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	161	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	42	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

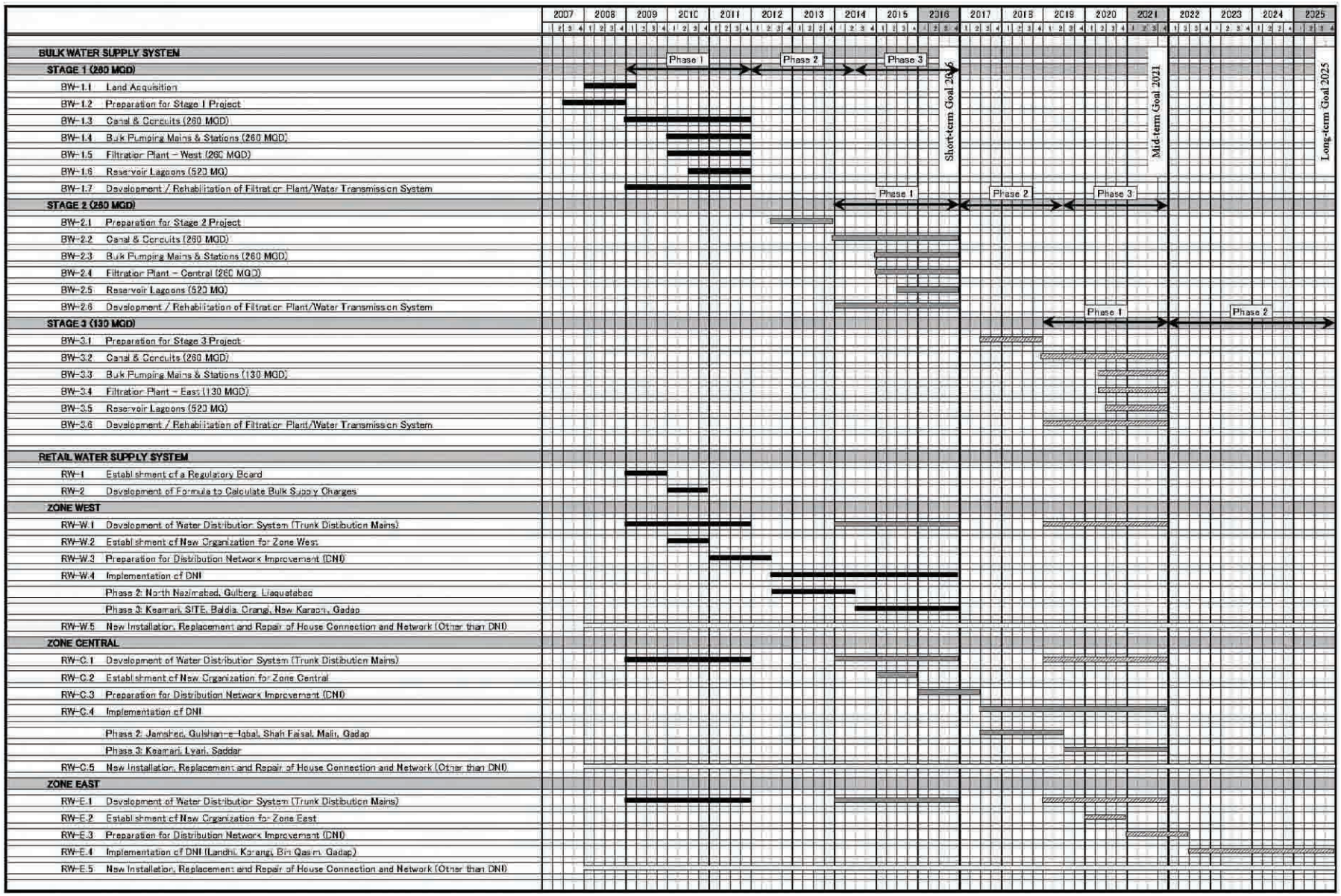
10.3.1 General

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)

