4.2.2 STORMWATER DRAINS/COMBINED SEWERS

(1) Combined Sewer System

Substantial areas in the Rusafa and Karkh Districts are provided with stormwater drains for road surface drain, which are separately managed from the sanitary sewers. The sewers constructed in the areas northeast to the Military Canal in the Rusafa District are mainly of the combined system, whereas old sewers in the areas south to the Canal are of the separate sewers. Small sewer networks (smaller than 400mm in diameter) in these areas are mainly constructed by PVC pipes.

In the Karkh District, old sewers built in the northwestern are of the separate type. Where the separate sewers were provided the stormwater runoffs are drained directly the Tigris and Khir Rivers; while in other areas, runoffs are collected through street inlets and catch basins to sanitary sewers.

Where no sewers are provided, many of the existing surface drains have been suffered from the excessive raw wastewater inflows, due to illicit connections of wastewater pipe to the surface drains.

(2) Rainfall Intensity-duration-frequency

The design stormwater intensity for drains and combined sewers are developed based on the highest intensity storm events occurred over a 20-year period “extreme value” statistical methods to determine the rainfall intensity-duration-frequency curves. The relation between estimated total storm per occurrence and return period estimated are:

Table 4.4 Total Rainfalls and Return Period

Return Period (year)	Total Rainfall Per Storm Occurrence (mm)
1. Twice per year	3.6
2. Once per year	8.5
3. Once in 2 years	13.3
4. Once in 5 years	20.0
5. Once in 10 years	25.0

Source: Greater Baghdad Sewerage Master Plan, 1981.

(3) Design Criteria for Stormwater/Combined Sewers

Based upon the hydraulic analyses, the master plan design criteria for the combined sewers were developed as follows:

- For the design of combined sewerage system, the rainfall of once in two-year storm is to be considered. For the combined subsidiary sewers of 250 mm in diameter and main sewers serving wholly or mainly residential areas are to be designed on the basis of 4 x DWF (Dry weather flow), running full. The same criteria were applied in principle to industrial, administrative, commercial or public facility areas;

- Pumping stations be designed so that under surcharge conditions the discharge is not to be greater than 4 x DWF; and

- The combined trunk sewers are to be designed generally on a peak factor of 4 x DWF.

4.3 Pumping Stations

4.3.1 General

As the Baghdad Region lies on the flat and low land, with the ground surface elevations ranging from 23 to 34 m above mean sea water level, intermediate pumping stations are required at many locations. So far totally 271 pump stations —141 vertical and 130 submersible types have been constructed throughout the sewer districts.

A survey conducted by UNICEF after the War identified that 73 pump stations were severely damaged and obsolete: hence, rehabilitation or replacement of structures, electrical/mechanical equipment, and control system were immediately required.

Other pumping stations, although in general workable conditions, some of the pump capacities are not sufficient to discharge the influents particularly when the stormwater runoffs inflow to the sewers. These conditions result in low rate wastewater collection and occasional spills of the wastewater. Thus, much part of the incoming wastewater overflows are discharged directly to nearby drains or directly to the River.

Rehabilitation works for pumping stations have been ongoing by UNDP in the Rusafa District (as of 2004), and the situation is expected to be gradually improved, while those in the Karkh District were left unimproved.

4.3.2 Rusafa District

The main trunk sewers in the District convey the wastewaters to Habeebiya pumping station through a pipe of 2,000 mm in diameter, then through a 3,000 mm diameter pipeline to Rustamiya WWTP, as shown in Figure 3.1.

At present, the Habeebiya pumping station has been operated at a total hydraulic capacity of 267,300m^3/d, which accounts for 75 percent of the total design capacity, whereas outfall pipe has a capacity of 275,400 m^3/day. The balance of 129,600 m^3/day, between the design and operating capacities, is that the upstream of existing trunk sewers are frequently overloaded and caused wastewater stagnations in Baladiyat, Al-Amin and Mashtal areas.

In solving the problems, such missing links as Southeast and South-north line trunks connecting sewer networks to the pumping station is to be constructed, in addition to the improvement of the pumping station.

4.3.3 KARKH DISTRICT

The pumping stations in Karkh District comprise three drainage basins, each basin draining the dry weather and wet weather flows through drainage trunk lines, namely;

(1) P-line
(2) N- line
(2) D- line

The collected wastewaters transmitted through P and N Trunks inflow to PN- Pumping Station, and then transmitted farther to Doura Pumping Station (*For locations see Figure-3.1 and 5.1)*. The wastewater coming from the D-line drain also joins Doura Pumping Station, from where all the wastewaters are conveyed to Karkh WWTP.

The average daily wastewater generation in Karkh District, estimated based on the present population, is approximately 450,000m^3 of which 250,000 m^3 and 200,000 m^3 was planned to come from PN-line and D-line, respectively.

Although the wastewater collected through the D-line drain was originally planned to inflow Doura No.2 pumping station, construction of the station was aborted. As a result, part of the wastewater from the D-line is being discharged directly to the River. The existing pumping stations in Karkh District are as summarized below:

Table 4.5 Pumping Stations in Karkh District

Pumping Station	Wet weather discharge (m^3/min.)	Dry weather discharge (m^3/min.)	Pumps
A1 (Stormwater drainage P.S.)	192	-	ϕ 600mm x 3
T1 (Stormwater drainage P.S.)	822	-	ϕ 700mm x 1, ϕ 1100mm x 5
P5 (Combined P.S.)	300	48	ϕ 400mm x 2, ϕ 600mm x 2, ϕ 900mm x 2
P2 (Combined P.S.)	438	78	ϕ 400mmmx 2, ϕ 700mm x 2, ϕ 900mm x 2
N3 (Combined P.S.)	324	54	ϕ 400mm x 2, ϕ 600mm x 2,

			ϕ 900mm x 2
N2 (Combined P.S.)	468	78	ϕ 400mm x 2, ϕ 00mm x 2, ϕ 900mm x 2
PN (Combined P.S.)	917	161	ϕ 600mm x 6, ϕ 900mm x 6

Source: Draft Final Report "Preliminary Survey on Iraq Reconstruction Plan, March 2004 (in Japanese version)."

