33	0.95	0.80	1.83	2.63	0.34	13.76	9.16	22.93
2012	2.81	1.12	3.93	0.21	0.09	0.29	0.00	0.15	0.06	0.21	0.24	0.43	0.67	0.08	3.41	1.77	5.18
2013	4.16	1.66	5.82	0.31	0.13	0.44	0.00	0.22	0.09	0.31	0.44	0.79	1.23	0.12	5.13	2.78	7.91
2014	14.01	6.93	20.94	1.10	0.47	1.57	0.00	0.76	0.37	1.13	1.74	3.91	5.66	0.44	17.60	12.13	29.73
2015	14.24	7.02	21.26	1.12	0.48	1.59	0.00	0.77	0.37	1.14	2.04	4.68	6.71	0.46	18.16	13.01	31.17
2016	14.29	7.02	21.31	1.12	0.48	1.60	0.00	0.77	0.38	1.15	2.32	5.43	7.75	0.48	18.49	13.78	32.28
2017	3.98	1.53	5.51	0.29	0.12	0.41	0.00	0.21	0.08	0.30	0.72	1.37	2.09	0.12	5.21	3.23	8.44
2018	6.25	2.41	8.66	0.45	0.19	0.65	0.00	0.34	0.13	0.47	1.25	2.46	3.71	0.20	8.29	5.40	13.69
2019	10.58	5.40	15.98	0.84	0.36	1.20	0.00	0.57	0.29	0.86	2.35	6.12	8.46	0.40	14.33	12.56	26.89
2020	9.81	5.10	14.91	0.78	0.34	1.12	0.00	0.53	0.27	0.80	2.37	6.47	8.84	0.39	13.49	12.57	26.06
2021	9.84	5.11	14.95	0.78	0.34	1.12	0.00	0.53	0.27	0.80	2.59	7.21	9.80	0.40	13.74	13.33	27.08
2022	3.42	1.27	4.69	0.25	0.11	0.35	0.00	0.18	0.07	0.25	0.96	2.02	2.98	0.12	4.81	3.58	8.39
2023	5.34	2.02	7.36	0.39	0.17	0.55	0.00	0.29	0.11	0.40	1.62	3.54	5.15	0.20	7.63	6.03	13.66
2024	5.40	2.03	7.43	0.39	0.17	0.56	0.00	0.29	0.11	0.40	1.75	3.90	5.66	0.21	7.83	6.42	14.25
2025	5.45	2.04	7.48	0.39	0.17	0.56	0.00	0.29	0.11	0.40	1.88	4.29	6.18	0.22	8.01	6.83	14.84
Total	144.39	69.67	214.06	11.24	4.82	16.05	1.55	7.78	3.80	11.58	24.05	56.74	80.79	4.86	187.46	141.44	328.90

Economic Value

(Unit: Rs. Billion)

Year	Direct Cost			Engineering			Land Acq.	Physical Contingency			Price Contingency			Administration	Total		
	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Local	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Local	Foreign	Local	Total
2008	1.13	0.41	1.54	0.08	0.03	0.12	0.00	0.06	0.09	0.15	0.00	0.00	0.00	0.05	1.28	0.57	1.85
2009	11.13	5.41	16.54	0.91	0.34	1.25	0.00	0.60	0.29	0.89	0.00	0.00	0.00	0.27	12.64	6.31	18.95
2010	11.14	5.41	16.56	0.91	0.34	1.25	0.00	0.60	0.29	0.89	0.00	0.00	0.00	0.28	12.66	6.33	18.98
2011	11.42	5.51	16.93	0.93	0.35	1.28	0.00	0.62	0.29	0.91	0.00	0.00	0.00	0.30	12.97	6.45	19.42
2012	2.81	0.99	3.79	0.21	0.08	0.28	0.00	0.15	0.05	0.20	0.00	0.00	0.00	0.07	3.17	1.18	4.35
2013	4.16	1.46	5.62	0.31	0.12	0.42	0.00	0.22	0.08	0.30	0.00	0.00	0.00	0.10	4.69	1.76	6.45
2014	14.01	6.10	20.10	1.10	0.41	1.51	0.00	0.76	0.33	1.08	0.00	0.00	0.00	0.39	15.86	7.23	23.09
2015	14.24	6.18	20.41	1.12	0.42	1.54	0.00	0.77	0.33	1.10	0.00	0.00	0.00	0.41	16.12	7.33	23.45
2016	14.29	6.18	20.47	1.12	0.42	1.54	0.00	0.77	0.33	1.10	0.00	0.00	0.00	0.42	16.17	7.35	23.53
2017	3.98	1.35	5.33	0.29	0.11	0.40	0.00	0.21	0.07	0.29	0.00	0.00	0.00	0.11	4.49	1.64	6.12
2018	6.25	2.12	8.37	0.45	0.17	0.63	0.00	0.34	0.11	0.45	0.00	0.00	0.00	0.18	7.04	2.59	9.63
2019	10.58	4.75	15.33	0.84	0.32	1.15	0.00	0.57	0.25	0.82	0.00	0.00	0.00	0.35	11.99	5.67	17.66
2020	9.81	4.49	14.30	0.78	0.30	1.08	0.00	0.53	0.24	0.77	0.00	0.00	0.00	0.34	11.12	5.36	16.48
2021	9.84	4.50	14.34	0.78	0.30	1.08	0.00	0.53	0.24	0.77	0.00	0.00	0.00	0.35	11.16	5.39	16.54
2022	3.42	1.12	4.53	0.25	0.09	0.34	0.00	0.18	0.06	0.24	0.00	0.00	0.00	0.11	3.85	1.38	5.22
2023	5.34	1.78	7.12	0.39	0.15	0.53	0.00	0.29	0.10	0.38	0.00	0.00	0.00	0.18	6.01	2.20	8.21
2024	5.40	1.79	7.19	0.39	0.15	0.54	0.00	0.29	0.10	0.39	0.00	0.00	0.00	0.19	6.08	2.21	8.30
2025	5.45	1.79	7.24	0.39	0.15	0.54	0.00	0.29	0.10	0.39	0.00	0.00	0.00	0.19	6.13	2.23	8.36
Total	144.39	61.31	205.70	11.24	4.24	15.48	0.00	7.78	3.35	11.13	0.00	0.00	0.00	4.28	163.41	73.17	236.58

(3) Economic Evaluation

Economic costs and benefits during the economic evaluation period are shown in **Table 112.4.15**. The table shows an economic and cost stream, and economic indices. The evaluation indices were 15.7% of EIRR, Rs.52.0 billion of NPV and 1.39 of B/C. Then, the project is viable from the economic point of view, because its EIRR was much higher than the social discount rate, 12%.

Item	EIRR (%)	NPV (Rs. Billion)	B/C
Evaluation Indices	15.7	52.0	1.39

The indices were calculated on the basis of tangible benefits discussed in **Section 11.2.4-(1)-C)**. Although there are many project benefits in addition to the tangible benefits as mentioned in **Section 11.2.4-(1)-B)**, the majority of them are intangible benefits. Even if some benefits are considered as tangible benefits, they could not be quantified as tangible benefit because of little information and data. Hence, some major benefits which were not quantified in the previous sections are discussed with their background in the following paragraphs.

A) Impact on Regional Economy

It is obvious that commencement of construction works such as water supply and sewerage project induces regional economy to activate in the sectors related to construction works as well as construction sector itself. In general, one unit of construction work could induce 1.50 to 2.00 units of economic effects in the national and regional economy. In other words, a construction work would bring about 50% to 100% ripple effect on related works in various economic sectors in monetary terms in addition to the said construction work. This effect could stimulate the regional economy in Karachi City and its surrounding areas.

According to the “2005-06 Pakistan Economic Survey”, 7.7% of the labour force in Pakistan is not employed. The investment of the proposed project would activate the regional economy and at the same time create opportunities for temporary jobs during the construction period of more than 14 years. Accordingly, it would be clear that the investment proposes new labour opportunities for the people unemployed and underemployed in the province.

B) Conservation of Water Resources

The proposed water supply project embodies water conservation in a form of reduction of water leakage through transmission and distribution network pipes. The conservation effects are reflected to slow down the speed of capital investment for increasing water resources, i.e., saving effect for water resource development investment. Furthermore, water saved from the proposed project can also be transferred to some other purposes such as industrial and agricultural production. These phenomena would contribute to conservation of natural environment, as well.

C) Intensification of land owing to water supply services

It is said that introduction of water supply services contribute to intensify the land value. Moreover, it also contributes to improve the degree of freedom for urban planning. These benefits are well known in general. However, it is difficult that their benefits are quantified through anticipation of their future effects. Furthermore, it is not considered as direct benefit for water supply project.

Table 112.4.15 Economic Cost and Benefit Stream and Evaluation Indices of Proposed Water Supply Projects in Master Plan

(Unit: Rs. Billion)

No.	Year	Cost				Benefit						Balance
		Capital Investment	O&M	Replace-ment	Total	Domestic Saving	Medical Benefit	Non-domestic Saving	Saving of Ex. O&M Costs	Negative Benefit	Total	
1	2008	1.85	0.00		1.85	0.00	0.00	0.00	0.00	0.00	0.00	-1.85
2	2009	18.95	0.00		18.95	0.00	0.00	0.00	0.00	0.00	0.00	-18.95
3	2010	18.98	0.00		18.98	0.00	0.00	0.00	0.00	0.00	0.00	-18.98
4	2011	19.42	0.00		19.42	0.00	0.00	0.00	0.00	0.00	0.00	-19.42
5	2012	31.30	0.49		31.79	4.81	0.92	0.35	0.09	9.59	-3.42	-35.21
6	2013	6.45	0.72		7.17	7.81	1.48	0.56	0.14	5.34	4.66	-2.51
7	2014	23.09	0.95		24.04	11.29	2.12	0.81	0.21	5.60	8.83	-15.21
8	2015	23.45	1.21		24.66	15.33	2.86	1.10	0.28	6.43	13.13	-11.53
9	2016	23.53	1.44		24.96	19.62	3.59	1.39	0.36	6.75	18.20	-6.76
10	2017	6.12	2.08		8.21	23.43	4.18	1.64	0.42	4.68	24.99	16.79
11	2018	9.63	2.56		12.19	29.81	5.18	2.05	0.53	9.45	28.12	15.94
12	2019	17.66	2.95		20.61	35.35	6.00	2.40	0.63	6.91	37.47	16.86
13	2020	16.48	3.23		19.71	39.63	6.56	2.66	0.70	3.97	45.58	25.87
14	2021	16.54	3.42		19.96	44.11	7.13	2.92	0.78	4.05	50.88	30.92
15	2022	5.22	3.99		9.21	48.01	7.59	3.12	0.84	2.58	56.98	47.76
16	2023	8.21	4.34	0.00	12.55	53.37	8.25	3.40	0.93	4.74	61.21	48.66
17	2024	8.30	4.71	5.38	18.39	59.09	8.94	3.70	1.02	5.03	67.72	49.33
18	2025	8.36	5.09	5.38	18.84	65.19	9.65	4.01	1.12	5.32	74.64	55.81
19	2026		5.09	8.79	13.89	65.19	9.65	4.01	1.12	0.00	79.97	66.08
20	2027		5.09	3.23	8.32	65.19	9.65	4.01	1.12	0.00	79.97	71.65
21	2028		5.09	3.47	8.56	65.19	9.65	4.01	1.12	0.00	79.97	71.41
22	2029		5.09	7.54	12.64	65.19	9.65	4.01	1.12	0.00	79.97	67.33
23	2030		5.09	7.44	12.53	65.19	9.65	4.01	1.12	0.00	79.97	67.44
24	2031		5.09	7.46	12.55	65.19	9.65	4.01	1.12	0.00	79.97	67.41
25	2032		5.09	3.25	8.34	65.19	9.65	4.01	1.12	0.00	79.97	71.63
26	2033		5.09	3.44	8.54	65.19	9.65	4.01	1.12	0.00	79.97	71.43
27	2034		5.09	7.39	12.48	65.19	9.65	4.01	1.12	0.00	79.97	67.49
28	2035		5.09	7.42	12.51	65.19	9.65	4.01	1.12	0.00	79.97	67.46
29	2036		5.09	7.13	12.23	65.19	9.65	4.01	1.12	0.00	79.97	67.74
30	2037		5.09	3.23	8.32	65.19	9.65	4.01	1.12	0.00	79.97	71.65
31	2038		5.09	3.47	8.56	65.19	9.65	4.01	1.12	0.00	79.97	71.41
32	2039		5.09	8.92	14.02	65.19	9.65	4.01	1.12	0.00	79.97	65.95
33	2040		5.09	8.82	13.91	65.19	9.65	4.01	1.12	0.00	79.97	66.06
34	2041		5.09	8.84	13.93	65.19	9.65	4.01	1.12	0.00	79.97	66.03
35	2042		5.09	3.25	8.34	65.19	9.65	4.01	1.12	0.00	79.97	71.63
36	2043		5.09	3.44	8.54	65.19	9.65	4.01	1.12	0.00	79.97	71.43
37	2044		5.09	7.66	12.76	65.19	9.65	4.01	1.12	0.00	79.97	67.21
38	2045		5.09	7.68	12.78	65.19	9.65	4.01	1.12	0.00	79.97	67.19
39	2046		5.09	7.42	12.51	65.19	9.65	4.01	1.12	0.00	79.97	67.46
40	2047		5.09	3.23	8.32	65.19	9.65	4.01	1.12	0.00	79.97	71.65
41	2048		5.09	3.47	8.56	65.19	9.65	4.01	1.12	0.00	79.97	71.41
42	2049		5.09	7.27	12.36	65.19	9.65	4.01	1.12	0.00	79.97	67.61
43	2050		5.09	7.17	12.26	65.19	9.65	4.01	1.12	0.00	79.97	67.70
44	2051		5.09	7.18	12.27	65.19	9.65	4.01	1.12	0.00	79.97	67.70
45	2052		5.09	3.25	8.34	65.19	9.65	4.01	1.12	0.00	79.97	71.63
46	2053		5.09	3.44	8.54	65.19	9.65	4.01	1.12	0.00	79.97	71.43
47	2054		5.09	9.04	14.14	65.19	9.65	4.01	1.12	0.00	79.97	65.83
48	2055		5.09	9.06	14.16	65.19	9.65	4.01	1.12	0.00	79.97	65.81

Remark: In 2008, the existging fixed assets of water supply system were carried over into the proposed project, which were assessed as Rs. 28.8 billion as book value.

EIRR: 15.7% **NPV: 52.0 Billion Rupees** **B/C: 1.39**

11.2.5 Sewerage Projects

(1) Economic Benefits

A) Benefits of Proposed Sewerage Project

Sewerage system is one of the most fundamental urban infrastructures, as well. One of main goals of sewerage project is to improve public health and well-being. The people of low income class would receive the largest benefit from the sewerage project. The present sewerage system almost covers the project areas. However, it does not function well at present. In their service areas, some of domestic sewer pipes can not connect to sewerage system, so their domestic wastewater is discharged without treatment to surrounding areas or roads. They grasp the environmental problems of water pollution in their circumstance. Thus, the proposed sewerage project will give various advantages to the people and the regional economy in and around the project areas. **Table 112.5.1** lists up the benefits accruing from the sewerage project.

Table 112.5.1 Benefits Accruing from Sewerage Project

A. Improvement of Public Health	a.	Improvement of current sewerage treatment level in service areas
	b.	Improvement of water source quality owing to improved treated effluent disposal
	c.	Reduction of water borne diseases
	d.	Reduction of medical expenses
B. Enhancement of Amenity and Well-being	a.	Elimination of environmental pollutant
	b.	Improvement of living environmental condition owing to sewage exclusion
	c.	Reduction of absence from work because of water borne diseases
	d.	Saving of water sources owing to recycling treated effluent water
	e.	Evasion of flood damage due to contaminated inland water inundation
	f.	Elimination of septic tank and other treatment facilities
	g.	Reduction of operation and maintenance expenses of existing sewerage system
C. Social Issues Related to Water Supply	a.	Enlightenment effects for environment awareness in community
	b.	Increase of productivity in agriculture and fishery cultivation
	c.	Stimulation of project investment to regional economy
	d.	Promotion of tourism and recreation activities
	e.	Improvement of degree of freedom for urban planning
	f.	Increase of land values

Among these benefits, benefits in lines with A and B in the table above are considered as direct benefits. The proposed project directly brings about those benefits to the beneficiaries. Benefits in line with C are considered as indirect benefits. The project has ripple effects on people or regional environment in relation to the project.

B) Quantifiable Direct Benefits

The benefits listed in the table above are furthermore classified into two categories. They are quantifiable or tangible, and non-quantifiable or intangible. To calculate evaluation indices for economic evaluation, only tangible benefits are applied as project benefits. In this study, the following benefits are selected as tangible benefit, and they are bound into five components.

1° Benefits of B.-a., b. and c.: Environmental improvement effects for residents through new sewerage system
2° Benefits of A.-c. & d.: Public health improvement benefit for residents
3° Benefits of B.-f.: Saving benefit of septic tank management
4° Benefit of B.-a.: Environmental improvement effects for residents through

new sewerage system covering non-residential sewage generators

5° Benefits of B.-g.: Reduction of O&M expenses of existing sewerage system

The proposed project is evaluated on the basis of estimated economic benefits and costs for the entire project. The benefits and costs are calculated in economic values converted applying the SCF to those estimated in market prices. This procedure was already discussed in **Section 11.2.2**. The benefits in market prices are quantified regarding the aforesaid five items by means of the methods mentioned in the following sub-sections. The project costs are estimated by the engineers of the JICA Study Team, which were described in **Chapter 10**.

The project benefits for residential beneficiaries in the project areas consist of three main categories, i.e., a) benefit accruing from comfortable environment improved by the sewerage system rehabilitated and enhanced by the proposed project; b) public health improvement benefit; and c) saving benefit from elimination of septic tank operation and maintenance. The benefit for non-domestic beneficiaries is also quantified based on environment improved by the new sewerage system. In this study, the intangible benefits are considered as indirect benefits, which are not quantified and only mentioned as their effective phenomena as shown in **Table 112.5.1**.

C) Estimate of Unit Economic Benefits

In Karachi City, most of toilet facilities of residential houses have already connected with gutter (drainage) or gutter line (sewer pipe). According to the “Water Awareness Survey” conducted by the JICA study team, around 90% of household have connection pipe of toilet to these public pipes. In urban areas, particularly, more than 95% of households connect to the public pipes. Even in lower income classes such as Type 1 and Type2, more than 90% of households connect to the public pipes. Only 8% of households have any connection to the public pipes. More than a half of them, however, install their individual septic tank for disposing human waste.

Yet, more than a half of the sewerage users have specific requests on sewerage disposal. Some of them have actually reported complains about sewerage to the agencies concerned. However, the situation of sewerage system has not been improved. Their living environment is not improved even if the sewerage system is installed and operated by the managing entities. The key point of this issue is that the sewerage system is not functioning well as the people expect.

On the other hand, the current level of sewerage charges is only around 0.2% of their household income level, according to the survey. The amount is less than the average maintenance cost of toilets/latrines that are not connected to sewerage in the same area. If they notice this financial gap between the sewerage charge and their expectation for sewerage effects, the financial situation for the sewerage managing entities might be improved in the future.

The survey found out the issue that the households of low and lower-middle income level and of no-connection to sewerage system bear the expense for new sewerage connection to improve their environment at 1% of their income level. In other words, they have the willingness-to-pay (WtP) of “1% of their income level” for their improved household lives. Moreover, they spend medical expenses of more than 2.5% of their household expenditure for water borne diseases. Once they become aware that the better environment affects to decrease the morbidity rate of water borne diseases in their lives, they would have much more intention of higher WtP.

According to “Study on Economic Evaluation Methodology in Development Project” by JICA, affordability-to-pay for environmental services sector is set up a benchmark as follows: 4% of household’s disposable income for water supply service; 2% for waste disposal service; and 1%

for sewerage service, referring to "Project Appraisal Manual, World Bank". In the World Bank's manual, thus, 1% of disposable income is considered to be a benchmark for sewerage service.

a) Benefit from Environment Improved for Residents

Project benefit accrued from environment improved by the new sewerage system is valuated through WtP, which is estimated by beneficiaries of the proposed project. In other words, there may be a virtual market for the services improved by the proposed project, and the beneficiaries valuate such services with a certain amount of monetary value. In this study, then, the benefit accruing is set up as 1% of beneficiaries' income level in this study, as discussed in the previous section.

Income distribution of household is the most basic information to quantify the WtP. The recent income distribution was surveyed in the report of "Socio Economic Survey Report-2005 V1.0 (Table 11), Karachi Master Plan 2020, CDGK". It is already summarised in **Table 112.4.8**. An average monthly income was calculated at Rs.12,700 per household in 2007. The average monthly income of the respective types was calculated as follows: Rs.7,200 of Type 1 (low income level) accounting for 72% of the total number of households; Rs.19,800 of Type 2 (middle income level), 20%; Rs.30,600 of Type 3 (upper middle income level), 4%; and Rs.55,000 of Type 4 (high income level), 4%.

There are 18 towns in Karachi City. The distribution ratio of income levels in the respective towns is quite different among them. The average monthly household income in the respective towns is diversified from Rs.9,800/month/household of the lowest in Malir Town to Rs.20,100/month/household of the highest in Gulshan-e-Iqbal Town. The difference of the average monthly income is more than two times between the two towns. **Figure 112.5.1** reveals these distribution conditions among 18 towns. The detailed distribution of the respective towns is shown in **Table A112.3.1** of **Appendix A112.3**.

An annual benefit is calculated as 1% of the average household income. This calculation is summarised in **Table 112.5.2**. The WtP of the respective types is as follows: Rs.864/year/household(HH) of Type 1; Rs.2,376/year/HH of Type 2; Rs.3,672/year/HH of Type 3; and Rs.6,600/year/HH of Type 4. On the other hand, annual sewage volume is estimated as 70% of the water consumption, it is calculated as follows: 28,800 gallon/year/HH or 131 m^3/year/HH of Type 1; 45,800 gallon/year/HH or 208 m^3/year/HH of Type 2; 51,700 gallon/year/HH or 235 m^3/year/HH of Type 3; and 57,000 gallon/year/HH or 259 m^3/year/HH of Type 4. Then, the unit benefit is calculated using these figures as follows: Rs.30/1000 gallon or Rs.6.6/m^3 of Type 1: Rs.52/1000 gallon or Rs.11.4/m^3 of Type 2; Rs.71/1000 gallon or Rs.15.6/m^3 of Type 3; and Rs.116/1000 gallon or Rs.25.5/m^3 of Type 4. Considering the composition of the respective types, the overall unit benefit is calculated at Rs.39.4/1000 gallon or Rs.8.7/m^3 at market price. Then, the economic unit benefits from the market prices of the respective types are converted to Rs.26.4/1000 gallon or Rs.5.8/m^3 of Type 1: Rs.45.6/1000 gallon or Rs.10.0/m^3 of Type 2; Rs.62.4/1000 gallon or Rs.13.7/m^3 of Type 3; and Rs.102/1000 gallon or Rs.22.4/m^3 of Type 4. The overall unit benefit is calculated at Rs.34.7/1000 gallon or Rs.7.6/m^3. The details are shown in **Table A112.3.2** of **Appendix A112.3**.

Table 112.5.2 Willingness-to-Pay by Income Level

Item	Type 1	Type 2	Type 3	Type 4
1° Annual Income (Rs./household)	86,400	237,600	367,200	660,000
2° Composition of Type (%)	72%	20%	4%	4%
3° WtP*1 (Rs./household)	864	2,376	3,672	6,600
4° Sewage Volume (m^3/HH/year)	131	208	235	259
5° Unit Benefit (Rs./m^3)	6.6	11.4	15.6	25.5
6° Unit Benefit in economic value				
(Rs./m^3)	5.8	10.0	13.7	22.4
(Rs./1000 gallon)	26.4	45.6	62.4	102.0
7° Overall Unit Benefit (Rs./m^3 in Economic Value)				**7.6**
(Rs./1000 gallon in Economic Value)				**34.7**

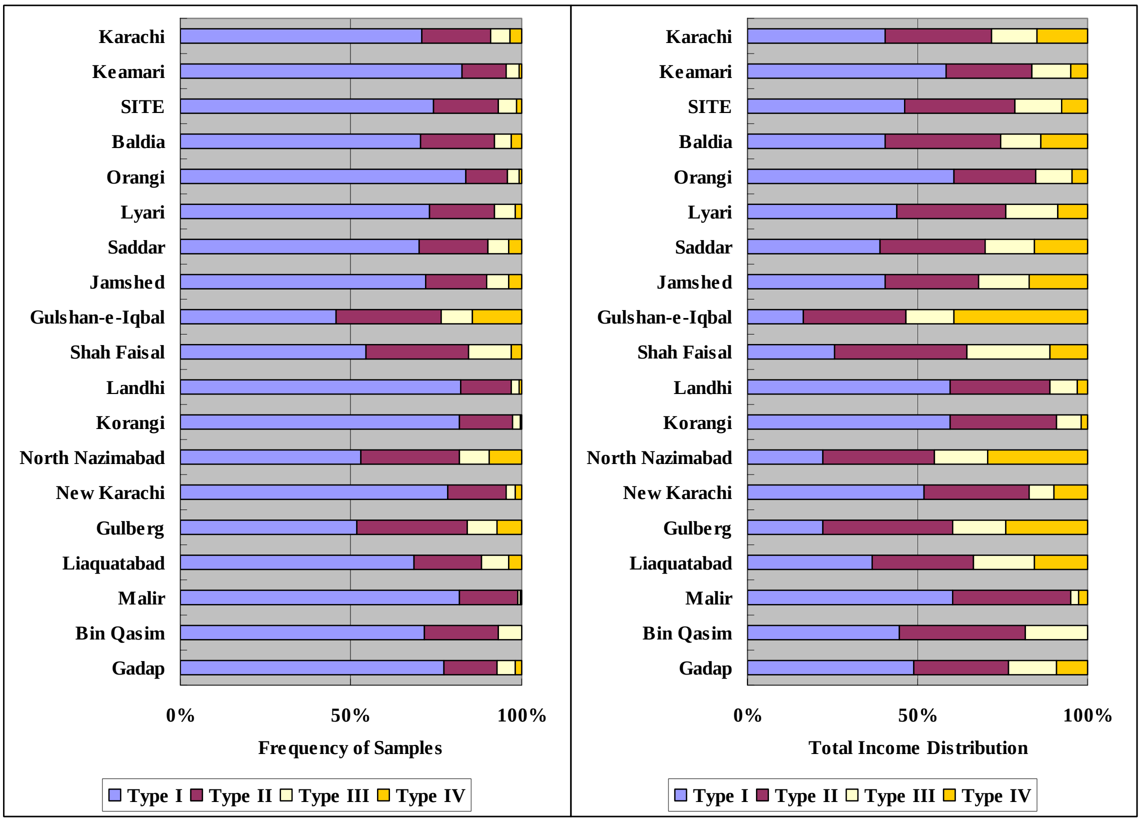


Figure 112.5.1 Income Distribution by Household Type and by Town in Karachi

b) Benefits from Public Health Improvement for Residents

The sewerage system contributes to improve the people's living environment. The improved environment can decrease the occurrence of water borne diseases. Then, medical expenses will be reduced in the both sides of residents in the project area and health care institutions. These reductions are one of the economic benefits for the society and also for the nation. This surplus can be utilised for other purposes as economic surplus in the nation.

As mentioned in **Section 11.2.5-(1)-C)**, 1% of household income is the amount of WtP for improved living environment of the beneficiaries. This percentage is valuated on improved environment by the new sewerage system. If the beneficiaries considered the effects of the new system on decreasing contraction of water borne diseases, they would have answered a higher percentage for the new system. Then, in this section, the effects on public health improvement are estimated as another project benefit as well as WtP.

Unit benefit from public health improvement in Karachi was already estimated in **Section 11.2.4**. As discussed in **Section 11.2.3-(3)-C)-4°**, 20% of the total benefit from public health improvement is accrued from sewerage system.

1) Saving of Household Medical Expenditures

The household medical expense for water borne diseases in Karachi was calculated in **Table 112.4.6**. The following figures show the total saving values for project benefit from public health improvement. The figures are already converted into economic terms.

Type 1	Rs.3,147 /year
Type 2	Rs.2,629 /year
Type 3	Rs.3,231 /year
Type 4	Rs.6,790 /year

2) Saving of Medical Treatment Expenses

The following expenses for medical treatments in hospitals and other health facilities were summarised as follows. The figures are also converted into economic values.

For Outpatient:

Average annual number of visits to hospitals:	78 visits per 1,000 populations
Average amount of charges:	Rs.970 per visit in market value
	Rs.854 per visit in economic value

For Inpatient:

Average annual number of visits to hospitals:	316 times per 100,000 populations
Average amount of charges:	Rs.21,400 per hospitalisation in market value
	Rs.18,800 per hospitalisation in economic value

In addition, all patients generally use transportation to visit medical facilities, when they suffer from water borne diseases. The annual fare of this movement was estimated as Rs.285,700 per year per 100,000 populations in economic terms.

3) Decrease of Absence from Work due to Illness

The people suffering from water borne diseases have to be absent from their work and loose their working opportunities during these medical treatments. These losses in economic values were estimated as follows.

In case of Outpatient:

Average annual number of visits to hospitals:	78 visits per 1,000 populations
Average losses of working wage:	Rs.106 per visit in market value
	Rs.93 per visit in economic value

(Assumed to spend a half day for examination and treatment)

In case of Inpatient:

Average annual number of visits to hospitals:	316 times per 100,000 populations
Average amount of charges:	Rs.848 per hospitalisation in market value
	Rs.746 per hospitalisation in economic value

c) Benefits of Saving Septic Tank Management Costs

In urban areas where no sewerage services are available in Karachi, some of households install septic tank for disposing human waste. They belong to low and middle income class groups. Under the without-project condition, they have to continue their facilities even in the future. Under the with-project condition, these facilities are not necessary just after the completion of the project in the project areas. The management cost of these facilities could be eliminated from their household expenditure. This is a saving benefit of the proposed project.

A construction cost of septic tank with soak pit for domestic use is estimated at Rs.24,300. A family has to pay for Rs.1,500 for operation of this facility annually. In addition, the family also bear an annualised cost of the construction cost. The investment cost is commonly annualised applying a CRF (refer to **Section 11.2.4-(1)-C**)). The CRF is calculated at 0.134 with 20 years of septic tank's economic life. Then, the annualised cost is calculated at Rs.3,253. Finally, the total management cost is aggregated to Rs.4,753/year in market price. It is converted to Rs.4,180/year in economic value. The detailed estimate of septic tank is tabulated in **Table A112.3.3** of **Appendix A112.3**.

d) Benefit from Environment Improved for Non-domestic Sewage Generators

There are no guidelines for this benefit. However, low quality sewage from non-domestic sewage generators indisputably contaminate water environment. The new sewerage system clearly improves the living environment in the project areas. In this study, thus, the unit benefit from environment improved for non-domestic sewage generators is expected to be valuated at least at the same amount as that from environment improved for residents. The unit benefit is set up at Rs.34.7/1000 gallon or Rs.7.6/m^3 in economic value, which is shown as overall unit benefit in **Table 112.5.2**.

e) Reduction of Operation and Maintenance Expenses for Existing Sewerage System

In the case that the new sewerage system in the project areas under with-project case, the present operation and maintenance expenses are saved just after the inauguration of the proposed project. Under without-project case, all alternative sewage treatment costs that individual sewage generators and entrepreneurs are appropriated in benefit.

The benefit listed up in c) reduction of septic tank costs is one of these benefits. In addition, the reduction of present sewerage system costs is also the same kind of benefit. Its cost was estimated at Rs.4.9 per 1000 gallon of sewage, or Rs.1.1/m^3. It is converted to Rs.4.3/1000 gallon or 0.9/m^3 in economic value. That unit cost was calculated on the basis of KW&SB financial statement in the latest fiscal year 2004/05. It does not include depreciation and financial charges. In this study, this unit value is used as unit benefit of O&M expense reduction.

f) Negative Benefits

As discussed in the water supply project, the proposed sewerage project also makes some existing facilities unnecessary after the inauguration of the project. In sewerage system, septic tank in domestic sewage generator becomes unnecessary under with-project condition. In this evaluation study of sewerage system, septic tank is counted as negative benefit.

The amount of this negative benefit is valuated referring to residual value of septic tank. In this study, the residual vale is assumed to be a half of the investment cost on average. Since the construction cost was estimated at Rs.24,300, as explained in c) above, the unit negative benefit was calculated at Rs.12,150. It is converted to Rs.10,700 in economic value.

D) Estimate of Overall Economic Benefits

The benefit of sewerage project is basically calculated as a product of sewage discharge volume or the number of beneficiaries, and unit benefit. The unit benefits of the tangible benefits were already discussed in the previous **Section C)**.

a) Beneficiaries and Sewage Discharge Volume

The number of beneficiaries is key data to the quantification of economic benefits brought by the proposed project. **Table 112.5.3** summarises the number of beneficiaries and sewage discharge volume by the beneficiaries from the year 2008 when the economic benefits begins owing to TP3 to the target year 2025. It shows that a ratio of beneficiaries starts from 7% of the total population in Karachi City in 2008. In the target year, the ratio will reach to 100%, so all residents in Karachi City can enjoy the healthy living environment owing to the new sewerage system. The detail calculation of the beneficiaries and sewage volume is tabulated in **Table A112.3.4** of **Appendix A112.3**.

Table 112.5.3 Beneficiaries and Sewage Volume for Benefit Estimation: 2008 to 2025

Item	2008	2012	2016	2021	2025
1° Beneficiaries (Population Base, Unit:1000)					
Total Population	17,218	20,190	23,585	28,541	32,506
Beneficiaries of Project	645	2,350	6,614	21,215	32,506
2° Beneficiaries (Household Base, Unit:1000)					
Number of Households	2,460	2,884	3,369	4,077	4,644
Beneficiaries of Project	92	336	945	3,031	4,644
3° Volume of Sewage Discharged in Project Areas (Unit: Billion gallon/Year)					
Total of Sewage Discharged	110	131	159	212	257
(Unit: Million m^3/Year)	501	596	722	964	1,167
4° Volume of Treated Sewage from Beneficiaries (Unit: Billion gallon/Year)					
Total of Treated Volume	7	23	55	156	257
(Unit: Million m^3/Year)	31	103	252	709	1,167
Treated Volume from Domestic	6	15	40	101	164
(Unit: Million m^3/Year)	26	67	183	457	746
Treated Vol. from Non-domestic	1	8	15	56	93
(Unit: Million m^3/Year)	4	37	69	253	421

b) Annual Economic Benefits

The economic benefit of sewerage project is calculated as a product of unit benefit and the numerical numbers concerned to beneficiaries. The total economic benefits were estimated at Rs.0.35 billion in 2008. The negative benefit mentioned above is also calculated in the same procedure. It was calculated at Rs.0.04 billion in 2008. Accordingly, the net economic benefit was estimated at Rs.0.31 billion, in 2008. The total benefit in the following years is tabulated in **Table 112.5.4**. As shown in the table, it becomes to Rs.3.05 billion in 2016, Rs.9.24 billion in 2021 and Rs.15.22 billion in the target year 2025.

(2) Economic Costs

A) Capital Investment Costs

The estimate of the proposed sewerage project was already described in **Chapter 10**. The estimate, however, was enumerated in market prices, i.e., "financial value". In economic evaluation, every cost is estimated applying economic value. As mentioned in **Section 11.2.2**, the financial value has to be converted into economic value. The costs of foreign portion show international market value, so they are the same values as the market prices. On the other hand, the costs of local portion is converted applying the SCF into economic values. The price contingency is not included in the economic evaluation.

The construction costs are annually disbursed in accordance with the implementation schedule. After the completion of the proposed project, the beneficiaries can enjoy the improved environment in their living areas. **Table 112.5.5** shows the annual disbursement of direct construction cost and its related costs in market prices. The total costs of the project were estimated as Rs.381 billion by the target year 2025. The table also included the economic costs converted from the market prices. The total economic costs were calculated at Rs.203 billion by 2025.

The existing sewerage facilities are involved into the project and used as a part of the proposed system. Their costs are valuated at Rs.5.85 billion applying the book values of KW&SB in market value at the end of the fiscal year 2005/06. It is segregated into Rs.3.71 billion of sewerage facilities and Rs.2.14 billion of land.