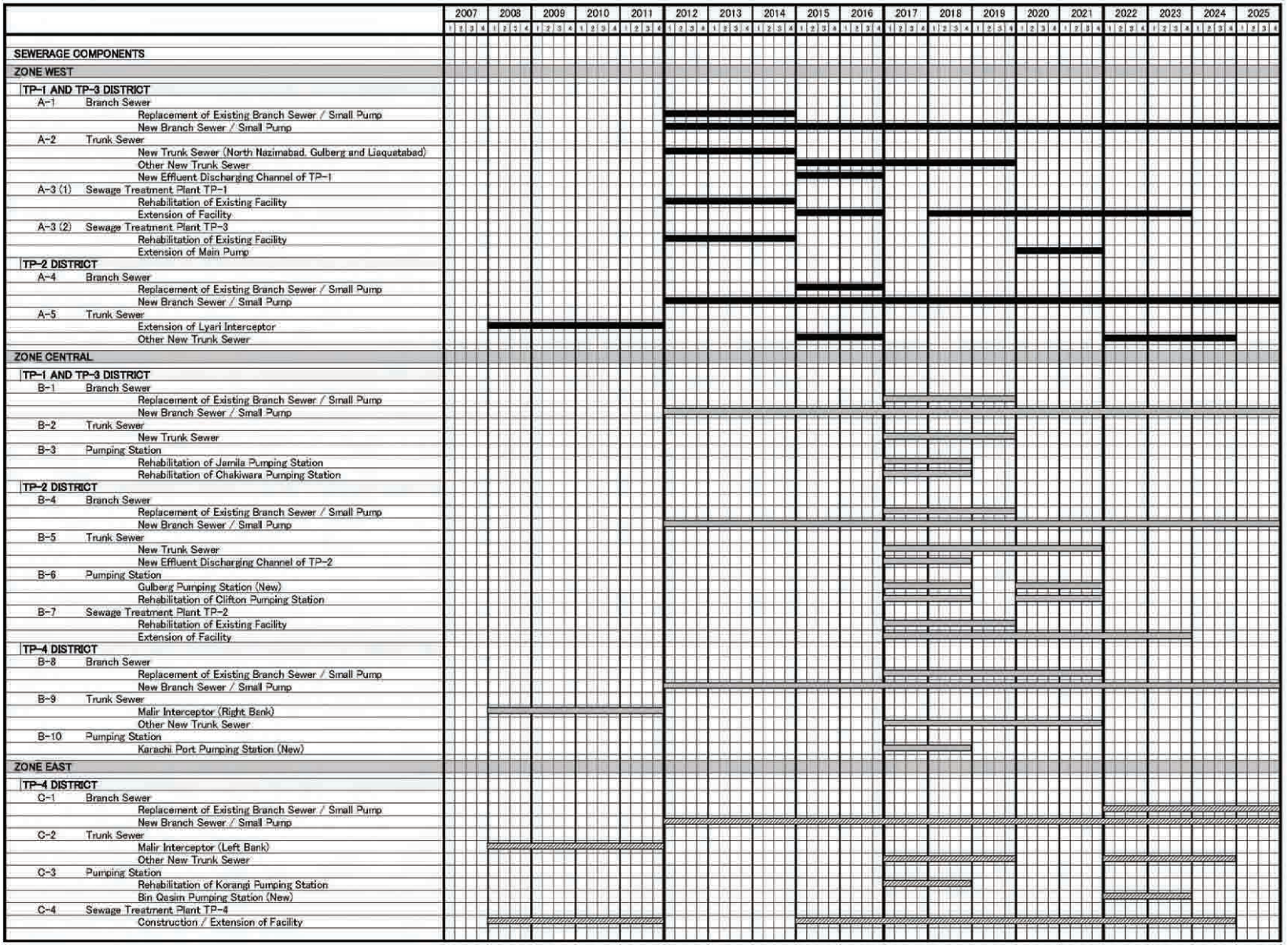
3. Development of New Distribution Network System for New Residential Areas

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



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

[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 rows 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 / Zone	Proposed				Rehabilitation/ Replacement			
	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 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 happen as the population in Karachi City is increasing in future,
- The leakage rate will remain high and the large quantity 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 mainly by precipitation which falls in the watershed area of the basins. Since the major streams and nallahs are ephemeral in nature, most of the precipitation is lost through surface runoff.