4.4 WASTEWATER TREATMENT PLANTS (WWTPS)

4.4.1 PRESENT STATE OF WWTPS

At present, three independent public WWTPs exist in BM area, Karkh WWTP in Karkh District and Rustamiyah WWTP (comprising Rustamiyah No. 0-1-2 plant and Rustamiyah No.3 plant constructed by stage) as shown in Table 4.6.

Table-4.6 Baghdad's WWTPs

Governorate	Project	Design Capacity (m^3/day)	Treatment Process
Mayoralty of Baghdad	Rustamiyah 0&1	79,200	Conventional activated sludge
Mayoralty of Baghdad	Rustamiyah 2	90,000	Conventional activated sludge
Mayoralty of Baghdad	Rustamiyah 3	340,000	Conventional activated sludge
Mayoralty of Baghdad	Karkh	205,000	Conventional activated sludge
Total		714,200	

Source:BSA

BM estimates that about 75 percent of the wastewaters in Baghdad builtup urban districts are being collected through the existing sewer networks: however, only about 55percent of the collected wastewaters are transmitted to the existing WWTPs in Rusafa and Karkh Sewer Districts, the rest having been discharged to the Tigris River without receiving any treatment.

The total present WWTPs capacity is 714,200m^3/day, which serves about 55percent of the wastewater generated. The remaining wastewater has been discharged to the Tigris River without receiving

4.4.2 CURRENT IMPROVEMENT PROGRAMS OF WWTPS

Currently, rehabilitation and improvement work for WWTPs in the Rusafa District are underway by UNDP and other organizations, and the present deteriorated situation is expected to improve shortly (as of 2004). In the Karkh District, however, a minor rehabilitation work of Karkh WWTP was on-going in 2004 and expected to be completed in 2004, but no expansion of the present treatment capacity of 205,000m^3/day was planned.

The existing Karkh WWTP was constructed in 1975, with the designed treatment capacity of 205,000m^3/day and receiving the average daily wastewater influent of 270,000 m^3/day.

Because of its high treatment efficiency, reliability, long operational experience in the existing facilities, and high cost performance, the activated sludge treatment process is the optimum treatment method for the Baghdad wastewater system program, which can remove 90 to 95 percent organic pollutant loads in the wastewater if properly operated and managed.

The WWTPs operation is significantly influenced by the social instability. Electric supply to the plants is limited and occasionally suspended, and the plants' power generators were damaged. Consequently, the operation rates have been significantly reduced to the level of 30 to 50 percent of the originally designed treatment capacity. Presently, the operation of WWTP is entirely closed down.

4.4.3 Planning Basis of WWTPs

Under the "Greater Baghdad Sewerage Study, Preliminary Report," the Baghdad's WWTPs were planned with a view that the plants effluent may comply with the national effluent quality requirement of 40mg/L BOD_5 and 60mg/L SS.

For the Rustamiyah and Karkh Districts, the activated sludge process was selected, which could achieve 95 percent removal of such pollutant loads, producing 20mg/L BOD_5 and 30mg/L SS when properly operated.

Because of the combined sewer system, the WWTPs were designed to receive some part of the stormwater runoffs to treat preliminary and primary with disinfection. Storm retention tanks having a capacity of one hour dry weather flow were planned so as to avoid overflows of contaminated stormwater under conditions of limited rainfalls.

The service populations by these WWTPs in 2000 were projected at:

Rusafa District	2,350,000
Karkh District	1,950,000
Total	4,300,000

The applied process and facility configuration are in general the same for all the WWTPs. As shown in Figure 4.1, the treatment process comprises; i) preliminary, ii) primary and iii) secondary treatment processes, and the treated wastewater effluent is discharge to the Tigris River after being disinfected.

The WWTP receives both dry weather and stormwater flows, but most of the wet weather flows are discharged to the River after being stored in stormwater tanks and disinfected. The excess sludge is anaerobically digested and dried on sand drying beds for final disposal. The sludge gas has not been used either for heating or other purposes.

4.4.4 Design Criteria

The applied design parameters to the WWTP in West Bank were similar to those in the East Bank and major criteria (as applied to Karkh WWTP) are as follows:

Table-4.7 Design Parameters for WWTP Facilities

Item	Unit	Parameter
Liquid Treatment		
1. Grit removal	DWF x	7.6
2. Primary settling tank loading at peak flow		
Overflow rate	$m^3/m^2/d$	94
Hydraulic retention time	hrs	0.8
3. Aeration tank loading at DWF		
Hydraulic retention time	hours	7.2
BOD_5 loading	$kg/m^3/d$	1.13
4. Final settling tank loading at peak flow		
Overflow rate	$m^3/m^2/d$	47
Weir loading	$m^3/m/d$	252
Hydraulic retention time	hrs	1.5
Sludge Treatment		
1. Sludge thickener, loading rate	$pop./m^3$	227
2. Anaerobic sludge digester, population loading rate	$pop./m^3$	25
3. Digester hydraulic retention time	days	28
4. Heating	-	H
5. Population loading rate	$pop./m^2$	10

Source: Greater Baghdad Sewerage Study, Preliminary Report Volume Two, February 1981.