Table 112.5.4 Economic Benefit of Proposed Sewerage Project in Master Plan

(Unit: Rs. Billion)

Year	Domestic Benefit of Improved Environment					Non-domestic Benefit of Imp. Environment	Medical Benefit						
							Family Expense				Medical Treatment	Absence from Work	Sub-total
	Type 1	Type 2	Type 3	Type 4	Sub-total		Type 1	Type 2	Type 3	Type 4			
2008	0.08	0.06	0.02	0.04	0.19	0.06	0.08	0.02	0.01	0.01	0.03	0.00	0.14
2009	0.09	0.06	0.02	0.04	0.21	0.07	0.09	0.02	0.01	0.01	0.03	0.00	0.15
2010	0.10	0.07	0.02	0.04	0.23	0.08	0.09	0.02	0.01	0.01	0.03	0.00	0.17
2011	0.20	0.14	0.05	0.09	0.48	0.27	0.20	0.05	0.01	0.02	0.07	0.00	0.36
2012	0.20	0.15	0.05	0.10	0.50	0.35	0.23	0.05	0.01	0.03	0.08	0.01	0.41
2013	0.21	0.15	0.06	0.10	0.52	0.42	0.25	0.06	0.02	0.03	0.09	0.01	0.46
2014	0.47	0.34	0.12	0.22	1.15	0.50	0.45	0.10	0.03	0.05	0.16	0.01	0.81
2015	0.53	0.38	0.14	0.25	1.30	0.57	0.51	0.12	0.03	0.06	0.18	0.01	0.91
2016	0.59	0.42	0.16	0.28	1.45	0.65	0.57	0.13	0.04	0.07	0.20	0.01	1.02
2017	0.85	0.61	0.23	0.41	2.09	0.90	0.78	0.18	0.05	0.09	0.28	0.02	1.40
2018	0.97	0.70	0.26	0.47	2.39	1.16	0.93	0.22	0.06	0.11	0.34	0.02	1.67
2019	1.24	0.89	0.34	0.61	3.08	1.42	1.08	0.25	0.07	0.12	0.39	0.02	1.94
2020	1.42	1.02	0.39	0.70	3.53	1.67	1.22	0.28	0.08	0.14	0.44	0.03	2.20
2021	1.59	1.15	0.45	0.79	3.99	1.93	1.37	0.32	0.09	0.16	0.49	0.03	2.46
2022	1.84	1.33	0.52	0.92	4.60	2.25	1.55	0.36	0.10	0.18	0.56	0.04	2.78
2023	2.07	1.49	0.59	1.05	5.20	2.57	1.72	0.40	0.11	0.20	0.62	0.04	3.09
2024	2.32	1.68	0.67	1.19	5.86	2.89	1.91	0.44	0.12	0.22	0.69	0.04	3.43
2025	2.59	1.87	0.75	1.33	6.54	3.21	2.10	0.49	0.13	0.24	0.76	0.05	3.76

Year	Saving Benefit of O&M Expenses of Septic Tank			Reduction of O&M Expenses	Positive Benefit	Negative Benefit			Grand Total
						Elimination of Septic Tanks			
	Type 1	Type 2	Total		Total	Type 1	Type 2	Total	
2008	0.02	0.01	0.03	0.00	0.43	0.05	0.03	0.07	0.35
2009	0.02	0.01	0.03	0.00	0.47	0.01	0.00	0.01	0.46
2010	0.02	0.01	0.03	0.00	0.52	0.01	0.00	0.01	0.51
2011	0.05	0.03	0.07	0.02	1.20	0.07	0.04	0.10	1.10
2012	0.05	0.03	0.08	0.02	1.36	0.02	0.01	0.02	1.34
2013	0.06	0.03	0.09	0.03	1.52	0.02	0.01	0.02	1.50
2014	0.11	0.06	0.17	0.08	2.70	0.12	0.07	0.19	2.52
2015	0.12	0.07	0.19	0.09	3.07	0.04	0.02	0.05	3.01
2016	0.14	0.07	0.21	0.11	3.43	0.04	0.02	0.05	3.37
2017	0.19	0.10	0.29	0.20	4.89	0.13	0.07	0.20	4.69
2018	0.22	0.12	0.34	0.27	5.84	0.09	0.05	0.14	5.70
2019	0.26	0.14	0.40	0.34	7.17	0.09	0.05	0.14	7.03
2020	0.29	0.16	0.45	0.42	8.27	0.09	0.05	0.14	8.14
2021	0.33	0.18	0.50	0.50	9.38	0.09	0.05	0.14	9.24
2022	0.37	0.20	0.57	0.64	10.85	0.11	0.06	0.17	10.68
2023	0.41	0.22	0.63	0.78	12.27	0.10	0.06	0.16	12.11
2024	0.46	0.25	0.70	0.94	13.82	0.12	0.06	0.18	13.64
2025	0.50	0.27	0.77	1.10	15.40	0.12	0.06	0.18	15.22

The depreciation and some expansion/rehabilitation investments continue after 2000-01 until 2005-06, and their balance was calculated to increase at around 3% per annum for these years. The existing facilities are put into the proposed project in accordance with appropriate timing as follows: (i) in 2008, TP3 and its related facilities with the book value of Rs.1.66 billion in financial value, converted to Rs.1.46 billion in economic value; (ii) in 2014, TP1 and their related facilities with the book value of Rs.0.88 billion evaluated as of 2014, re-converted to Rs.0.77 billion, (iii) in 2017, TP2 system with the book value of Rs.1.90 billion, converted to Rs.1.67 billion, and (iv) in 2021, TP4 of the existing piping network with the book value of Rs.2.50 billion, converted to Rs.2.20 billion. The respective existing facilities are estimated as the value including expansion by the year involved into the project. The expansion growth rate of the facilities was set as 3% per annum, applied the same rate in the past trend.

B) Operation and Maintenance Costs

The O&M cost is annually required during the economic life of the proposed project. In 2008, TP3 functions as perfect services for some residents in its services areas. Then, this service is brought in the proposed project. Its O&M cost starts from the beginning of 2008. It was estimated at Rs.26 million per annum in 2008 in market prices. It was converted to Rs.24 million in economic value. In 2011, TP4 starts its services for the service areas. Its O&M cost estimated at Rs.50 million together with TP3 operation in market prices. It was converted to Rs.42 million in economic value. In 2014, TP1 starts its services after the completion of rehabilitation works, the total O&M costs were estimated at Rs.0.25 billion. It is converted to Rs.0.18 billion in economic terms. Finally, TP2 is inaugurated into the treatment services in 2017. The total O&M cost was estimated at Rs.0.80 billion, which is converted to Rs.0.52 billion.

The O&M cost increases year by year in accordance with the increment of the service areas. In 2017, the sewerage services enlarge to outer three towns. Afterwards, the sewerage services swiftly increase until the target year 2025. Beyond 2025, it is considered to keep the same O&M costs as that in 2025. The annual O&M costs of both financial and economic values are enumerated in **Table A112.3.5** in **Appendix A112.3**.

C) Replacement Costs

The electrical and mechanical equipment is considered that its economic life is 15 year in general. On the other hand, the other facilities such as buildings, piping network, and civil works are considered that their economic life is more than 30 years. Thus, the former equipment has to be replaced in every 15 years within the evaluation period. The first replacement cost starts in 2023, which is 15 year after the completion of the starting construction work. These replacement costs are tabulated in **Table A112.3.6** in **Appendix A112.3**.

(3) Economic Evaluation

Economic costs and benefits during the economic evaluation period are shown in **Table 112.5.6** in the following page. The table shows an economic cost and benefit stream, and also economic indices. The evaluation indices were 3.8% of EIRR, minus Rs.30.2 billion of NPV and 0.56 of B/C. Then, the proposed project is not viable from the economic point of view, because its EIRR was much lower than the social discount rate, 12%.

Item	EIRR (%)	NPV (Rs. Billion)	B/C
Evaluation Indices	3.8	-30.2	0.56

Table 112.5.5 Economic Cost of Proposed Sewerage Project in Master Plan

Financial Value (Unit: Rs. Billion)

Year	Direct Cost			Engineering			Physical Contingency			Price Contingency			Administration	Total		
	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Local	Foreign	Local	Total
2008	1.04	1.30	2.34	0.12	0.05	0.18	0.06	0.07	0.13	0.02	0.09	0.10	0.04	1.24	1.55	2.79
2009	1.04	1.30	2.34	0.12	0.05	0.18	0.06	0.07	0.13	0.04	0.18	0.21	0.04	1.26	1.64	2.90
2010	1.04	1.30	2.34	0.12	0.05	0.18	0.06	0.07	0.13	0.06	0.27	0.33	0.04	1.28	1.74	3.02
2011	0.85	1.25	2.10	0.11	0.05	0.16	0.05	0.07	0.11	0.06	0.36	0.42	0.04	1.07	1.77	2.84
2012	0.73	1.68	2.40	0.13	0.05	0.18	0.04	0.09	0.13	0.07	0.61	0.68	0.05	0.97	2.48	3.45
2013	0.73	1.68	2.40	0.13	0.05	0.18	0.04	0.09	0.13	0.08	0.76	0.84	0.05	0.98	2.63	3.61
2014	0.64	1.67	2.30	0.12	0.05	0.17	0.04	0.09	0.12	0.09	0.91	1.00	0.05	0.88	2.76	3.65
2015	4.86	5.40	10.26	0.54	0.23	0.77	0.27	0.28	0.55	0.72	3.51	4.23	0.24	6.38	9.66	16.04
2016	4.86	5.40	10.26	0.54	0.23	0.77	0.27	0.28	0.55	0.81	4.08	4.90	0.25	6.48	10.24	16.72
2017	7.23	12.32	19.54	1.03	0.44	1.47	0.41	0.64	1.05	1.39	10.59	11.98	0.51	10.06	24.50	34.55
2018	8.17	12.81	20.98	1.10	0.47	1.57	0.46	0.66	1.13	1.73	12.53	14.26	0.57	11.47	27.04	38.52
2019	7.82	12.56	20.38	1.07	0.46	1.53	0.44	0.65	1.10	1.83	13.83	15.66	0.58	11.16	28.08	39.24
2020	6.89	11.54	18.44	0.97	0.41	1.38	0.39	0.60	0.99	1.76	14.23	15.99	0.55	10.02	27.33	37.35
2021	6.89	11.54	18.44	0.97	0.41	1.38	0.39	0.60	0.99	1.91	15.84	17.75	0.58	10.17	28.98	39.14
2022	5.31	10.08	15.38	0.81	0.35	1.15	0.31	0.52	0.83	1.61	15.29	16.89	0.51	8.02	26.74	34.77
2023	5.31	10.08	15.38	0.81	0.35	1.15	0.31	0.52	0.83	1.73	16.86	18.59	0.54	8.14	28.34	36.49
2024	4.30	9.36	13.66	0.72	0.31	1.02	0.25	0.48	0.73	1.52	17.19	18.70	0.51	6.78	27.85	34.63
2025	3.33	8.36	11.69	0.61	0.26	0.88	0.20	0.43	0.63	1.27	16.78	18.05	0.47	5.42	26.30	31.72
Total	71.03	119.61	190.64	10.01	4.29	14.30	4.05	6.20	10.25	16.69	143.89	160.59	5.64	101.78	279.63	381.41

Economic Value (Unit: Rs. Billion)

Year	Direct Cost			Engineering			Physical Contingency			Price Contingency			Administration	Grand Total		
	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Foreign	Local	Sub-Total	Local	Foreign	Local	Total
2008	1.04	1.15	2.19	0.12	0.05	0.17	0.06	0.06	0.12	0.00	0.00	0.00	0.04	1.22	1.29	2.51
2009	1.04	1.15	2.19	0.12	0.05	0.17	0.06	0.06	0.12	0.00	0.00	0.00	0.04	1.22	1.29	2.51
2010	1.04	1.15	2.19	0.12	0.05	0.17	0.06	0.06	0.12	0.00	0.00	0.00	0.04	1.22	1.29	2.51
2011	0.85	1.10	1.95	0.11	0.04	0.15	0.05	0.06	0.11	0.00	0.00	0.00	0.03	1.01	1.24	2.24
2012	0.73	1.47	2.20	0.13	0.05	0.17	0.04	0.08	0.12	0.00	0.00	0.00	0.04	0.90	1.64	2.53
2013	0.73	1.47	2.20	0.13	0.05	0.17	0.04	0.08	0.12	0.00	0.00	0.00	0.04	0.90	1.64	2.53
2014	0.64	1.47	2.10	0.12	0.05	0.17	0.04	0.08	0.11	0.00	0.00	0.00	0.04	0.80	1.62	2.42
2015	4.86	4.75	9.61	0.54	0.20	0.74	0.27	0.25	0.52	0.00	0.00	0.00	0.16	5.67	5.36	11.03
2016	4.86	4.75	9.61	0.54	0.20	0.74	0.27	0.25	0.52	0.00	0.00	0.00	0.16	5.67	5.36	11.03
2017	7.23	10.84	18.06	1.03	0.39	1.41	0.41	0.56	0.97	0.00	0.00	0.00	0.31	8.67	12.09	20.76
2018	8.17	11.27	19.45	1.10	0.42	1.52	0.46	0.58	1.05	0.00	0.00	0.00	0.33	9.74	12.60	22.34
2019	7.82	11.05	18.87	1.07	0.40	1.47	0.44	0.57	1.02	0.00	0.00	0.00	0.32	9.33	12.35	21.68
2020	6.89	10.16	17.05	0.97	0.37	1.33	0.39	0.53	0.92	0.00	0.00	0.00	0.29	8.25	11.34	19.59
2021	6.89	10.16	17.05	0.97	0.37	1.33	0.39	0.53	0.92	0.00	0.00	0.00	0.29	8.25	11.34	19.59
2022	5.31	8.87	14.17	0.81	0.30	1.11	0.31	0.46	0.76	0.00	0.00	0.00	0.24	6.42	9.87	16.29
2023	5.31	8.87	14.17	0.81	0.30	1.11	0.31	0.46	0.76	0.00	0.00	0.00	0.24	6.42	9.87	16.29
2024	4.30	8.24	12.54	0.72	0.27	0.99	0.25	0.43	0.68	0.00	0.00	0.00	0.21	5.27	9.15	14.41
2025	3.33	7.35	10.69	0.61	0.23	0.85	0.20	0.38	0.58	0.00	0.00	0.00	0.18	4.14	8.15	12.29
Total	71.03	105.26	176.29	10.01	3.77	13.78	4.05	5.45	9.50	0.00	0.00	0.00	2.99	85.09	117.48	202.57

Table 112.5.6 Economic Cost and Benefit Stream and Evaluation Indices of Sewerage Projects in Master Plan

(Unit: Rs. Billion)

No.	Year	Cost: Capital Invest-ment	Cost: O&M	Cost: Replace-ment	Cost: Total	Benefit: Domestic Benefit	Benefit: Medical Benefit	Benefit: Non-domestic Benefit	Benefit: Saving of O&M Cost: Septic Tank	Benefit: Saving of O&M Cost: Existing Sewerage System	Benefit: Nega-tive Benefit	Benefit: Total	Balance
1	2008	3.97	0.02		3.99	0.23	0.07	0.03	0.02	0.00	0.04	0.31	-3.68
2	2009	2.51	0.02		2.53	0.25	0.07	0.03	0.02	0.00	0.00	0.38	-2.15
3	2010	2.51	0.02		2.53	0.28	0.07	0.03	0.02	0.00	0.00	0.41	-2.13
4	2011	4.44	0.04		4.48	0.53	0.25	0.22	0.05	0.01	0.09	0.98	-3.51
5	2012	2.53	0.11		2.65	0.57	0.27	0.28	0.06	0.02	0.01	1.19	-1.46
6	2013	2.53	0.13		2.66	0.61	0.29	0.34	0.06	0.02	0.01	1.31	-1.34
7	2014	3.19	0.19		3.38	1.26	0.50	0.40	0.10	0.05	0.11	2.21	-1.17
8	2015	11.03	0.26		11.29	1.42	0.72	0.46	0.15	0.08	0.07	2.76	-8.53
9	2016	11.03	0.28		11.31	1.59	0.77	0.52	0.16	0.08	0.07	3.05	-8.26
10	2017	22.43	0.53		22.96	2.21	1.24	0.80	0.25	0.17	0.25	4.43	-18.53
11	2018	22.34	0.67		23.01	2.48	1.45	1.09	0.30	0.23	0.11	5.43	-17.58
12	2019	21.68	0.82		22.50	3.14	1.66	1.37	0.34	0.29	0.11	6.68	-15.82
13	2020	19.59	1.19		20.78	3.56	2.20	1.65	0.45	0.42	0.28	8.00	-12.79
14	2021	19.59	1.38		20.97	3.99	2.46	1.93	0.50	0.50	0.14	9.24	-11.73
15	2022	16.29	1.59		17.88	4.60	2.78	2.25	0.57	0.64	0.17	10.68	-7.20
16	2023	16.29	1.82	1.00	19.10	5.20	3.09	2.57	0.63	0.78	0.16	12.11	-6.99
17	2024	14.41	2.05	1.00	17.46	5.86	3.43	2.89	0.70	0.94	0.18	13.64	-3.82
18	2025	12.29	2.27	1.00	15.55	6.54	3.76	3.21	0.77	1.10	0.18	15.22	-0.33
19	2026		2.27	0.78	3.04	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.35
20	2027		2.27	0.25	2.51	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.88
21	2028		2.27	0.25	2.51	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.88
22	2029		2.27	0.15	2.41	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.98
23	2030		2.27	4.74	7.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.39
24	2031		2.27	4.74	7.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.39
25	2032		2.27	5.58	7.85	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.55
26	2033		2.27	6.51	8.78	6.54	3.76	3.21	0.77	1.10	0.00	15.40	6.62
27	2034		2.27	6.28	8.55	6.54	3.76	3.21	0.77	1.10	0.00	15.40	6.85
28	2035		2.27	5.74	8.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.39
29	2036		2.27	5.74	8.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.39
30	2037		2.27	4.08	6.35	6.54	3.76	3.21	0.77	1.10	0.00	15.40	9.05
31	2038		2.27	6.07	8.34	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.06
32	2039		2.27	4.93	7.19	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.20
33	2040		2.27	3.89	6.16	6.54	3.76	3.21	0.77	1.10	0.00	15.40	9.24
34	2041		2.27	0.78	3.04	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.35
35	2042		2.27	0.24	2.51	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.89
36	2043		2.27	0.24	2.51	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.89
37	2044		2.27	0.14	2.41	6.54	3.76	3.21	0.77	1.10	0.00	15.40	12.99
38	2045		2.27	4.73	7.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.40
39	2046		2.27	4.73	7.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.40
40	2047		2.27	5.53	7.79	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.60
41	2048		2.27	6.46	8.72	6.54	3.76	3.21	0.77	1.10	0.00	15.40	6.67
42	2049		2.27	6.23	8.49	6.54	3.76	3.21	0.77	1.10	0.00	15.40	6.90
43	2050		2.27	5.74	8.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.39
44	2051		2.27	5.74	8.00	6.54	3.76	3.21	0.77	1.10	0.00	15.40	7.39
45	2052		2.27	4.14	6.40	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.99
46	2053		2.27	5.13	7.40	6.54	3.76	3.21	0.77	1.10	0.00	15.40	8.00
47	2054		2.27	3.99	6.25	6.54	3.76	3.21	0.77	1.10	0.00	15.40	9.14
48	2055		2.27	2.90	5.16	6.54	3.76	3.21	0.77	1.10	0.00	15.40	10.23

Remark: The existging fixed assets of sewerage systems were carried over into the proposed project as follows: Rs.1.46 billion of TP3 in economic value in 2008; Rs.2.20 billion of TP4 in 2011; and Rs.0.77 billion of TP1 in 2014 and Rs.1.67 billion of TP2 in 2017.

EIRR: 3.8%   NPV: -30.2 Billion Rupees   B/C: 0.56

(4) Evaluation of Proposed Sewerage Project Excluding Outer Three Towns

As discussed in the previous section, the proposed sewerage project is not viable from the economic point of view. One of the reasons of the negative viability, the capital investment and O&M costs for the outer three towns are considered to be too large as compared with the benefits in the existing inner towns. In this section, thus, a scheme of the proposed sewerage project excluding the outer three towns is evaluated in the same conditions and assumptions as done for the originally proposed sewerage project. Hereinafter, this case is named as “Case 2” of economic evaluation for the project without the outer three towns.

A) Economic Benefits of Case 2

The benefit of sewerage project is basically calculated as a product of sewage volume discharges or beneficiaries, and unit benefit. The unit benefit is already estimated in **Section 8.2.5-(1)-C)**. The number of beneficiaries in Case 2 is enumerated in **Table A111.3.7** of **Appendix A112.3**. The difference of this table from the original entire scheme is to exclude the beneficiaries in outer three towns. Based on the beneficiaries, the economic benefit of Case 2 is tabulated in **Table A111.3.8** of **Appendix A112.3** in detail. The benefits is summarised in **Table 112.5.7**. The economic benefit is estimated at Rs.0.31 billion in the beginning year 2008. In the target year 2025, it increases to Rs.11.98 billion.

Table 112.5.7 Summary of Economic Benefits of Sewerage Project (Case 2)

(Unit: Rs. Billion)

Year	Benefit of Imporved Environment		Medical	Elimination of Septic	Reduction of	Negative	Total
	Domestic	Non-domestic	Benefit	Tank	O&M Exp.	Benefit	
2008	0.23	0.03	0.07	0.02	0.00	0.04	0.31
2009	0.25	0.03	0.07	0.02	0.00	0.00	0.38
2010	0.28	0.03	0.07	0.02	0.00	0.00	0.41
2011	0.53	0.22	0.25	0.05	0.01	0.09	0.98
2012	0.57	0.28	0.27	0.06	0.02	0.01	1.19
2013	0.61	0.34	0.29	0.06	0.02	0.01	1.31
2014	1.26	0.40	0.50	0.10	0.05	0.11	2.21
2015	1.42	0.46	0.72	0.15	0.08	0.07	2.76
2016	1.59	0.52	0.77	0.16	0.08	0.07	3.05
2017	2.19	0.74	1.16	0.24	0.16	0.21	4.28
2018	2.50	0.95	1.30	0.27	0.20	0.07	5.15
2019	2.82	1.16	1.44	0.30	0.25	0.07	5.90
2020	3.14	1.37	1.91	0.39	0.36	0.24	6.93
2021	3.46	1.58	2.10	0.43	0.43	0.10	7.90
2022	3.89	1.79	2.31	0.47	0.53	0.11	8.88
2023	4.29	2.00	2.50	0.51	0.63	0.10	9.84
2024	4.76	2.21	2.73	0.56	0.75	0.12	10.89
2025	5.25	2.42	2.96	0.61	0.86	0.12	11.98

B) Economic Costs of Case 2

In the same manner, the economic costs are estimated in market value in **Chapter 10**. Since the estimate was enumerated in market prices, it must be converted into economic value applying the SCF, through the same procedure as mentioned previous sections. The economic costs are tabulated in **Table A112.3.9** of **Appendix A112.3** in detail. The economic investment costs is summarised in **Table 112.5.8**. The total cost is estimated at Rs.112.74 billion in economic value. The annual disbursement is estimated at Rs.2.51 billion in the beginning year 2008 and Rs.2.31 billion in economic value in the target year 2025.

The O&M cost of Case 2 is tabulated in **Table A112.3.10** of **Appendix A112.3**. It costs Rs.0.02 billion in economic value in the beginning year 2008 and increases to Rs.1.47 billion in the target year 2025. The annual figures of O&M cost are shown in **Table 112.5.9**.

Table 112.5.8 Summary of Economic Costs of Sewerage Project (Case 2)

(Unit: Rs. Billion)

	Direct Cost	Engineering	Physical Contingency	Administration	Total
2008	2.19	0.17	0.12	0.04	2.51
2009	2.19	0.17	0.12	0.04	2.51
2010	2.19	0.17	0.12	0.04	2.51
2011	1.95	0.15	0.11	0.03	2.24
2012	2.20	0.17	0.12	0.04	2.53
2013	2.20	0.17	0.12	0.04	2.53
2014	2.10	0.17	0.11	0.04	2.42
2015	9.61	0.74	0.52	0.16	11.03
2016	9.61	0.74	0.52	0.16	11.03
2017	9.38	0.73	0.51	0.16	10.78
2018	10.77	0.83	0.58	0.18	12.36
2019	10.19	0.79	0.55	0.17	11.70
2020	8.37	0.65	0.45	0.14	9.61
2021	8.37	0.65	0.45	0.14	9.61
2022	5.49	0.43	0.30	0.09	6.31
2023	5.49	0.43	0.30	0.09	6.31
2024	3.86	0.30	0.21	0.07	4.43
2025	2.01	0.16	0.11	0.03	2.31
Total	98.17	7.61	5.29	1.67	112.74

The replacement cost is also tabulated in **Table A112.3.11** of **Appendix A112.3**. It starts in 2023 as mentioned in **Section 11.2.5-(2)-C)**. It is estimated at Rs.1.00 billion in economic value in 2023. Afterwards, it continues consecutively during the economic life. The annual figures of replacement costs are also shown in **Table 112.5.9**.

C) Economic Evaluation of Case 2

Economic costs and benefits during the economic evaluation period are shown in **Table 112.5.9**. The evaluation indices were 6.8% of EIRR, minus Rs.14.5 billion of NPV and 0.69 of B/C, as shown in the table below. Then, the sewerage project (Case 2) is also not viable from the economic point of view, because it's the EIRR was still lower than the social discount rate, 12%. This EIRR becomes higher than that of the original case, so the economic prospect may be much improved as compared the original case. The EIRR, however, be still lower than 12%, so it would be very difficult unless the planning policy is radically amended in the service areas and/or implementation timing, and accepted by beneficiaries.

Item	EIRR (%)	NPV (Rs. Billion)	B/C
Evaluation Indices	6.8	-14.5	0.69

Table 112.5.9 Economic Cost and Benefit Stream and Evaluation Indices of Proposed Sewerage Project (Case 2) in Master Plan

(Unit: Rs. Billion)

No.	Year	Cost				Benefit							Balance
									Saving of O&M Cost				
		Capital Invest-ment	O&M	Replace -ment	Total	Domestic Benefit	Medical Benefit	Non-domestic Benefit	Septic Tank	Existing Sewerage System	Nega-tive Benefit	Total	
1	2008	3.97	0.02		3.99	0.23	0.07	0.03	0.02	0.00	0.04	0.31	-3.68
2	2009	2.51	0.02		2.53	0.25	0.07	0.03	0.02	0.00	0.00	0.38	-2.15
3	2010	2.51	0.02		2.53	0.28	0.07	0.03	0.02	0.00	0.00	0.41	-2.12
4	2011	4.44	0.04		4.48	0.53	0.25	0.22	0.05	0.01	0.09	0.98	-3.50
5	2012	2.53	0.10		2.63	0.57	0.27	0.28	0.06	0.02	0.01	1.19	-1.44
6	2013	2.53	0.11		2.65	0.61	0.29	0.34	0.06	0.02	0.01	1.31	-1.33
7	2014	3.19	0.17		3.36	1.26	0.50	0.40	0.10	0.05	0.11	2.21	-1.15
8	2015	11.03	0.24		11.27	1.42	0.72	0.46	0.15	0.08	0.07	2.76	-8.51
9	2016	11.03	0.25		11.28	1.59	0.77	0.52	0.16	0.08	0.07	3.05	-8.24
10	2017	12.45	0.41		12.86	2.19	1.16	0.74	0.24	0.16	0.21	4.28	-8.58
11	2018	12.36	0.48		12.84	2.50	1.30	0.95	0.27	0.20	0.07	5.15	-7.69
12	2019	11.70	0.56		12.26	2.82	1.44	1.16	0.30	0.25	0.07	5.90	-6.36
13	2020	9.61	0.84		10.45	3.14	1.91	1.37	0.39	0.36	0.24	6.93	-3.52
14	2021	9.61	0.95		10.56	3.46	2.10	1.58	0.43	0.43	0.10	7.90	-2.66
15	2022	6.31	1.07		7.38	3.89	2.31	1.79	0.47	0.53	0.11	8.88	1.50
16	2023	6.31	1.20	1.00	8.51	4.29	2.50	2.00	0.51	0.63	0.10	9.84	1.33
17	2024	4.43	1.34	1.00	6.77	4.76	2.73	2.21	0.56	0.75	0.12	10.89	4.12
18	2025	2.31	1.47	1.00	4.77	5.25	2.96	2.42	0.61	0.86	0.12	11.98	7.21
19	2026		1.47	0.78	2.24	5.25	2.96	2.42	0.61	0.86	0.00	12.10	9.86
20	2027		1.47	0.25	1.72	5.25	2.96	2.42	0.61	0.86	0.00	12.10	10.39
21	2028		1.47	0.25	1.72	5.25	2.96	2.42	0.61	0.86	0.00	12.10	10.39
22	2029		1.47	0.15	1.61	5.25	2.96	2.42	0.61	0.86	0.00	12.10	10.49
23	2030		1.47	4.74	6.21	5.25	2.96	2.42	0.61	0.86	0.00	12.10	5.90
24	2031		1.47	4.74	6.21	5.25	2.96	2.42	0.61	0.86	0.00	12.10	5.90
25	2032		1.47	3.85	5.32	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.79
26	2033		1.47	4.78	6.24	5.25	2.96	2.42	0.61	0.86	0.00	12.10	5.86
27	2034		1.47	4.55	6.02	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.09
28	2035		1.47	4.00	5.47	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.63
29	2036		1.47	4.00	5.47	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.63
30	2037		1.47	2.35	3.81	5.25	2.96	2.42	0.61	0.86	0.00	12.10	8.29
31	2038		1.47	4.34	5.80	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.30
32	2039		1.47	3.19	4.66	5.25	2.96	2.42	0.61	0.86	0.00	12.10	7.44
33	2040		1.47	2.16	3.62	5.25	2.96	2.42	0.61	0.86	0.00	12.10	8.48
34	2041		1.47	0.78	2.24	5.25	2.96	2.42	0.61	0.86	0.00	12.10	9.86
35	2042		1.47	0.24	1.71	5.25	2.96	2.42	0.61	0.86	0.00	12.10	10.39
36	2043		1.47	0.24	1.71	5.25	2.96	2.42	0.61	0.86	0.00	12.10	10.39
37	2044		1.47	0.14	1.61	5.25	2.96	2.42	0.61	0.86	0.00	12.10	10.49
38	2045		1.47	4.73	6.20	5.25	2.96	2.42	0.61	0.86	0.00	12.10	5.90
39	2046		1.47	4.73	6.20	5.25	2.96	2.42	0.61	0.86	0.00	12.10	5.90
40	2047		1.47	3.79	5.26	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.84
41	2048		1.47	4.72	6.19	5.25	2.96	2.42	0.61	0.86	0.00	12.10	5.91
42	2049		1.47	4.49	5.96	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.14
43	2050		1.47	4.00	5.47	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.63
44	2051		1.47	4.00	5.47	5.25	2.96	2.42	0.61	0.86	0.00	12.10	6.63
45	2052		1.47	2.40	3.87	5.25	2.96	2.42	0.61	0.86	0.00	12.10	8.23
46	2053		1.47	3.40	4.87	5.25	2.96	2.42	0.61	0.86	0.00	12.10	7.24
47	2054		1.47	2.25	3.72	5.25	2.96	2.42	0.61	0.86	0.00	12.10	8.38
48	2055		1.47	1.16	2.63	5.25	2.96	2.42	0.61	0.86	0.00	12.10	9.47

Remark: The existging fixed assets of sewerage systems were carried over into the proposed project as follows:
Rs.1.46 billion of TP3 in economic value in 2008; Rs.2.20 billion of TP4 in 2011; and Rs.0.77 billion of TP1 in 2014 and Rs.1.67 billion of TP2 in 2017.

EIRR: 6.8% **NPV: -14.5 Billion Rupees** **B/C: 0.69**

11.2.6 Integrated Project

In the previous sections, the respective infrastructure projects of water supply and sewerage systems in the master plan were evaluated individually from the economic point of view. These projects are inseparably related to each other in general. It is a known fact that KW&SB has managed these systems together for long time. Hence, the projects of water supply and sewerage systems are evaluated in combination with these systems as an integrated project in this section.

The criteria and preconditions are completely the same as set in **Section 11.2.3** even in this evaluation. The specification of the respective project schemes is also the same as discussed in the respective sections. Thus, details of these backgrounds are referred to the sections related in the previous parts. In this section, the results of evaluation factors are provided together with the cost and benefit stream.

(1) Evaluation of Integrated Project (Case 1)

In the sewerage project, two cases were discussed: (i) the project covering entire areas of Karachi City (Case 1) and (ii) the project excluding the outer three towns (Case 2). In this part, the integrated project of Case 1 is evaluated from the economic viewpoint.

Table 112.6.1 shows an economic cost and benefit stream of Case 1. The cost and benefit in the respective years consist of those of water supply and sewerage systems. Their detail figures of cost and benefit are shown in **Table 112.4.15** and **Table 112.5.6**, respectively. As shown in the table, the mature benefit of water supply service in 2025 attains to Rs.80 billion per annum. On the other hand, that of sewerage service in the same year is only Rs.15 billion, accounting for less than 20% of water supply. The total investment costs in economic value were Rs.237 billion of water supply and Rs.203 billion of sewerage. The sewerage cost accounted for 85% of the water supply cost. This is a main reason of the opposite economic viability between the two systems.

As shown in the table, however, EIRR of the integrated project is 13.3%. Other indices were minus Rs.21.8 billion of NPV and 1.11 of B/C. Thus, the Case 1 project is viable from the economic point of view, because its EIRR exceeded the social discount rate of 12%, owing to the good economic efficiency of the water supply system.

(2) Evaluation of Integrated Project (Case 2)

Table 112.6.2 shows an economic cost and benefit stream of Case 2. Their detail figures of cost and benefit are shown in **Table 112.4.15** and **Table 112.5.9** respectively. The mature benefit of water supply service in 2025 attains to Rs.80 billion, as mentioned in the paragraph above. On the other hand, that of sewerage service in the same year is Rs.12 billion, accounting for only 15% of water supply. The total investment costs in economic value were Rs.237 billion of water supply and Rs.112 billion of sewerage. Unlike Case 1, the sewerage cost decreased to nearly 47% of the water supply cost.

As shown in the table, EIRR of the integrated project is 14.2%. Other indices were Rs.37.5 billion of NPV and 1.21 of B/C. Thus, the Case 2 is considered as quite viable from the economic point of view, because its EIRR considerably exceeds the social discount rate, 12%. This result suggests that the integrated project of Case 2 would be economically feasible, provided that internal cross subsidisation between water supply and sewerage services is approved by the society.

Table 112.6.1 Economic Cost and Benefit Stream and Evaluation Indices of Integrated Project (Case 1) in Master Plan

(Unit: Rs. Billion)

No.	Year	Cost: Capital Investment	Cost: O&M	Cost: Replace-ment	Cost: Total	Benefit: Water Benefit	Benefit: Sewerage Benefit	Benefit: Negative Benefit	Benefit: Total	Balance
1	2008	5.82	0.02		5.84	0.00	0.35	0.04	0.31	-5.53
2	2009	21.46	0.02		21.48	0.00	0.38	0.00	0.38	-21.10
3	2010	21.49	0.02		21.51	0.00	0.41	0.00	0.41	-21.11
4	2011	23.86	0.04		23.90	0.00	1.07	0.09	0.98	-22.92
5	2012	33.83	0.61		34.43	6.16	1.20	9.60	-2.23	-36.67
6	2013	8.98	0.85		9.83	10.00	1.32	5.35	5.97	-3.86
7	2014	26.28	1.14		27.41	14.43	2.32	5.71	11.04	-16.38
8	2015	34.48	1.47		35.95	19.57	2.83	6.50	15.90	-20.05
9	2016	34.55	1.72		36.27	24.96	3.12	6.82	21.25	-15.02
10	2017	28.56	2.61		31.17	29.67	4.67	4.93	29.42	-1.75
11	2018	31.97	3.23		35.20	37.58	5.54	9.57	33.55	-1.65
12	2019	39.34	3.78		43.11	44.38	6.80	7.02	44.15	1.04
13	2020	36.08	4.42		40.49	49.55	8.28	4.25	53.57	13.08
14	2021	36.14	4.79		40.93	54.94	9.38	4.19	60.13	19.20
15	2022	21.52	5.58		27.09	59.56	10.85	2.75	67.65	40.56
16	2023	24.50	6.16	1.00	31.65	65.95	12.27	4.90	73.33	41.67
17	2024	22.71	6.76	6.38	35.85	72.75	13.82	5.21	81.36	45.51
18	2025	20.65	7.36	6.38	34.39	79.97	15.40	5.50	89.86	55.47
19	2026		7.36	9.57	16.93	79.97	15.40	0.00	95.36	78.44
20	2027		7.36	3.48	10.84	79.97	15.40	0.00	95.36	84.53
21	2028		7.36	3.72	11.07	79.97	15.40	0.00	95.36	84.29
22	2029		7.36	7.69	15.05	79.97	15.40	0.00	95.36	80.32
23	2030		7.36	12.18	19.54	79.97	15.40	0.00	95.36	75.83
24	2031		7.36	12.20	19.56	79.97	15.40	0.00	95.36	75.81
25	2032		7.36	8.83	16.19	79.97	15.40	0.00	95.36	79.17
26	2033		7.36	9.96	17.31	79.97	15.40	0.00	95.36	78.05
27	2034		7.36	13.67	21.03	79.97	15.40	0.00	95.36	74.33
28	2035		7.36	13.15	20.51	79.97	15.40	0.00	95.36	74.85
29	2036		7.36	12.87	20.23	79.97	15.40	0.00	95.36	75.14
30	2037		7.36	7.31	14.67	79.97	15.40	0.00	95.36	80.69
31	2038		7.36	9.54	16.90	79.97	15.40	0.00	95.36	78.47
32	2039		7.36	13.85	21.21	79.97	15.40	0.00	95.36	74.15
33	2040		7.36	12.71	20.07	79.97	15.40	0.00	95.36	75.29
34	2041		7.36	9.62	16.98	79.97	15.40	0.00	95.36	78.39
35	2042		7.36	3.49	10.85	79.97	15.40	0.00	95.36	84.51
36	2043		7.36	3.69	11.05	79.97	15.40	0.00	95.36	84.32
37	2044		7.36	7.80	15.16	79.97	15.40	0.00	95.36	80.20
38	2045		7.36	12.42	19.78	79.97	15.40	0.00	95.36	75.59
39	2046		7.36	12.15	19.51	79.97	15.40	0.00	95.36	75.86
40	2047		7.36	8.76	16.12	79.97	15.40	0.00	95.36	79.25
41	2048		7.36	9.92	17.28	79.97	15.40	0.00	95.36	78.09
42	2049		7.36	13.50	20.86	79.97	15.40	0.00	95.36	74.51
43	2050		7.36	12.91	20.27	79.97	15.40	0.00	95.36	75.10
44	2051		7.36	12.92	20.28	79.97	15.40	0.00	95.36	75.09
45	2052		7.36	7.39	14.74	79.97	15.40	0.00	95.36	80.62
46	2053		7.36	8.58	15.94	79.97	15.40	0.00	95.36	79.43
47	2054		7.36	13.03	20.39	79.97	15.40	0.00	95.36	74.97
48	2055		7.36	11.96	19.32	79.97	15.40	0.00	95.36	76.05

Remark: (1) In 2008, the existing fixed assets of water supply system were carried over into the proposed project, which were assessed as Rs. 0.6 billion as book value.

(2) The existging fixed assets of sewerage systems were carried over into the proposed project as follows: Rs.1.46 billion of TP3 in economic value; Rs.2.20 billion of TP4 in 2011; and Rs.0.80 billion of TP1 and Rs.1.58 billion of TP2 in 2015.