The request for additional 1,200 cusecs 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 for watering plants and sprinkling 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 Kinjhar 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 these 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 9 expansion reservoirs are proposed in M/P and the land acquisition for these facilities are necessary.	Permanent	Minimization of resettlement is important. 8 new and 9 expansion reservoirs are proposed. All 8 new reservoirs are proposed in arid and vacant area which is not used for any purpose. 5 reservoirs among 9 expansions are located away from the city and enough space for expansion of the facilities near existing locations is available. Land acquisition is necessary but no resettlement is expected to occur. 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 implemented capacity of High Service is larger than the proposed capacity, the replacement will be done within the existing site area thus the land acquisition and resettlement are not required. For COD and University reservoirs, some space in existing boundary and additional land acqisition will meet the requirement (see Appendix 111.8.1).
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 landowners. 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 acqisition for new facilities.	Permanent	Change in land use is not significant. The site of all 8 new and 9 expansion reservoires are selected in arid and vacant area.
4	Existing social infrastructures and services	Serious disruptions of vehicular traffic and pedestrian, traffic jams, bottlenecks, delays and inconveniences to general public will be expected.	Temporary	The impact is temporary (during construction phase) and with short duration. The annoncement 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 / washing 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 at 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 (ha)	Name	Land (ha)	Name	Land (ha)
Zone west					
Hub *	4.2	Orangi *	2.2	West **	7.6
W01 **	0.6				
Zone central					
COD *	1.6	NEK old *	7.4	NEK new *	4.0
University *	2.2	High Service *	2.2	Central **	1.4
C01 **	2.7				
Zone east					
Gharo *	0.7	Pipri *	7.2	East **	2.6
E01 **	1.4	E02 **	0.3	E03 **	0.3

* - expansion, ** - new

The eight new and nine expansions of the distribution reservoirs are proposed and each location is checked by the satellite image. All eight new reservoirs are proposed to be located away from the city and in arid/vacant area which is not used for any purposes. Additional land acquisition will be necessary for seven reservoirs for expansion and the space is available near the existing location and the expansion of other two reservoirs is possible within the existing boundary. Thus, 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 that are not in the service area by any water supply or experience 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 operation and management 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 temporary 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 proper collection, treatment and disposal of sewage, and enhancement of the human health,
- Improvement of sanitary 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 water 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 viewpoints.

(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 occur.
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 traffic and pedestrian, traffic jams, bottlenecks, delays and inconveniences to general public will be expected.	Temporary	The impact is temporary (during construction phase) and with 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 discharged 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	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 at 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 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 Rivers 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 temporary 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 with 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. Each sector also has 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 optimal plan in the fields of utilising resources from the viewpoint of national economy. 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 (iv) 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**.