Table 4.8 Design Criteria for Karkh WWTP

Item	Per Stream	Total
Population	300,000	1,800,000
Per capita wastewater flow	114 Lcd	114 Lcd
Dry weather flow	34,200 m^3/day	205,000 m^3/day
Peak flow (4 x DWF)	5,700 m^3/hr	34,200 m^3/hr
Max. flow to facilities (2 x DWF)	2,850 m^3/hr	17,100 m^3/hr

BOD loading (60g/cd)	18,000kg/day	108,000kg/day
SS loading (90g/cd)	27,000kg/day	162,000kg/day

Source: Greater Baghdad Sewerage Study, Preliminary Report Volume Two, February 1981 .

The average daily incoming pollutant loads to the WWTP were calculated in the Master Plan Report as:

	BOD_5	SS
Rusafa District	218,000kg	274,000kg
Karkh District	199,000kg	243,000kg
Total	417,000kg	517,000kg

In the design it was planned that totally 4 x DWF was conveyed to the WWTP and the surcharge wastewaters were overflowed after receiving chlorine disinfection to the River.

4.4.4 Component Facilities

As shown in Figure-4.1 "Flow Schematic of Karkh WWTP," the process comprises; i) preliminary, ii) primary and iii) secondary treatment processes, and the treated wastewater effluent is discharge to the Tigris River after being disinfected.

The component facilities are summarized in the following:

Table-4.9 WWTP Facilities

Liquid Treatment Facility	Sludge Treatment Facility
1. Influent chambers	1. Sludge thickeners
2. In-plant pumping station	2. Anaerobic sludge digesters
3. Pre-aeration tanks	3. Excess sludge gas incinerators
4. Oil/grease separators	4. Gas holders
5. Screens and grit chambers	5. Sludge drying beds
6. Primary sedimentation tanks	6. Disposal for land fill
7. Aeration tanks	
8. Final sedimentation tanks	
9. Chlorine contact tanks	
10. Stormwater tanks	

Source: Greater Baghdad Sewerage Study, Preliminary Report, Volume Two, February 1981.

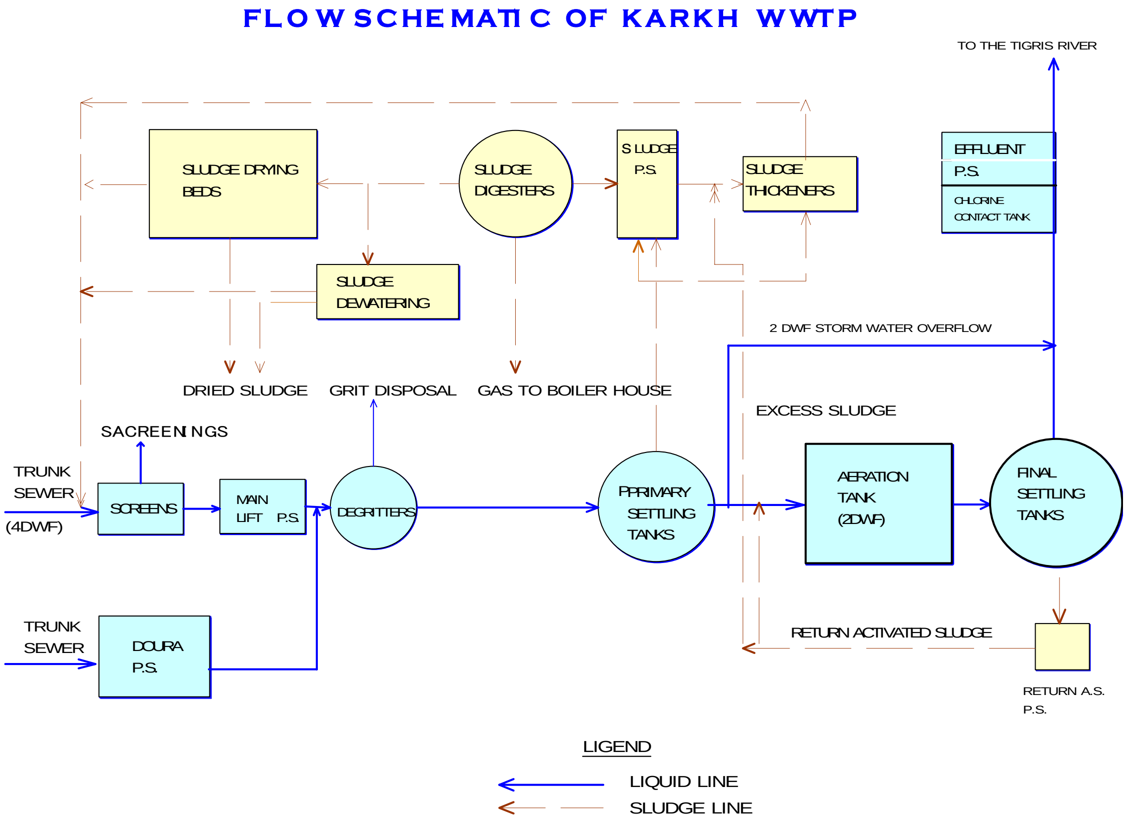


Figure 4.2 Flow Schematic of WWTP

4.5 Need for Sewerage Improvement Project

4.5.1 Collection System

(1) Improvement of Existing Sewer Networks

Although further investigations are required to identify the actual condition of present sewers, it is roughly estimated that about 40 percent or 1,600km of existing sewer reticulations are more or less damaged and need appropriate rehabilitation or replacement of such sewers.