EIRR: 13.3% **NPV: 21.8 Billion Rupees** **B/C: 1.11**

Table 112.6.2 Economic Cost and Benefit Stream and Evaluation Indices of Integrated Projects (Case 2) in Master Plan

(Unit: Rs. Billion)

No.	Year	Cost				Benefit				Balance
		Capital Investment	O&M	Replace-ment	Total	Water Benefit	Sewerage Benefit	Negative Benefit	Total	
1	2008	5.82	0.02		5.84	0.00	0.35	0.04	0.31	-5.53
2	2009	21.46	0.02		21.48	0.00	0.38	0.00	0.38	-21.10
3	2010	21.49	0.02		21.51	0.00	0.41	0.00	0.41	-21.10
4	2011	23.86	0.04		23.90	0.00	1.07	0.09	0.98	-22.92
5	2012	33.83	0.59		34.42	6.16	1.20	9.60	-2.23	-36.66
6	2013	8.98	0.83		9.81	10.00	1.32	5.35	5.97	-3.84
7	2014	26.28	1.12		27.40	14.43	2.32	5.71	11.04	-16.36
8	2015	34.48	1.45		35.93	19.57	2.83	6.50	15.90	-20.03
9	2016	34.56	1.69		36.25	24.96	3.12	6.82	21.25	-14.99
10	2017	18.57	2.49		21.07	29.67	4.49	4.89	29.27	8.20
11	2018	21.99	3.04		25.03	37.58	5.23	9.53	33.28	8.25
12	2019	29.35	3.51		32.87	44.38	5.97	6.98	43.36	10.49
13	2020	26.09	4.07		30.16	49.55	7.18	4.21	52.51	22.35
14	2021	26.16	4.36		30.52	54.94	8.00	4.15	58.78	28.26
15	2022	11.53	5.06		16.59	59.56	8.99	2.69	65.86	49.27
16	2023	14.52	5.54	1.00	21.06	65.95	9.94	4.84	71.05	49.99
17	2024	12.73	6.05	6.38	25.16	72.75	11.01	5.15	78.60	53.45
18	2025	10.67	6.56	6.38	23.61	79.97	12.10	5.45	86.63	63.02
19	2026		6.56	9.57	16.13	79.97	12.10	0.00	92.07	75.94
20	2027		6.56	3.48	10.04	79.97	12.10	0.00	92.07	82.03
21	2028		6.56	3.72	10.28	79.97	12.10	0.00	92.07	81.80
22	2029		6.56	7.69	14.25	79.97	12.10	0.00	92.07	77.82
23	2030		6.56	12.18	18.74	79.97	12.10	0.00	92.07	73.33
24	2031		6.56	12.20	18.76	79.97	12.10	0.00	92.07	73.31
25	2032		6.56	7.10	13.66	79.97	12.10	0.00	92.07	78.41
26	2033		6.56	8.22	14.78	79.97	12.10	0.00	92.07	77.29
27	2034		6.56	11.94	18.50	79.97	12.10	0.00	92.07	73.57
28	2035		6.56	11.42	17.98	79.97	12.10	0.00	92.07	74.09
29	2036		6.56	11.14	17.70	79.97	12.10	0.00	92.07	74.38
30	2037		6.56	5.58	12.14	79.97	12.10	0.00	92.07	79.94
31	2038		6.56	7.80	14.36	79.97	12.10	0.00	92.07	77.71
32	2039		6.56	12.12	18.68	79.97	12.10	0.00	92.07	73.39
33	2040		6.56	10.98	17.54	79.97	12.10	0.00	92.07	74.53
34	2041		6.56	9.62	16.18	79.97	12.10	0.00	92.07	75.89
35	2042		6.56	3.49	10.05	79.97	12.10	0.00	92.07	82.02
36	2043		6.56	3.69	10.25	79.97	12.10	0.00	92.07	81.82
37	2044		6.56	7.80	14.37	79.97	12.10	0.00	92.07	77.71
38	2045		6.56	12.42	18.98	79.97	12.10	0.00	92.07	73.09
39	2046		6.56	12.15	18.71	79.97	12.10	0.00	92.07	73.36
40	2047		6.56	7.02	13.58	79.97	12.10	0.00	92.07	78.49
41	2048		6.56	8.19	14.75	79.97	12.10	0.00	92.07	77.33
42	2049		6.56	11.76	18.32	79.97	12.10	0.00	92.07	73.75
43	2050		6.56	11.17	17.73	79.97	12.10	0.00	92.07	74.34
44	2051		6.56	11.18	17.74	79.97	12.10	0.00	92.07	74.33
45	2052		6.56	5.65	12.21	79.97	12.10	0.00	92.07	79.86
46	2053		6.56	6.84	13.40	79.97	12.10	0.00	92.07	78.67
47	2054		6.56	11.30	17.86	79.97	12.10	0.00	92.07	74.21
48	2055		6.56	10.23	16.79	79.97	12.10	0.00	92.07	75.29

Remark: (1) In 2008, the existing fixed assets of water supply system were carried over into the proposed project, which were assessed as Rs. 0.6 billion as book value.

(2) The existging fixed assets of sewerage systems were carried over into the proposed project as follows: Rs.1.46 billion of TP3 in economic value; Rs.2.20 billion of TP4 in 2011; and Rs.0.80 billion of TP1 and Rs.1.58 billion of TP2 in 2015.

EIRR: 14.2% **NPV: 37.5 Billion Rupees** **B/C: 1.21**

11.3 SELECTION OF PRIORITY PROJECTS

11.3.1 Identification of Priority Projects

The existing water distribution network has many problems which combined have resulted in the current low quality of the service in Karachi. Many residents have a very negative impression of KW&SB and the service it provides and are therefore reluctant to pay water charges. As a result, KW&SB faces a very low level of revenue collection and severe financial constraints. It is expected that Distribution Network Improvements (DNI) will be able to address those problems efficiently and effectively and thereby substantially improve the current situation. It is also expected that, with the introduction of a 'dual pricing structure' as discussed in **Section 7.2.4**, it will be possible to implement DNI on a financially sustainable basis while minimizing negative social impacts and potential wastage and misuse of water by residents at the same time. All these considerations led to a conclusion that DNI should be selected as the 'Priority Project' and given a high priority for implementation.

In the past, large capital investment works were implemented mostly for the purpose of developing large bulk supply schemes to bring water from distant water sources to Karachi. This has created a huge backlog of network replacement, reinforcement and extension in the water distribution system. As a result, many water distribution pipes in the system have already been undersized and deteriorated, and the current levels of leakage and non-revenue water in the distribution system are unacceptably high. In most parts of the urban areas, residents are obliged to spend money on ground-level water reservoirs, suction/booster pumps, roof-top storage tanks, and water filters, and even then water must be boiled prior to drinking. While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonably high. Many households are compelled to use secondary sources of water such as shallow wells or tanker supplies just to meet their basic needs. Where tanker supplies are unaffordable, people have no option but to use untreated subsoil water or go to the river to bathe or wash their clothes. The expense of not having an adequate supply of potable water is compounded by the inevitable medical bills resulting from the treatment of water-borne diseases (typhoid, cholera, and hepatitis are common) and the loss of income due to sick time.

It is only if customers are satisfied with the quality of the service they receive that they find themselves willing to pay for the service. The water awareness survey conducted as part of the JICA study indicated that many households were willing to pay higher charges for a reliable supply of good quality water. With regard to the actual supply of water, the clear targets for the improved quality of the service can be summarized as follows:

- satisfy the customers' water demands so that they no longer need to utilize secondary sources (such as shallow wells and tanker supplies)
- water should be of a potable standard (this would make filtering and boiling of water unnecessary) and be aesthetically pleasing
- water should be supplied at an adequate pressure (this would make the use of suction/booster pumps and roof-top storage tanks unnecessary)
- water should be available on a 24-hour continuous basis to keep the supply system always full of water and under pressure to avoid both contamination and excessive air entrainment (this would make the use of ground-level water reservoirs unnecessary)

It is anticipated that DNI will be able to attain these improvements efficiently and effectively. DNI will embrace the rehabilitation of water trunk mains, trunk distribution mains and distribution network mains, and the refurbishment of service connections including installation of retail supply metres. Where necessary, it will also include improvements to the existing sewerage system. In addition, DNI will also have efficient systems with regard to:

- Developing/maintaining GIS-based accurate customer/asset databases
- Metre reading;

- Metre installation/replacement/repair/calibration;
- Billing based on metre reading;
- Bill collection;
- Receiving customer complaints and feedback and responding accordingly;
- Install new service connections;
- Minimizing leakage and wastage;
- Removing/regularizing illegal/unauthorized connections;
- Increasing awareness on water conservation;
- Record keeping and data collection; and
- Liaison with other utility service authorities.

11.3.2 Location of Priority Projects

Given the immense size of the city and the current poor conditions of the existing distribution network, it would require huge investments and more than 10 years of timeframe to complete DNI across all urban areas of Karachi. DNI therefore can only be implemented on an area-by-area basis in a progressive way. With respect to the institutional reform, the JICA Study proposes that Karachi should be divided into three independent retail service zones by the Lyari and Malir Rivers (see **Figure 91.6.1**), and that in the long run the responsibilities for providing retail services (water supply and sewerage services) should gradually be transferred from KW&SB to 'corporatised' retail entities on a zone-by-zone basis as shown in **Figure 91.6.2**. It is also suggested that the first stage of this reform process will take place in Zone West in early 2011, and that the new Zone West retail entity will implement DNI in Zone West.

In determining the zonal sequence in which the reform would be implemented, two options were evaluated. The first option is to proceed from Zone West through Zone Central to Zone East. The second option is just the reverse of the first option. It is to proceed from Zone East through Zone Central to Zone West. Any options starting from Zone Central were considered inappropriate. It was because of our assessment that DNI would be most difficult to implement in Zone Central and hence it would be unwise to start it from this zone.

There are a large number of bulk customers in Zone East, which include the Pakistan Steel Mill, Port Qasim Authority, and Korangi and Landhi Industrial Estates. As such, Zone East has served as a strong revenue base for KW&SB. In order to avoid any further deterioration of the KW&SB's already weak financial position, it was decided that the responsibility for providing retail services in Zone East should remain with KW&SB until the last stage of the reform. As a result of these evaluations, the first option (as shown in **Figure 91.6.2**) was finally adopted.

Zone West encompasses a number of Towns. They are New Karachi, North Nazimabad, Gulberg, Liaquatabad, S.I.T.E., Orangi, Baldia, Keamari and Gadap. With the exception of Keamari and Gadap, other towns are fully developed urban areas. The JICA Study selected three towns, namely North Nazimabad, Gulberg and Liaquatabad, as the 'priority towns' where DNI should be implemented on a priority basis. This selection was made based on the following criteria.

(1) Towns where a stable supply can be maintained

One of the key objectives of DNI is to provide a 24-hour continuous supply at an adequate pressure. The results of our water distribution analysis for Zone West have suggested that Orangi, Baldia and S.I.T.E. should be supplied from the Hub Filtration Plant, while Gadap, New Karachi, North Nazimabad, Gulberg and Liaquatabad from the NEK Old Filtration Plant and Keamari from COD Filtration Plant. The analysis also indicated that a sufficient head is available between the NEK Old Filtration Plant and the three towns, namely North Nazimabad, Gulberg and Liaquatabad, and that water from the filtration plant can therefore gravitate across all areas of these three towns at an adequate pressure. Gadap and New Karachi were excluded from the 'priority towns' because of their relatively high altitudes. It is recommended that DNI in these two towns should be delayed until completion of a new K-IV water filtration plant (130 mgd) which is proposed to be constructed at a higher elevation to the north of the NEK Old.

A new 100 mgd water filtration plant is proposed to be constructed at the NEK Old under the first tranche of the ADB's US$ 800 million loan. This will increase the total filtration capacity of the plant to 125 mgd which is sufficient to meet the total water demand of the five towns, namely Gadap, New Karachi, North Nazimabad, Gulberg and Liaquatabad until 2016. It was judged from the foregoing assessments that the 'priority towns' would be able to receive a stable supply once DNI is completed in these towns.

(2) Towns where 'Ability to Pay' of residents is high

The residents of the three 'priority towns' have a relatively high 'ability to pay' as compared with the residents of other towns in Zone West. As such, it is expected that they would agree to pay a water charge that is some multiple of the current level of water charges once they receive an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis. This is necessary: (a) to generate the revenues in the short or medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods.

Figure 113.2.1 shows the location of the three 'priority towns'. **Table 113.2.1** provides some basic features of these towns. The total population in the three towns was approximately 2.4 million in 2005 which was equivalent to 15.8% of the total municipal population in Karachi (15.2 million) or 38% of the total population in Zone West (6.4 million) in the same year.

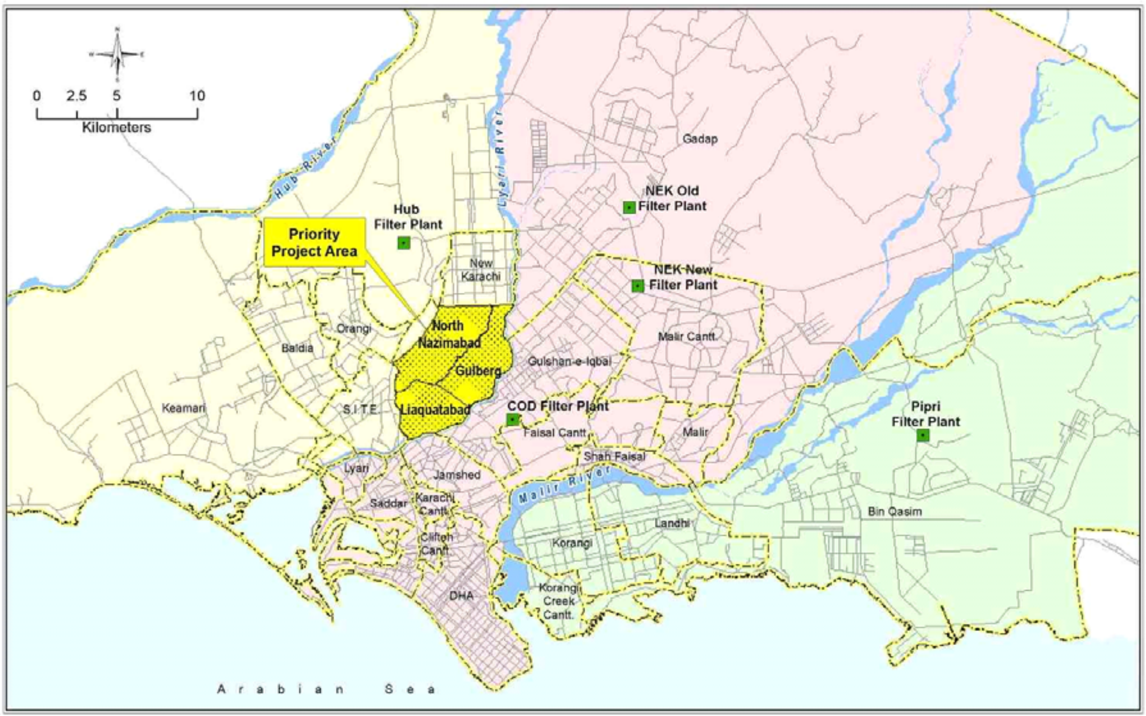


Figure 113.2.1 Location of Priority Project Area

Table 113.2.1 Basic Features of Three 'Priority Towns'

Town	Area		Population				
	acre*	km^2	2005*	2010	2015	2020*	2025
North Nazimabad	4,127	17	753,423	815,407	889,328	979,450	1,069,572
Gulberg	3,417	14	688,581	745,229	812,788	895,154	977,520
Liaquatabad	2,685	11	985,577	999,095	1,015,211	1,034,860	1,054,509
Total	10,229	42	2,427,581	2,561,741	2,719,342	2,911,484	3,103,626

Source: Figures with *- Karachi Strategic Development Plan 2020 (Final Report, August 2007); other figures-JICA Study Team

CHAPTER 12

FEASIBILITY STUDY

12 FEASIBILITY STUDY

12.1 SCOPE AND FRAMEWORK OF PRIORITY PROJECTS

12.1.1 Water Supply Projects

(1) Components of Priority Project

Distribution Network Improvement (DNI) for the three towns in Zone West (i.e. North Nazimabad, Gulberg and Liaquatabad) was selected as the priority project of water supply in this JICA Study from technical, economical, financial and institutional points of view as described in the previous chapter. The scale of the water supply priority project was set based on the overall schedule of DNI for the whole Karachi City prepared in the stage of Master Plan, water demand, supply capacity and bulk water availability related to K-IV project. The selected priority project includes not only DNI for the three towns but also components for stably and safely conveying filtered water from NEK Old Filtration Plant (F/P) to these three towns as shown in **Figure 121.1.1** and described below:

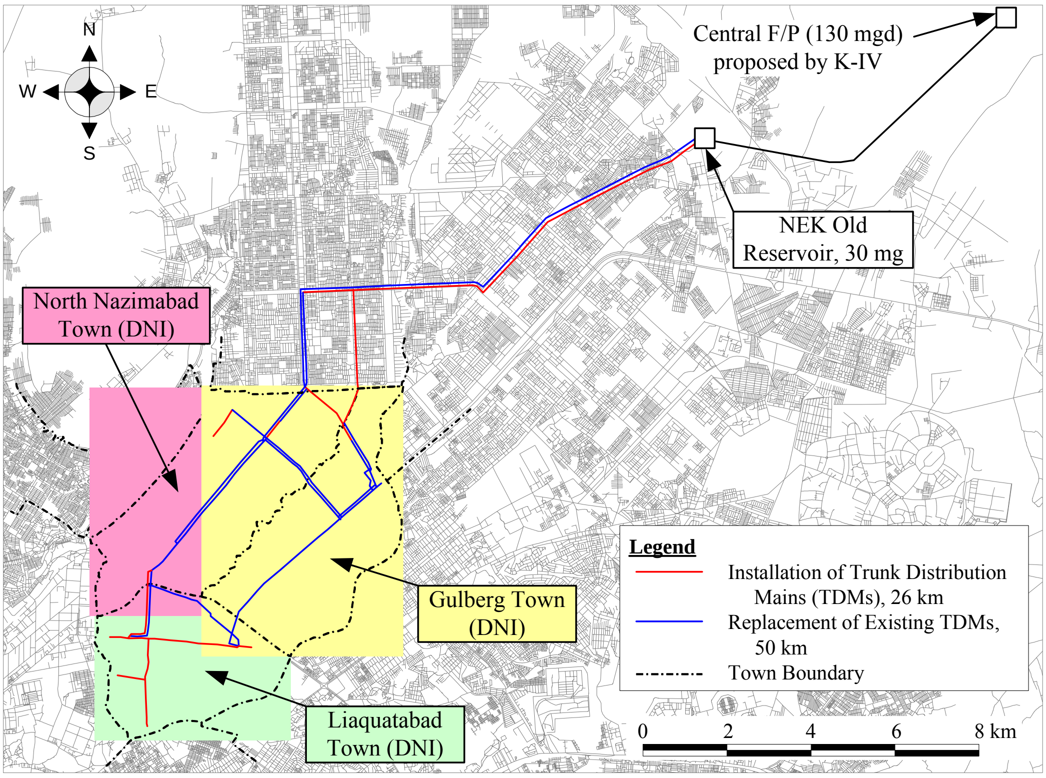


Figure 121.1.1 Components of the Water Supply Priority Project

- Replacement of all the existing distribution network mains in the three towns (about 1,000 km in total length)
- Rehabilitation/replacement of all the existing service pipes branched from the distribution network mains in the three towns (about 230,000 connections in total)

- Installation of individual flow metres at all the existing service connections in the three towns (about 230,000 connections in total)
- Replacement of about 50 km of essential existing trunk distribution mains for supplying water to the three towns (blue lines in **Figure 121.1.1**)
- Installation of about 26 km of new trunk distribution mains (red lines in **Figure 121.1.1**)
- Installation of 17 district flow metres
- Expansion of the existing NEK Old Reservoir (30 mg)

In addition to the above components, it is a precondition for the implementation of the priority project to complete the first phase of K-IV project by the year 2011 successfully. KW&SB should also rehabilitate or replace the existing trunk distribution mains other than those included in the priority project. KW&SB should also execute leakage control before, during and after the DNI in the priority project.

(2) Conditions for Feasibility Study

1) Water Supply System in 2016 for Zone West

The balance between water demand and supply capacity in Zone West is shown in **Table 121.1.1**.

Table 121.1.1 Water Balance of Each Zone

Target Year	2006	2011	2016	2021	2025
A. Supply Capacity (mgd)	75	75	75	205	335
B. Water Demand* (mgd)	191	222	264	310	346
C. Balance (B-A) (mgd)	-116	-147	-189	-105	-11

*: including water supply of 5 mgd to Barochistan Province

In 2016, which is the target year of this feasibility study, Zone West has only one filtration plant which is Hub F/P (75 mgd). Although the water demand of Zone West will be 264 mgd in 2016, the existing Hub F/P of 75 mgd will still be the only filtration plant at that time within Zone West. Therefore, it was planned to partially cover the remaining demand of 189 mgd by supplying water from Zone Central as shown in **Figure 121.1.2**.

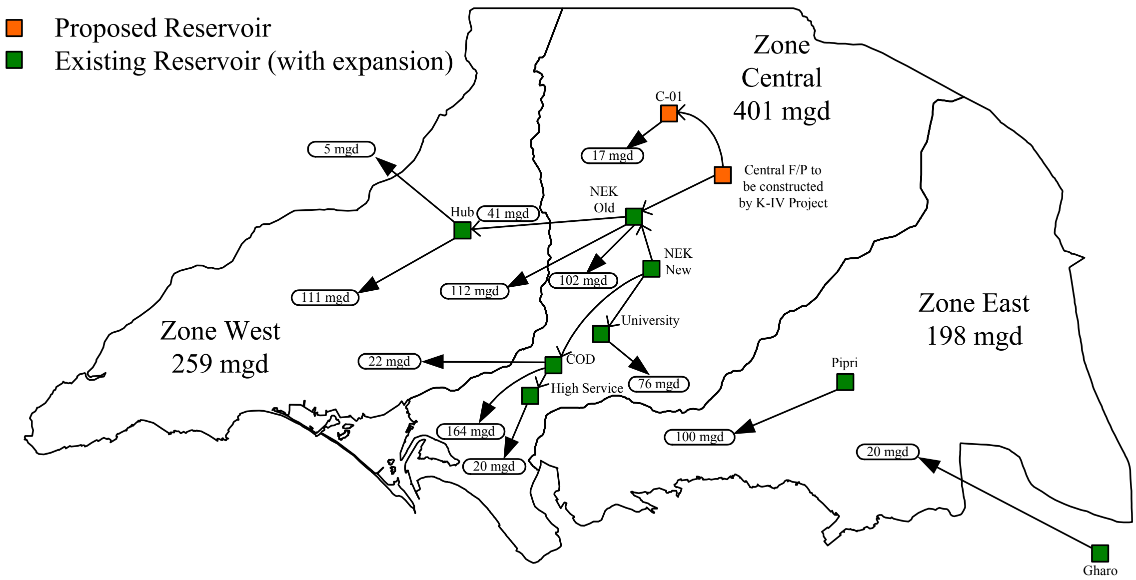


Figure 121.1.2 Schematic Diagram of the Distribution System in 2016

K-IV project includes the construction of a new filtration plant (Central F/P) at the central area of Gadap Town as shown in **Figure 121.1.2**. After the completion of constructing Central F/P in 2011 filtered water should be supplied or transferred to certain areas or reservoirs without delay. JICA Study proposed in the water supply master plan to covey treated water from Central F/P to the reservoir at NEK Old F/P by gravity and to supply water to areas around the F/P through new transmission system. Therefore, KW&SB should provide the filtered water transmission mains from new Central F/P to the reservoir at NEK Old F/P in order to start supplying the water filtered in Central F/P immediately after the completion of the first phase of K-IV project. KW&SB also has another plan of constructing a new F/P of 100 mgd at the same location of NEK Old F/P as part of K-III System by ADB loan. The schematic diagram of the future development around the existing NEK Old F/P is shown in **Figure 121.1.3**.

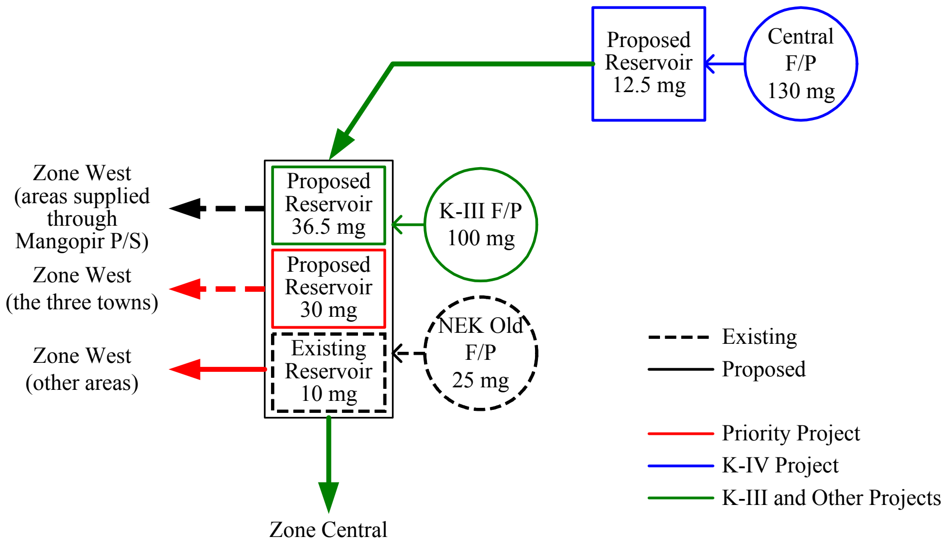


Figure 121.1.3 Schematic Diagram of Future Development around Existing NEK Old F/P

2) Target Area of the Priority Project

The priority project consists of above-mentioned components for supplying water to the three towns of North Nazimabad, Gulberg and Liaquatabad. The current and future populations of the three towns are shown in **Table 121.1.2**.

Table 121.1.2 Population Growth of North Nazimabad, Gulberg and Liaquatabad

Name of Town	Population				
	2006	2011	2016	2021	2025
North Nazimabad	765,820	830,191	907,352	997,474	1,069,572
Gulberg	699,910	758,741	829,261	911,627	977,520
Liaquatabad	988,284	1,002,318	1,019,141	1,038,790	1,054,509
Total	2,454,014	2,591,250	2,755,754	2,947,891	3,101,601

The existing water supply system supplies water mainly from NEK Old F/P to North Nazimabad and Gulberg and from COD F/P to Liaquatabad, respectively. It is recommended to integrate the existing water supply facilities of the three towns into one water supply system connected from NEK Old by 2016.

3) Water Demand of the Three Towns

As discussed in **Chapter 6 Water Demand Forecast**, the future water demand for the three towns is estimated as shown in **Table 121.1.3**.

Table 121.1.3 Water Demand of North Nazimabad, Gulberg and Liaquatabad

Name of Town	Water Demand (mgd)				
	2006	2011	2016	2021	2025
North Nazimabad	24.65	26.34	28.71	32.13	35.03
Gulberg	21.61	23.47	25.83	28.88	31.48
Liaquatabad	30.06	29.43	29.42	30.53	31.51
Total	76.32	79.24	83.96	91.54	98.02

The water demand of Liaquatabad Town was estimated to decrease from 30.06 in 2006 to 29.42 mgd in 2016. This is because the reduction of leakage in Liaquatabad is expected to exceed the water demand increase due to the population increase trend in the same town. Liaquatabad is already densly-populated so that its population increase will be limited.

4) Water Distribution System within the Three Towns

Figure 121.1.4 shows trunk distribution mains required in 2016 for the three towns. In addition to the trunk distribution mains to be installed or replaced in the priority project shown in **Figure 121.1.1**, the water distribution system in 2016 for the three towns will also utilise other existing trunk distribution mains shown as black lines in **Figure 121.1.4**. KW&SB should rehabilitate or replace the other existing trunk distribution mains to secure the full capacity of the distribution system for accommodating the future water demand increase in the three towns.

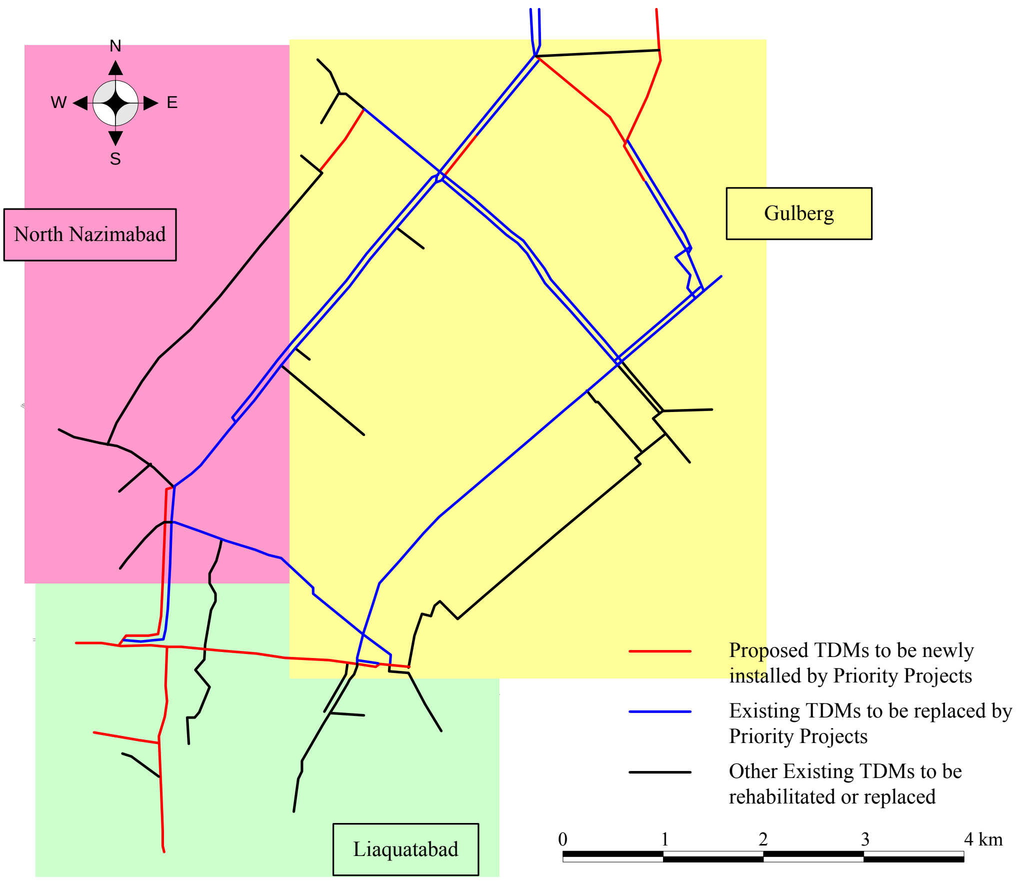


Figure 121.1.4 Distribution System for the Three Towns

The proposed water distribution system of trunk distribution mains was analysed under the following conditions:

a. Formula for friction loss calculation	: Hazen-Williams Formula
b. Hazen-Williams Coefficients (C Value)	: 110 for trunk distribution mains
c. Hourly peak factor	: 1.5

The distribution network system consists of not only trunk distribution mains but also distribution network mains as shown in **Figure 121.1.5**. Details of the proposed trunk distribution mains forming the distribution blocks of the distribution network are explained in **Appendix A123.1**. Distribution network mains usually reach roads and streets around the households of customers.

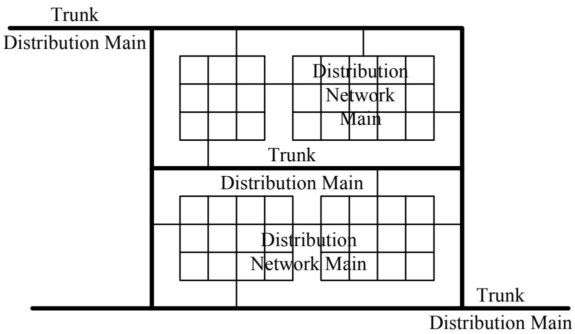


Figure 121.1.5 Trunk Distribution Mains and Distribution Network Mains

5) Distribution Reservoir

Distribution reservoirs should have enough capacity to cope with water demand fluctuation in a day. In general, peaks in water demand appear in the morning, at noon and in the evening. However, hourly demand fluctuation is difficult to accurately quantify because the metreing system does not exist in the current system. Based on engineering experiences, the capacity of distribution reservoir is proposed to be the eight-hour worth of daily demand. Because the total water demand of the three towns will be 84 mgd in 2016, securing a storage capacity of 30 mg will be sufficient for the three towns.

In addition, to monitor and control the water supply volume to each water supply area including the one covering the three towns, flow metres and flow control valves should be installed at each outlet pipe of the reservoirs at NEK-Old F/P.

6) Distribution Network Mains and Service Connections

Considering the deteriorate conditions of present water supply service and the low quality materials of existing distribution network mains, it is necessary to improve the entire distribution network system. The existing distribution network mains are mainly Asbestos Cement (AC) pipes (about 65%). Therefore, most of the existing distribution network mains need to be replaced in Distribution Network Improvement (DNI) town by town. At the same time water meters will be installed to all the existing service connections (see **Table 121.1.4**). Service pipes branched from distribution network mains to customers will also be rehabilitated or replaced.

Table 121.1.4 Number of Existing Service Connections

Name of Town	Number of Existing Service Connections as of 2006		
	Domestic	Non-Dom.	Total
North Nazimabad	49,700	15,300	65,000
Gulberg	55,000	12,800	67,800
Liaquatabad	47,900	20,500	68,400
Total	152,600	48,600	201,200

Source: KW&SB

Separately from the trunk distribution mains, distribution network mains were preliminarily designed by using Hazen-Williams Formula based on the water demand shown in **Table 121.1.3** and the following conditions;

- Hazen-Williams Coefficients (C Value) : 140 for distribution network mains
- Hourly Peak Factor : 1.5

Details of the proposed distribution network mains are shown in **Appendix A123.2**.

12.1.2 Sewerage Projects

(1) General

Sewerage projects selected as priority projects include the collection and treatment of sewage generated in three target towns of North Nazimabad, Gulberg and Liaquatabad where DNI will be implemented as priority projects for water supply. The implementation of DNI will inevitably increase sewage generation, which in turn requires the rehabilitation and extension of sewerage facilities there. People residing in these three towns will receive "complete" water supply and sewerage services at the same time and are expected to be satisfied with improved services and consequently to pay the user charge though it would be much more higher than the current one.

Figure 121.2.1 shows the location of three towns and the major sewerage facilities to be rehabilitated and/or implemented as the priority projects.

(2) Basic conditions

Table 121.2.1 outlines the general features of three towns of North Nazimabad, Gulberg and Liaquatabad that are the target towns of Feasibility Study.

Table 121.2.1 Outline of Target Towns (2016)

	Area (ha)	Population (person)	Sewage Generation (mgd / m^3/d)
North Nazimabad Town	1,670	907,400	14.6 66,200
Gulberg Town	1,380	829,300	13.1 59,600
Liaquatabad Town	1,090	1,019,100	14.9 67,900
Total	4,140	2,755,800	42.6 193,700

(3) Principles of Sewage Collection and Its Treatment System Improvement

It is needed to collect all the generated sewage in the target year of 2016 and to convey the collected sewage to either TP-1 or TP-3 where the sewage will be treated with the effluent BOD of less than 80 mg/l.

Existing branch sewers will be partly rehabilitated and additional branch sewers will be installed in the areas that are not sewered for the time being. Sub main sewers and trunk sewers will be implemented where necessary.

When TP-1 was rehabilitated in 1995, two out of four final settling tanks were converted to primary settling tanks, which resulted in three times larger overflow rate of final settling tanks than that of primary settling tanks. This imbalance has to be rectified by diverting flow directions among treatment facilities. Besides, all the mechanical and relevant electrical equipment including pipes connecting treatment facilities and sludge conveyance are decayed and has to be replaced.

TP-3 is equipped with less mechanical and electrical equipment except for plant inlet, primary pumps and secondary pumps. The detailed site survey found that primary pumps are fully functional while secondary pumps need replacement mainly because they are of submersible type and hence difficult to maintain. These pumps are to be replaced with vertical axial type pumps.