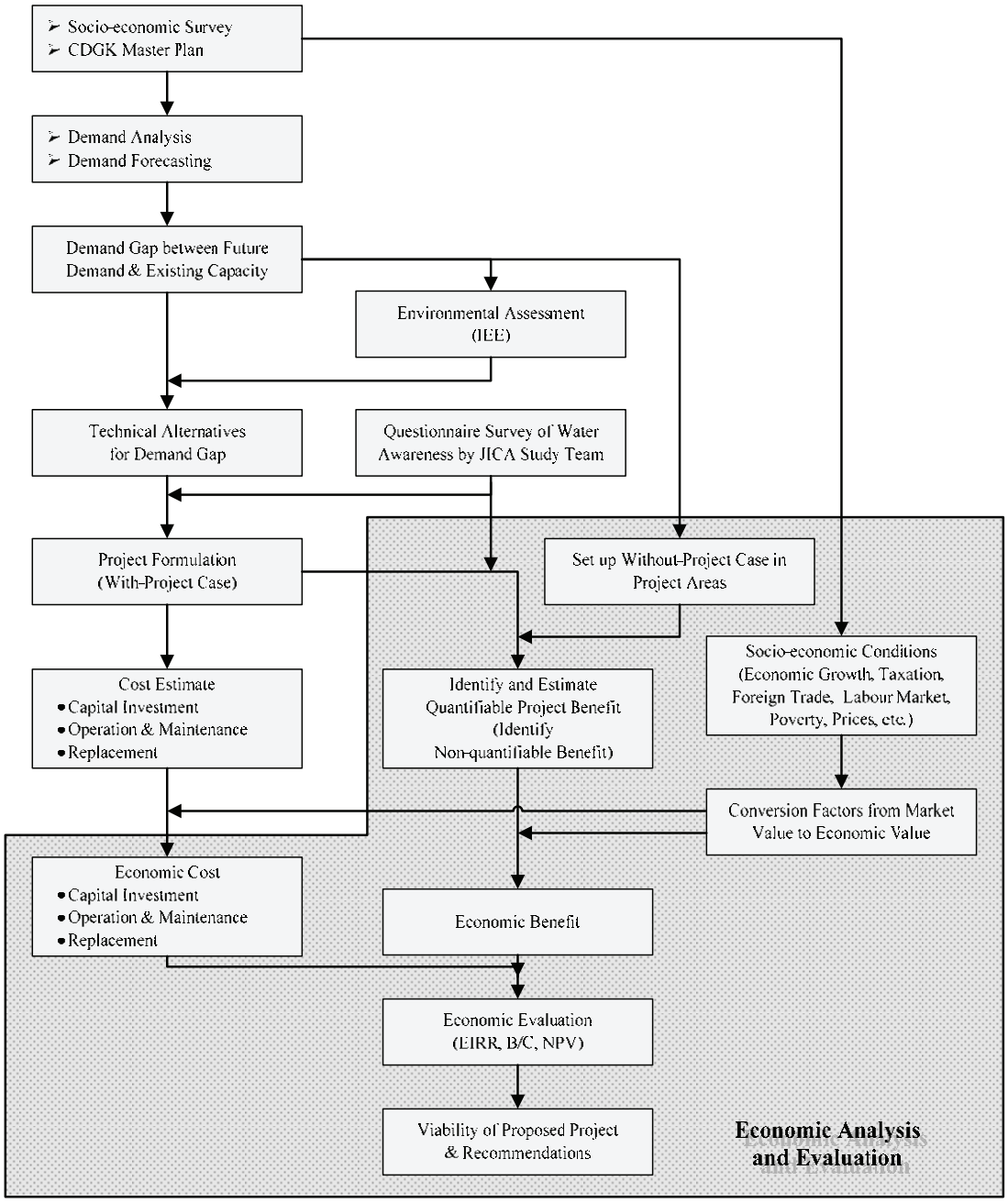


Figure 112.2.1 Flow Chart of Economic Evaluation Procedure in Master Plan Stage

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 means 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° 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 distribution 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 gallons or Rs.54/m^3 for Type 1, Rs.278/1000 gallons or Rs.61/m^3 for Type 2, Rs.302/1000 gallons or Rs.66/m^3 for Type 3, and Rs.441/1000 gallons 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 gallons)	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 a morbidity rate 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 lose 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.

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) 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 gallons 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 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.