With a result of preliminary field surveys and inquiries with concerned personnel, sewers subject to urgent improvement and rehabilitation works are:

- Sewers more than 20 years of age laid under the busy streets are vulnerable to heavy vehicles and other traffics;
- Old concrete pipelines that are corroded by sulfide buildup in pipelines;

- Close or shut off inflows of overland flows and illegal wastewater connection to the public sanitary sewers (separate system); and

- Repair or replace defected manholes and stormwater inlets;

In both Sewer Districts, the sewer networks are to be expanded as the population increases, and urban districts extend in the future. The present sewer service area covers about 75 percent of the urban builtup districts according to BSA's estimate, and the remaining 25 percent of the area is to be sewered possibly by 2018. Totally about 400km long network sewers (smaller than 400mm in diameter) are to be extended to cover the whole sewer service area..

(2) Extension of Main/Submain Sewers

Additional main/submain sewers are required for both Rusafa and Karkh Districts to convey the ever-increasing wastewater inflows from sewer reticulations not yet connected to pumping stations and WWTPs.

Because of the missing main sewer lines in both Sewer Districts, much portion of the collected raw wastewater is being discharged to the River directly from the pumping stations.

Early construction of main sewers is sought to connect sewer reticulations to pumping stations and transport finally to WWTPs.

The above Photo shows stormwater stagnation on the streets in Karkh District due to sewer failures and insufficient sewer flow capacity.

Table 4.10 summarizes the conditions of main/submain sewers, which require immediate construction and improvement to allow early alleviation of wastewater stagnations in tributaries.

Table- 4.10 Main/Submain Sewers Urgent Improvement is Required

Item	Size and Length
1. Karkh Sewer District	
Ghazaliya Connection	ϕ 2,200mm x 5km(shield tunneling)
West Trunk Line	ϕ 2,800mm – ϕ 3,600mmx 10 km
2. Rusafa Sewer District	
Northeast Trunk Line	ϕ 2,800mm – ϕ 3,600mmx 10 km
Al-Sadr City Trunk Line	ϕ 2,000mm x 5km
Southwest Trunk Line	ϕ 2,200mm x 10km

Note: These figures and items may be subject to change when detailed survey/design are made.

4.5.2 PUMPING STATIONS

Insufficient number and capacity of pumping equipment to handle all the inflowing wastewater are the major cause of low wastewater collection rate, thereby creating a considerable quantity of wastewater spills directly to the drains and river.

Some of sewage pumps should be replaced with necessary electric, instrumental and auxiliary equipment, and repair or replace old bar screens, gates, etc. by new ones.

It is assumed that the total discharge of the existing pumping stations is presently about 50 percent of their originally planned capacity, and the capacities of P2 and N2 Pumping Stations are apparently not sufficient to discharge the incoming wastewater/stormwater hence causing frequent inundations within the tributary. Further, PN pumping station cannot discharge all the wastewater to WWTP and that the raw wastewater is being discharged directly to the River.

The West Trunk Line of 12km long 3,000mm diameter connects the existing PN pumping station to Karkh WWTP, which is further pumped up by Doura pumping station located about 4km upstream of the WWTP. However, the hydraulic capacities of the existing trunk lines and pumping stations are apparently not sufficient to convey all the wastewater to the WWTP.

In cognizant of such condition, a construction plan was made about 20 years ago for the West Trunk Line and Doura-II pumping station, and design and tender documents were prepared for construction.

The new Doura-II pumping station would comprise the following component facilities:

(1) Sewer - combined sewerage;
(2) Planned pumping capacity- 729m^3/min.;
(3) Pump equipment- ϕ 800mm x 81m^3/min x TDH 28m x 9 units; and
(4) Motor outputs, 585kW x 9 units

The pumping stations that need urgent rehabilitation and construction are listed in the following:

Table- 4.11 Required Improvements for Pumping Stations

Pumping Station	Equipment for rehabilitation/replacement
1.P2 pumping station	2 pump units for each of ϕ 900, ϕ 700, ϕ 400mm, screens, generator
2.N2 pumping station	One pump unit of ϕ 900mm, 2units of screens, generator
3.PN pumping station	One pump unit of ϕ 600mm, generator
4.D1 pumping station	2 pump units
5.Construction of D2 p.s.	Construction of new station, ϕ 800mm x 9units and electrical and control facility.

Note: These figures and items may be subject to change when detailed survey/design are made.

4.5.3 Wastewater Treatment Plants

As mentioned previously, the rehabilitation and expansion of Karkh WWTP are the most urgently required to preclude the uncontrolled discharge of raw wastewater to the River.

As the first step for the improvement of such condition, the provision of additional primary treatment facilities will be of the most cost-effective way to remove the wastewater pollutants. The secondary treatment facilities will then be added later to the primary facilities under the second stage program when the condition allows to do so.