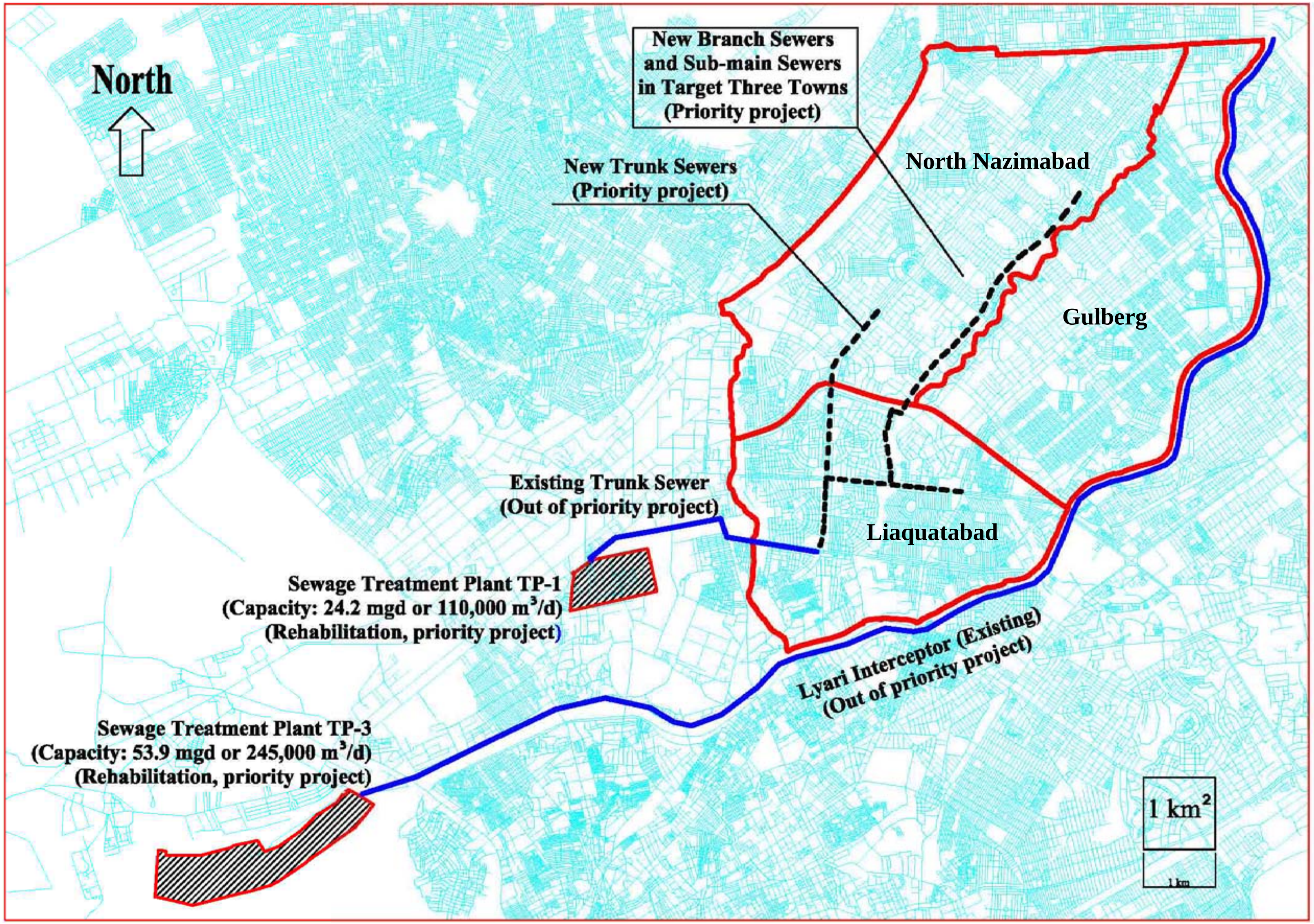


Figure 121.2.1 Location of Priority Projects

(4) Scope of Sewerage Projects

Scope of Sewerage Projects is shown in **Table 121.2.2**.

Table 121.2.2 Outline of Sewerage Projects

	Name	Dimension/Specification	Quantity	Remarks
Sewers	Branch sewers Sub-main sewers Trunk sewers	10” 12” to 36” Larger than 42”	269 km 43 km 11 km	To rehabilitate or newly install To newly install To newly install
TP-1	Inlet pumps Primary settling tanks Trickling filter Final settling tanks Connecting pipes	0.52 m^3/s/unit 42 m diametre 41.4 m diametre 42 m diametre -	7 units 4 units 8 units 4 units 1 (LS)	Capacity: 110,000 m^3/d Process: high rate trickling filter Only mechanical and associated electrical equipment Connecting inlet works, primary settling tanks, trickling filters and final settling tanks for sewage. Connecting primary/final settling tanks and sludge handling facilities for sludge.
TP-3	Secondary pumps	Vertical centrifugal type 0.83 m^3/s/unit	8 units	Capacity: 245,000 m^3/d Process: stabilization pond

12.2 INSTITUTIONAL DEVELOPMENT

12.2.1 Establishment of A ‘Corporatised’ Retail Entity in Zone West

With respect to the institutional reform, the JICA Study suggests that the Karachi city should be divided into three independent retail service zones by the Lyari and Malir Rivers (see **Figure 91.6.1**), and that in the long run the responsibilities for providing retail services (water supply and sewerage services) should gradually be transferred from KW&SB to ‘corporatised’ retail entities on a zone-by-zone basis as shown in **Figure 91.6.2**. The first stage of this reform process will take place in Zone West in early 2011. The Zone West retail entity will make improvements to the retail services (water supply and sewerage) within the Zone West through implementation of the Distribution Network Improvements (DNI) in the zone. Zone West embraces all of the three ‘priority towns’ selected in **Section 11.3** for implementation of DNI on a priority basis. As such, it is envisaged that DNI in these ‘priority towns’ will be implemented by the new Zone West retail entity.

The Zone West retail entity would be established as a ‘Public Limited Company (PLC)’ under the provisions of the Companies Ordinance 1984. The PLC will purchase treated water from KW&SB in bulk and distribute it to retail customers (both residential and non-residential) within Zone West. They will also be accountable for collection, transportation and treatment of sewage generated in Zone West. The PLC would take responsibility for all financial and technical aspects of the operation and management of water supply and sewerage services within Zone West including the collection of tariffs, employment of staff, dealing with customer complaints, etc. The objective of the PLC would be to undertake the operation of water supply and sewerage services in Zone West in accordance with high commercial and professional standards and without external interference in the day-to-day management of the services. There would be no political representation on the Board of the PLC and the articles of association and shareholders’ agreement would specify that members of the Board should be selected on the basis of their commercial, professional, managerial and/or technical qualifications and experience.

12.2.2 Establishment of An Independent Regulatory Board

JICA Study proposes that an independent Regulatory Board (RB) should be formed for economic and technical regulation of water supply and sewerage services in Zone West (see **Figure 91.6.3**). The RB should have the obligation to ensure that the new retail entity in Zone West is able to recover the reasonable financial and economic costs of providing water supply and sewerage services in Zone West. The RB would monitor the performance of the Zone West retail entity against the prescribed service standards and will also act as 'Ombudsman' in dealing with customer complaints and related issues of customer service. It would also be responsible for setting out and enforcing 'Water Supply and Sewerage Services Regulations' which define clearly the statutory rights and obligations of both the Zone West retail entity and its customers in delivering and receiving the services.

12.2.3 Way Forward

It should be noted that the 'JICA Study Team' are primarily concerned with the identification of possible reform options and therefore has sought to provide an outline of suggested reforms in principle at this stage. It is expected that detailed studies related to the suggested reforms will be carried out by the Water and Sanitation Program (WSP) and the ADB assisted 'Karachi Mega City Sustainable Development Program (KMCSDP)'.

In order to put the institutional reforms suggested by the JICA Study into effect, separate studies will need to be conducted:

- To draft amendments to relevant laws, ordinances and/or regulations that are necessary to enable KW&SB to relinquish responsibility for provision of retail services (water supply and sewerage) in Zone West
- To draft articles of association and shareholders agreement of the Zone West retail entity
- To develop a tariff structure which would be applied in areas where DNI has already been completed, and which, while providing adequate protection for the poor and a strong incentive for efficient use of water, ensure that the Zone West retail entity is able to recover the reasonable costs of providing the services including debt service on loans borrowed for financing DNI.
- To establish a mechanism for the transfer of KW&SB's employees currently engaged in provision of retail services in Zone West to the Zone West retail entity, including transfer of employees' pension rights, severance funds, etc.
- To establish a mechanism to determine the condition of retail assets and for the valuation and transfer of retail assets to the Zone West retail entity
- To establish a mechanism for dealing with the liabilities and receivables associated with the retail assets and customer base transferred to the Zone West retail entity
- To establish an independent Regulatory Board for economic and technical regulation of the water supply and sewerage services
- To draft 'Bulk Treated Water Purchase Agreement' between KW&SB and the Zone West retail entity

It is expected that the reform process would be put into effect through the 'Reform Committees' that have already been established under WSP's initiatives, which would take responsibility for ensuring the progressive implementation of reforms in close coordination with the Local Support Unit (LSU)-CDGK of the ADB assisted KMCSDP.

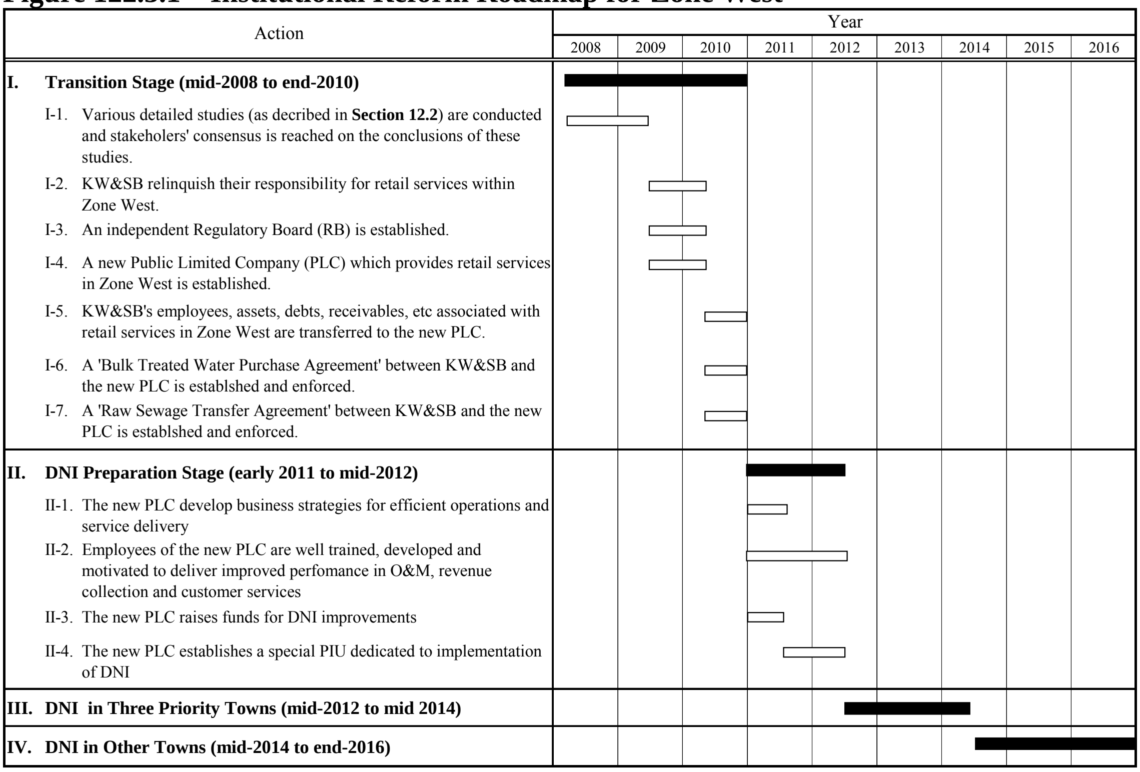
It is envisaged that the preparatory stage for DNI in Zone West will start from early 2011 and it will be followed by the actual implementation of DNI from mid-2012. It is likely that this timing will coincide with the availability of additional water (130 mgd) from the K-IV Project.

In order to achieve these goals, the following actions as a minimum will need to be put into effect between now and mid-2012.

- KW&SB relinquish their responsibility for retail services within Zone West
- A new Public Limited Company (PLC) which provides retail services in Zone West is established
- An independent Regulatory Board is established
- KW&SB's employees, assets, debts, receivables associated with Zone West are transferred to the new PLC
- A 'Bulk Treated Water Purchase Agreement' between KW&SB and the new PLC is established and enforced
- A 'Raw Sewage Transfer Agreement' between KW&SB and the new PLC is established and enforced
- The new PLC develops business strategies for efficient operations and service delivery
- Employees of the new PLC are well trained, developed and motivated to deliver improved performance in O&M, revenue collection and customer services
- The new PLC raises funds for implementation of DNI
- The new PLC establishes a specialist unit (PIU) dedicated to implementation of DNI

Timeframes in which each of these actions will need to be put into effect are given in **Figure 122.3.1**.

Figure 122.3.1 Institutional Reform Roadmap for Zone West



12.3 PRELIMINARY DESIGN OF WATER SUPPLY PROJECT

12.3.1 Distribution Facilities

(1) Distribution System

It is proposed that filtered water supplied to the three towns (North Nazimabad, Gulberg and Liaquatabad) will be conveyed from the proposed service reservoir at NEK Old F/P by existing and new trunk distribution mains.

The diametre of the trunk distribution mains distributing water to the priority project area should have an enough capacity covering the total estimated water demand of the priority project area in 2016 as shown in **Table 121.1.3**. The proposed trunk distribution mains consist of not only new pipelines but also the existing pipelines such as NEK 3rd Phase Trunk Main, and water will be supplied to the three towns thorough the central part of New Karachi Town.

Water supply system in 2016 is proposed in a way that the existing system should be utilized effectively as much as possible. The priority project is part of Stage I of the proposed three stages of the Water Supply Master Plan. The main purpose of Stage I is to divide the water supply system by zones, and to install new pipes of minimum requirement for the change into the zone-wise water supply. The proposed water supply system for the priority project area will supply water from NEK Old F/P, while the existing water supply system supplies water from the three F/Ps of NEK Old, COD and Hub.

Although water is supplied to Liaquatabad Town from COD F/P at present by Federal Trunk Main (FTM), it is proposed that water should be supplied to Liaquatabad Town from NEK Old F/P reservoir, and that FTM should be used to supply water to only Keamari Town. Therefore, new trunk distribution mains should be installed, instead of FTM, to supply water to Liaquatabad Town.
A hydraulic analysis was conducted to preliminarily design the water supply system for the three towns. The results of the analysis are attached to **Appendix A123.1**. In the analysis, capacity of the existing mains, economical pipe diametre for new mains, and residual water pressure were examined. The proposed layout of the distribution system for the project area is shown in **Figure 123.1.1**. Among the existing trunk distribution mains included in the distribution system for the project area shown in **Figure 123.1.1**, the mains of special importance for supplying water to the area are selected to replace with new pipes by the priority project as shown in **Figure 123.1.1**. Other existing mains will be rehabilitated or replaced by other projects.

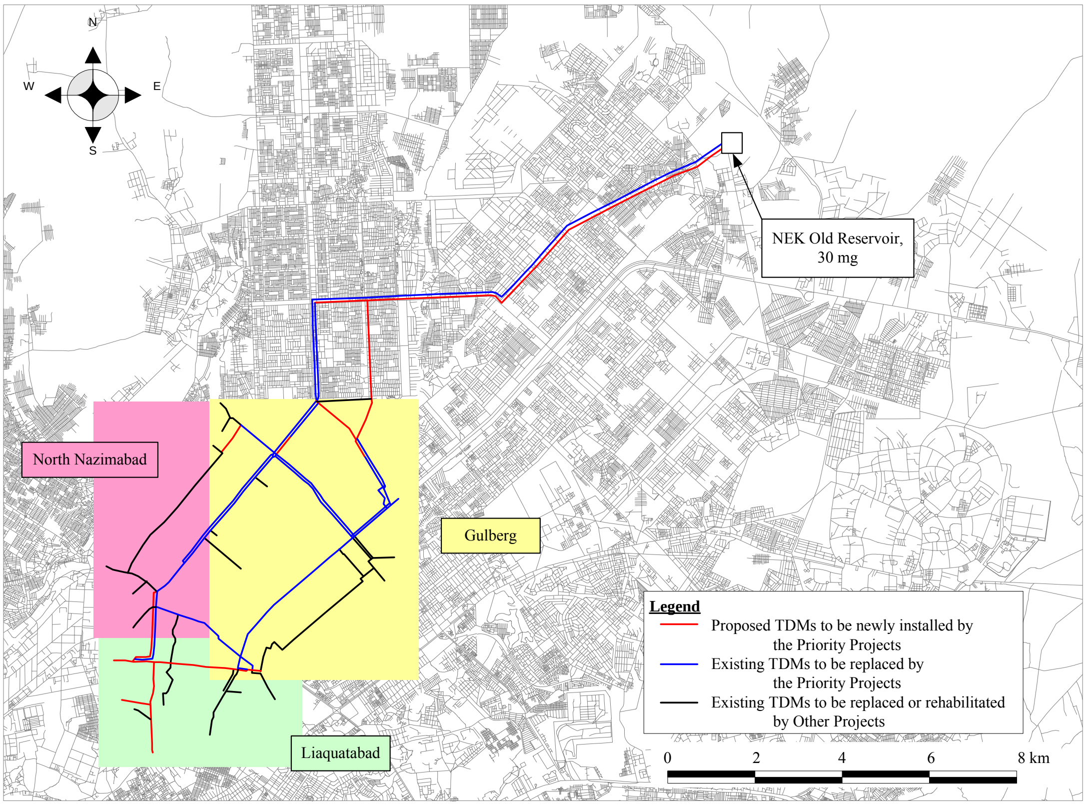


Figure 123.1.1 Distribution System for the Priority Area

(2) Distribution Reservoir

The construction of a distribution reservoir of 30 mg (136,000 m^3) at NEK Old F/P is proposed for cowping with the fluctuation of hourly water demand and for securing water supply in case of power outage at the F/P. Its capacity of 30 mgd is equivalent to the 8-hour worth water demand of the three towns. The top water level and the bottom water level of this reservoir should be +82.33m and +77.42m, respectively, which are equal to those of the existing service reservoir at NEK Old F/P. The standard drawing for service reservoirs with large capacity is shown in **Figure 123.1.2**.

The proposed service reservoirs should be divided into more than two parts for facilitating its maintenance and coping with any accidents, and should have chlorination facilities, control valves, flow measurement equipment, water level measurement equipment, etc.

Typical Service Reservoir

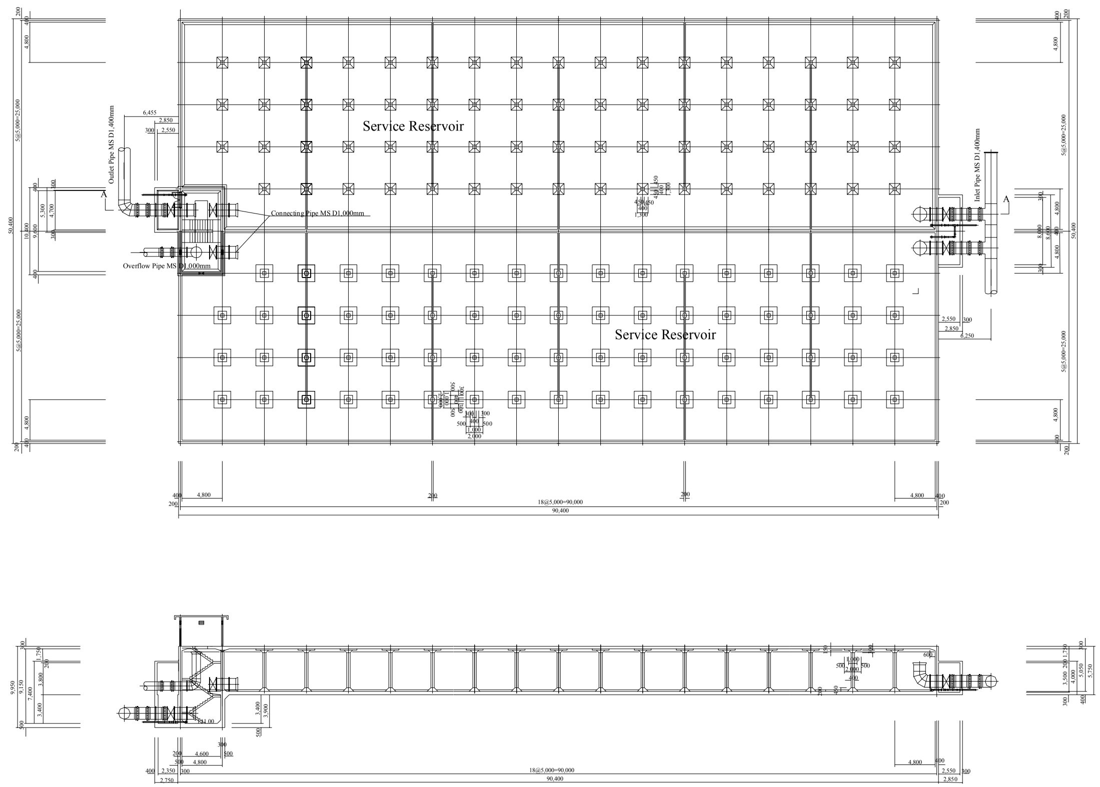


Figure 123.1.2 Standard Drawing of Service Reservoir

(3) Trunk Distribution Mains

1) Material Selection

The proportion of Pre-stressed Reinforced Cement Concrete (PRCC) pipes used in the existing water trunk mains is about 80 %. In general Mild Steel (MS) pipes and Ductile Iron (DI) pipes are widely used for pressured and treated water pipeline of large diametres (300 mm and more) in other countries. PRCC pipes have disadvantages of workability, durability, difficulty of modification at field required to adjust to differing site conditions, and difficulty of repairs for leakages and damages.

Given the important role of the trunk distribution mains, the strength and durability of pipes are among the first factors to be considered. To achieve these requirements, DI pipes or MS pipes should be selected for the trunk distribution mains. The study recommends MS pipes for the trunk distribution mains to be installed in the priority project because KW&SB has experience with MS pipes and MS pipes are available in Karachi.

On the other hand, in general Polyvinyl Chloride (PVC), Polyethylene (PE), MS and DI pipes are used for distribution network mains of small diametre. At present KW&SB are using PE pipes for distribution network mains. Therefore, it is proposed to use PE pipes for the distribution network mains less than 300 mm in diametre.

2) Installation of New Trunk Distribution Mains

To transmit and distribute filtered water from the proposed service reservoir at NEK Old F/P to the three towns, the minimum required new trunk distribution mains, which were identified in the hydraulic analysis described in **Appendix A123.1**, should be installed during the priority project as already explained. The trunk distribution mains to be installed by the priority project are listed in **Table 123.1.1**.

Table 123.1.1 Trunk Distribution Mains for the Priority Project

Diametre (in)	Length (m)	
	New Mains to be installed	Existing Mains to be replaced
100	9,620	0
88	2,320	0
72	1,210	0
64	30	4,180
56	3,830	4,660
48	1,820	19,160
36	3,120	0
32	10	1,030
28	90	0
24	1,360	10,550
18	2,140	4,210
16	440	2,460
14	0	3,240
Total	25,990	49,490

3) Rehabilitation of Existing Trunk Distribution Mains

The conditions of most of the existing trunk distribution mains are old and deteriorated. Some of the existing trunk distribution mains, which are important for supplying water to the three towns, should be replaced with MS pipes by the priority project. The trunk distribution mains to be replaced by the priority project are listed in **Table 123.1.1**. The replaced trunk distribution mains should be re-connected to the replaced distribution network mains which are explained in **Section 12.3.2**.

(4) District Metre

In order to improve the efficiency of distribution system and to supply water equitably to service areas, it is necessary to understand how much water flows into each service area. For this purpose, flow metres (district metres with flow control valves) for trunk distribution mains should be installed to the outlet pipes of the NEK Old F/P Reservoir, at Lyari River crossing point as the boundary between Zone-Central and Zone-West, and at boundaries between towns for monitoring and controlling the water flow, which is shown in **Figure 123.1.3**. The number of district metres proposed for the priority project is listed in **Table 123.1.2**. The standard drawing of metre chamber is shown in **Figure 123.1.4**.

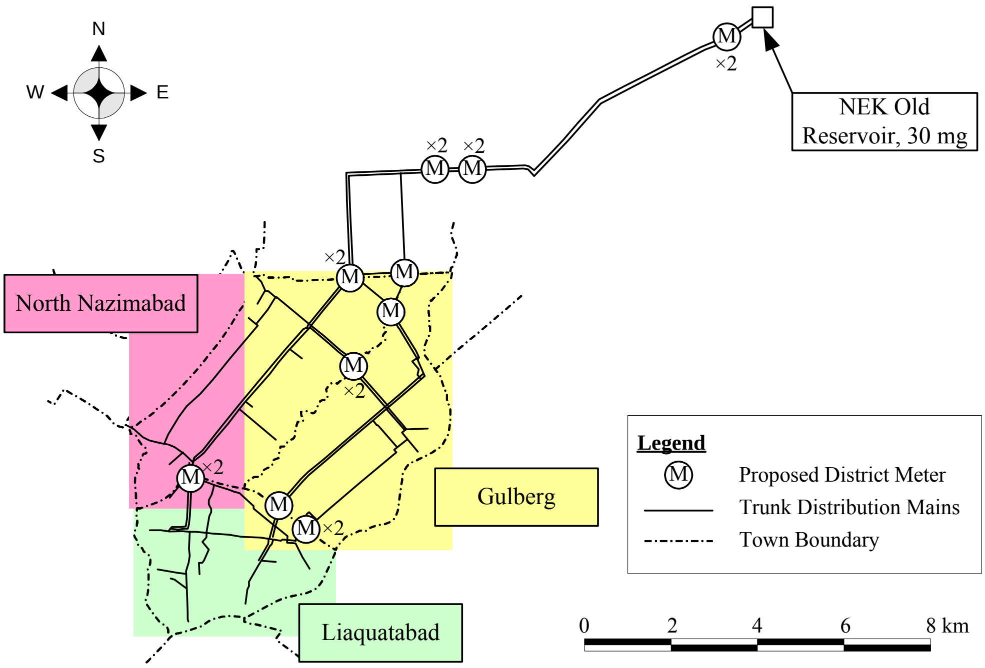


Figure 123.1.3 Locations of Proposed District Metres

Table 123.1.2 Number of District Metres

Diametre (in)	Number
100	3
72	2
64	1
56	1
54	2
48	4
24	2
18	2
Total	17

Also, it is desirable to install sub-district metres (see **Figure 123.1.5**) for flow monitoring and control at each branch of trunk distribution mains connecting to distribution network mains. Only small chambers will be required if mobile type flow metres is used for the flow monitoring and control.

(5) Other Facilities

In addition, air valves, blow-off valves and sluice valves should be installed to the system. The details of these facilities should be designed in the stage of detailed design. The standard drawings of these facilities as well as those of pipe installation works are shown in **Figures 123.1.6** to **123.1.9**.

Typical Flow Meter Chamber (14" ~)