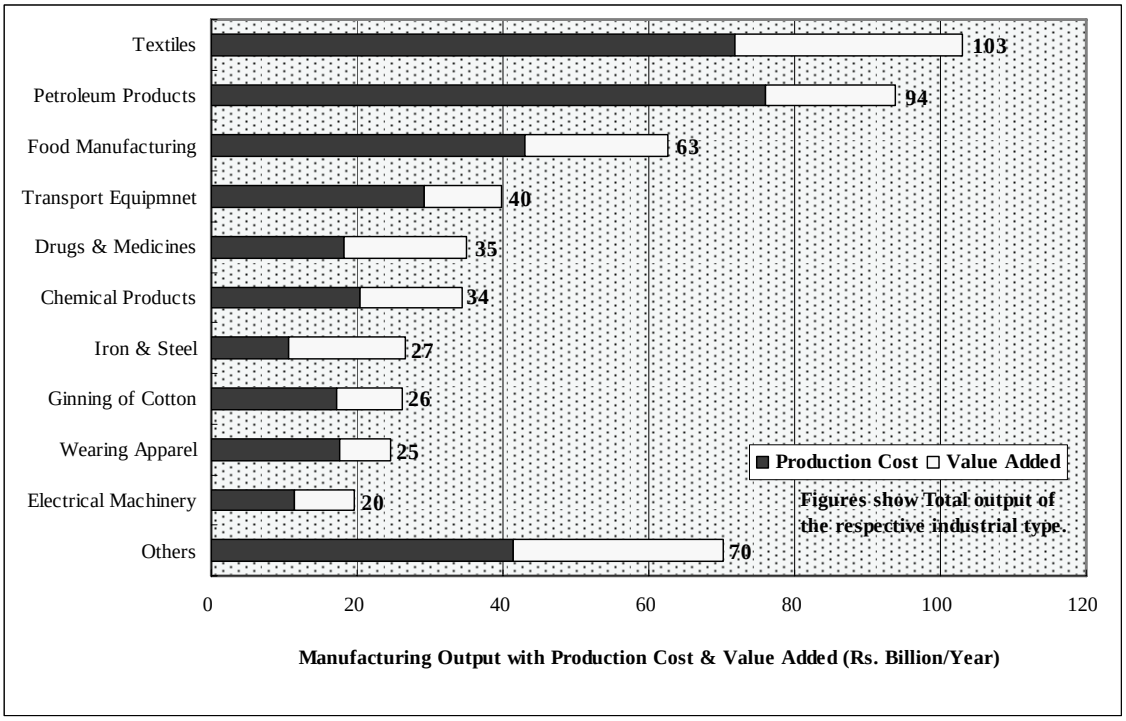


Figure 112.4.1 Manufacturing Output of Major Industrial Types in Sindh Province: 2000-01

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.31.4/1000 gallons 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 consume 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./1000gallons)
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 gallons or Rs.3.1/m^3 in economic value.

The unit cost of Rs.14/1000 gallons 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 gallons or 0.10 million m^3 per year. The unit negative benefit is assumed to be calculated at Rs.65.0/1000 gallons 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 gallons 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 gallons or Rs.54/m^3 of Type 1; Rs.278/1000 gallons or Rs.61/m^3 of Type 2; Rs.302/1000 gallons or Rs.66/m^3 of Type 3; and Rs.441/1000 gallons 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.31.4/1000 gallons 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.14/1000 gallons 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 gallons 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 are 15.7% in EIRR, Rs.52.0 billion in NPV and 1.39 in B/C. Therefore, the project is viable from an economic point of view, because its EIRR is 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 further 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 not 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 gallons/year/HH or 131 m^3/year/HH of Type 1; 45,800 gallons/year/HH or 208 m^3/year/HH of Type 2; 51,700 gallons/year/HH or 235 m^3/year/HH of Type 3; and 57,000 gallons/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 gallons or Rs.6.6/m^3 of Type 1: Rs.52/1000 gallons or Rs.11.4/m^3 of Type 2; Rs.71/1000 gallons or Rs.15.6/m^3 of Type 3; and Rs.116/1000 gallons 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 gallons 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 gallons or Rs.5.8/m^3 of Type 1: Rs.45.6/1000 gallons or Rs.10.0/m^3 of Type 2; Rs.62.4/1000 gallons or Rs.13.7/m^3 of Type 3; and Rs.102/1000 gallons or Rs.22.4/m^3 of Type 4. The overall unit benefit is calculated at Rs.34.7/1000 gallons 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 gallons)	26.4	45.6	62.4	102.0
7° Overall Unit Benefit (Rs./m^3 in Economic Value)				**7.6**
(Rs./1000 gallons in Economic Value)				**34.7**