The additional primary treatment capacity of 205,000m^3/day would allow an immediate reduction of 30,750kg BOD_5 and 61,500kg SS daily—assuming the removal rates of 25% for BOD_5 and 50% for SS, with the assumed influent concentrations of 150mgL and 300mg/L, respectively. The preliminary and primary treatment facilities may comprise the following component facilities:

Table-4.12 Wastewater Treatment Plant Improvement

Component	Quantity	Treatment Capacity
1.Preliminary treatment facilities	1 lot	Max. treatment capacity up to 4DWF
2.Primary treatment facilities	16units	- " -
3.Secondary treatment facilities	16units	Max. treatment capacity up to 2DWF
4.Sludge treatment facilities	1lot	
5.Electrical and control equipment	1 lot	
6.Piping and valves	1 lot	
7.Auxiliary facilities	1 lot	

Note: The number and size are those tentatively planned, and subject to review at the time of M/P and F/S.

5. STRATEGIC PLAN

5.1 GENERAL

The wastewater system improvement program is to be implemented over a thirteen-year period from 2005 to 2018. Because at the beginning of the program, human and financial resources are likely to be limited, the whole program formulated in the strategy plan may be divided into the following three continuous stages:

- The First Stage program for four years from 2005 to 2008, and

- The Second and Third Stage programs each for five years from 2009 to 2018

The staging should not be rigid, but rather flexible reflecting the changing situations. When one stage is approaching toward its end, the next stage should be renewed based on the previous achievements.

5.2 LONG-RANGE PROGRAM (2005 TO 2018)

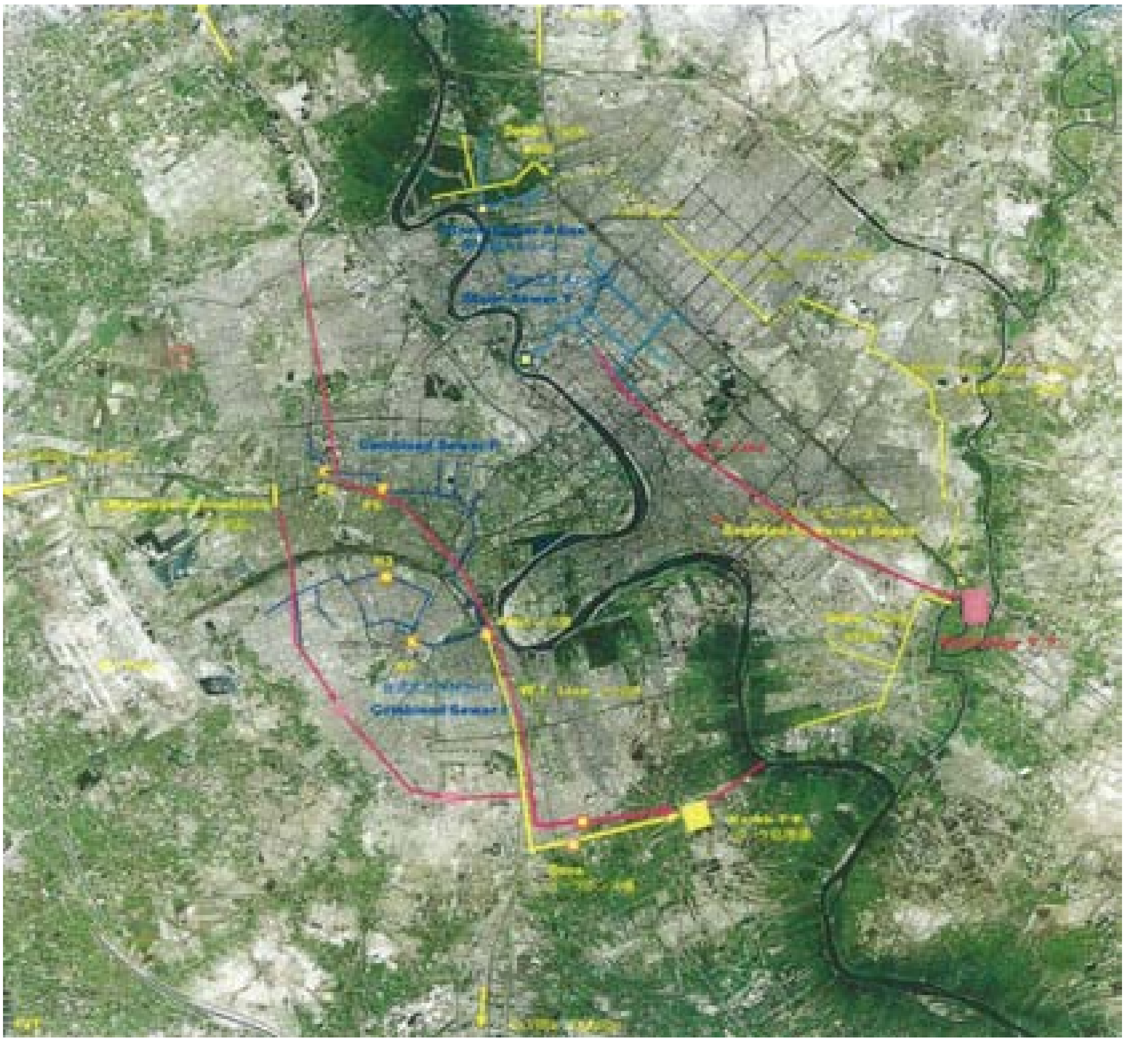
The purpose of developing a strategic plan through the year 2018 is to ensure that the project proposed for implementation in 2005 to 2008 is the optimal project for the period, consistent with the optimal long-term development of the sewerage system in Baghdad. The strategic plan presented in this report confirms the bases for the forthcoming M/P and F/S

As show in Table 4.2, the wastewater productions by construction stage are expected to increase from the present level of 1,040,000m^3/day to 1,610,000 m^3/day by 2017. Accordingly, the capacities of sewers, pumping stations, and WWTPs capacities are to be increased stage by stage.