Structure and Piping Scale=1/50

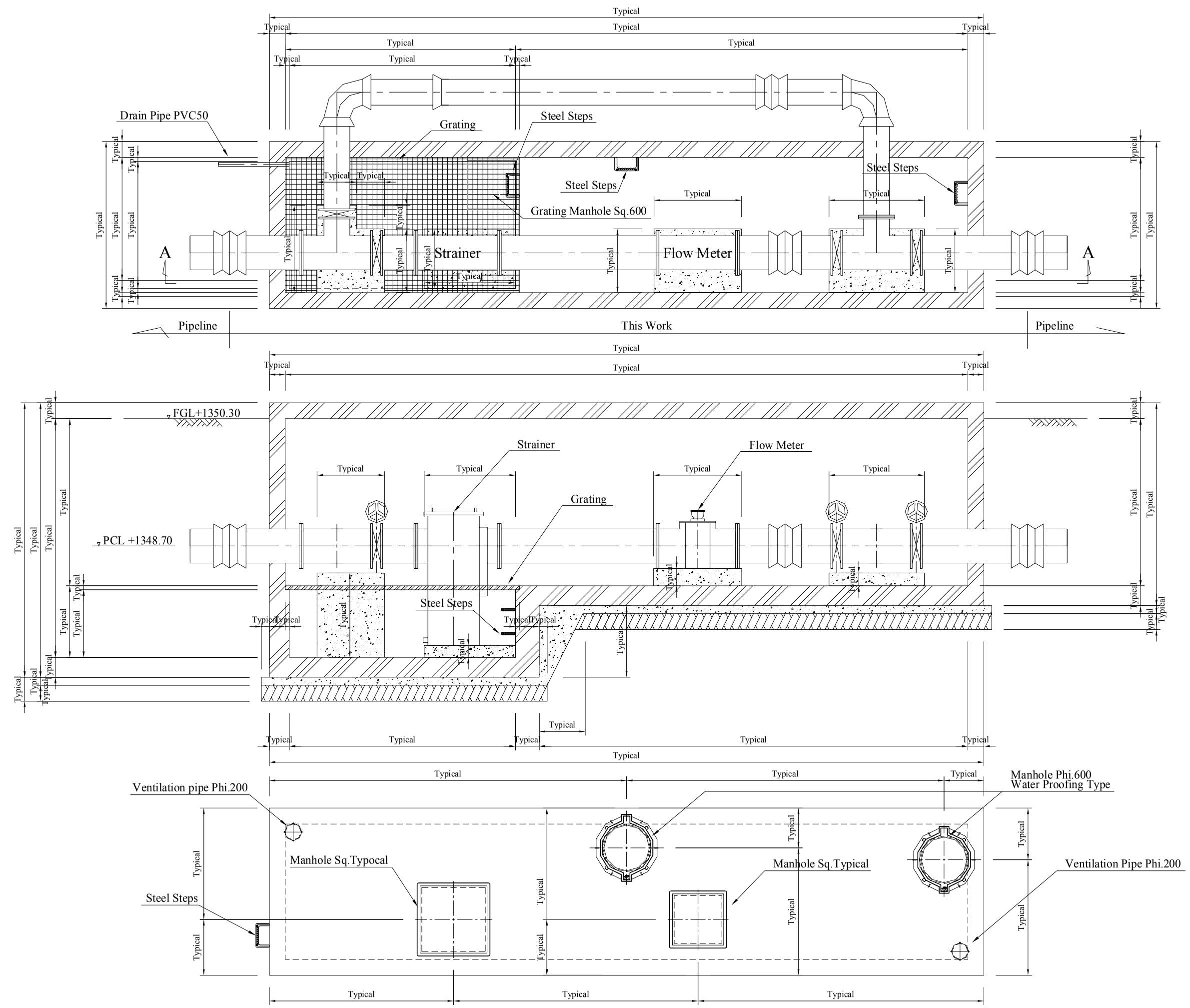


Figure 123.1.4 Standard Drawing of Flow Metre Chamber of Large Diametre

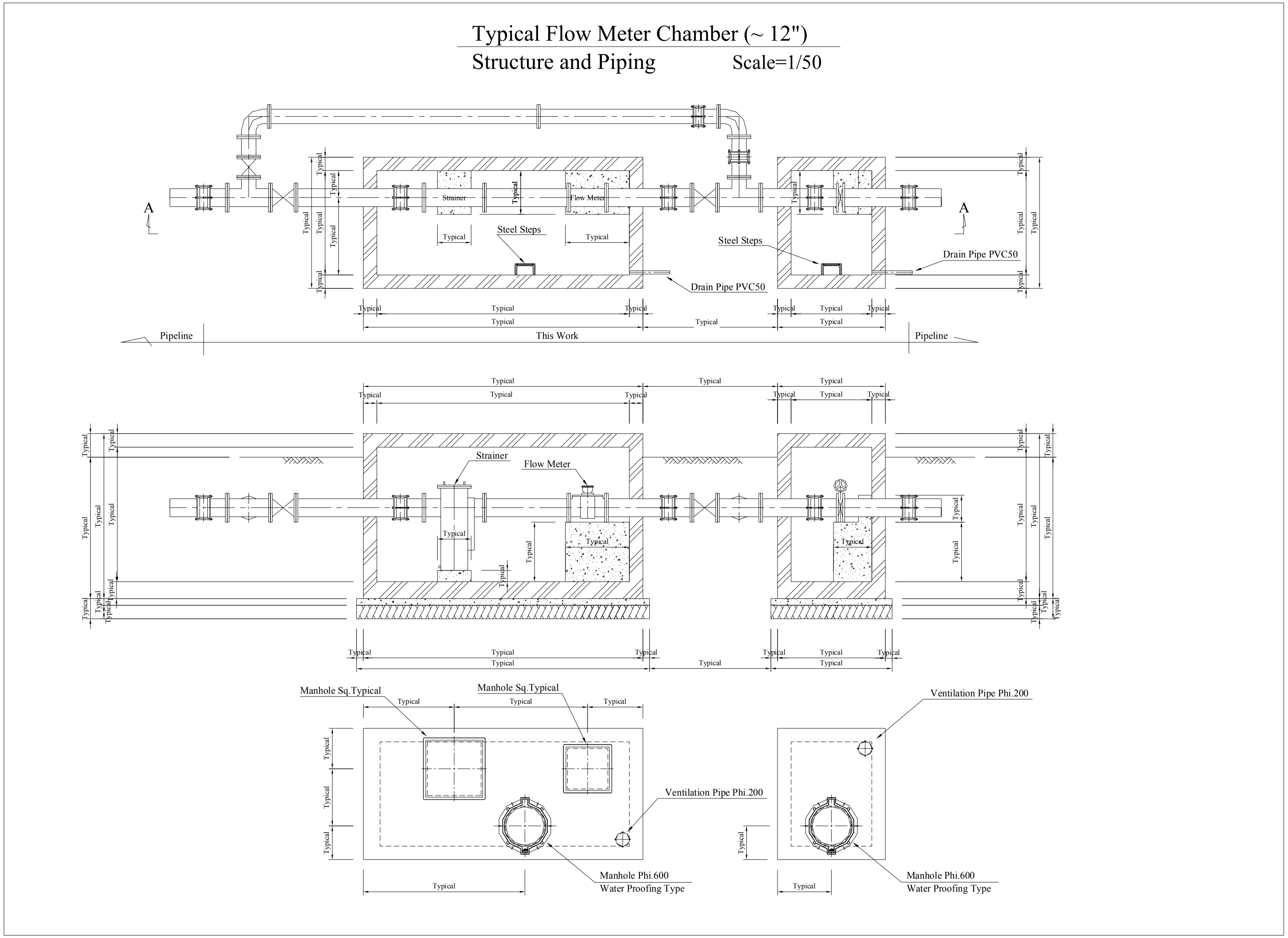


Figure 123.1.5 Standard Drawing of Flow Metre Chamber of Samll Diametre

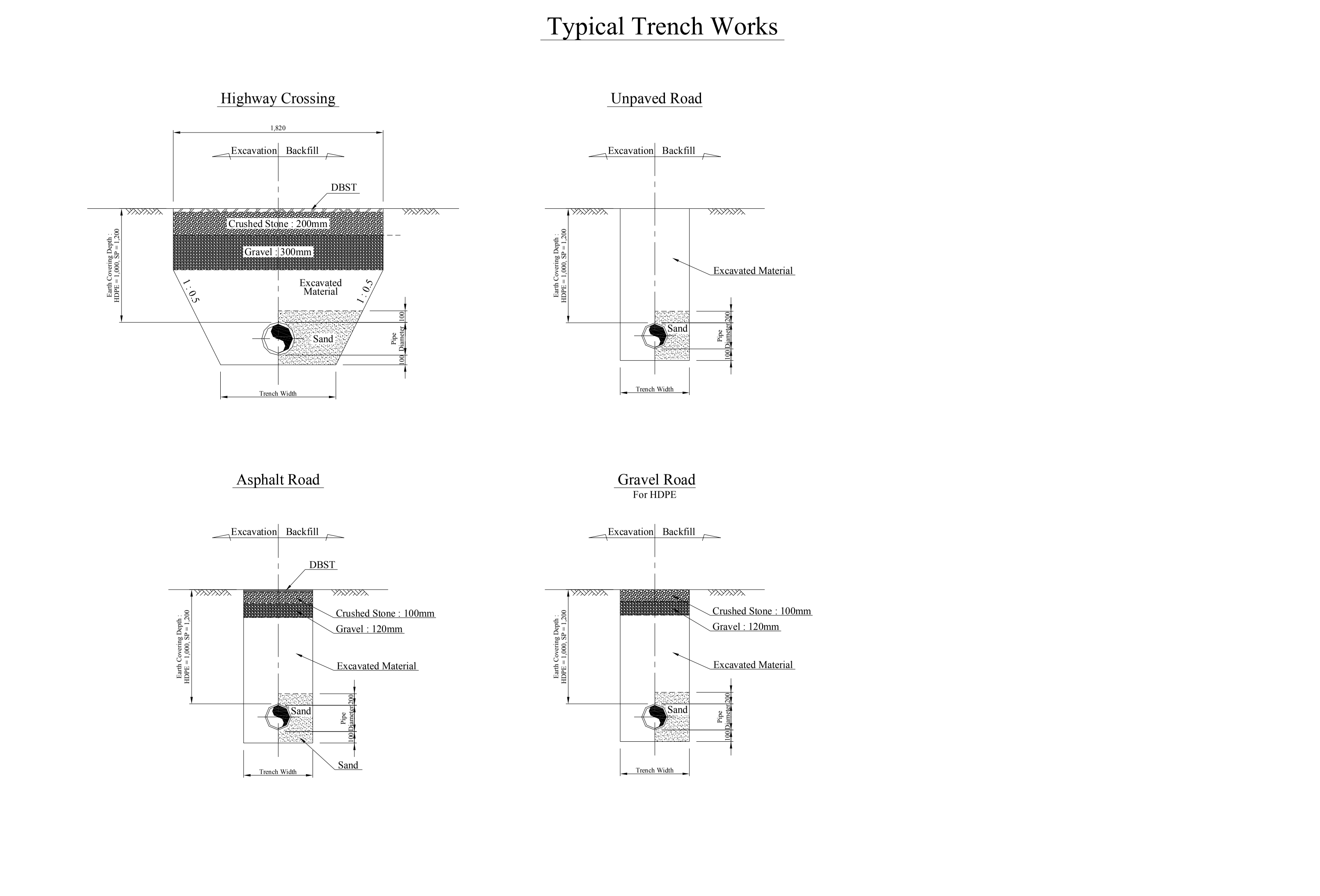


Figure 123.1.6 Standard Drawing of Trench Works

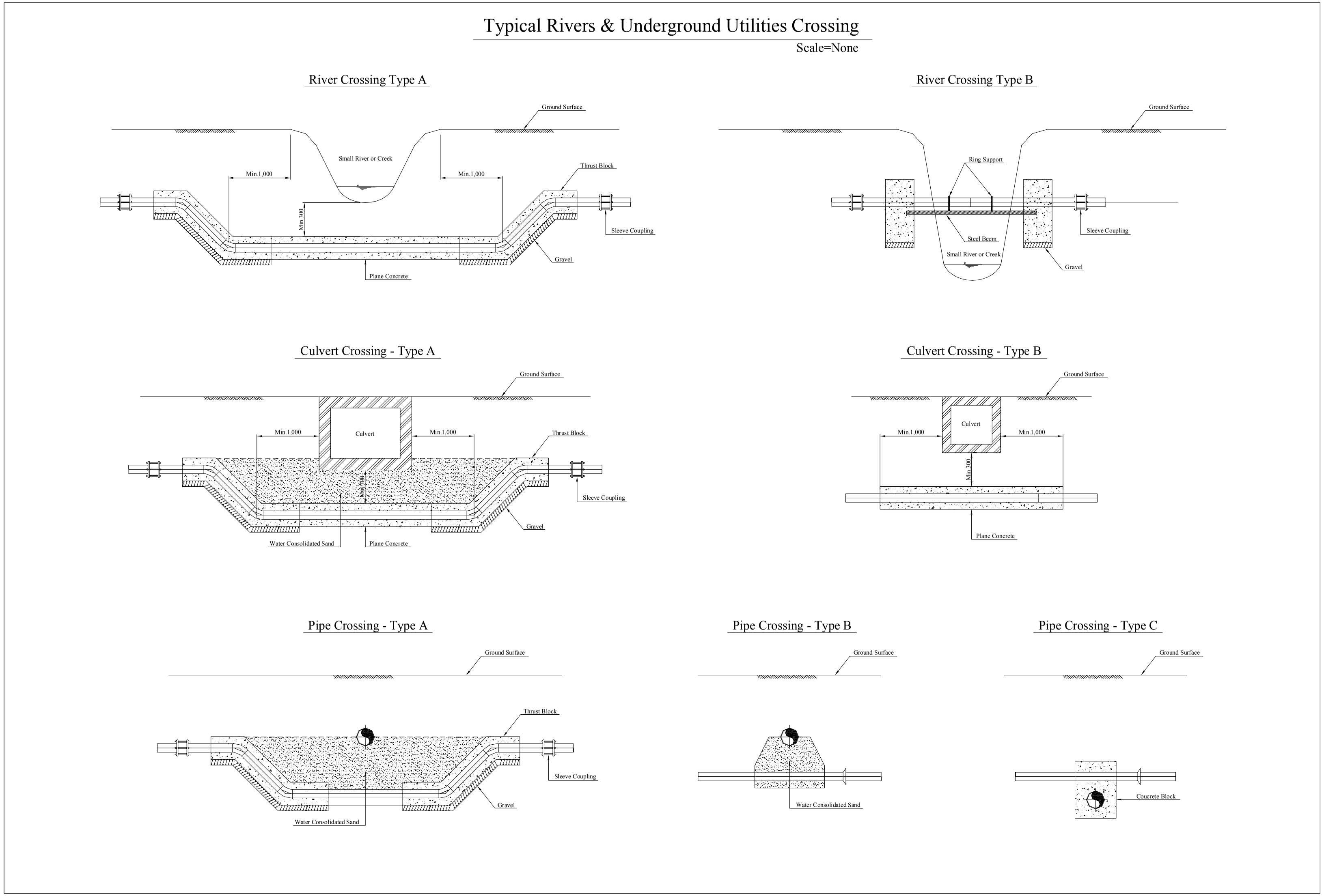


Figure 123.1.7 Standard Drawing of River and Underground Utility Crossing

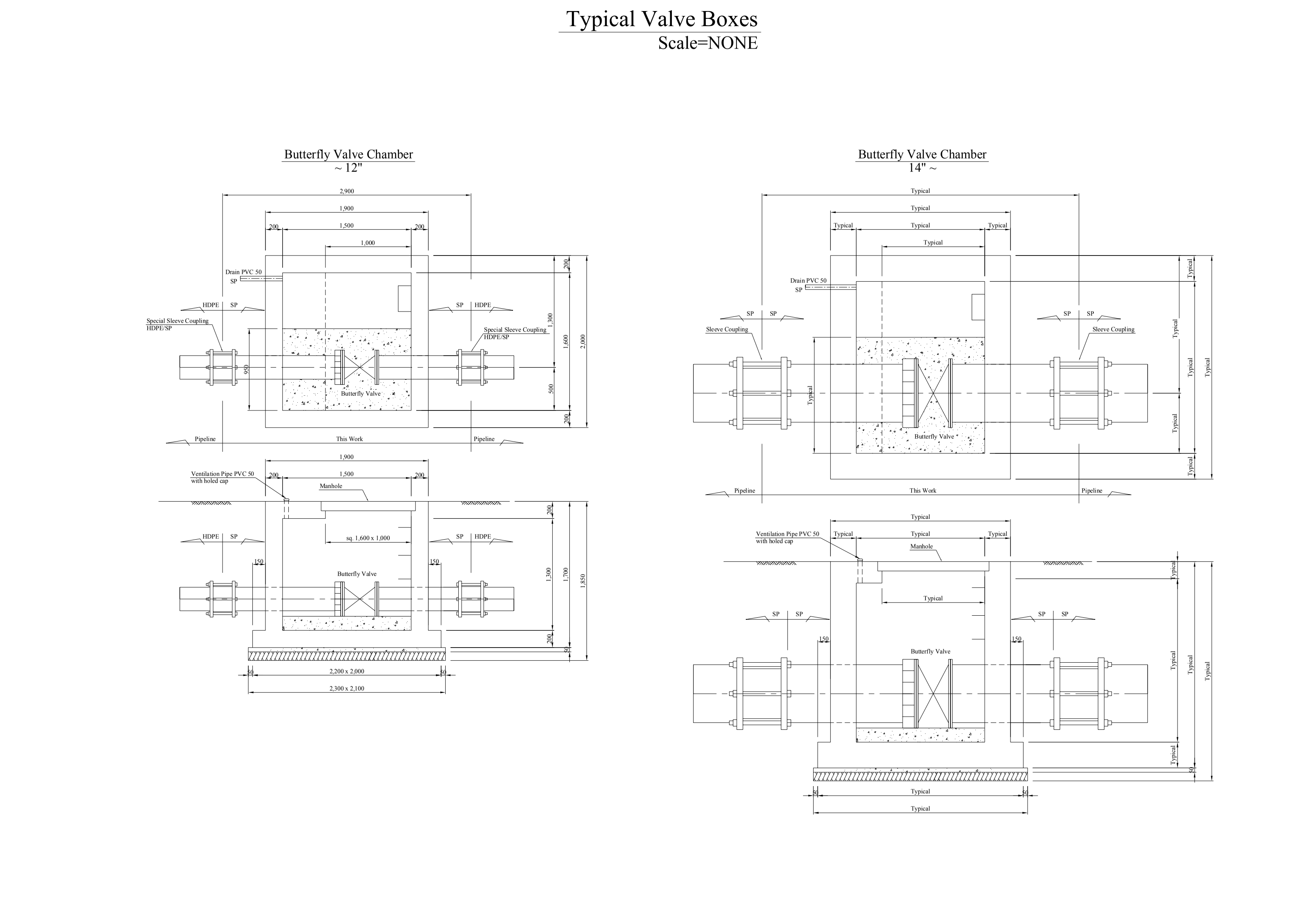


Figure 123.1.8 Standard Drawing of Valve Chamber of Large Diametre

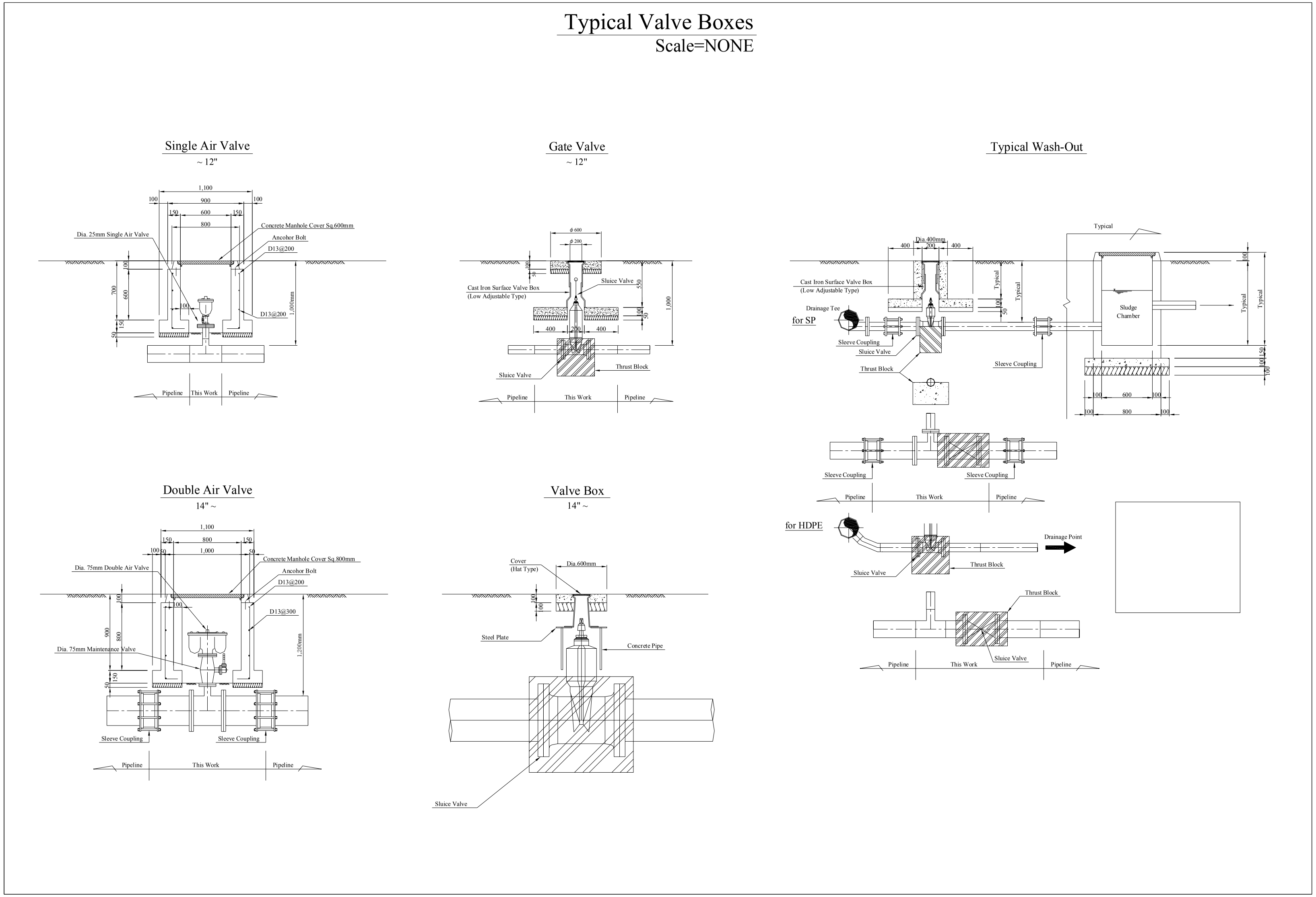


Figure 123.1.9 Standard Drawing of Valve Box

12.3.2 Distribution Network Improvement (DNI)

(1) General

The most important thing for the improvement of distribution network system is the reduction of leakage mainly from the pipeline joints which are the weakest parts of pipelines. Therefore, pipes should be connected properly at joints. It is observed that majority of the existing distribution network mains are of AC pipes, poorly constructed and inappropriately connected. It is recommended that all the existing distribution network mains should be replaced to new PE pipes, except for those which have been recently replaced by TKP projects.

Distribution network improvement (DNI) is divided into two categories of improvement. One is replacement of existing distribution network mains and another is rehabilitation and replacement of existing service connections composed of saddle branches, service pipes and metres. Distribution network mains distribute water to whole service area. Service connections will be connected to distribution network mains with saddle branches and water flows through service pipes and water meters to individual premises.

The boundary between service provider and customers is at water meter, and customers are responsible for maintaining the service pipe such as fixing leakages after the water meter. The standard drawing of service connection is shown in **Figure 123.2.1**.

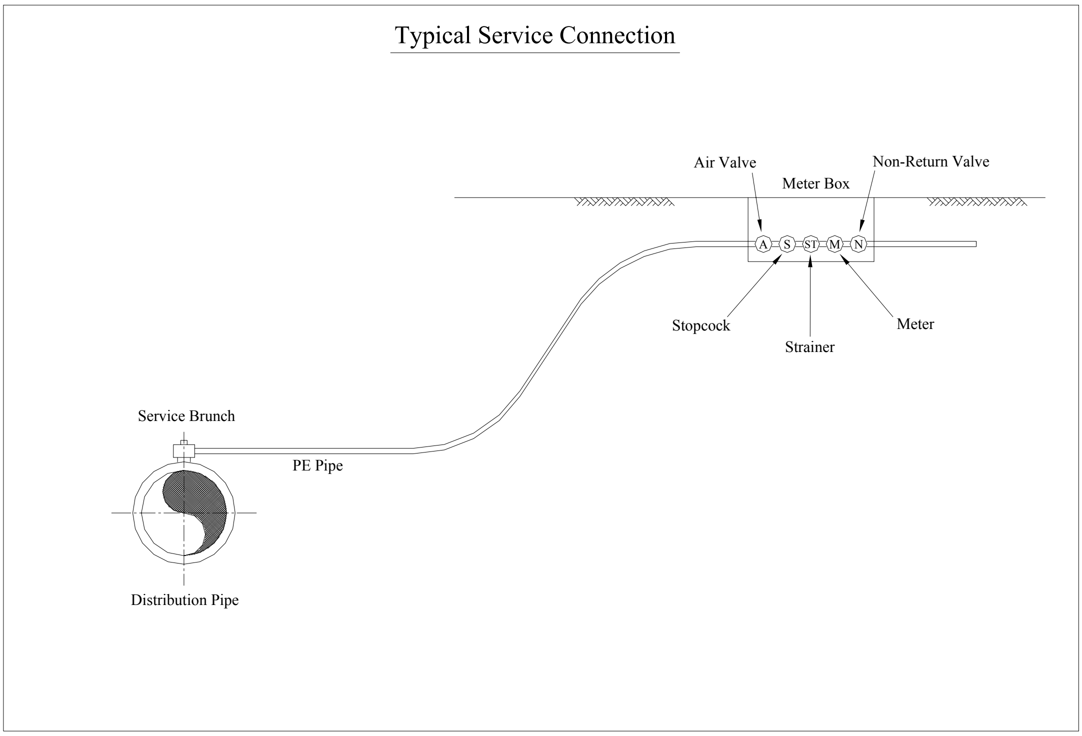


Figure 123.2.1 Standard Drawing of Service Connection

The proposed distribution network system is hydraulically isolated by the boundaries of the towns and their UCs. The system is further segmented into distribution blocks which are separated in consideration of road network configuration and routes of existing and planned trunk distribution mains. These distribution blocks should be connected with trunk distribution mains at several points. and flow measurement and control facilities should be installed at these connecting points in order to control how much water flows into each block.

Based on the things described above, hydraulic analysis for distribution network mains has been conducted and its details are attached to **Appendix A123.2**. For example, UC 5 (Sakhi Hassan) is divided into five distribution blocks and the existing network system will be renewed by DNI as shown in **Figure 123.2.2** (one of the five distribution blocks).

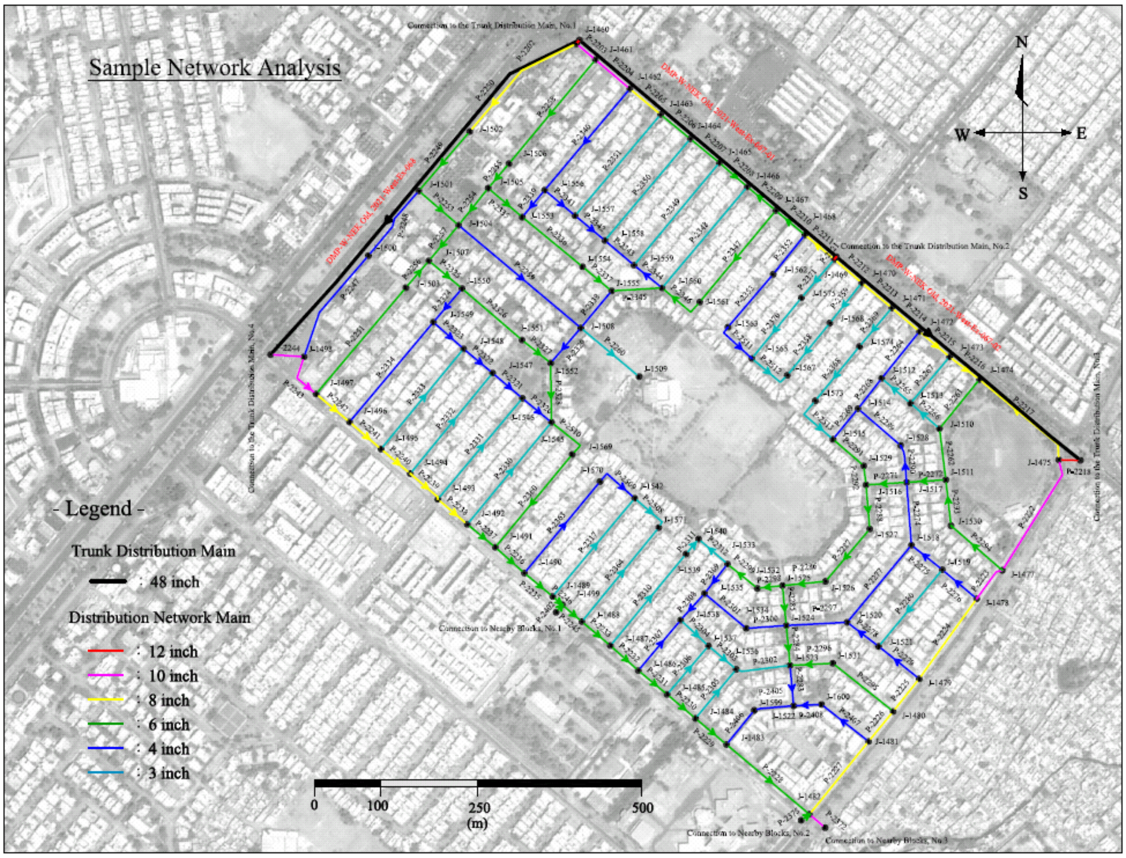


Figure 123.2.2 Distribution Network Mains to be renewed by DNI

(2) Improvement of Existing Distribution Network Mains

As already mentioned the existing distribution network mains should be replaced with new PE pipes of 12 inch or less in diametre by DNI. The total length of the proposed distribution network mains were estimated based on the hydraulic analysis of sample design areas set within the priority area as shown in **Figure 123.2.2**. The length of distribution network mains to be replaced in each town by DNI is summarised in **Table 123.2.1** and the length of replacement in each UC is detailed in **Appendix A123.2**. The total length of replacement in the three towns was estimated at 1,062 km. TKP projects have already replaced and installed new distribution network mains of PE pipes, 66 km in total, so that during the DNI of the priority project, the old distribution network mains of about 996 km will be needed to replace for the three towns of North Nazimabad, Gulberg and Liaquatabad.

Table 123.2.1 Length of Distribution Network Mains to be replaced by DNI

Name of Town	Population in 2016	Area (ha)	DNM Length (m)		
			Estimated	Installed by TKP*	Priority Projects
North Nazimabad	907,352	1,716	353,300	16,700	336,600
Gulberg	829,262	1,428	391,000	16,100	374,900
Liaquatabad	1,019,142	1,126	317,800	33,200	284,600
Total	2,755,756	4,270	1,062,100	66,000	996,100

(3) Improvement of Existing Service Connections

The existing service connections should be rehabilitated or replaced because thier conditions are deteriorated. Since the existing connections have no water meters, water maters should be newly installed to all the connections during DNI. The number of service connections to be rehabilitated or replaced by the DNI will be 228,300 in total for the three towns as shown in **Table 123.2.2**.

Table 123.2.2 Number of Service Connections to be rehabilitated by DNI

Name of Town	Existing Service Connection as of 2006			Expected Service Connection as of 2014		
	Domestic	Non-Dom.	Total	Domestic	Non-Dom.	Total
North Nazimabad	49,700	15,300	65,000	59,200	18,200	77,400
Gulberg	55,000	12,800	67,800	64,700	16,000	80,700
Liaquatabad	47,900	20,500	68,400	49,400	20,800	70,200
Total	152,600	48,600	201,200	173,300	55,000	228,300

12.3.3 Implementation Schedule

As engineering services, detail design works will begin in early 2012 followed by construction supervision which will be finalized in mid 2014. Construction works of reservoir, trunk distribution main, flow metres of trunk distribution main, distribution network main, and service connections will commence simultaneously in mid 2012 and will be finalized in mid 2014. **Figure 123.3.1** shows the implementation schedule of these construction works for water supply priority projects.

No.	Components	Unit	Quantity	Year 2012	2013	2014	2015	2016
1	**Engineering Service**							
	Reservoir	-	-					
	Trunk Distribution Main and Flow Meter	-	-					
	Distribution Network Main	-	-					
	House Connection	-	-					
2	**Reservoir**							
	Reservoir	mg	30					
3	**Trunk Disatribution Main**							
	3.1 New Installation							
	DN 100 inch	m	9,620					
	DN 88 inch	m	2,320					
	DN 72 inch	m	1,210					
	DN 64 inch	m	30					
	DN 56 inch	m	3,830					
	DN 48 inch	m	1,820					
	DN 36 inch	m	3,120					
	DN 32 inch	m	10					
	DN 28 inch	m	90					
	DN 24 inch	m	1,360					
	DN 18 inch	m	2,140					
	DN 16 inch	m	440					
	Total		25,990					
	3.2 Rehabilitation/Replacement							
	DN 64 inch	m	4,180					
	DN 56 inch	m	4,660					
	DN 48 inch	m	19,160					
	DN 32 inch	m	1,030					
	DN 24 inch	m	10,550					
	DN 18 inch	m	4,210					
	DN 16 inch	m	2,460					
	DN 14 inch	m	3,240					
	Total		49,490					
4	**Flow Meter**							
	DN 100 inch	nos.	3					
	DN 72 inch	nos.	2					
	DN 64 inch	nos.	1					
	DN 56 inch	nos.	1					
	DN 54 inch	nos.	2					
	DN 48 inch	nos.	4					
	DN 24 inch	nos.	2					
	DN 18 inch	nos.	2					
	Total		17					
5	**Distribution Network Main**							
	North Nazimabad Town	m	336,600					
	Gulberg Town	m	374,900					
	Liaquatabad Town	m	284,600					
	Total		996,100					
6	**House Connection**							
	6.1 Water Meter Only							
	North Nazimabad Town	nos.	8,800					
	Gulberg Town	nos.	9,200					
	Liaquatabad Town	nos.	2,100					
	Total		20,100					
	6.2 Water Meter and Service Pipe							
	North Nazimabad Town	nos.	68,600					
	Gulberg Town	nos.	71,500					
	Liaquatabad Town	nos.	68,100					
	Total		208,200					

Figure 123.3.1 Implementation Schedule of Water Supply System

12.3.4 Plans for Construction and Procurement of Equipment/Materials

(1) Plans for Construction

Plans for construction are prepared based on the implementation schedule. Construction materials are procured according to plan for procurement of equipment/material. In order to obtain high quality outcome of the construction works, plans for construction will include routine quality control, schedule control and safety management. Vibration, noise, liquid and solid wastes that are expected to be generated during the construction works have to be minimized, which will be incorporated in the plans for construction. As a whole, the following items will be taken into account in the preparation of the plans for construction.

Reservoir

The reservoir to construct has the volume of 30 million gallons or about 136,000 m^3. The soil bearing capacity of its base has to be verified by plate bearing test. Since the reservoir functions to store potable water and no water leakage should occur, concrete quality will be controlled during its placement and curing avoiding any cracks.

Trunk distribution main

Trunk distribution main constructed as priority projects have diametres ranging between DN 14 inches and DN 100 inches with the total length of 75 kilometres. Pipe material is steel and the accuracy of joint welding is very important. Hence, the accuracy has to be checked by radiographic inspection or by ultrasonic inspection. The possibility of electric corrosion occurrence has to be checked where there are high voltage facilities near pipe installation site and anticorrosion measures need to be taken if necessary.

Distribution network main

Total length of distribution network main to replace is 999 km and there may be lots of construction sites in urbanized areas. Plans for construction need to be prepared taking traffic jams and water supply disruption in replacement of old pipes with new ones into account. Safety measures for pedestrians have to be taken to avoid any traffic accidents.

Many asbestos cement pipes are used for existing distribution network main. Asbestos dust can be carcinogens and asbestos cement pipes should not be removed and be left as they are underground for safety reasons.

Service connection

The number of service connections will be 228,300 part of which will install service pipes and water meters. Water leakage will be larger if service pipes between divaricated service connections and water meters are constructed with less accuracy. It is important to employ the contractors with sufficient expertise in service connection works.

Water meters are installed in a private plot at the spot nearest to public and private boundary. The spot is selected taking into account easy metre reading, no sewage or storm water intrusion and less possibility of putting obstacles. Water meters have to be placed on the level and the arrow at their surface showing the flow direction has to be the same as the actual flow direction.

As-built drawings

As-built drawings are to be prepared for concrete structures and water supply pipes at the time of construction completion and to be used for operation and maintenance purposes at the later stage.

(2) Procurement of Equipment/Materials

Construction of water supply facilities require various kinds of equipment and materials such as concrete, reinforcing steel bars, pipes, valves, flow metres and water meters. Concrete, reinforcing steel bars, pipes, and flow metres are locally procured and valves and water meters are imported.

Table 123.4.1 Procurement of Equipment and Material for Water Supply System

Item	Description	Procurement
Reservoir	Reinforced Concrete	Domestic
Trunk Distribution Main		
Pipe	Steel Pipe	Domestic
Valve	Sluice Valve and Butterfly Valve	Overseas
Flow Metre	Electromagnetic Type	Domestic
Distribution Network Main		
Pipe	Polyethylene Pipe	Domestic
Valve	Sluice Valve	Overseas
Service Pipe	Polyethylene Pipe	Domestic
Water meter	Rotary Vane Wheel Type	Overseas

12.3.5 Plans for Operation and Maintenance of Priority Projects

(1) Maintenance of Distribution Network

After completion of DNI, the distribution network will be maintained by leakage/NRW reduction survey teams. With the use of a portable flow metre, they will measure the minimum night flow (MNF) in small District Metreing Areas (DMAs) with a view to reducing leakage assuming that MNF represents the magnitude of leakage occurring within the DMA.

Each survey team will consist of one engineer, one technical assistant and three workers, and will be equipped with one portable ultrasonic flow metre, one leak detector, two listening rods, one metal pipe locator, one metal detector, and three pressure recorders.

On average, one survey team would be able to cover about 8 km length of distribution mains per week or 32 km per month. It is estimated that after completion of DNI the total length of distribution network mains in one town will be approximately 370 km. Thus, if covered by two teams, it will take about six months (370 / 64 = 5.8) to complete the survey in one town. This will ensure that each and every distribution main in the town will be subject to the survey once in every six months, which is more or less in line with international practices. Ultimately, two survey teams will need to be established for each town or six teams for the three ‘Priority Towns’. The number of survey teams can be increased gradually corresponding to the progress of DNI.

The network maintenance work will be conducted in collaboration with the repair/correction section of the operations department. Leaks and other anomalies such as illegal/unauthorized connections and metre tampering detected during the survey will be reported to the repair/correction section for immediate repair and correction.

In the past, leakage/NRW reduction surveys were not conducted by KW&SB. As such, extensive training will need to be provided to staff who take on leakage/NRW reduction surveys. They will require the training on how to isolate a DMA from the rest of the distribution network, how to measure the minimum night flow in the DMA, and how to use ultrasonic flow metres, leakage detectors, pressure recorders and other survey equipment. To this end, it is recommended that the retail entity should request the Japan International Cooperation Agency (JICA) for its technical assistance through implementing a ‘Technical Cooperation Project (TCP)’. TCP would be able to offer a comprehensive package of technical assistance to support the self-help efforts of the retail entity, which would include (a) the dispatch of leakage/NRW reduction experts from Japan to provide technical supports, (b) training of relevant local staff in Japan or in other countries, and (c) the supply of necessary equipment on a grant basis.

(2) Metre Reading/Billing

After implementation of DNI, the distribution network and customer base will be managed by the Zone West retail entity. It is predicted that the number of service connections in Zone West at the start of DNI (2011) will be approximately 600,000 and in the three 'Priority Towns' there will be approximately 217,000 connections.

DNI will be operated on the basis of 100% metreing of bulk and retail customers and therefore will require the installation of revenue metres to every service connection. Due to the scale of metre installations required this will be implemented progressively throughout the three 'Priority Towns' on a priority basis in order to maximise revenues.

Efficient metre reading and billing activities will be crucial to the commercial success of the retail entity and as such they will need to invest in a Customer Information System (CIS). To ensure 100% billing, initially a complete customer survey will need to be conducted to ensure that all customers are registered on the CIS database and therefore are subject to regular billing. Regular customer surveys will also be required to eliminate illegal connections and to ensure that all new connection applications are installed and registered correctly on the database.

As household metreing will be a new concept for Karachi (currently KW&SB do not metre households), extensive training will be provided to transferred staff from KW&SB to the retail entity, in the use of modern billing and metre reading techniques including the hardware, software and technologies employed. Metres will be read on a monthly basis to maximise revenues and cash flows.

Based on the number of service connections in the three 'Priority Towns', it is expected that approximately 100 qualified and trained metre readers will be required ultimately. This is based on the assumption that each metre reader will be capable of reading approximately 100 metres per day on each of the 22 working days per month which is line with international standards with use of modern metres and electronic 'hand held devices'. The number of metre readers can be increased gradually corresponding to the actual progress of DNI. The 'hand held device' will be linked locally at the town office for downloading metre reading routes to the device from the billing system and for uploading metre readings back to the billing system to update customer accounts. The hardware and software for modern hand held devices as well as proprietary billing/data management systems such as CIS are readily available on the market. Necessary training can be provided by the manufactures of these hardware and software and therefore it should be included as part of the procurement contract.

The hand held devices will deploy modern technology capable of 'local bill presentment' which means that the metre reader will be able to print the bill after reading the metre and present this to the customer at the time of reading. This will minimise the chance of frauds by metre readers and will also eliminate the need for centralised bill printing and bill delivery, thus reducing operating costs and the time for the customer to pay the bill. The use of modern technology such as this (instead of the traditional manual methods) will be prerequisite to processing as many as 10,000 (100 metre readers × 100 metres per metre reader per day) metre readings and consumer bills per day.

(3) Metre Repair/Testing

It is expected that good quality domestic metres will be purchased and installed that will comply with international standards to ensure a long service life. Metres will be the property of the retail entity who rent them out to customers. The retail entity will recover the cost of the metre through tariffs in the long run. The retail entity will therefore invest in good quality metres complying with ISO 4064-1:2005 standards. Whilst the unit price will be higher than cheaper metres available locally, good quality metres would be expected to last trouble-free between 5-10 years in service and therefore the overall life-cycle cost will be lower. Metres of this quality would be procured on the basis of being supplied and maintained by a certified manufacturer/supplier for the life of the metre (possibly with a minimum of 5-year warranty). Each metre would be calibrated, tested and sealed at the manufacturers and come complete with a test/calibration certificate. Metres would be intrinsically sealed and tamper proof to ensure longevity and will prevent illegal tampering by customers. Any tampering will be evident by broken seals etc. to be inspected on a monthly basis by the metre reader.

On this basis it is expected that household metres would be replaced periodically (every 5-10 years and will be determined by field experience over time) and as such it is envisaged that it will not be cost effective for the retail entity to operate a metre repair workshop. Instead, it is suggested that a service contract will be let to a specialist contractor certified by the metre manufacturer for repair of household metres.

The retail entity will invest in and deploy portable metre test equipment (that will be certified and regularly calibrated for accuracy) to test household metres (0.5 to 2 in) where customers complain of irregularities. The retail entity will also need to invest in a metre test bench to conduct the regular calibration of the test equipment. The test metre is taken to site and installed in series with the existing metre to test the revenue metre's recording accuracy. Metres will be replaced at the cost of the retail entity and bills adjusted in cases where metres are determined to be faulty. At the end of their useful life metres will be returned to the manufacturer/supplier for recycling (reuse of the metre housing). The value of returned metres will be taken into account when negotiating the new metre purchase price. It is estimated that approximately 200 sets of such portable metre test equipment (60 sets for 0.5 in, 50 sets for 0.75 in, 30 sets each for 1.0, 1.5 and 2.0 in) will be required for each town ultimately, but this number can be increased gradually corresponding to the actual progress of DNI.

Bulk metres (3 to 24 in) are limited in number at present, but are expected to increase substantially in future since they will be installed at all multi-storey condominiums and apartment buildings in the three 'Priority Towns' during the implementation of DNI. As such it is recommended that the retail entity will invest in bulk metre (3 to 24 in) calibration equipment and facilities (similar to that provided at COD filtration plant) in order to check and confirm bulk metre recording accuracy at the request of bulk customers. Bulk metres will also be the property of the retail entity who rent them out to customers. The retail entity will recover the cost of the bulk metres through tariffs in the long run. It is suggested that a service contract will be let for repair of malfunctioning bulk metres. This is a specialist job and therefore the service contract will be let to the metre manufacturer or a specialist contractor certified by the metre manufacturer. It is also suggested that the retail entity should maintain a stockpile of approximately 50 standby bulk metres which consist of 10 metres each for 3 and 4 in, 8 metres each for 6, 8 and 12 in, 4 metres for 15 in, and 2 metres for 24 in. These bulk metres will be used to replace customer metres while they are being calibrated or repaired.

12.4 PRELIMINARY DESIGNS OF SEWERAGE PROJECTS

12.4.1 Sewage Collection System

Table 124.1.1 outlines target three towns of the priority project.

Table 124.1.1 Outline of Target Towns
(a) Area

	Area (ha)
North Nazimabad Town	1,670
Gulberg Town	1,380
Liaquatabad Town	1,090
Total	4,140

(b) Population and Sewage Generation

	Population		Sewage Generation upper: mgd lower: m^3/d	
	2016	2025	2016	2025
North Nazimabad Town	907,400	1,069,600	14.6 66,200	20.9 94,800
Gulberg Town	829,300	977,500	13.1 59,600	18.7 85,100
Liaquatabad Town	1,019,100	1,054,500	14.9 67,900	18.8 85,200
Total	2,755,800	3,101,600	42.6 193,700	58.3 265,100

Generally, trunk sewers and sub-main sewers should be designed based of sewage generation of target year of the master plan, because it is almost impossible to increase flow capacity in multiple steps to fit sewage generation. Since existing trunk sewer connecting to sewage treatment plant TP-1 has enough flow capacity for sewage generation in 2016 in downstream stretch near TP-1, the downstream end of proposed trunk sewers is to be connected to the existing trunk sewer in Liaquatabad Town as shown in **Figure 124.1.1.**

Sewage generated in target towns flow into sewage treatment plant TP-1 or TP-3. In 2016, capacity of rehabilitated TP-1, 24.2 mgd or 110,000 m^3/d, is not sufficient for the whole sewage generation of target towns; therefore, sewage from some strips along with Gujjar Nallah or Lyari River should flow into TP-3 through existing Lyari Interceptor laid at the right bank side of Lyari River.

The preliminary design in feasibility study stage was done using the results of levelling survey and detailed street map developed in GIS study.

Figure 124.1.1 shows alignments and size of trunk sewers and sub-main sewers. Outlines of trunk sewers and sub-main sewers are shown in **Table 124.1.2**, and outlines of branch sewers in **Table 124.1.3**. Refer to Appendix **A124.1** for design conditions and results of the preliminary design.

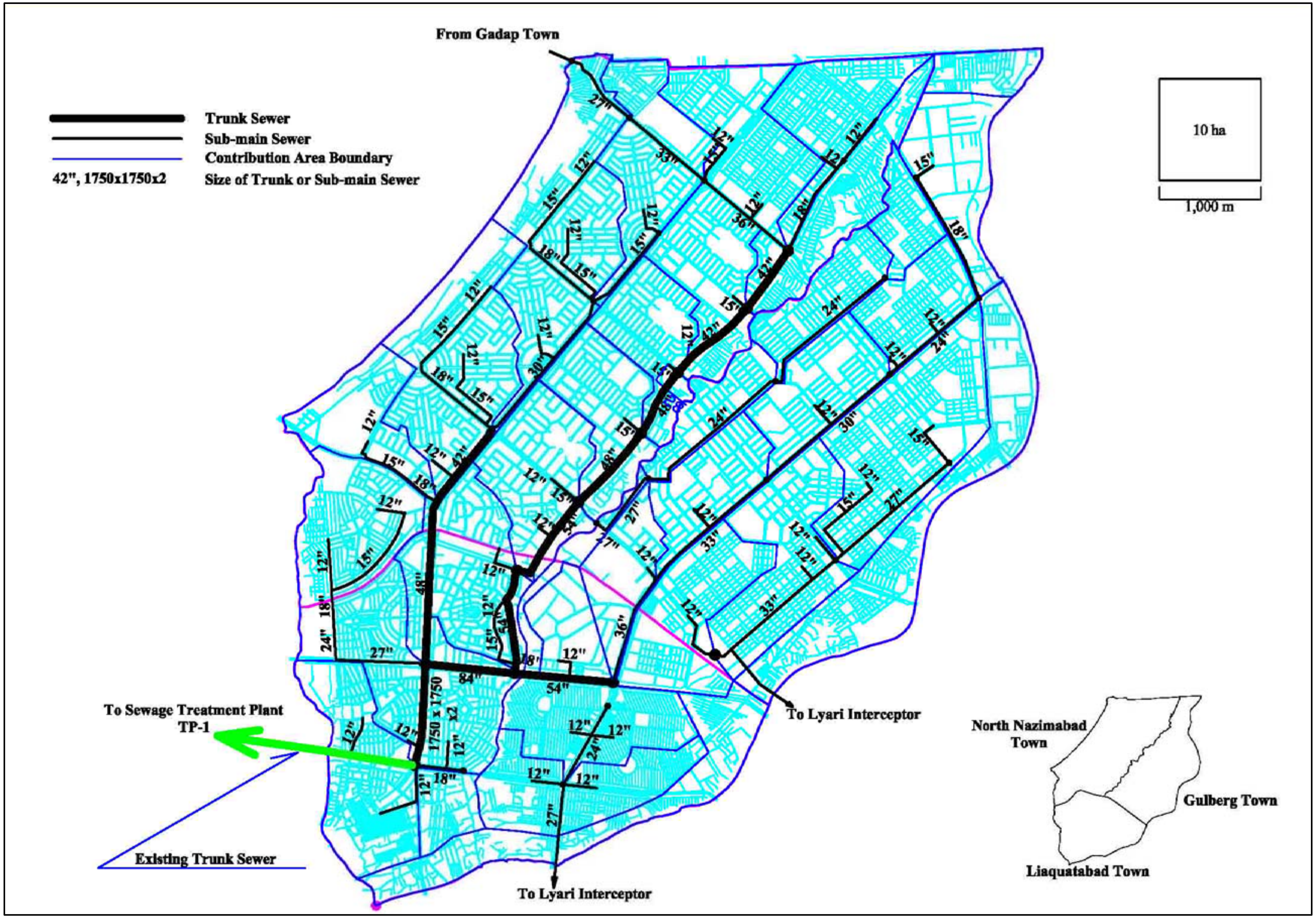


Figure 124.1.1 General Plan of Trunk and Sub-main Sewer

Table 124.1.2 Town-wise Trunk Sewer and Sub-main Sewer Length

Size (inch)	Size (mm)	Length (m) North Nazimabad	Gulberg	Liaquatabad	Total
Sub-main Sewer					
12	290	3,680	1,540	4,410	9,630
15	370	4,570	1,650	2,000	8,220
18	440	2,790	1,350	1,390	5,530
24	590	0	4,410	1,200	5,610
27	660	820	2,290	1,760	4,870
30	730	1,630	1,600	0	3,230
33	810	970	3,090	0	4,060
36	880	1,080	0	1,130	2,210
Trunk Sewer					
42	1,020	2,460	0	0	2,460
48	1,170	1,630	0	1,610	3,240
54	1,320	990	0	2,040	3,030
84	2,050	0	0	890	890
1750 x 1750 x 2		0	0	1,010	1,010
Total		20,620	15,930	17,440	53,990

Table 124.1.3 Outlines of Branch Sewers

	North Nazimabad	Gulberg	Liaquatabad	Total
(1) Area (ha)	1,670	1,380	1,090	4,140
(2) Road Length (m)	365,500	316,800	301,300	983,600
(3) Branch Sewer Length (m)				
(3-a) Existing Length (m)	321,640	278,790	265,150	865,580
(3-b) Required Length (m)	35,740	30,980	29,460	96,180
Total (m)	357,380	309,770	294,610	961,760
A. Rehabilitation Length	64,330	55,760	53,030	173,120
B. Newly construction Length	35,740	30,980	29,460	96,180
C. Total	100,070	86,740	82,490	269,300

Note:
(1) Area and road length of each town were measured in GIS study.
(2) Total branch sewer length was determined by this preliminary design.
(3) Length of existing branch sewer was estimated to be 90% of total based on the interviews to officers of each town. Hence, the length of branch sewers to newly lay is 10% of the total length of branch sewers.
(4) Rehabilitation length in this project was presumed to 20% of existing length of sewers.