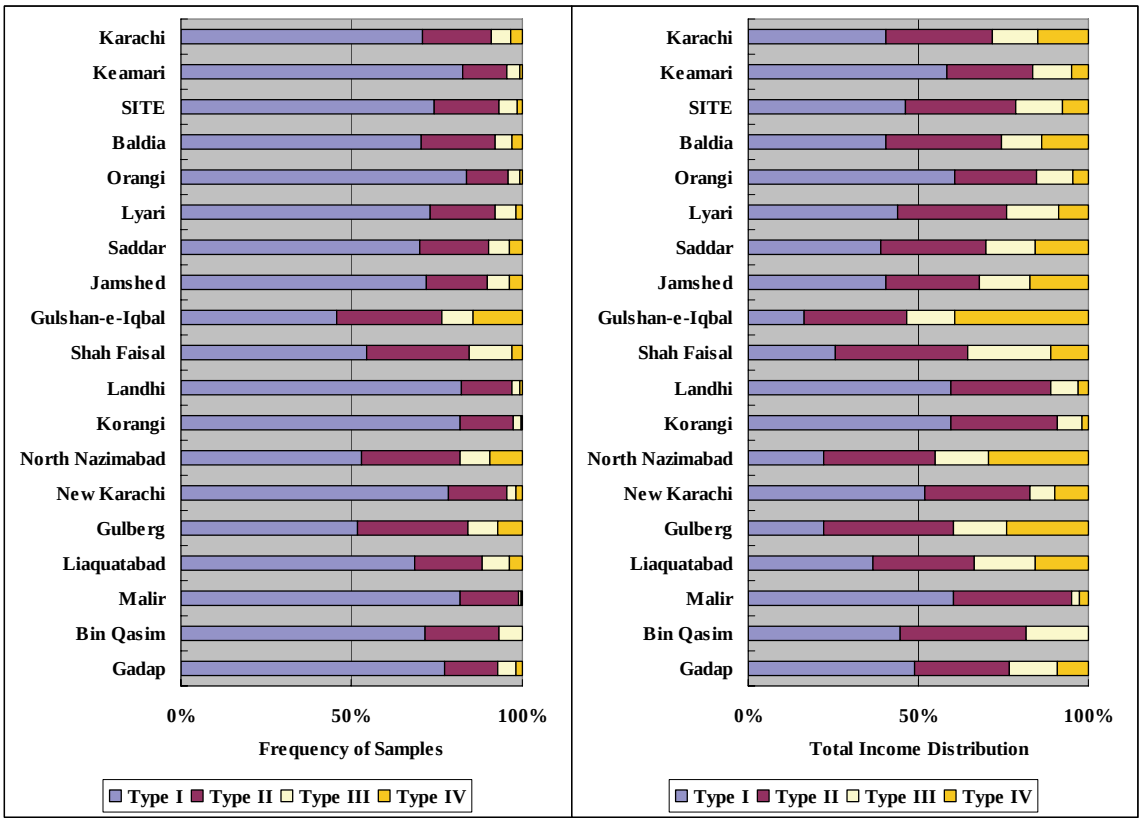


Figure 112.5.1 Income Distribution by Household Type and by Town in Karachi

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.