Table 5.1 tabulates the sewerage facilities that are to be added or improved by 2018 so as to collect and treat all the wastewater flows within the sewer districts (34,000ha.). Locations of major sewers, pumping stations and WWTPs are presented in Figure 5.1.

5.3 PRIORITIZATION FOR IMPLEMENTATION

To determine an appropriate implementation priority of the sewerage improvement program, each of the candidate plans has been evaluated as to its significance in terms of quantifiable and non-quantifiable factors.



KEY

- Major Existing Combined Sewers
- Major Existing Storm Drains
- Major Existing Sanitary Sewers
- Major Sanitary Sewers Improvement is Required
- Pumping Station
- Existing Wastewater Treatment Plant

Figure 5.1 Layout of Main/Submain Sewers, Pumping Stations and WWTPs

The result is considered to be a good indication of the overall needs of sewerage in various sewer districts/systems, and is to be taken into consideration in determining the priority of sewer district/system implementation program.

The sewerage implementation should be staged according to the priority indicated in this study assuming that the present evaluations are brought up-to-date if continuing growth and development show conditions different from those assumed in the current grading.

Table-5.1 Required Sewerage Components by Stage

Component Facilities	Present	First Stage	Second Stage	Third Stage	Total
Total Average Daily Wastewater Production (m^3/d)	**1,040,000**	**1,200,000**	**1,380,000**	**1,610,000**	
(1) Sewer Reticulations (ha)					
Karkh District (Service area of sewer network.)	10,200 ha	0	1,700 ha	1,700 ha	13,600 ha
Rusafa District (Service area of sewer networks)	15,300 ha	0	2,550 ha	2,550 ha	20,400 ha
Total of (1)	25,500 ha	0	4,250 ha	4,250 ha	**34,000 ha**
(2) Trunk Sewers					
Trunk sewer (2,200 to 3,200mm) in Rusafa District	–	25 km	0	0	25km
Trunk sewer (1,600 to 3,600mm) in Karkh District	–	36 km	0	0	36km
Total of (2)	–	61 km	0 km	0 km	**61 km**
3) Pumping Stations Capacity					
Karkh District (Required p.s. average capacity, m^3/d))	416,000	64,000	72,000	92,000	644,000
Rusafa District (Required p.s.average capacity, m^3/d))	624,000	96,000	108,000	138,000	966,000
Total of (3)	1,040,000	1,200,000	1,380,000	1,610,000	**1,610,000 m3/d**
(4) Wastewater Treatment Plants Capacity					
Karkh District (Required average daily capacity,m^3/d)	205,000	205,000	100,000	100,000	610,000
Rusafa District (Required average daily capacity,m^3/d)	500,000	200,000	200,000	100,000	1,000,000
Total of (4)	705,000	1,110,000	1,410,000	1,610,000	**1,610,000 m3/d**

Although there are no significant distinctions among the alternative programs, the priority for improvement of Karkh WWTP is evaluated to be the highest followed by the connecting West and Southwest Trunk Sewers to Karkh WWTP.

The rehabilitation works for the pumping stations in Karkh District (P2, P5, N2, N3, PN, and D1) and the construction of new Doura –II pumping station are also considered to be higher priority than other facilities, so that all the wastewater currently being bypassed to the River can be conveyed to Karkh WWTP.

The WWTPs both in Rusafa and Karkh Districts need to be expanded and improved to have sufficient treatment capacities to treat the increased wastewater inflows. As shown in Table 5.1, both Karkh and Rusafa WWTPs will need to be expanded from the present 205,000m^3/day and 500,000 m^3/day to 610,000m^3/day and 1,000,000m^3/day, respectively, by the year 2017—

assuming that the Rusafa and Karkh WWTPs treats respectively 60% and 40% of all the wastewater produced. Thus, by 2018 all the wastewaters within the sewer districts will be collected and appropriately treated.

The high priority sewerage facilities improvement should be carried out under the First Stage Program from 2005 to 2008, whereas other sewerage facilities may be realized under the Second and Third Stages from 2009 through 2018, if and when the projects become financially affordable.

It should be noted that the evaluation of projects does not include any financial analysis, and while the evaluation results have clearly indicated the priority order of system implementation, when the detailed financial analysis is made and the magnitude of the project budget is decided, the package of the First Stage Program may be either increased or reduced, according to the results of detailed financial analysis.

5.4 First Stage Program (2005 to 2008)

The First Stage Program (Immediate Improvement Program) formulated under the Sewerage Strategic Plan is to be implemented over a four-year period from 2005 through 2008. As shown in Table5.2 and Figure 5.1, the Project concentrates upon the enhancement of existing sewerage system and construction of new facilities in the high-priority areas.

The most immediately needed sewerage component facilities are selected for the Immediate Improvement Program. The First Stage Program comprises rehabilitation/expansion of sewers, pumping stations and WWTP in the both Rusafa and Karkh Sewer Districts.

When the First Stage Program completes, most of the wastewater in the Karkh District will be collected from individual households connected to the existing sewers, and conveyed through pumping stations to WWTPs.