12.4.2 Rehabilitation of Sewage Treatment Plants

(1) Sewage Treatment Plant TP-1

Figure 124.2.1 shows general plan of sewage treatment plant TP-1.

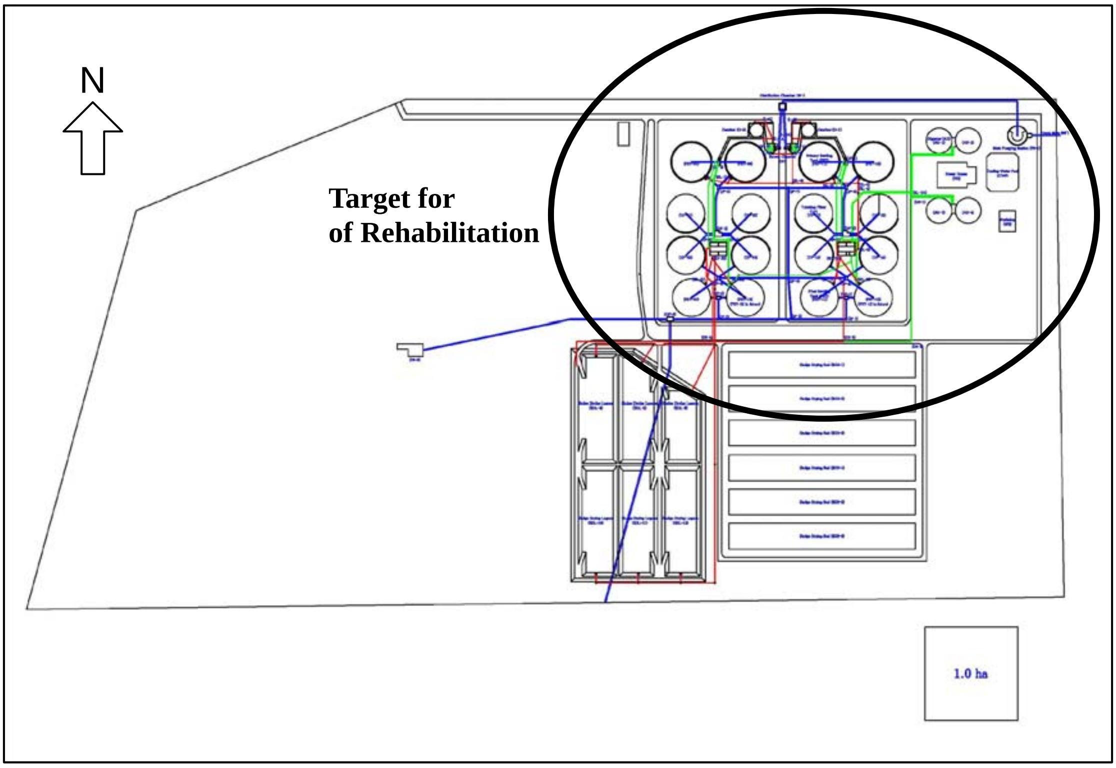


Figure 124.2.1 General Plan of Sewage Treatment Plant TP-1

The scope of rehabilitation for mechanical and electrical work is illustrated in **Figure 124.2.2**. The component of this rehabilitation work is tabulated in **Table 124.2.1** and **Table 124.2.2**.

The details of the rehabilitation work are attached as **Appendix A124.2** to this report.

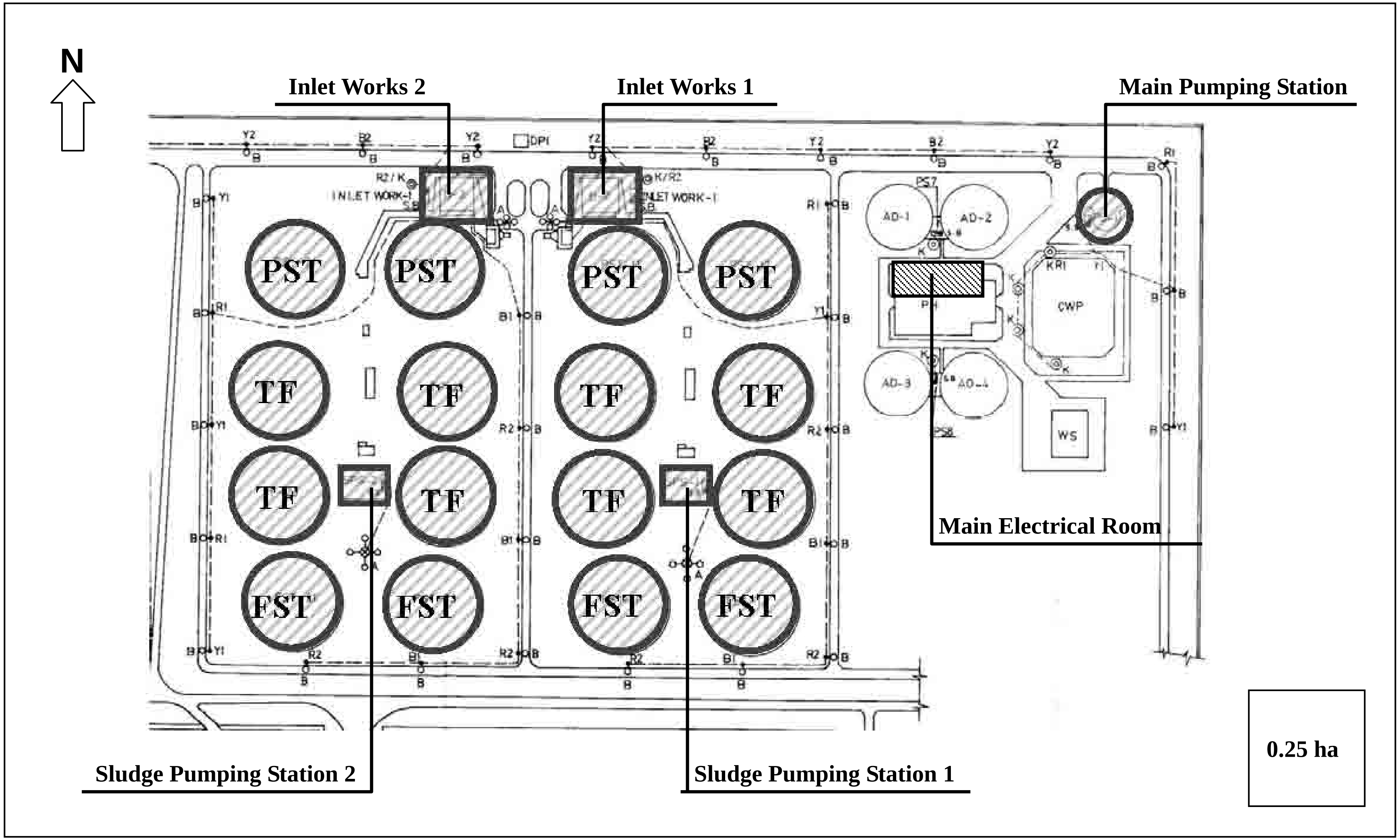


Figure 124.2.2 Scope of Rehabilitation for Mechanical and Electrical Work at TP-1

Table 124.2.1 List of Equipment to Rehabilitate in TP-1

Equipment Name	Specification			Qty
(a) Main Pumping Station				
Main Pump	Multistage Vertical Centrifugal Sewage Pump		400V 3phase 90.00kW	7
	$0.52m^3/s \times 10mH$			
Motor for Bar Screen			400V 3phase 1.50kW	4
Ventilation Fan			400V 3phase 2.20kW	2
Sump Pump	Submersible Pump		400V 3phase 1.50kW	2
(b) Screen, Grit Chamber, Partial Flume (Inlet Works 1&2)				
Motor for Mechanical Screen			400V 3phase 1.50kW	4
Motor for Grit Collector			400V 3phase 3.00kW	2
Motor for Organic Pump			400V 3phase 0.20kW	2
Motor for Grit Seperator			400V 3phase 1.50kW	2
(c) Primary Settling Tank				
Sludge Collector for PST	Centre Driven Column Type	42 m in dia	400V 3phase 3.00kW	4
(d) Trickling Filter				
Trickling Filter		41.4 m in dia		8
(e) Final Settling Tank				
Sludge Collector for FST	Centre Driven Column Type	42 m in dia	400V 3phase 3.00kW	4
(f) Sludge Pumping Station No.1 at Train 1				
Humus Sludge Pump	Vertical Centrifugal Sewage Pump $0.04m^3/s \times 12.3mH$		400V 3phase 11.00kW	2
Lagoon Feed Pump	Vertical Centrifugal Sewage Pump $0.03m^3/s \times 20mH$		400V 3phase 15.00kW	3
Ventilation Fan			400V 3phase 2.20kW	1
Sump Pump	Submersible Sewage Pump		400V 3phase 1.50kW	2
(g) Sludge Pumping Station No.2 at Train 2				
Humus Sludge Pump	Vertical Centrifugal Sewage Pump $0.04m^3/s \times 12.3mH$		400V 3phase 11.00kW	2
Pressure Pump	Centrifugal Type, with pressure tank		400V 3phase 2.50kW	1
Ventilation Fan			400V 3phase 2.20kW	1
Sump Pump	Submersible Sewage Pump		400V 3phase 1.50kW	2
(h) Electrical Equipment				
Incoming Panel		Indoor Installation		2
Transformer	1000kVA	Indoor Installation		1
Main Low Voltage Panel		Indoor Installation		1
PF Improvement Panel		Indoor Installation	SC 100kVar x1	2
PF Improvement Panel		Indoor Installation	SC 125kVar x1	1
Motor Control Centre	PS-1	Indoor Installation		1
Motor Control Centre	Inlet Works 1	Outdoor Installation		1
Motor Control Centre	Inlet Works 2	Outdoor Installation		1
Motor Control Centre	SPS-1	Indoor Installation		1
Motor Control Centre	SPS-2	Indoor Installation		1
Local Control Switch				55
Generator Set	Diesel Type 750kVA with 4500 Liter Fuel Tank		Indoor Installation	1
Level Metre	Ultrasonic Type	0 to 5m	Outdoor Installation	7
Flow Metre	Ultrasonic Open Channel Type	0 to $3500m^3/h$	Outdoor Installation	2

Table 124.2.2 List of Connecting Pipes in TP-1

	Diametre / Length	Length
Connecting Pipes	100-300mm, 1050mm L= 4,870 m	Connecting inlet works, primary settling tanks, trickling filters and final settling tanks for sewage. Connecting primary/final settling tanks and sludge handling facilities for sludge.

As shown in **Figure 124.2.2**,**Table 124.2.1**, and **Table 124.2.2** major rehabilitation works include;

- replace main pumps with new ones
- replace sludge scrapers of four primary settling tanks and four final settling tanks with new ones
- replace primary effluent sprinklers of eight trickling filters with new ones
- replace sludge withdrawal pipes of four primary settling tanks and four final settling tanks with new ones
- replace pipes connecting treatment facilities for sewage conveyance and sludge conveyance with new ones
- install flow metre
- replace associated electrical equipment with new one

The rehabilitation works will enable TP-1 to treat the flow of 110,000 m^3/d to meet the effluent standard of BOD of less than 80 mg/l.

(2) Sewage Treatment Plant TP-3

Figure 124.2.3 shows general plan of sewage treatment plant TP-3.

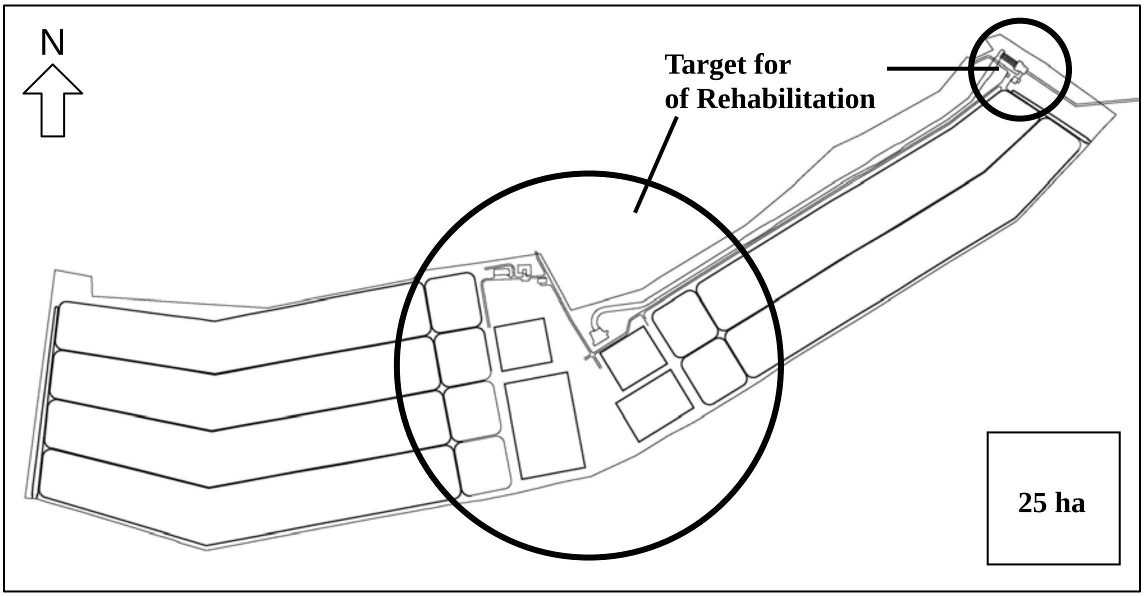
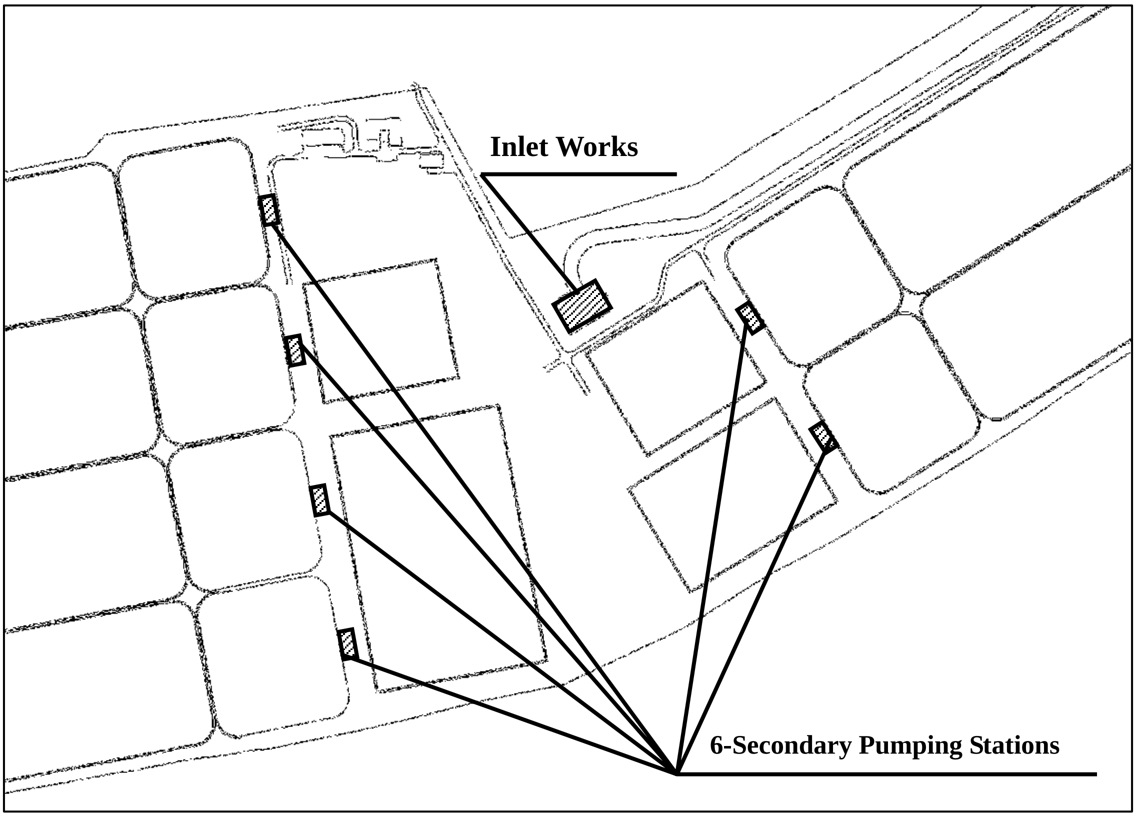


Figure 124.2.3 General Plan of Sewage Treatment Plant TP-3

The scope of rehabilitation for mechanical and electrical work is illustrated in **Figure 124.2.4**. The component of this rehabilitation work is tabulated in **Table 124.2.3**.

The details of the rehabilitation work are attached as **Appendix A124.2.1** to this report.



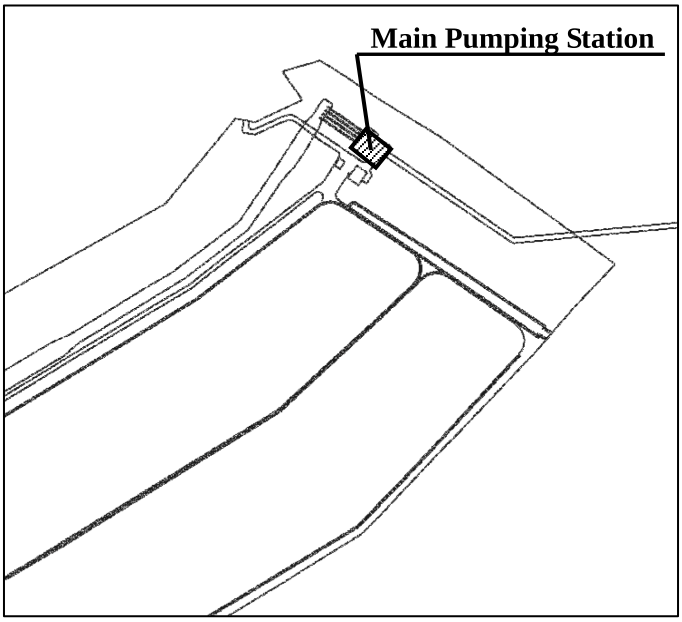


Figure 124.2.4 Scope of Rehabilitation for Mechanical and Electrical Work at TP-3

Table 124.2.3 List of Equipment to Rehabilitate in TP-3

Equipment Name	Specification			Qty
(a) Main Pumping Station				
Motor for Bar Screen			400V 3phase 1.50kW	4
Potable Water Pump	Centrifugal Pump			3
(b) Screen, Grit Chamber (Inlet Works)				
Motor for Mechanical Screen			400V 3phase 1.50kW	5
Motor for Grit Collector			400V 3phase 3.00kW	3
Motor for Organic Pump			400V 3phase 0.20kW	3
Motor for Grit Separator			400V 3phase 1.50kW	3
Potable Water Pump	Centrifugal Pump			2
Drainage Pump	Submersible Sewage Pump			2
(c) Anaerobic Pond				
Secondary Pump	Vertical Sewage Pump $0.83m^3/s \times 7mH$		400V 3phase 75.00kW	18
Ventilation Fan			400V 3phase 2.20kW	6
Sump Pump	Submersible Sewage Pump		400V 3phase 1.50kW	12
(d) Electrical Equipment				
Motor Control Centre	Inlet Works	Indoor Installation		1
Motor Control Centre	SPS	Indoor Installation		6
Local Control Switch				61
Level Metre	Ultrasonic Type	0 to 5m	Outdoor Installation	6
Flow Metre	Ultrasonic Open Channel Type		Outdoor Installation	6

Major rehabilitation works include;
- replace 18 submersible pumps with 18 vertical pumps
- construct six pump services with pump sumps where three secondary pumps are installed for each
- install flow metre
- replace associated electrical equipment with new one

The rehabilitation works will enable TP-3 to treat the flow of 245,000 m^3/d to meet the effluent standard of BOD of less than 80 mg/l.

12.4.3 Implementation Schedule

As engineering services, detail design works will begin in early 2012 followed by construction supervision which will be finalized in mid 2014. Replacement works of mechanical and electrical equipment of two sewage treatment plants of TP-1 and TP-3 and construction works of branch and trunk sewers will commence simultaneously in mid 2012 and will be finalized in mid 2014. **Figure 124.3.1** shows the implementation schedule of these construction works for sewerage priority projects.

No.	Components	Description	Unit	Quantity	2012	2013	2014	2015	2016
					Year				
1	**Engineering Service**								
	Engineering Service	TP-1 and TP-Sewage Treatment Plant, Sewer and Box Culvert	-	-	■	■	■		
2	**TP-1 Sewage Treatment Plant**								
	2.1 Mechanical Equipment								
	a) Main Pumping Station				■	■	■		
	Main Pump	Vertical Centrifugal, 31.2m^3/min 10.0m 90kw	sets	7					
	Electric Winch for Coarse Screen	1,000kg 1.5kw	sets	4					
	Sump Pump	Submerged pump 1.1kw	sets	2					
	b) Screen Chamber	Drive Equipment for Mechanical Rake 1.5kw	sets	4	■	■			
	c) Detritor				■	■	■		
	Drive Equipment for Grit Collector Rake	3.0kw	sets	2					
	Organics Return Pump	0.18L/s 1.0m 0.2kw	sets	2					
	Drive Equipment for Grit Removal Rake	1.5kw	sets	2					
	d) Primary Settling Tank	Equipment of Sludge Collector Rake Diameter 42.0m	sets	4	■	■	■		
	e) Trickling Filter	Water Spray Bar Diameter 41.4m	sets	8	■	■	■		
	f) Final Settling Tank	Equipment of Sludge Collector Rake Diameter 42.0m	sets	4	■	■	■		
	g) Sludge Pump Station No.1				■	■	■		
	Humus Sludge Pump	Vertical Centrifugal, 2.4m^3/s 12.3m 11.0kw	sets	2					
	Lagoon Feed Pump	Vertical Centrifugal, 2.0m^3/min 20.0m 15.0kw	sets	3					
	Sump Pump	Submerged Pump 1.5kw	sets	2					
	h) Sludge Pump Station No.2				■	■	■		
	Humus Sludge Pump	Vertical Centrifugal, 2.4m^3/s 12.3m 11.0kw	sets	2					
	Pressure Pump	Horizontal Centrifugal 2.5kw, with Pressure Tank	set	1					
	Sump Pump	Submerged Pump 1.5kw	sets	2					
	2.2 Electrical Equipment				■	■	■		
	Incoming Panel		sets	2					
	Electrical Transformer	1,000kVA	set	1					
	Main Low Voltage Panel		set	1					
	PF Improvement Panel	SC 100kVarxl 2sets, SC125kV arxl 1set	l.s.	1					
	Motor Control Center	PS-1 1set, Inlet Works -1 1set, Inlet Works-2 1set	l.s.	1					
	Motor Control Center	SPS-1 1set, SPS-2 1set	l.s.	1					
	Local Control Switch		sets	55					
	Generator Set	Diesel Type 750kVA 4,500 litter Fuel Tank	set	1					
	Level Meter and Flow Meter	Ultrasonic Type 7sets, Ultrasonic Open Channel Type 2sets	l.s.	1					
	2.3 Internal pipe of Sewage Treatment Plant								
	Chamber of JP5, JP6 to F. Settling Tank	DN 1,050mm	m	70	■	■	■		
	Sludge, Scum and Drain Pipe Line	DN 100 - DN 300mm	m	4,800	■	■	■		
3	**TP-3 Sewage Treatment Plant**								
	3.1 Mechanical Equipment								
	a) Main Pumping Station	Motor for Bar Screen 1.5kw 4sets, Potable Water Pump 3sets	l.s.	1	■	■			
	b) Screen Chamber	Drive Equipment for Mechanical Rake 1.5kw	sets	5	■	■			
	c) Detritor				■	■			
	Drive Equipment for Grit Collector Rake	3.0kw	sets	3					
	Drive Equipment for Grit Removal Rake	1.5kw	sets	3					
	Pump	Organics Return 3sets, Potable Water 2sets, Drainage 2sets	l.s.	1					
	d) Anaerobic Pond				■	■	■		
	Secondary Pump	Vertical Sewage Pump 50m3/min 7m 75kw	sets	18					
	Sump Pump	1.5kw	sets	12					
	3.2 Electrical Equipment				■	■	■		
	Motor Control Center		set	1					
	Motor Control Center	SPS	sets	6					
	Local Control Switch		sets	61					
	Level Meter and Flow Meter	Ultrasonic Type 6sets, Ultrasonic Open Channel Type 6sets	l.s.	1					
	3.3 Pump House for Secondary Pump	W=10.0m L=15.0m H=5.0m	hou.	6					
4	**Sewer and Box Culvert**								
	4.1 Branch Sewer								
	North Nazimabad Town	DN 10 inch	m	100,100	■	■	■		
	Gulberg Town	DN 10 inch	m	86,700	■	■	■		
	Liaquatabad Town	DN 10 inch	m	82,500	■	■	■		
	Total			269,300					
	4.2 Trunk Sewer								
	North Nazimabad Town	DN 12 inch	m	3,680	■	■	■		
		DN 15 inch	m	4,570	■	■	■		
		DN 18 inch	m	2,790	■	■	■		
		DN 27 inch	m	820		■	■		
		DN 30 inch	m	1,630	■	■			
		DN 33 inch	m	970	■	■			
		DN 36 inch	m	1,080	■	■			
		DN 42 inch	m	2,460	■	■	■		
		DN 48 inch	m	1,630	■	■			
		DN 54 inch	m	990	■	■			
	Gulberg Town	DN 12 inch	m	1,540		■	■		
		DN 15 inch	m	1,650		■	■		
		DN 18 inch	m	1,350		■	■		
		DN 24 inch	m	4,410	■	■	■		
		DN 27 inch	m	2,290	■	■	■		
		DN 30 inch	m	1,600	■	■			
		DN 33 inch	m	3,090	■	■	■		
	North Nazimabad Town	DN 12 inch	m	4,410	■	■	■		
		DN 15 inch	m	2,000	■	■	■		
		DN 18 inch	m	1,390		■	■		
		DN 24 inch	m	1,200		■	■		
		DN 27 inch	m	1,760		■	■		
		DN 36 inch	m	1,130	■	■			
		DN 48 inch	m	1,610	■	■			
		DN 54 inch	m	2,040	■	■	■		
		DN 84 inch	m	890	■	■			
		1,750x1,750 Box Culvert (Double Culvert)	m	1,010	■	■	■		
	Total			53,990					

Figure 124.3.1 Implementation Schedule of Sewerage System

12.4.4 Plans for Construction and Procurement of Equipment/Materials

(1) Plans for Construction

Plans for construction are prepared based on the implementation schedule. Construction materials are procured according to plan for procurement of equipment/material. In order to obtain high quality outcome of the construction works, plans for construction will include routine quality control, schedule control and safety management. Vibration, noise, liquid and solid wastes that are expected to be generated during the construction works have to be minimized, which will be incorporated in the plans for construction. As a whole, the following items will be taken into account in the preparation of the plans for construction.

Sewage treatment plants of TP-1 and TP-3

Plans for construction have to be prepared by minimizing interrupted operation, since these two plants in operation are to be rehabilitated. TP-3 is close to the sea and salt erosion free paint will be used for mechanical equipment.

Trunk and branch sewers

Circular trunk sewers have diametres ranging between 12 and 84 inches and box culvert has the dimension of 1,750 mm by 1,750 mm. Their total length is 54.0 km. Sheet piles and other soil retaining apparatus will be adopted for larger diametre pipe laying and deeper excavation. Branch sewers are defined as those of 10 inches diametre and their total length is 269 km. Replacement of sewers is planned with smooth flow diversion and abandoned sewers are left underground as they are.

As-built drawings

As-built drawings are to be prepared for concrete structures and sewer pipes at the time of construction completion and to be used for operation and maintenance purposes at the later stage.

(2) Procurement of Equipment/Materials

Construction of sewerage facilities requires pumps, mechanical and electrical equipment for sewage treatment, pipes, valves, concrete and reinforcing steel bars. Mechanical and electrical equipment, concrete, reinforcing steel bars and concrete pipes are locally procured. Pumps, cast iron pipes valves and pumps are to be imported.

Table 124.4.1 Procurement of Equipment and Material for Sewerage System

Item	Description	Procurement
TP-1		
Main Pumping Station	Vertical1 Centrifugal	Overseas
Primary Settling Tank	Equipment of Sludge Collector Rake	Domestic
Trickling Filter	Water Spray Bar	Domestic
Final Settling Tank	Equipment of Sludge Collector Rake	Domestic
Sludge Pump Station No.1	Humus Sludge Pump, Lagoon Feed Pump	Overseas
Sludge Pump Station No.2	Humus Sludge Pump, Pressure Pump	Overseas
Electrical Equipment		Domestic
Pipe	Cast Iron Pipe	Overseas
Valve	Sluice Valve	Overseas
TP-3		
Secondary Pump	Vertical Pump	Overseas
Electrical Equipment		Domestic
Pump House for Secondary Pump	Reinforced Concrete and Concrete Block	Domestic
Trunk Sewer		
84inch:	Pre-stressed Reinforced Concrete Pipe	Domestic
72inch less or equal	Reinforced Concrete Pipe	Domestic
Box Culvert	Reinforced Concrete	Domestic
Branch Sewer	Reinforced Concrete Pipe	Domestic

12.4.5 Plans for Operation and Maintenance of Priority Projects

O&M activities and improvement plans for the sewerage facilities are designed to fit in with the priority projects identified during the Feasibility phase; namely the rehabilitation of branch sewers, installation of branch and trunk sewers, as well as rehabilitation of main pumps at TP-1 and secondary pumps at TP-3 and rehabilitation of treatment facilities at TP-1. Improvements to O&M practices are required as part of DNI in line with modern methods to be adopted by the retail entity responsible for sewerage services within Zone West. The priority will be to operate and maintain sewerage facilities to ensure efficient collection and treatment of sewage, safe disposal of sewage sludge and effluent discharge that complies with environmental standards.

For the sewerage facilities within Zone West, DNI is based on the following premise:

- Effective operations and maintenance practices and methods will be employed.
- Effective methods of process control will be employed including the testing of effluents prior to discharge into public water bodies to ensure compliance with environmental legislation in force. This includes the safe disposal of screenings, grit and sludge generated at plants as a result of sewage treatment
- Effective operations management practices will be employed including the need to collect and act on asset data
- Effective maintenance management practices will be deployed including the need to employ a more proactive approach to maintenance such as the use of planned preventive maintenance practices to ensure efficient plant availability and operability
- Modern techniques and tools will be employed to ensure that the sewer networks are regularly cleaned and maintained to prevent sewer blockages and sewage flooding
- High safety standards will be employed to ensure safe installation, maintenance and operation of equipment in potentially explosive atmosphere

Modern techniques and tools will be employed to ensure that the sewerage networks are regularly cleaned and maintained to prevent sewer blockages and sewage flooding.

High safety standards will be employed to ensure safe installation, operation and maintenance of equipment in potentially explosive atmospheres.

Modern O&M methods employed by the Zone West retail entity will include:

- Policy formulation, setting of departmental targets and objectives
- Asset management plans and the recording of asset information
- O&M manuals that clearly state the parametres, procedures, schedules and responsibilities for effective operation of collection and treatment systems
- 'Planned preventative maintenance' practices
- H&S policy/manuals and contingency/emergency plans
- Providing and acting on meaningful and timely management information
- The use of information systems and technology for all O&M activities such as computerised maintenance management systems (CMMS) and GIS

In the short to medium term this will require the retail operator to:

- Implement best operating practices and manuals
- Implement safe systems of work
- Improve safety standards at sewage pumping stations (PS's), sewage treatment plants (TP's) and the sewer networks
- Upgrade electrical installations at TP's and PS's to comply with safety regulations in force
- Provide tools for effective maintenance of PS's, TP's and the sewer networks
- Measure the performance of assets and staff

- Record process and asset data and maintain asset records
- Act on process, asset and management information
- Implement proactive maintenance practices
- Enhance skills through training

It is envisaged that in the medium and long term, Regional Control Centres (RCC) will be established for effective control of sewerage facilities. The treatment plants, pumping stations and sewer networks within each region would be monitored and controlled from the RCC's. The RCC's would have a communications link with the Central Control Centre at the service provider's HQ site for monitoring and control purposes. A communications network would provide the communications 'backbone' for purposes of providing management information and telemetry of critical assets and control points such as the PS's.

In order to improve network performance and service standards the retail entity will need to adopt a number of improvements as detailed in the improvement plan shown at **Appendix A124.3**.

(1) Sewage Treatment Plants

After implementation of DNI, the sewage treatment plants, sewage pumping stations and the sewer networks associated with Zone West will be managed by the Zone West retail entity. The retail entity will therefore be responsible for the O&M of TP-1, TP-3 and associated pumping stations.

DNI will be operated on the basis of charging domestic, commercial and bulk customers a sewerage charge set at a fixed % rate of the water charge. This will be determined, agreed upon and monitored by the independent regulator.

Operation and maintenance manuals will be used to document procedures for plant operation and maintenance and will be used for training purposes. This will ensure the deployment of standard operating procedures and practices at each plant.

Training of staff in the use of modern operation and maintenance techniques such as planned preventative maintenance and predictive maintenance techniques, including the hardware, software and technologies employed will be through extensive training programmes for staff transferred to the retail entity from KW&SB.

The sewage treatment plants will be rehabilitated to comply with effluent standard stipulated in NEQS. It is estimated that 62 trained and qualified staff members will be required to comply with efficient operation of the treatment plants . This is based on international best practice and assumes that O&M staff will be responsible for regular 'running' maintenance of the plant and will employ modern O&M techniques. Running maintenance includes regular inspection, oiling and greasing of plant and equipment.

The TP's will be operated on a 24-7 basis and all facilities will be subject to daily and periodic inspection of concrete structures, mechanical and electrical equipment.

Concrete structures include inlet pumping station, grit chambers, primary settling tanks, trickling filters and final settling tanks. Mechanical and electrical equipment include pumps, screens, rakes, grit collectors, scrapers of primary and final settling tanks and sprayers of trickling filters.

Treatment control parametres including influent and effluent qualities will be monitored as a minimum as well as the following:

- Flow rate
- Water level at the plant inlet, primary settling tanks, final settling tanks, anaerobic and facultative ponds
- Water quality including water temperature, pH, BOD, SS, of the plant influent and effluent
- Sludge layer thickness at the bottom of anaerobic and facultative ponds

Major breakdowns or periodic rehabilitation work to plant and equipment will be through maintenance contracts let to specialist maintenance companies to be selected and certified by the retail entity.

Sewage treatment plants constantly generate grit, screenings and sludges removed from raw sewage, and dried sludge from their treatment processes. Such solid wastes shall be removed from the TP's and properly disposed of or reused.

(2) Sewage Collection System

It is estimated that the length of sewers in the three towns will be approximately 1,018km in 2016. Maintenance of sewers includes three major tasks of regular inspection, cleaning and repairs. Maintenance manuals will be used to document procedures for the maintenance of sewers and will be used for training purposes. This will ensure the deployment of standard operating procedures and practices throughout the sewers located within three towns.

Regular maintenance of sewers will include the need to periodically remove deposits, grit and debris. For larger diametre sewers, it will be necessary to use mechanised sewer cleaning equipment.