<u>For Outpatient:</u>

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

<u>For Inpatient:</u>

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 lose their working opportunities during these medical treatments. These losses in economic values were estimated 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) 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 gallons 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 gallons of sewage, or Rs.1.1/m^3. It is converted to Rs.4.3/1000 gallons or Rs.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 value 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 gallons/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 gallons/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	0.09	0.07	0.02	0.04	0.23	0.03	0.04	0.01	0.00	0.00	0.01	0.00	0.07
2009	0.10	0.08	0.03	0.05	0.25	0.03	0.04	0.01	0.00	0.00	0.01	0.00	0.07
2010	0.12	0.08	0.03	0.05	0.28	0.03	0.04	0.01	0.00	0.00	0.01	0.00	0.07
2011	0.22	0.16	0.06	0.10	0.53	0.22	0.14	0.03	0.01	0.02	0.05	0.00	0.25
2012	0.23	0.17	0.06	0.11	0.57	0.28	0.15	0.04	0.01	0.02	0.05	0.00	0.27
2013	0.25	0.18	0.07	0.12	0.61	0.34	0.16	0.04	0.01	0.02	0.06	0.00	0.29
2014	0.51	0.37	0.13	0.24	1.26	0.40	0.28	0.06	0.02	0.03	0.10	0.01	0.50
2015	0.58	0.42	0.15	0.27	1.42	0.46	0.40	0.09	0.03	0.05	0.14	0.01	0.72
2016	0.64	0.46	0.17	0.31	1.59	0.52	0.43	0.10	0.03	0.05	0.15	0.01	0.77
2017	0.89	0.64	0.24	0.43	2.21	0.80	0.69	0.16	0.04	0.08	0.25	0.02	1.24
2018	1.00	0.72	0.27	0.49	2.48	1.09	0.81	0.19	0.05	0.09	0.29	0.02	1.45
2019	1.26	0.91	0.35	0.62	3.14	1.37	0.93	0.21	0.06	0.11	0.33	0.02	1.66
2020	1.43	1.03	0.40	0.71	3.56	1.65	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 Total	Negative Benefit Elimination of Septic Tanks			Grand Total
	Type 1	Type 2	Total			Type 1	Type 2	Total	
2008	0.01	0.01	0.02	0.00	0.35	0.03	0.01	0.04	0.31
2009	0.01	0.01	0.02	0.00	0.38	0.00	0.00	0.00	0.38
2010	0.01	0.01	0.02	0.00	0.41	0.00	0.00	0.00	0.41
2011	0.03	0.02	0.05	0.01	1.07	0.06	0.03	0.09	0.98
2012	0.04	0.02	0.06	0.02	1.20	0.01	0.00	0.01	1.19
2013	0.04	0.02	0.06	0.02	1.32	0.01	0.00	0.01	1.31
2014	0.07	0.04	0.10	0.05	2.32	0.07	0.04	0.11	2.21
2015	0.10	0.05	0.15	0.08	2.83	0.05	0.02	0.07	2.76
2016	0.10	0.06	0.16	0.08	3.12	0.05	0.02	0.07	3.05
2017	0.16	0.09	0.25	0.17	4.67	0.16	0.09	0.25	4.43
2018	0.19	0.10	0.30	0.23	5.54	0.07	0.04	0.11	5.43
2019	0.22	0.12	0.34	0.29	6.80	0.07	0.04	0.11	6.68
2020	0.29	0.16	0.45	0.42	8.28	0.18	0.10	0.28	8.00
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 economic life of electrical and mechanical equipment is considered to be 15 year in general. On the other hand, the economic life of other facilities such as buildings, piping network, and civil works are considered to be more than 30 years. Thus, the former equipment has to be replaced every 15 years throughout the evaluation period. The first replacement cost will incur in 2023, which is 15 years after the completion of the initial 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 are 3.8% in EIRR, minus Rs.30.2 billion in NPV and 0.56 in B/C. Therefore, the proposed project is not viable from an economic point of view, because its EIRR is 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				Benefit							
									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	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 Benefit	Elimination of Septic Tank	Reduction of O&M Exp.	Negative Benefit	Total
	Domestic	Non-domestic					
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 are 6.8% in EIRR, minus Rs.14.5 billion in NPV and 0.69 in B/C, as shown in the table below. Although EIRR in this case is higher than that of the original case, it is still lower than 12%, so the implementation of the proposed sewerage master plan alone would be difficult from the viewpoint of economic viability.

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							
									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	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	-2.12
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 benefit of water supply service in 2025 is expected to reach 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 are Rs.237 billion for water supply and Rs.203 billion for sewerage. The sewerage cost accounts for 85% of the water supply cost.