The new Doura-II pumping station will pump up and transport the peak inflow of 729m^3/day through the force main to Karkh WWTP. The program components elaborated are summarized in the following table:

Table-5.2 Components to be Implemented under the First Stage Improvement Program

Component	Type/Size	Remarks
1. Trunk, Network Sewers		
1.1 Rusafa District		
ϕ 3,200mm	10km	

ϕ 2,000mm	5km	
ϕ 2,200mm	10km	
1.2 Karkh District		
Gazaliya connection ϕ 2,200mm (Shield tunneling)	5km	
West Trunk(Gravity) ϕ 2,800mm to ϕ 3,600mm	10km	
New West Trunk ϕ 3,600mm	2.2km	
- " - ϕ 3,000mm	1.0km	
- " - ϕ 2,800mm	4.1km	
New West Trunk (Force main) ϕ 1,600mm	4.5km x 3 lines	
2. Pumping Stations		
Rehabilitation of P5,P2,N3,N2,PN pumping stations in Karkh	Replacement of pumps, screens, control panels	
Doura –II pumping station in Karkh	Hydraulic capacity, 729m^3/min	
3. Wastewater Treatment Plant	Primary/secondary treatment facilities	Av. 205,000 (m^3/d) capacity.

Note: These may be subject to change when the scale and scope of the First Stage Project are finally fixed.

6. IMPLEMENTATION SCHEDULE

6.1 First Stage Program Schedule

The implementation and commissioning of the main sewerage components under the First Stage Project are programmed to start within 2005 and last until the end of 2008, as shown in Figure 6.1.

For each of the sewer districts, design and tender preparation work for the major facilities of collection and WWTP systems is scheduled to complete within 12 months, followed by the construction supervision services.

Interim commissioning of the project facilities may be carried out during the implementation period to enable earliest possible utilization of the new facilities and early introduction of cost recovery measures, including six months for the Karkh WWTP operation startup and acclimation.

It is envisaged that implementation of the First Stage Project be proceeded rapidly, because the major construction works will be carried out under several large parallel contracts covering the construction of collection, treatment and disposal facilities.

This provisional definition of contracts might be either reduced or increased if BM chooses to combine certain elements of the work. The BM is responsible for implementation of all the sewerage programs, which will be undertaken by contractor(s) working for BM.

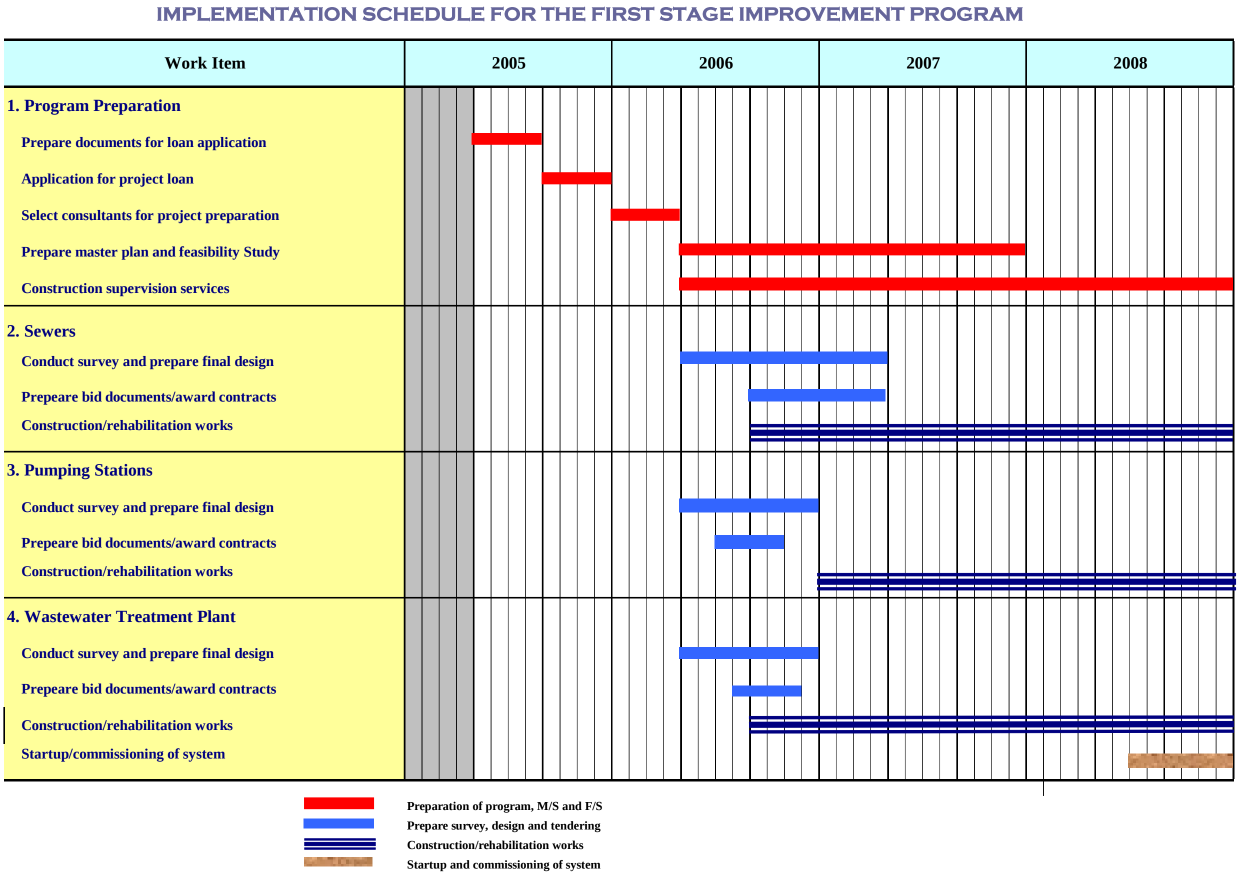


Figure 6.1 First Stage Implementation Schedule (2005 to 2008)

The schedule for specific contract allows for time for all steps necessary to select and employ the contractors, including:

- Completion of final designs;
- Preparation, review and approval of contract documents;
- Tender period (at least two months for major contracts);
- Review of bids and approval of choice of contractors;
- Contract negotiation and signature; and
- Mobilization by contractors.