The most commonly used mechanized equipment is high-pressure water tankers used with sludge vacuum tankers (or "gully suckers") as illustrated in **Figure 124.5.1**:

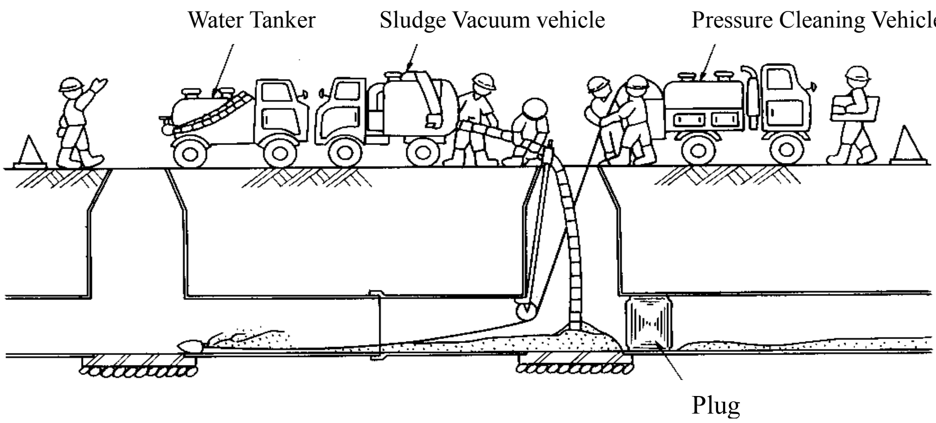


Figure 124.5.1 Mechanized Sewer Cleaning

Where equipment such as sludge vacuum vehicles and jetting machines are available in KW&SB at the time of starting DNI in Zone West it is assumed that the appropriate equipment will be transferred to the new company at that time along with the appropriate staff.

Sewers should be cleaned at least every five years. It is assumed that a sewer cleaning team with mechanised equipment would be able to clean 100m per day. Supposing one team for standby, three teams of six members for each or 18 staff members in total will be in charge of above mentioned maintenance works.

Operation and maintenance manuals will be used to document procedures for branch sewer operation and maintenance and will be used for training purposes. This will ensure the deployment of standard operating procedures and practices throughout the networks located within each town.

Regular operation and maintenance of branch sewers will include the need to regularly remove deposits, grit and debris.
For smaller size sewers, manual cleaning equipment will be deployed extensively such a rodding and swabbing tools, however the use of mechanised equipment would speed up the process in cases where sewers are being cleaned for the first time.

Ten teams of five members for each or 50 staff members in total will be in charge of maintenance works of collection network. Typical manual cleaning equipment such as the Hand Reel Winch type is shown in **Figure 124.5.2**:

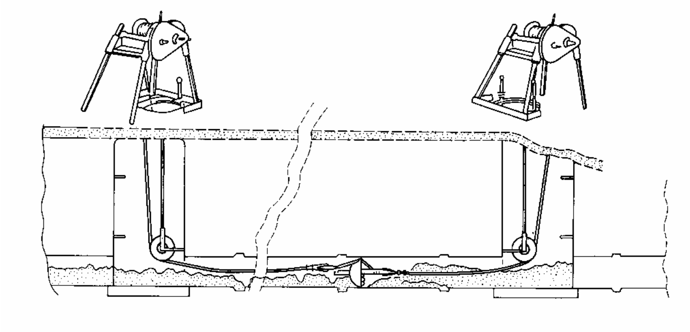


Figure 124.5.2 Manual Sewer Cleaning

The total number of staff members required to inspect and maintain both trunk and branch sewers is 68 including the operation of mechanised and manual cleaning equipment.

A detailed cost benefit analysis will need to be done to determine whether sewer cleaning should be done in-house or contracted out. This warrants further separate study.

If sewer cleaning is conducted in-house, staff transferred to the retail entity from KW&SB will be subject to extensive training in the use of modern operating and maintenance techniques for the regular removal of deposits, grit and debris and for dealing with emergencies such as sewage overflows or sewage flooding, especially where this relates to property flooding.

12.5 PRELIMINARY COST ESTIMATES AND FINANCING PLANS

12.5.1 Preliminary Cost Estimates

(1) Construction Cost

Table 125.1.1 summarizes the construction cost of water supply and sewerage projects. The former is Rs.12,452 million, and the latter is 3,976 million with the total cost of Rs.16,428 million. Refer to **Appendix 125.1** for the details.

Table 125.1.1 Construction Cost of Water Supply and Sewerage Systems

(unit: Rs.thousand)

Water Supply System			Sewerage System			Grand Total
Components	Description	Amount	Components	Description	Amount	
1) Reservoir	Capacity 30mgd	490,860	1) TP-1 Sewage Treatment Plant	Capacity 24mgd Rehabilitation	337,279	
2) Trunk Distribution Main	DN14 - DN100inch L=75,480m	4,605,980	2) TP-3 Sewage Treatment Plant	Capacity 54mgd Rehabilitation	198,685	
4) Flow Meter	DN18 - DN100inch N=17nos.	46,125	3) Branch Sewer	DN10inch L=269,300m	942,550	
5) Distribution Network Main	L=996,100m	2,988,300	4) Trunk Sewer	DN12 - DN84inch, Box Culvert L=53,990m	1,171,080	
6) House Connection	N=228,300nos.	1,035,540	-		-	
Total		9,166,805	Total		2,649,594	11,816,399
Engineering Fee	7.5%	687,510	Engineering Fee	7.5%	198,720	
Land Acquisition		3,680	Land Acquisition		-	
Physical Contingency	5.0%	492,899	Physical Contingency	5.0%	142,416	
Price Contingency	foreign currency1.5% local currency 6.0%	1,916,802	Price Contingency	foreign currency1.5% local currency 6.0%	927,044	
Project Administration	1.5%	184,015	Project Administration	1.5%	58,767	
Total		3,284,906	Total		1,326,947	4,611,853
Grand Total		12,451,711	Grand Total		3,976,541	16,428,252

(2) Operation and Maintenance Cost

1) Water Supply System

Table 125.1.2 shows the operation and maintenance cost for water supply system in the feasibility study area. Bulk water of 84 mgd is purchased from Bulk Water Supply Central. The unit purchasing cost is estimated to be Rs.21/thousand gallon taking into account operation and maintenance costs of Bulk Water Supply Common and Bulk Water Supply Central. Operation cost is estimated for Hub Water Supply System, while maintenance cost is estimated excluding reservoir, trunk distribution main and flow meters associated with Bulk Water Supply Central. Refer to **Appendix 125.1** for the details.

Table 125.1.2 Operation and Maintenance Cost of Water Supply System

Component	Amount (Rs. Million/year)		
Water Supply Project			
Purchased Water Fee			643.8
Trunk distribution main			92.1
Operation Cost		0.0	
Maintenance Cost		92.1	
Distribution Network Main			59.8
Operation Cost		0.0	
Maintenance Cost		59.8	
House connection			68.5
Operation Cost		0.0	
Maintenance Cost		68.5	
Total			864.2

2) Sewerage System

Table 125.1.3 shows the operation and maintenance cost for sewerage system in the feasibility study area. Operation cost is estimated for the necessary expenditure such as personnel cost, utility cost, sludge disposal cost and water quality analysis cost needed to operate two sewage treatment plants of TP-1 and TP-3. Maintenance cost includes those for trunk and branch sewers and mechanical electrical equipment of two sewage treatment plants of TP-1 and TP-3.

Refer to **Appendix 125.1** for the details.

Table 125.1.3 Operation and Maintenance Cost of Sewerage System

Component	Amount (Rs. Million/year)		
Sewerage Project			
Sewage Treatment Plant TP-1	42.5		
Operation Cost		41.1	
Personnel			13.8
Electricity			16.1
Diesel			4.2
Polymer			0
Sludge Disposal			4.2
Laboratory and other			2.8
Maintenance Cost		1.4	
Sewage Treatment Plant TP-3	37.8		
Operation Cost		36.9	
Personnel			9.6
Electricity			18.8
Diesel			4.2
Polymer			0
Sludge Disposal			1.7
Laboratory and other			2.6
Maintenance Cost		0.9	
Cleaning Cost of Branch and Trunk Sewer	9.7		
Sub-total	90.0		
Total	954.2		

12.5.2 Financing Plans

The Zone West retail entity will need to raise funds for the implementation of the Priority Projects. The total project cost is estimated at Rs. 16.4 billion as shown in **Table 125.2.1**. This will provide for the following:

(Water Supply)

- A 30 mg water distribution reservoir,
- 75 km of trunk distribution mains,
- 996 km of distribution network mains, and
- 228,300 service connections including revenue metres.

(Sewerage)

- 269 km of branch sewers
- 54 km of trunk sewers,
- replacement of mechanical and electrical equipment at TP-1, and
- replacement of pumps at TP-3

Table 125.2.1 Summary of Priority Project Cost

Items	Rs. (million)	US$ (million)
Base Costs	11,817	194.4
Water Supply	9,162	150.8
Sewerage	2,650	43.6
Other Costs	4,612	75.9
Engineering Fee	886	14.6
Land Acquisition	4	0.1
Physical Contingency	635	10.4
Price Contingency	2,844	46.8
Project Administration	243	4.0
Total Project Cost	16,429	270.3

Apart from internal financing by Government, there are two prospective external sources of fund which would possibly be used for financing the implementation of the Priority Project. They are ADB and JBIC loans.

(1) ADB Loan

The Asian Development Bank (ADB) fielded an appraisal mission to Pakistan from 21 - 25 January 2008 to conduct loan appraisal of the Karachi Mega City Sustainable Development Program (KMCSDP). The Government of Pakistan (GOP) has requested ADB to provide financing through a 'Multitranche Finance Facility (MFF)' for US$ 800 million over 8 years, for selected infrastructure investments and associated public sector reform and institutional development initiatives in Karachi. The MFF has a maximum utilization period of 10 years, and the 'Periodic Financing Requests (PFRs)' will be converted into separate loans.

The Investment Program under KMCSDP will comprise the following parts:

Part A: Institutional Reform, Implementation Support and Capacity Development.
Part B: Water Supply and Wastewater Management.
Part C: Urban Transport.
Part D: Katchi Abadi Improvement and Low-income Housing.

The Part B Program (Water Supply and Wastewater Management) is intended to help develop effective institutional arrangements for delegated management of water supply and wastewater management by assisting CDGK to (i) establish KW&SB's accountability and commercial freedom, (ii) pilot distribution network improvements in one zone of the water supply network, and (iii) finance improvements in raw water quality and transmission.

The total cost of Karachi's urban sector development plan and strategy is estimated to be equivalent to US$ 8.5 billion over the period 2008 to 2020. The total cost of the Investment Program supported by ADB's MFF, from 2008 through 2015, is expected to be equivalent to US$ 1,135 million, comprising 13.3% of the KSDP-2020 investment requirements.

The GOP has entered into a 'Framework Financing Agreement (FFA)' with ADB for up to US$ 800 million through individual loans. In accordance with the FFA, GOP has submitted the first PFR to ADB in an amount of US$ 210 million. The first PFR in the water sector is expected to amount to US$ 93 million which will finance (i) TA for the establishment of KW&SB's accountability and commercial autonomy, (ii) a pilot distribution network improvement (DNI) scheme in one area of the water supply network; (iii) urgent improvements in the quality and transmission of raw water; and (iv) transaction advice for a management, lease or concession contract (or contracts). It is likely that further investments in distribution network improvement (DNI) will be made in the subsequent tranches.

The total cost of the Program is estimated at US$ 1,135 million of which the identified investment requirements to be funded by ADB under the MFF are estimated at US$ 800 million or 70% of the total Program cost as shown in **Table 125.2.2**.

Table 125.2.2 Details of Program Cost

Source	US$ (million)	Share
ADB Ordinary Capital Resources (OCR)	710	62%
ADB Asian Development Fund (ADF)	90	8%
Government	267	23%
Other sources (including private sector)	68	7%
Total	1,135	100%

Source: ADB

An MFF of up to US$ 800 million equivalent will provide loans for (i) up to an aggregate of US$ 710 million equivalent from ADB's ordinary capital resources (OCR) under ADB's

London interbank offered rate (LIBOR)-based lending facility, and (ii) up to US$ 90 million equivalent in Special Drawing Rights from ADB's Special Fund Resources. Each loan will be extended to finance projects subject to submission of related Periodic Financing Requests (PFRs) by the Government. The Government intends to finance the Program with the submission of four PFRs. The last loan is expected to be executed no later than the estimated project completion date of 30 June 2016. The deadline for submission of the last PFR is expected to be 31 December 2012.

Financing from OCR resources will be subject to interest to be determined in accordance with ADB's LIBOR based lending facility, and commitment charge of 0.75% per annum and other terms and conditions. The Special Funds resources will have a 32-year term including a grace period of 8 years, and with an interest rate of 1.0% per annum during the grace period and 1.5% per annum thereafter.

The borrower of the loan will be GOP. All loans from OCR and the Special Funds will be onlent by GOP to the Government of Sindh (GOS) at the same terms and conditions as those of the ADB loans to the GOP. GOS will bear the foreign exchange risk for all loans. The Finance Department of the GOS will be the Executing Agency (EA).

It is currently expected that about 46% of the US$ 800 million loan (US$ 368 million) will be allocated for Part B: Water Supply and Wastewater Management. Although US$ 93 million has already been allocated for Part B in the first PFR, a large portion of the balance US$ 275 million can be allocated in the subsequent tranches for financing the implementation of the Priority Projects.

(2) JBIC Loan

In the past, JBIC provided a Japanese Yen Loan (L/A No.PK-P40 dated November 22, 1994) for the implementation of the 'Karachi Water Supply Improvement Project'. The project with the major objective of improving the quality of water supplied to Karachi provided for construction of the 100 mgd Manghopir Pumping Station and the 80 mgd Hub Filtration Plant and the capacity expansion by 50 mgd of the Pipri Water Treatment Plant. The JBIC loan amounted to JPY 10.3 billion was a general untied loan carrying 2.6% interest rate and 30 years repayment period including 10 years of grace period.

JBIC loan for the main components of the Priority Projects would be a general untied loan carrying an interest rate of 1.2% with 30 years repayment period including 10 years of grace period. For consulting services, the interest rate will be minimal (0.01%) and the repayment, grace period and conditions for procurement will be the same as those for main components. In addition, an amount equivalent to 0.1% of the total unused loan amount would be levied by JBIC as a commitment charge.

JBIC loan would be able to cover almost the entire project cost shown in **Table 125.2.1** except for the costs associated with land acquisition and project administration.

12.6 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

12.6.1 Background

Environment and social consideration for the Master Plan were already carried out, and the result is shown in **Chapter 11**. According to the results of environment and social consideration, although some adverse impacts on environment and society are expected, it was predicted that adverse impacts could fully be controlled by common mitigation measures.

Consequently, KW&SB and JICA Study Team judged the Master Plan to be category-B based on the JICA EIA Guidelines. From the JICA EIA Guidelines, EIA Study is not essential requirement for the implementation of Category B Project.
In final process of the Master Plan Study, priority project is selected as the Feasibility Study project from the components of the Master Plan. Three towns (North Nazimabad, Gulberg and Liaquatabad Towns) as the priority project area are selected, and the priority project which are mainly distribution network improvement for water supply system and collection network improvement for sewerage system are selected.
In this section, the EIA Study for the priority project is performed. As mentioned above, from the result of environmental and social consideration of the Master Plan, it is concluded that the serious adverse impacts are not generated.
On the other hand, the regulation concerning the EIA of Pakistan requires EIA Study to water supply and sewerage projects with the project cost of Rs. 25 million or more. The project cost of the priority project is **Rs. 16,428 million.** EIA has to be carried out by the time of project implementation, not in Feasibility Study stage.
From the above background, the EIA Study concerning the priority project shall be carried out in the Feasibility Study. However, EIA Study done in the Feasibility Study is taken as EIA Study (Draft) for the following reasons.

Stakeholder Meetings
In this JICA Study, three stakeholder meetings (in the early Study stage, the Master Plan stage and the Feasibility stage) were planned in consideration of implementation of EIA Study. If it is under ordinary circumstances, the broad opinion acquired in stakeholder meetings is reflected into the priority project plan. Consequently, the priority project can be formulated with more residents involvement.
The first stakeholder meeting was held in September 2006. The second stakeholder meeting was proposed to be held at the end of the Master Plan stage to inform of contents of the Master Plan and result of environmental and social considerations in the Master Plan to the stakeholders. JICA discussed the holding of second stakeholder meeting with KW&SB as the KW&SB should take necessary steps to organise the meeting. As the K-IV project and S-3 Project, the former is under PC-1 process and the latter is under pre-qualification stage of consultants, are included in the M/P, KW&SB was reluctant to disclose the information to the public at this stage. Therefore, the stakeholder meeting to inform of the contents of the Master Plan and results of environmental and social considerations was not held. By postponing the 2nd stakeholder meeting, 3rd meeting is not held yet.

Land Acquisition
There are some components with land acquisition in the priority project. However, actual location of land to acquire is not determined yet.

The above-mentioned two items are very important when implementing the priority project. Since these items are not determined at present, the EIA Study in the Feasibility Study may not include all the required items. As mentioned above, EIA has to carry out by the time of project implementation. Prior to EIA report preparation, necessary land has to be acquired and stakeholder meetings have to be held.
The EIA Report (Draft) in the Feasibility Study is shown in **Appendix A126.1**, and Main Report includes the following items as a summary of the EIA report.

1) Project Description

Components of the Priority Project
Justification of the Priority Project

2) Impact Identification and Mitigation Measures

Impact Identification and Mitigation Measures
Risk Analysis and Mitigation Plan

Monitoring Programme

3) Conclusions

12.6.2 Project Description

The priority project selected three towns of North Nazimabad, Gulberg and Liaquatabad Towns in western zone of Karachi City to improve water supply and sewerage system. The priority project consists of water supply and sewerage systems. Components of the priority project for water supply system are expansion of reservoir and improvement of distribution network. Components of sewerage system consist of collection /conveyance network implementation and replacement of equipment in the two associated sewage treatment plants. Components of the priority project are shown in **Table 126.2.1**.

Table 126.2.1 Components of Priority Project

	Components		Quantity
Water Supply System	Expansion of reservoir (NEK Old reservoir)	Capacity (million gallons)	 30
	Rehabilitation of Trunk Distribution Mains	Pipe length (m): Diametre (inch):	25,990 16 - 100
	Installation of Trunk Distribution Mains	Pipe length (m): Diametre (inch):	49,490 14 - 64
	Installation of Flow Mete	Flow mete (nos)	17
	Rehabilitation of Distribution Network Mains	Pipe length (m) North Nazimabad Town: Gulberg Town: Liaquatabad Town: Total	 336,600 374,900 284,600 996,100
	Improvements to House Connections	**Water meter only** North Nazimabad Town: Gulberg Town: Liaquatabad Town: Total **Water meter and service pipe** North Nazimabad Town: Gulberg Town: Liaquatabad Town: Total	 8,800 9,200 2,100 20,100 68,600 71,500 68,100 208,200
Sewerage System	Rehabilitation of Collection & Trunk Sewers	Pipe length (m): Pipe diametre (inch): Box culvert (mm)	36,570 15 – 84 1,750 × 1,750
	Rehabilitation of Sewage Treatment Plant (TP-1)	Pumps and other equipment	-
	Rehabilitation of Sewage Treatment Plant (TP-3)	Pumps and other equipment	-

Justification of the Priority Project

Since the priority project is a part of the Master Plan, there is no alternative study about the priority project itself.

Alternative study of the Master Plan for water supply was carried out from two viewpoints of water source and water transmission system, and details are shown in **Chapter 11.1.2**.

Similarly, alternative study for sewerage system was carried out from technical, economic, environmental and social viewpoints, and details are shown in **Chapter 11.1.3**.

If the priority project is not implemented, the current problems will remain unsolved will be further deteriorated with an increase of population in the future. If the priority project is implemented, the existing problems will be solved.

The existing problems in the project area, and benefits of the implementation of the priority project are shown in **Table126.2.2**.

Table 126.2.2 The Problems and Benefits without/with the Priority Project

The Existing Problems (without Project)	Benefits with the Priority Project
Water Supply System	
Water supply service level is low. Actual service hour (the majority of the population only receives water for a few hours supply every 3 to 4 days.) Since water supply water pressure is low, private storage tank and suction pump are required. Since water pressure is low, ingress of polluted water to the distribution pipe is expected. In order to compensate the amount of insufficient water supply, water supply by a tanker is performed. House connection has many unsuitable facilities because of private responsibility.	All households receive water supply service. Service hour is 24 hours a day and seven days a week. Sufficient water pressure is maintained. Therefore, the private storage tank and the suction pump will be unnecessary. The ingress of polluted water to the distribution pipe is not expected. All households receive the appropriate water supply service. Consequently, water supply by tanker will be unnecessary. All of service connection facilities are reconstructed by the priority project.
The capacity of distribution line is insufficient. There is very high ratio of leakage and non-revenue water. (Average ratio of leakage: 30 – 35 % as the study area) It is possible that without the implementation of the DNI leakage could increase to 60 to 70%.	All households receive water supply service. Improvement is expected.
Many residents of Karachi have a very negative impression of KW&SBB and the service it provides and are therefore reluctant to pay water charges. While the basic cost of piped water in Karachi may be cheap, the indirect costs associated with its use are unreasonable high. With increase in population, the existing problems are aggravated further.	Water meter installation and introduction of a metre-charge system Improvement in the rate of charge collection A financial improvement is prospective. Improvement in water-saving consciousness Improvement is expected.
Sewerage System	
The existing sewage collection ratio: 90 % The capacity of collection and conveyance sewer is insufficient.	The whole quantity of sewage will be collected and the sewage can be conveyed to the sewage treatment plant.
The existing treatment plants are not functional.	The treated effluent will meet the effluent water quality standards.

12.6.3 Impact Identification and Mitigation Measures

The first step in EIA is to identify the potentially significant impacts. The various aspects considered in impact identification of the project are as follows:

- Project components
- Project stages
- Impact generating activities
- Type of impact

A matrix table was used to overall identify the impacts. The matrix thus identifies the environmental factors likely to be affected, and the activities responsible for this. The cells, which fall at the junction of an activity and an affected parametre, have been graded as A, B, C and blank. (See **Table 126.3.1**).

The adverse impacts have been classified in two categories, namely construction stage and operational stage. Impacts during construction stage may be regarded as temporary or short-term whereas those during operation stage are likely to have long-term effects. The environmental impacts have been discussed separately for the construction stage and the operational stage.

Table 126.3.1 Scope Matrix for Project Components

Environmental Elements / Development Scheme		Affected parametres																						
		Social Environment									Natural Environment								Pollution					
		Resettlement	Economic Activity	Traffic/Public Facilities	Split of Communities	Cultural Properties	Water Right/Right of Common	Public Health Condition	Solid Waste	Hazard (Risk)	Topography and Geology	Soil Erosion	Groundwater	Hydrological Situation	Coastal Zone	Flora and Fauna	Meteorology	Landscape	Air Pollution	Water Pollution	Soil Contamination	Noise and Vibration	Ground Subsidence	Offensive Odor
Activities																								
Water Supply System																								
Expansion of reservoir (NEK Old reservoir)	cs	B		C				C	C									C	C			C		
	os						C											C		C		C		
Replacement of trunk distribution main	cs		C	B				B	C	B								C	B			B		
	os		B		C															C				
Installation of trunk distribution main	cs		C	B				B	C	B								C	B			B		
	os		B		C															C				
Installation of flow metres /Flow control valves	cs		C	B				B	C	B								C	B			B		
	os		B		C															C				
Installation of distribution main	cs		C	B				B	C	B								C	B			B		
	os		B		C															C				
Installation of service connection	cs		C	B				B	C	B								C	B			B		
	os		B		C															C				
Sewerage System																								
Replacement of existing sewer line	cs		C	B				B	C	B								C	B			B		
	os				C																			
Installation of new sewer line	cs		C	B				B	C	B								C	B			B		
	os				C																			
Rehabilitation of Sewage Treatment Plant (TP-1)	cs								C															
	os								C											C		C		C
Rehabilitation of Sewage Treatment Plant (TP-3)	cs								C															
	os								C											C		C		C

Note:
cs: Indicates construction (rehabilitation) stage.
os: Indicates operation stage.

A: Indicates that the development scheme is foreseen to have strong impact on the environmental element.
B: Indicates that the development scheme is foreseen to have some impact on the environmental element.
C: Indicates the impact is not quite sure but minor impact is expected.

Adverse impacts and mitigation measures during construction stage and operation stage are summarized in **Appendix A126.1** and items which are important or need explanation are described below.

Expansion of Reservoir (NEK Old Reservoir) - Construction Stage, Water Supply System

Resettlement

Impact:

Expansion of existing reservoir (NEK Old Reservoir) is proposed as the priority project component, and the land acquisition for expansion is necessary. Resettlement and disappearance of productive green /agricultural land may cause by land acquisition.

Mitigation Measures:

The NEK Old Reservoir is located in a suburb area of the north side of the Study Area. However, actual location of construction site is not determined yet. The existing boundary of water supply facilities area and an adjoining vacant area are shown in **Figure 126.3.1**.

Land owner of this vacant area is the Sindh Provincial Government, and there is no house and any facilities. If it is possible that the adjoining vacant area is able to acquire for the expansion project site, the level of adverse impacts caused by the land acquisition for the expansion of reservoir is expected not significant. The requirement of the land acquisition is shown in **Table 126.3.2**.

Table 126.3.2 The Land Acquisition for the Expansion of Reservoir

Project Component	Capacity of Facility to be Expanded	Area Need to Acquire
Expansion of NEK Old Reservoir	30 million gallons	1.5 ha

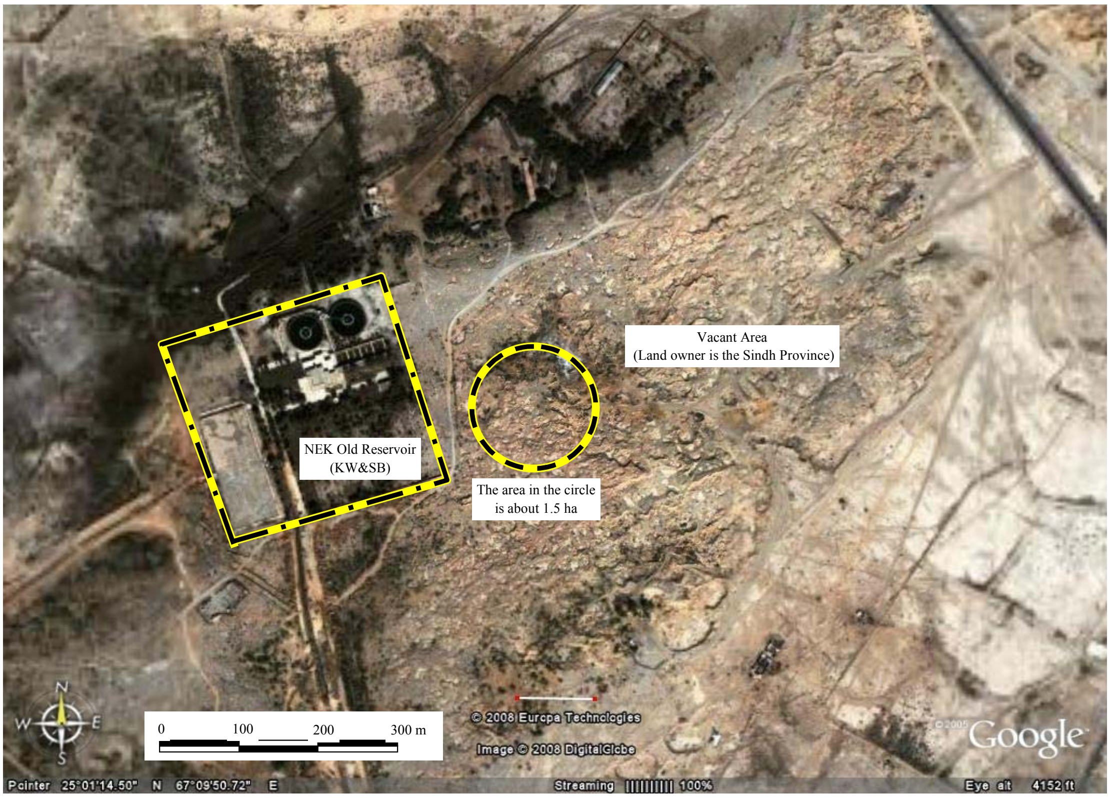


Figure 126.3.1 The Suitable Site for the Expansion of Reservoir

Construction of Distribution Network - Construction Stage, Water Supply System

Construction of distribution network is an integrated combination of the following works:

Replacement of trunk distribution main
Installation of trunk distribution main
Installation of flow metres /Flow control valves
Installation of distribution main and line
Installation of service connection

Traffic/Public Facilities

Impact:

During the construction stage, serious disruptions of vehicular traffic and pedestrian, traffic jams, bottlenecks and blockages to roads will be expected.

During the construction of service connection, water supply may be partly disrupted for a certain period of time.

Mitigation Measures:

These impacts could be mitigated or minimized by the following countermeasures:

The announcement and public notification concerning the construction of facilities and its schedule before the construction.

As mitigation measures, during the construction period, watchman or traffic control staff will be deployed at the site to control the traffic, and schedule of the transport of construction material should be controlled.

Traffic diversion management should be properly implemented to control pedestrian movement.

Temporary fences with appropriate warning signs should be used to isolate the construction site. Especially, construction sites in the vicinity of schools, mosques and locations of public concentration should be strictly fenced.

If blockages to roads and other services are unavoidable, such blockage areas should be identified well in advance and circulate to public with appropriate details on maps.

During the construction stage, the project owner or building constructor should arrange an information desk and a person responsible at the construction site office.

When construction of service connection is carried out, constructor should inform the related household about preparation of water for drinking and domestic use. If necessary, the project owner should arrange sharing water with neighbours or water service by tankers.

Hazard (Risk)

Impact

The accident by the unapproved entry to the construction site can be considered.

It is said that about 50% of the existing distribution line in the Study Area uses an asbestos cement pipe. Respiratory organs illness by asbestos to workers and residents possibly occur by work such as cutting of asbestos cement pipe.

Mitigation Measures (Accident)

At the time of construction, the safety of public is one of the most important issues. Following combination of the activities increases the risks of accidents (especially local population) during construction stage:

Unauthorized access to a construction site
Absence of control over access to construction sites
Collision with construction vehicles
Poor site safety measures and warning system
Inadequate site management

Countermeasures such as fences with appropriate warning signs and personnel assignment against the above-mentioned items should be taken.

Mitigation Measures (Asbestos Cement Pipe)

In principle, the existing distribution line will be abandoned with the present condition. Consequently, the adverse impact at construction sites or move-out processes will be not generated.

When the work such as cutting of asbestos cement pipe is needed, it is required to work with careful attention to the following points.

Workers wear an anti-dust mask and working clothes, and these equipments is discarded after the end of work.

In principle, cutting work of the pipe is avoided as much as possible.

When cutting a pipe, it should be done after pouring water and making pipes wet.

The scob of cutting is kept in a container with a lid and should be incinerated.

The construction site forbids entry except the persons concerned.

When conveyance of an asbestos pipe is needed, it should be packed up with a plastic sheet and scattering of asbestos is prevented.

Replacement of Existing Sewer Line & Installation of New Sewer Line - Construction Stage, Sewerage System

It is desirable to construct sewers and water supply distribution networks simultaneously, which possibly reduces the whole adverse impacts by construction. Work schedule and sequencing for combined construction works between sewers and water supply distribution networks should be considered. Normally, Sewers will be laid away from the water supply lines and at a greater depth.

Basically, adverse impacts during construction stage in sewage collection network are the same as these of distribution network for water supply except adverse impact concerning Asbestos Cement Pipe. Therefore, the possibility of the adverse impact is predicted concerning the following environmental elements.

Economic activity
Traffic /Public Facilities
Public Health Condition
Solid Waste
Hazard (Risk)
Landscape
Air Pollution
Noise and Vibration

Description of adverse impacts in the above environmental elements for the sewers (replacement of existing sewers and installation of new sewers) is omitted. (For details, refer to **Appendix A126.1**)

Rehabilitation of Sewage Treatment Plants (TP-1 & TP-3) - Construction Stage, Sewerage System

The rehabilitation of sewage treatment plants is only exchange work of equipment such as pumps, motors, sludge scraper, primary effluent sprinklers and electrical equipment with minor civil works. Therefore, it is expected that adverse impacts in the rehabilitation of sewage treatment plants are not significant to environmental and social aspects.

Solid Waste

Impact:

Solid waste is generated by replacement of equipment such as pumps and electrical equipment.

Mitigation Measures:

The generated solid waste is recyclable and valuable waste such as pumps and iron material.

Expansion of Reservoir (NEK Old Reservoir) - Operation Stage, Water Supply System

Water Right/Right of Common

Impact:

There may be a possible occurrence of adverse impact on the additional water right from the Indus River.

Mitigation Measures:

No additional water intake from Indus River is required till 2025. (For details, refer to **Chapter 3.2**)

Construction of Distribution Networks - Operation Stage, Water Supply System

Economic Activity

Impact:

The household which runs short of water or dose not have service connection receives water supply by a tanker that is operated by the Ranger. Therefore, if all the services have connection and sufficient water can be supplied, water supply tankers will become unnecessary and business will be suspended. There might be possible unemployment of Rangers.

Mitigation Measures:

The water supply facilities will be constructed step by step till 2025, and the demand for water supply tankers will not decrease immediately. Moreover, it is expected that the rapid increase in population of Karachi city will increase the necessity for water supply tankers.

Split of Communities

Impact:

An obvious difference will arise in the water supply service level between adjacent towns and the project area by the implementation of this project.

Mitigation Measures:

Neighbouring towns are also included in the sole Master Plan. The opportunity to receive the same water supply service with the project area in the future is obtained. However, project area has a charge system equivalent to water supply service level.

Rehabilitation of Sewage Treatment Plants (TP-1 & TP-3) - Operation Stage, Sewerage System

Offensive Odor

Impact:

Emission of odor is expected from the sewage and sludge treatment processes in the sewage treatment plants.

Mitigation Measures:

Basically, it is expected that if the plants are operated and maintained properly, it is possible to control odor emission to the minimum. In addition, it is expected that adverse impacts will be reduced at the circumference environment of the sewage treatment plant.

The east and west side of the sewage treatment plant (TP-1) are surrounded is vacant, and the northern and southern areas are occupied by many factories.

Similarly, the sewage treatment plant (TP-3) is surrounded by factories, container yards and sea area. Therefore, the odor from these sewage treatment plants is not considered to cause the adverse impacts to local residents.

However, the odor monitoring at the boundary of the sewage treatment plants should be carried out. According to the monitoring data, it can be judged that the circumference environment of the sewage treatment plants met environmental standards. It is recommended to accumulate the relevant data in the future.

Risk Analysis and Mitigation Plan

During the operation stage, attention should be paid to the following aspects as Risk Analysis.

Power supply

One of the main reasons for malfunction of the water supply facilities and the sewage treatment plants is energy shortage. It is suggested that the power generators and fuel storage against emergency be provided to ensure at least minimum services in case of power cuts.

Electrical & Mechanical Equipment Failure

Operational disruption due to electrical & mechanical equipment failures can be avoided by spare parts and stand-by provision available at site. Operation & maintenance instructions and manuals for emergency should be provided with training to the operation staff in the filtration plants and sewage treatment plants.

Water Pollution and Contamination (Water Supply System)

Raw water might be possible contaminated. Especially, the contamination by substance which has influence on water use and human health should be considered. If such a situation occurs, measures have to be taken such as raw water bypass and operation stop immediately.

These impacts can be mitigated by adopting the following measures:

- Regular water quality monitoring
- Establishment of urgent communication network with the river administrator and related organization.
- Preparation of the operations manual for emergency situation
- Training to the operation staff for the emergency situation

Water Pollution and Contamination (Sewerage System)

The possibility of water quality pollution and contamination of the sewage to the sewage treatment plant by an accidental industrial wastewater can be considered. Accidental water quality problems may cause the following problems:

Malfunction of treatment process

Non compliance with effluent quality standard

Influence on the reuse of treated effluent and sludge

These impacts can be mitigated by adopting the following measures:

- Regular water quality monitoring:
- Factory asset list preparation and its management that possibly emits hazardous wastes.
- Establishment of urgent communication network with listed factories and the Environmental Protection Agency (EPA –Sindh and others.).
- Preparation of the operations manual for emergency situation
- Training to the operation staff for the emergency situation

Monitoring Programme

The project owner should establish monitoring system to assess the quality of the neighbouring environment after the commissioning of the project. An environmental monitoring programme is important as it provides useful information and helps to:

- Verify the predictions on environmental impacts presented in this study,
- Assist in detecting the development of any unwanted environmental situation, and thus, provides opportunities for adopting appropriate control measures.

Monitoring plan for Water supply system

The sampling and water quality analysis of raw water and distributed water will be carried out to check the performance of treatment plant and safety of water supply service.

Monitoring plan for Sewerage System

The sampling and water quality analysis of influent and effluent in the sewage treatment plant will be carried out to check the performance of treatment plant. Moreover, sludge characteristics and air quality should be monitored for the consideration of environmental impacts.

The Preliminary Environmental Monitoring Programmes are summarized in **Table 126.3.3**.

Table 126.3.3 Preliminary Environmental Monitoring Programme

Object		Monitoring Point	Parametres	Frequency
Water Supply System	Water quality (Raw water)	NEK old reservoir	Basic parametres for water supply: Escherichia Coli, Color, Taste, Odor, Turbidity and etc. Hazardous substances: According to the WHO Guidelines	- Daily for basic items - Three or four times a year for hazardous substance
	Water quality (Distributed water)			
	Water quality and others (Tap water)	Selected service connections	Water pressure, pH, Turbidity, Escherichia Coli and etc.	- Once in a season for two seasons
Sewerage System	Water quality (Influent)	TP-1 and TP-3	Simple parametres: Temperature, pH, transparency and etc. Basic parametres: BOD, COD_{cr}, SS, Nitrogen and etc. Hazardous substance: According to the effluent Standards.	Daily for the simple parametres and weekly for the basic parametres - Three or four times a year for hazardous substances
	Water quality (Treated effluent)			
	Sludge characteristics		Hazardous substance and etc.	- Twice in a year
	Air quality		Ammonia, Methyl Mercaptan, Hydrogen Sulphide, and etc.	- Three consecutive days in each of two seasons

12.6.4 Conclusions

The expected positive impacts of the priority project include:

Realization of the living condition which has possibility to access safe water during all day;

Possibility to collect all of generated sewage and to treat appropriately, and expectation of the health, sanitary and environmental improvement as the result;

Enhanced employment opportunities particularly in the construction stage. Furthermore, promotion of the regional economy by improvement of the living environment of the overall project area is expected.