As shown in the table, EIRR of the integrated project is 13.3%. Other evaluation indices are Rs.21.8 billion in NPV and 1.11 in B/C. Therefore, the Case 1 project is viable from an economic point of view, because its EIRR exceeds 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 benefit of water supply service in 2025 is expected to reach 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 for water supply and Rs.112 billion for sewerage. Unlike Case 1, the sewerage cost accounts for only 47% of the water supply cost in this case.

As shown in the table, EIRR of the integrated project is 14.2%. Other evaluation indices are Rs.37.5 billion in NPV and 1.21 in B/C. Thus, the Case 2 is considered to be viable from an economic point of view, because its EIRR is considerably higher than the social discount rate, 12%. This result suggests that the integrated project of Case 2 would be economically more feasible than Case 1.

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				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	-21.11
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 meters. 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
- Meter reading;

- Meter installation/replacement/repair/calibration;
- Billing based on meter reading;
- Bill collection;
- Receiving customer complaints and feedback and responding accordingly;
- Installing 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 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, the other towns in Zone West 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 the 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 the 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 the 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 the 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.

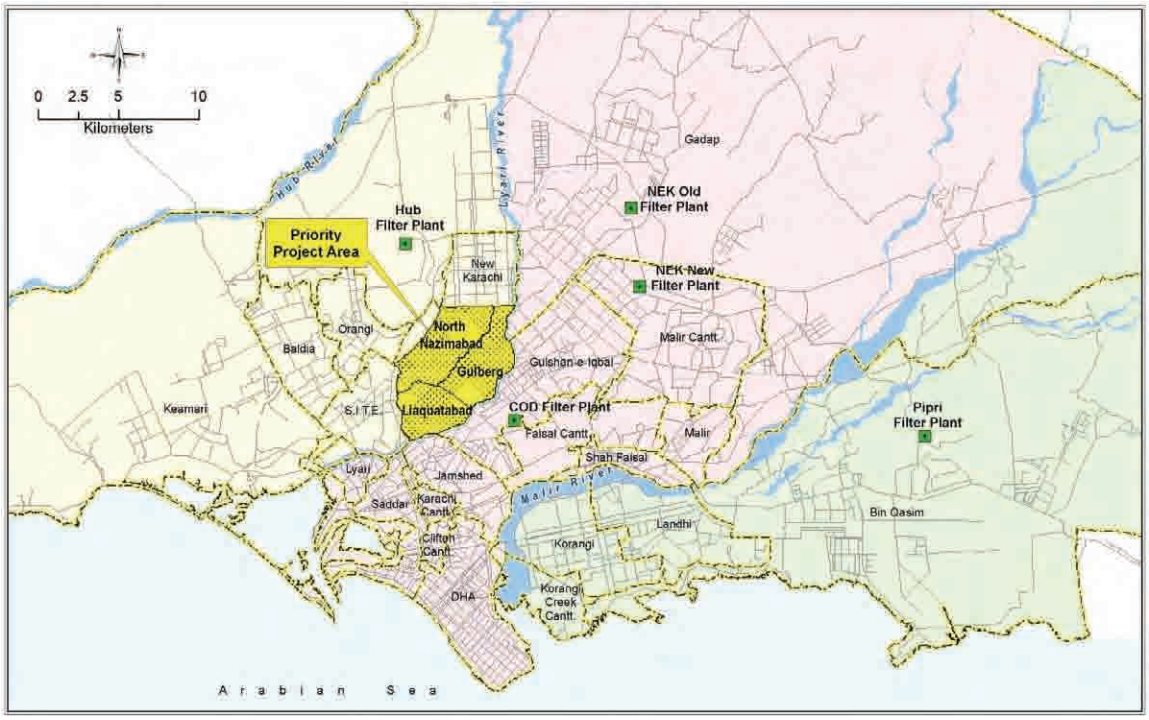


Figure 113.2.1 Location of Priority Project Area

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