Based on the findings of the EIA Study, the following items should be considered as mitigation measures for project implementation. However, the following adverse impacts are not fatal. If mitigation measures are taken properly, the adverse impacts will be satisfactorily controlled extremely.

Land acquisition for expansion of reservoir (NEK old)

The site (land owner is the Sindh Province) which adjoins the east side of the existing reservoir is not used for other project and there is sufficient area as the construction site for the expansion of reservoir (NEK Old Reservoir). If this site is determined as a proposed site, it is expected that adverse impacts of land acquisition are very small.

Construction of water distribution network and sewer collection network

The main adverse impacts in the construction stage of water distribution network and sewer collection network are effects of the economic activity, traffic situation, public health condition, air pollution, noise and vibration.

Especially, when appropriate measures are not performed, it is expected that serious traffic disturbance will occur. However, these are short-term impacts, and these can be reduced by appropriate construction site management including an announcement and traffic control.

Impact on the tanker water service by implementation of the Distribution Network Improvement

The Distribution Network Improvement in the priority project area will be completed by 2014. Consequently, it is predicted that the tanker water service will become unnecessary in the project area and its business will end. However, the water supply facilities in the Karachi city will be constructed step by step till 2025, the demand for tanker water supply will not decrease immediately. In fact, it is even predicted that the quick increase in population of Karachi City will raise the necessity for tanker water service.

Water pollution and offensive odor from sewage treatment plants (TP-1 and TP-3)

According to the sewerage system planning, if the treatment plants are properly operated and maintained, the effluent will meet the effluent water quality standards and no significant adverse impacts may be expected. Similarly, it is expected that when proper operation and maintenance is performed, odor emission can be controlled.

Impact due to disruption of operation of the water supply facilities and the sewage treatment plants (power cut and electrical accident)

A power failure can be compensated for the installation of power generator. The social infrastructure improvement concerning electricity progresses in the future, and it is expected that power failure will less frequently occur. Furthermore, the adverse Impacts can be controlled to the minimum by preparation of the spare electrical & mechanical equipment, operation manual for emergency, and training to the operation staff for the emergency situation.

12.7 EVALUATION OF PRIORITY RPOJECT AND RECOMMENDATIONS

12.7.1 Economic and Financial Evaluation

(1) Overview of Economic and Financial Evaluation

The priority project was evaluated from the economic and financial points of view. The economic evaluation of the priority project was conducted in the same manner as described for the master plan project in **Section 11.2**. In the financial evaluation, the priority project was examined in order to identify what financial conditions would make it feasible from the financial viewpoint through evaluation of financial indices. Finally, the financial conditions which would ensure the financially sustainability of the Zone West retail entity were studied through financial simulation analyses.

(2) Preconditions and Criteria of Evaluation

The evaluation method and procedure was already discussed in **Sections 11.2.2** and **11.2.3** in the master plan study. The priority project has the following features.

1°	Base Year:	Beginning of 2008.
2°	Construction Period:	The construction works of the priority project (DNI works) are implemented between 2012 and 2014. However, the construction works for water source development are started in advance in 2008. Therefore, these works which correspond to the demand capacity of the priority project are included as a part of the project.
3°	Disbursement Schedule:	Uniform distribution of project costs during the construction period above
4°	Economic Life:	30 years after the completion of the project
5°	Evaluation Period:	30 years after the completion of the construction work (2008–2044)

In the economic evaluation, the social discount rate is set at 12%, as was the case in the master plan study. Other criteria such as SCF, exchange rate, and benefit distribution of public health improvement were also considered for the economic evaluation in this study.

In the financial evaluation, the financial efficiency of the projects was evaluated by comparing the FIRR of the projects with a likely interest rate of foreign loans. According to the latest information available from agencies concerned and major foreign donors, the likely interest rate falls somewhere between 7% and 9% per annum (8% is adopted in this evaluation as medium rate) including the charges required to avert the risks associated with foreign exchange rates.

(3) Economic Evaluation of Priority Project

At first, economic evaluation of the priority project was conducted for water supply and sewerage projects separately. Then, both projects were combined and evaluated as one scheme as was the case for the master plan.

1) Water Supply System

The economic tangible benefits of the priority project were quantified based on the same data and information as used for the evaluation of the master plan. The structure of benefits is the same as discussed in **Section 11.2.4**. It is expected that the benefits will emerge immediately after completion of the distribution network improvement (DNI) in the project area, i.e. from the latter half of the year 2012. The total economic benefit was estimated at Rs.8.1 billion in the matured year 2015. The annual benefits of the respective components are summarized in **Table 127.1.1** (See **Table A127.1.2** of **Appendix 127.1** for details.).

Table 127.1.1 Economic Benefits of Water Supply Project: 2012-2015

(Unit: Rs. Million/Year)

Item	2012	2013	2014	2015
Domestic Saving Benefit	809	4,753	6,221	6,827
Medical Benefit	111	272	889	913
Non-domestic Saving Benefit	36	223	284	304
Reduction of O&M Expenses	11	45	81	93
Negative Benefit	4,293	8,578	4,648	0
Total	-3,326	-3,285	2,827	8,136

In the economic evaluation, the total economic cost was estimated as the sum of three cost components: (a) DNI in the priority project area: Rs.9.65 billion; (b) costs associated with the use of existing water supply facilities in the project area which were assumed as being sunk costs: Rs.3.01 billion; and (c) costs associated with the bulk water supply to project area, including the costs of reservoirs and transmission pipelines: Rs.3.70 billion. Details of the estimated costs (a) and (c) are provided in **Table A127.1.3** of **Appendix 127.1**. Item (b) was estimated on the basis of the book values provided in the financial statements of KW&SB for 2004/05. In addition, operation and maintenance costs of relevant facilities and replacement costs of electrical and mechanical equipment were also included as part of the economic cost. These costs are shown in **Tables A127.1.4** and **A127.1.5** of **Appendix A127.1**.

The economic evaluation of the water supply project revealed 23.5% of EIRR, Rs.17.9 billion of NPV and 2.40 of B/C. The stream of benefits and costs and evaluation indices are presented in **Table A127.1.6** of **Appendix A127.1**. The project was found to be quite viable from the economic point of view, since its EIRR is much higher than the social discount rate i.e.12%. The sensivity analsis indicated that EIRR was still more than 12% even in the case where the benefits decreased by 20% and the costs increased by 20% (See **Table A127.1.7** of **Appendix A127.1** for details.). The sensitivity test of the economic evaluation suggested no risk in terms of economic viability of the priority project. One reason for this is that the project area has already been fully urbanised and as such the intended benefits of the project are expected to emerge immediately after completion of DNI. Another reason is that most of the residents of the project area belong to a relatively high income group and spend a large amount of indirect costs associated with the use of piped water from KW&SB system.

2) Sewerage System

The economic tangible benefits of the priority project were quantified based on the same data and information as used for the economic evaluation of the master plan. It is expected that the benefits would emerge just after the rehabilitation project of the treatment plants in the second half of the year 2014. The matured benefit was estimated at Rs.1,246 million in 2015. The annual benefits of the respective components are summarized in **Table 127.1.2** (See **Table A127.1.9** of **Appendix 127.1** for details.).

Table 127.1.2 Economic Benefits of Sewerage Project: 2014-2015

(Unit: Rs. Million/Year)

Item	2014	2015
Domestic Benefit owing to Improved Environment	337	674
Medical Benefit	161	323
Non-domestic Benefit owing to Improved Environment	86	172
Reduction of O&M Expenses	24	48
Negative Benefit*1	136	0
Total	479	1,246

Note: *1 In 2012 and 2013, the useless existing sewer pipes is replaced in the priority project. Thus, these pipes are evaluated as negative benefit in the years.

Sewers have already been installed in most of the project area. It is therefore proposed that only 20% of the existing sewers would be rehabilitated under the priority project. It is also proposed that major mechanical and electrical equipment at the existing sewage treatment plants would be rehabilitated under the project. The residual values of existing sewers and sewage treatment plants were included as sunk cost based on the book values provided in the KW&SB's financial statements for 2004/05. The cost of the proposed rehabilitation works was estimated at Rs.2,672 million in economic terms (See **Table A127.1.10** of **Appendix A127.1** for details.). In addition, O&M and replacement costs were also included in the project cost (See **Tables A127.1.11** and **A127.1.12** of **Appendix A127.1** for details.).

The economic evaluation of the sewerage project indicated 20.3% of EIRR, Rs.2.1 billion of NPV and 1.82 of B/C. The stream of benefits and costs and evaluation indices are tabulated in **Table A127.1.13** of **Appendix A127.1**. The project was considered to be quite viable from the economic point of view, since its EIRR is significantly higher than the social discount rate i.e.12%. The sensitivity test of the economic evaluation suggested no risk in terms of economic viability of the priority project.

3) Integrated System

The water supply and sewerage projects were combined as one project and subjected to economic evaluation. The results indicated 23.0% of EIRR, minus Rs.18.1 billion of NPV and 2.29 of B/C. The stream of benefits and costs and evaluation indices are tabulated in **Table A127.1.15** of **Appendix A127.1**. Thus, the integrated project was also found to be quite viable from the economic point of view.

(4) Financial Evaluation of Priority Project

The following indices were used for financial evaluation of the priority projects: financial internal rate of return (FIRR); net present value (NPV) and B/C (benefit-cost ratio). The financial benefits would be derived from water sales to consumers, that is, the revenue of water sales. The financial viability of the project was judged by comparing the FIRR of the project with a likely interest rate of foreign loans used to finance the project i.e. 8% per annum. In order to make the project viable from the point of financial view, the FIRR of the priority project needs to be more than 8%.

1) Water Supply System

The present tariff of water supply for metreed bulk consumers is Rs.44/1000 gallon (Rs.9.7/m^3) for domestic use and Rs.73/1000 gallon (Rs.16.1/m^3) for non-domestic uses. It was found that the FIRR of the project would be negative if the present levels of tariffs were applied, but it would increase to 8.3% if tariffs were increased to Rs.128/1000 gallon (Rs.28/m^3) for domestic use and Rs.212/1000 gallon (Rs.47/m^3) for non-domestic use (See **Tables A127.1.17** and **A127.1.18** of **Appendix A127.1** for details.). The sensivity analysis of the financial evaluation indicated that if the tariffs were reduced by 20%, then the corresponding interest rate that would be needed to maintain the financial viability of the priority project should be less than 4% (See

Table A127.1.18 of **Appendix A127.1** for details.).

2) Sewerage System

The current sewerage charge is 25% of clean water charge. The FIRR of the project was also found to be negative if the current level of sewerage charge was applied, but it would increase to 8.2% if the charge was increased to 50% of clean water charge. The stream of revenue and cost of the project, and evaluation indices are tabulated in **Table A127.1.19** of **Appendix A127.1**. The sensitivity analysis of the priority project indicated that if the sewerage charge was reduced by 20%, the corresponding interest rate that would be needed to maintain the financial viability of the priority project should be around 5% (See **Table A127.1.20** of **Appendix A127.1** for details.).

3) Integrated System

The FIRR of the integrated project (water supply and sewerage) was estimated to be 8.3% if clean water charge was increased to Rs.128/1000 gallon (Rs.28/m^3) for domestic use and Rs.212/1000 gallon (Rs.47/m^3) for non-domestic use, and so was the sewerage charge to 50% of the clean water charge. The stream of revenue and cost of the project, and evaluation indices are tabulated in **Table A127.1.21** of **Appendix A127.1**.

4) Financial Impacts and Recommendations

An average water and sewerage service charge paid by the residents of the priority project area is estimated at Rs.290/month per household (5,300 gallon/month times Rs.44/1000 gallon plus 25% of sewerage surcharge). This accounts for 1.9% of the average household income (Rs.15,600/month) in the priority project area. However, the charge would increase to Rs.1,014/month per household if the increased tariffs as discussed above are applied; it would account for 6.5% of the household income, exceeding the level of affordability-to-pay suggested by World Bank (5%). This clearly indicates that increasing tariffs alone would not be able to make the priority project financially viable.

(5) Financial Management of Zone West Retail Entity

The financial sustainability of the Zone West retail entity was examined through a financial simulation analysis based on the schemes proposed in the master plan and priority projects, and by adopting the following assumptions.

1) Prices of water and sewerage services:
   - Domestic water: Rs.88/1000 gallon (2 times of present price)
   - Non-domestic water: Rs.146/1000 gallon (2 times of present price)
   - Sewerage Service: 40% of water charge
   - Price escalation: 10% per 3 years
2) Procurement of financial sources for capital investment:
   - Equity: Rs.14 billion (25% of total investment)
   - Transferred assets: (a) Rs.12 billion of existing facilities in Zone West as of 2008; (b) Rs.18 billion of facilities constructed between '08 and '11
   - Foreign loans: Rs.45 billion (80% of capital investment); Repayment period: 30 years, Grace period: 10 years; Interest rate: 8%, Other charges: 1%
3) Bulk treated water from KW&SB: Rs.23/1000 gallon
4) Stock dividend for share holders: 10% (when net profit after tax exceeds 10% of the total equity)
5) Income tax: 35% of profit of the year

The simulation results are shown as 'Base Case' in **Figure 127.1.1**. In this case, the retail entity would only be able to make profits in 2020 for the first time after 8 years of its operation;

accumulated deficits would not be able to be eliminated until 2031. The details of this simulation analysis are presented in **Table A127.1.23** of **Appendix 127.1**.

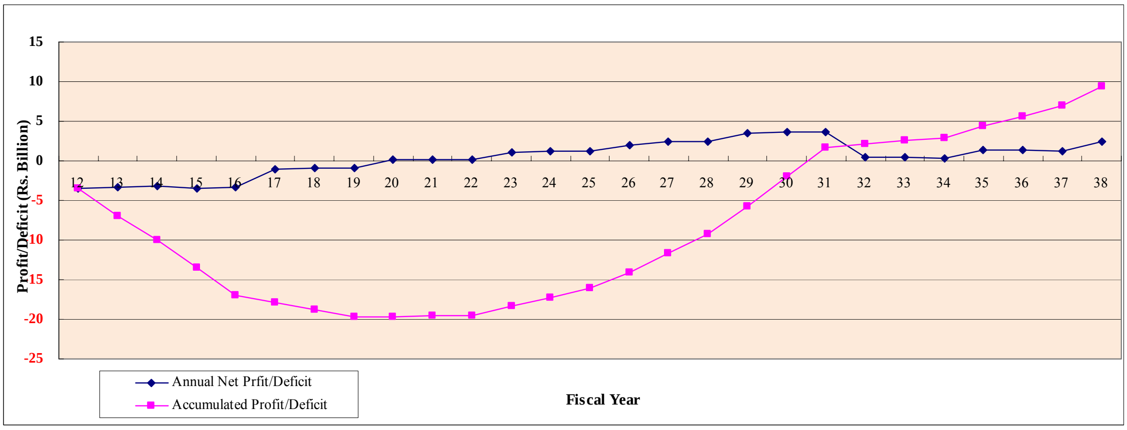


Figure 127.1.1 Results of Financial Simulation Analysis: Base Case

Then, the following changes were made to the assumptions adopted in 'Base Case' and another simulation analysis was conducted.

1) Bulk treated water from KW&SB is Rs.15/1000 gallon for the initial 5 years of operation and thereafter Rs.25/1000 gallon;
2) Interest rate of foreign loans is 4% per annum.

The results of this simulation analysis are shown as 'Case 1' in **Figure 127.1.2**. It was indicated in this case that the retail entity would be able to make profits in 2016; accumulated deficits would be able to be eliminated in 2023. The details of the simulation analysis for this Case 1 are presented in **Table A127.1.24** of **Appendix 127.1**.

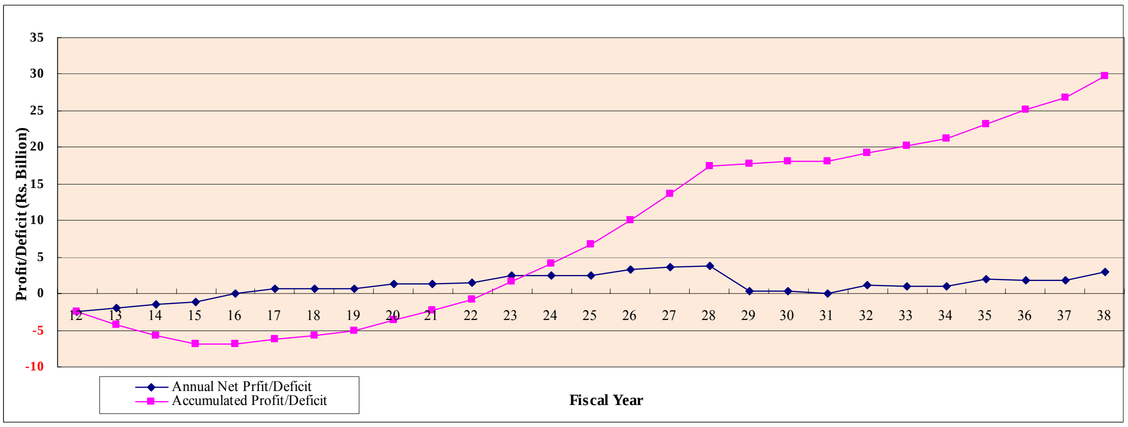


Figure 127.1.2 Results of Financial Simulation Analysis: Case 1

Finally, a simulation analysis was conducted for 'Case 2' shown in **Figure 127.1.3**. It was assumed in this case that the water supply and sewerage prices would be escalated at a rate of 15% per 3 years. Other assumptions are similar to those used for 'Case 1'. The results of this 'Case 2' analysis indicated that the retail entity would be able to eliminate accumulated deficits in 2020 (See **Table A127.1.25** of **Appendix 127.1** for details.). It is considered that this 'Case 2' would ensure the financial sustainability of the Zone West retail entity. In this case, the average monthly household expenditure for clean water and sewerage charges would be Rs.653 [(5,300 x 0.088) x 1.4], which is about 4.2% of the current average monthly household income of the residents in the priority project area, i.e. Rs.15,600.

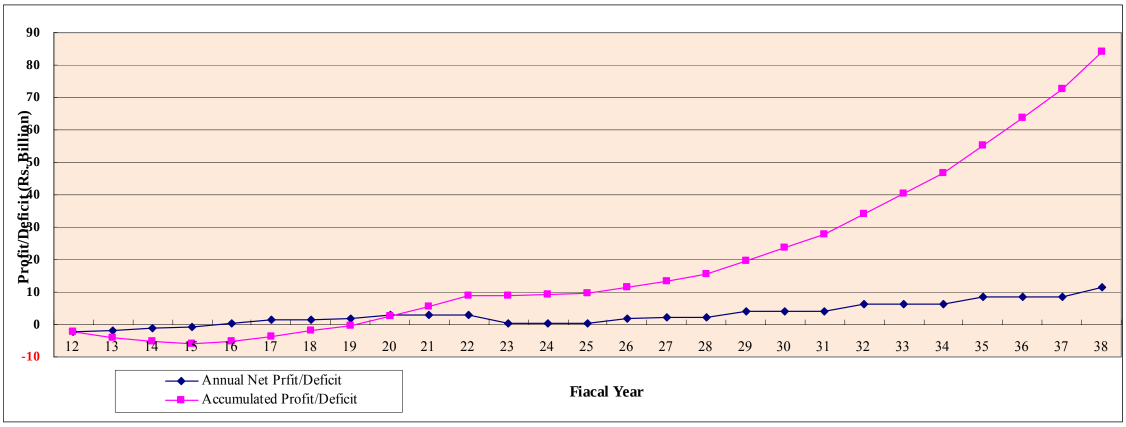


Figure 127.1.3 Results of Financial Simulation Analysis: Case 2

12.7.2 Evaluation of Environmental and Social Impacts

Components of the priority project are classified into two categories; one is water supply system with expansion of reservoir and distribution network improvement (DNI), and the other is sewerage system with improvement of sewage collection network and replacement of electrical equipment in TP-1 and TP-3 sewage treatment plants. Implementation of these components will bring about the following benefits and positive impacts.

<u>Water supply system</u>

- DNI enables access to safety water and sufficient amount of water on 7-24 basis.
- The existing ratio of leakage is estimated to be 30 to 35% of water supplied, and DNI is expected to improve the rate of water leakage effectively.
- By installing water meter to every service, a metre-charge system will be possible. Consequently, user will pay the water consumption corresponding charge, and it is expected to lead the improvement in users' water-saving awareness.
- By improving water supply service and reducing individual compulsory associated fees concerning water use such as installation of private tank and suction pump and operation costs, enhanced in the charge collection rate is expected.
- Financial improvement in the management of water and sewerage services is expected by improvement in the charge collection rate.

<u>Sewerage system</u>

- Improved sewage collection will collect all the sewage in the priority project area and convey it to STPs.
- By replacement of equipment in the TP-1 and TP-3 sewage treatment plants, proper sewage treatment is possible, and the water quality of the treated effluent will be possible to meet the effluent water quality standards.
- Consequently, reduction of the discharged pollution load to the public water bodies and water quality improvement in the public water bodies are expected.

According to the findings of the EIA Study, there are some adverse impacts that require mitigation measures in the priority project implementation. Main adverse impacts and mitigation measures are described below.

- <u>Adverse impacts on the land acquisition by the expansion of reservoir (NEK old reservoir)</u>

The site which adjoins the east side of the existing reservoir is not used for other projects and it has a sufficient area as the construction site for the expansion of reservoir. If this site is possible to use as a construction site, it is expected that adverse impacts of land acquisition are minimal.

- Adverse impacts on the construction for improvement of water distribution network and sewage collection network

The main adverse impacts in the construction stage of water distribution network and sewer collection network are the ones on the economic activity, traffic situation, public health condition, air pollution, noise and vibration. Especially, when appropriate measures are not taken serious traffic disturbance will possibly occur. However, these are short-term impacts, and these can be reduced by appropriate construction site management including announcements, traffic control and so on.

- Adverse impacts on the water environment by the increase in the amount of sewage

The increase in the amount of sewage by the DNI was considered in the sewerage system planning. When the treatment plants are properly operated and maintained, the effluent will meet the effluent standards, and water quality improvement in the public water bodies is expected.

- Adverse impacts from sewage treatment plants (TP-1 and TP-3)

Emission of odor is expected from sewage and sludge treatment processes in these sewage treatment plants. Basically, it is expected that if these plants are operated and maintained properly, it is possible to control odor emission to the minimum.

- Adverse impacts on the tanker water supply business

The DNI in the priority project area will be completed by 2014, and the tanker water service will end. However, the water supply facilities in the Karachi city will be constructed step by step till 2025, the demand for tanker water supply will not decrease immediately. Therefore, it is expected that adverse impacts on the tanker water service are not significant.

As a conclusion, though the above adverse impacts may be expected, all the adverse impacts are controlled to the minimum by taking appropriate measures. In addition, not only the above-mentioned benefits and positive impacts by implementation of the priority project, but improvement of the local economy and sanitary conditions as multiplied effects are also expected.

12.7.3 Evaluation of Technical Feasibility

(1) Water Supply Project

1) Evaluation

In order to maximize the benefits of implementing the water supply priority project, the sustainability of the project was discussed from an engineering point of view by taking into account the technical requirements during and after the implementation of the project and KW&SB's technical capabilities. The project includes only the installation/replacement of pipelines and the expansion of a reservoir as its major construction components. Since KW&SB has enough experiences in constructing pipelines and reservoirs, required knowledge and skills to implement the project are already available within KW&SB. However, some training programs will be required for the operation and maintenance of the new distribution network since 24-hour supply of pressured water and flow control based on measurements will be new in Karachi. In conclusion, no major technical constraints are envisaged during and after the implementation of the water supply priority project, as long as the new corporatised entity, which will be established in Zone West, inherits the experiences, knowledge and skills of

KW&SB efficiently.

Regarding the management during the implementation of DNI for the three target towns (i.e. North Nazimabad, Gulberg and Liaquatabad) of the priority project, KW&SB has some similar experiences including international tenders through the past loan projects financed by ADB and JBIC. Therefore, no major difficulties are envisaged in the management of its project implementation. However, since the scale and schedule of the DNI implemented in the priority project is demanding, a Project Implementation Unit (PIU) should be established within the project executing agency (KW&SB or Zone West Water Company).

2) Recommendations

a. onfirmation of Optimum Facility Designs in the Stage of Detailed Design

The preliminary design of distribution network was undertaken during the feasibility study of this JICA Study to identify potential pipe alignments and to propose a possible distribution network system for the three towns. The results of the preliminary design was also used to estimate the project costs for conducting economic and financial analyses and to provide basic information on the project for KW&SB and international donors. The prepared preliminary design of distribution network was based on the location, height, length, etc. of related facilities and geographical futures measured with the GIS established by JICA Study Team. The accuracy of the GIS-based measurements fulfilled the purposes of the preliminary design.

However, the preliminary design of distribution network is not suitable for the reference during the implementation of pipe construction works, as matter of off course, in terms of accuracy and details. Therefore, the detail design of distribution network including more accurate hydraulic analysis should be prepared, before implementing the project, based on detailed topographic and line surveys and geotechnical investigations.

The standard drawings prepared as part of the preliminary design of the proposed water supply facilities, such as reservoir, district mater chamber, service connection, should also be revised through more comprehensive considerations in the stage of detailed design.

b. Implementation of K-IV Projects without Delay

KW&SB are implementing the first phase of K-IV project at present. The project includes the construction of 260 mgd bulk water supply system from Kinjhar Lake to Karachi and the construction of 130 mgd filtration plant at the central part of Gadap Town. For the preparation of the feasibility study, those facilities to be constructed in K-IV project were taken into account. KW&SB should execute the first phase of K-IV project without any delay or suspension.

c. Coordination during DNI

It is important to cooperate with concerned authorities when installing pipes and related facilities by cutting, excavating, refilling and restoring paved roads.

d. Equitable Water Supply

It is necessary to take records of water consumption of each customer and to control the flow entering into each water supply block. Moreover, it is important to identify the customers consuming a lot of water because they may be causing leakage. Leakage survey and repair or warning and sanctions to the consumers causing major leakage are required to improve the effective allocation of the limited water sources of Karachi. And, it is also important to identify the customers consuming very limited amount of water, because it may be because of metre malfunction, illegal connection, or other undesirable reasons.

e. Update of GIS Database

KW&SB or the new corporatrised entity of Zone West should update and add pipeline information, on a day to day basis before, during and after DNI, to the GIS database of water supply network system which was established during the JICA Study and handed over to the newly established GIS Department of KW&SB. The GIS database is very helpful for planning, designing, maintaining and operating the network system effectively.

(2) Sewerage Projects

Priority project of sewerage targets three towns of North Nazimabad, Gulberg and Liaquatabad. These three towns are also the target of water supply project in which DNI is implemented. The implementation of DNI will bring about constant water supply which will inevitably increase sewage generation. Increased sewage has to be collected and treated as required.

Priority projects of sewerage will collect the increased amount of sewage generated in these three towns through new installation of branch sewers in currently non sewered areas and rehabilitation of existing sewers. One of the primary roles of sewage works to promptly collect generated sewage can be played by installation and/or rehabilitation of sewers while making full use of existing facilities.

Another primary role of sewage works is to treat collected sewage at the required level. Increased sewage will be collected and conveyed either to TP-1 or to TP3 where the collected sewage will be treated with the effluent BOD of less than 80 mg/l as stipulated in NEQS. Priority project also includes the rehabilitation of these two treatment plants to restore their original function.

The new installation and rehabilitation of sewerage facilities in these three towns and two sewage treatment plants do not require any sophisticated technologies. Operation and maintenance of implemented/rehabilitated facilities can be done by currently available techniques.

From above mentioned discussions, it is judged that the priority project proposed here is technically feasible.

12.7.4 Overall Evaluation and Recommendations

(1) Overall Evaluation

It is anticipated that the Priority Project would, through implementation of distribution network improvement (DNI), make a substantial improvement to water supply and sewerage services in the three towns located in the western part of Karachi, namely North Nazimabad, Gulberg and Liaquatabad. The total population in these three towns is approximately 2.5 million at present. Almost the entire area covered by these three towns have already been urbanised with the current average population density of the area being as high as 580 persons per hectare. As such, the Priority Project is considered to be a highly cost-effective investment, in which intended benefits of the project could emerge immediately upon completion of DNI.

The primary objective of DNI is to provide a 24 hour continuous supply on a regular basis with an adequate pressure. It is expected that once DNI has been completed, it would substantially reduce the indirect costs associated with the use of piped water in Karachi. They would include the costs for providing ground-level water reservoirs, suction/booster pumps, roof-top storage tanks and water filters, as well as electricity charges for pumping and fuel costs for boiling water prior to drinking. Many households who are compelled to use expensive tanker supplies would also be able to reduce their expenditure on water considerably.

Currently, low and negative pressures in the distribution system exposes the system to contamination from polluted ground water and there is a sever danger to public health. In addition, many households are obliged to use poor quality subsoil water from shallow wells.

The expense of not having an adequate supply of potable water is compounded by the inevitable medical bills resulting from the treatment of water-borne diseases (typhoid, cholera, and hepatitis are common) and the loss of income due to sick time. It is expected that once DNI has been completed, the distribution system would be kept always full of water and under pressure, and as such the chances of contamination would be drastically reduced, and so would be the risks of infection with water-borne diseases, spending on medical bills, and loss of time due to sick time.

It is expected that the Priority Project would considerably reduce the potential health risks associated with the repair, replacement, and demolition of existing asbestos cement pipes in the distribution system. For many years, asbestos cement pipes have been used for water mains in Karachi. As a result, they now constitute about 65% of existing water mains in the distribution system. Most of them have already been deteriorated and undersized, and despite the low system pressure the level of leakage in the distribution system is unacceptably high. It is anticipated that leakage and the incidence of pipe bursts would significantly increase when the system pressure is raised by completion of DNI. This would require all or part of the existing asbestos cement pipe network to be removed or disposed. However, asbestos, in an air borne condition, is a hazardous material. Asbestos cement pipe is non-friable in its intact state but is likely to become friable upon removal, demolition and/or disposal. Once it becomes friable, it will require special safety measures and procedures for handling, containerizing, transporting and disposal, which would also be very costly. It is therefore planned that DNI will develop an entirely new distribution network while leaving the existing distribution network intact. Upon completion of DNI, the new distribution network will replace the existing one completely. The completion of DNI will therefore make the use of the existing distribution network totally unnecessary, and as such it is expected that no repair, demolition, or replacement work of existing asbestos cement pipes would become necessary in future. It is suggested that existing asbestos cement pipes should continue to remain underground and maintain their non-friable state.

It is anticipated that the Priority Project would greatly enhance the efficient and effective use of water resources. DNI would bring about a substantial improvement to water service quality by significantly reducing leakage and other water losses and introducing metreed supplies with a volumetric tariff to all consumers. Introduction of a volumetric charging system would provide a strong incentive for the efficient use of water when it is accompanied by block tariff pricing with increased charges for consumption beyond essential use. This is necessary to prevent the households in areas where DNI has been completed from wasting/misusing water. The tariff structure should differentiate essential use from non-essential use. Low tariffs should be applied to the level of essential use while significantly high tariffs should be applied to the level of consumption that is considered non-essential. This would provide a strong incentive for the efficient use of water and also enable the cross-subsidization of water tariffs from the rich to the poor.

(2) Recommendations

It is recommended that DNI should use good quality pipe materials which comply with internationally accepted standards and competent contractors who would be able to execute pipe laying works in an orderly and disciplined manner. Despite the higher level of initial costs required, this would ensure the quality of constructed pipelines and the smooth execution of pipe laying works. Enforcement of stringent quality control would be required throughout the construction stage, in particular with respect to the pressure and leakage tests of pipelines. It is suggested that the Zone West retail entity should establish a special Project Implementation Unit dedicated to the implementation of DNI and to employ a foreign consultant/s who have had similar experience in other large cities in the past to manage the unit.

It is recommended that the cost for providing service connections should be included as part of the total project cost and recovered in the long run through water tariffs. This is necessary to ensure that proper materials and workmanship are used for construction of service connections and to minimize the chances of leakage in service connections in the future. This also applies to water meters. Metres should be the property of the Zone West retail entity who rent them out to customers. This is necessary to maintain the quality of water meters and to minimize the types of water meters used in the distribution system for ease of maintenance. It is recommended that a regulatory board to be established as part of the proposed institutional reform should be responsible for setting out and enforcing 'Water Supply and Sewerage Services Regulations' which clearly define the statutory rights and obligations of both the Zone West retail entity and its customers in delivering and receiving the services. The regulations should clearly define that although metres are the property of the Zone West retail entity, the responsibility for maintenance of metres invariably remains with customers.

It is recommended that bulk metres should be installed at all existing high-rise condominiums and apartment buildings. This is because of the difficulty of installing individual household metres in those buildings. However, in the absence of individual water meters, it is necessary to develop a special charging mechanism which will effectively prevent the tenants of the buildings from wasting/misusing water. Meanwhile, it is strongly suggested that individual water meters should be installed from the outset at all new high-rise condominiums and apartment buildings in the future.

With respect to the actual implementation of DNI, considerable attention should be drawn to the fact that approximately 65% of existing water distribution mains in Karachi are asbestos cement pipes. It is recommended that contractors should be made fully aware of this prior to the submission of tenders and they should be instructed not to cut, damage or demolish any pipes which are not picked up (registered) by metal detectors. Other utility service operators should also be informed about the danger and the Zone West retail entity should try to provide them with as much information on the existing distribution system as possible. In addition, both contractors and utility service operators should be informed about the procedures that should be followed by them when they accidentally or unknowingly disturbed existing asbestos cement pipes and thereby causing them to become friable.

There are not so many Katchi Abadies in North Nazimabad, Gulberg and Liaquatabad Towns. Nonetheless, where services must be provided free of charge the Zone West retail entity should be compensated by the relevant local body responsible for social welfare services. Although it is necessary to ensure that residents of Katchi Abadies will receive water for their essential use, it should not be realized at the expense of the Zone West retail entity.

DNI will involve not only physical improvement works; it will also include improvements to many institutional aspects, such as the introduction of a dual pricing system, elimination of illegal and unauthorised connections, and the strict enforcement of laws on payment defaulters. As such, it is very likely that the implementation of DNI would face severe political interference if it is financed by Government subsidies. It is therefore necessary to create a new institutional framework, whereby DNI can be implemented on a loan financing basis without any Government subsidies. We have provided in this report an outline of suggested reforms in principle at this stage, which would be necessary to create such a new institutional framework. It is expected that detailed studies related to the suggested reforms will be carried out under the assistance of ADB and WSP. It is also expected that the reform process would be put into effect through the two Reform Committees (one at provincial level and the other at CDGK level) that have already been established under WSP's initiatives, which would take responsibility for ensuring the progressive implementation of reforms in close coordination with the Local Support Unit of the ADB assisted Karachi Mega City Sustainable Development

Program.

Understanding and corporation of the public are indispensable for the smooth and effective execution of DNI. It is therefore recommended that the Zone West retail entity should endeavour to inform the public in advance about the objectives, targets and components of DNI through mass media such as newspapers, TV and radio. Since DNI is expected to take many years to complete across all areas of Karachi, it could only be implemented on an area-by-area basis. This creates the situation where some neighbourhoods enjoy an improved level of service whereas other neighbourhoods continue to suffer from the current poor level of services. This, although being unfavourable from the viewpoint of social justice and equity, is an unavoidable unless and until DNI has been completed across all areas of Karachi. It would therefore be absolutely necessary for the Zone West retail entity to inform the public about this and ask for their understanding. It would also be important for the retail entity to maintain close coordination with NGOs, CBOs, CCBs, UCs, TMAs, traffic police and other utility service operators.

It is recommended that customers in areas where DNI has already been completed (and receiving an improved service under which they are guaranteed that water will be available for 24 hours per day on a regular basis) would pay a water charge that is some multiple of the current level of water charges, whereas customers in areas where DNI has not been completed (and continuously receiving the current level of service with intermittent supply) would continue to pay the current level of water charges. This dual pricing structure is necessary: (a) to generate the revenues in the short to medium term that will be needed to service the loans taken to finance DNI (and thereby implement DNI on a financially sustainable basis); (b) to provide a strong incentive for the efficient use of water in areas where DNI has been completed (and customers are receiving an improved service); and (c) to avoid creating an impression that an improvement in service in one neighbourhood is at the expense of the level of service in other neighbourhoods. We consider that the introduction and enforcement of the dual pricing structure is a prerequisite for the successful implementation of DNI.

It is suggested that the KW&SB's assets relating to the water supply and sewerage system in Zone West would be transferred to CDGK initially and then from CDGK to the Zone West retail entity. CDGK would have an initial shareholding of less than 30% of the voting shares but would, in addition, hold convertible preference shares reflecting the value of the assets transferred from CDGK to the Zone West retail entity. Provisions would be made for converting these shares to voting share after the retail entity's first 5 years of operation. This would allow CDGK the option to ensure that the Zone West retail entity remains under public control after its first 5 years of operation.

All staff transferred from KW&SB to the Zone West retail entity would be on probation for a period of 12 months and would be paid in accordance with their existing contracts of employment. At the end of this period the retail entity will offer new terms and conditions of employment to those staff that it wishes to retain as employees of the retail entity. Staff who do not wish to accept this offer or are not offered continued employment would become the employees of KW&SB and would be eligible for immediate voluntary redundancy.

Because of the extremely poor conditions of the existing distribution network, huge investments would be required to make a substantial improvement to the service quality. Hence, it is likely that the Zone West retail entity's expenses would increase more rapidly than its revenues during the first 5 years of its existence. This implies that special arrangements would have to be made to finance the operating losses that the Zone West retail entity is likely to make during its first 5 years of operation.