The activities on the construction schedule of Figure 6.1 relate to the undertaking of individual contracts.

6.2 LONG-RANGE PROJECT SCHEDULE (2005 TO 2018)

The recommended plan leading to the 2018 sewerage system, and its tentative staging and costs are presented in this section. The recommended plan for the integrated sewerage system improvement in Baghdad is shown in Figures 6.2.

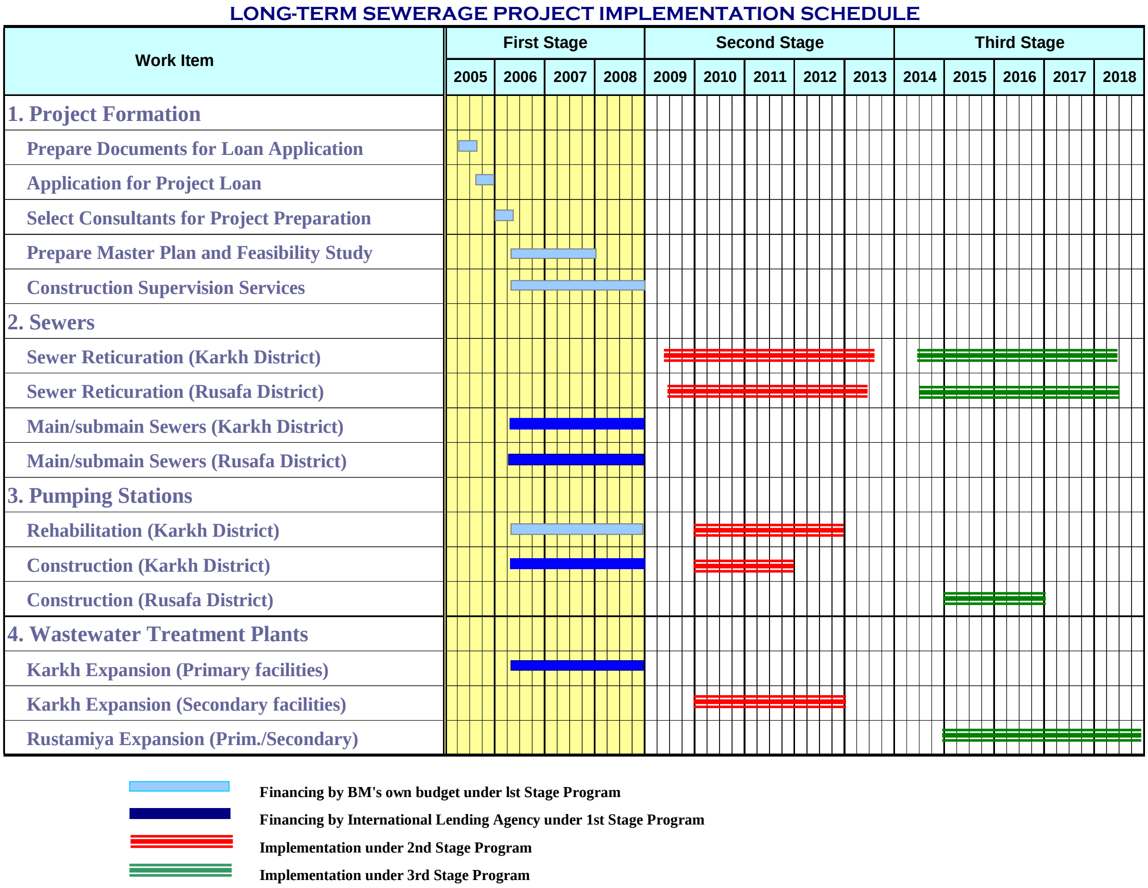


Figure 6.2 Long -Range Sewerage Improvement Project Staging

6.3 COST ESTIMATE

The exact numbers and sizes of the wastewater facilities to be built under the improvement project can only be determined when the comprehensive survey of the present wastewater and detailed design work are completed. Nevertheless, for the budgetary purpose, sufficiently accurate preliminary estimates of the program components have been made based on the presently available information and the field investigation conducted under the present study.

Cost estimates have been made for all the components proposed project on the basis of those obtained from the recent construction works undertaken in the Region. Equipment prices were quoted from manufacturers and contractors who have work experience in the Region.

It should be noted that the estimated construction costs do not include those for future escalation, administration, security, engineering and contingency, and are of order of magnitude or reconnaissance level only; and are not adequate for detailed financing plans and tendering purposes.

The tentatively estimated sewerage components construction costs are summarized in Table 6.1. The wastewater facilities to be included under the First Stage Program will require estimated cost of US$336.1million.

The total direct cost to be expended by 2018 is US$ 1,163million at mid-2004 price level, whereas the direct costs required under the Second and Third Stages will be US$460million and US$ 367million, respectively.

Table 6.1 Estimated Overall Direct Costs of the Project

Item	First	Second	Third	Total
(1) Sewer Reticulations				
Karkh District (Service area of sewer network.)	0	83,400	83,400	166,800
Rusafa District (Service area of sewer networks)	0	76,200	76,200	152,400
Total of (1)	0	159,600	159,600	**319,200**
(2) Trunk Sewers				
Trunk sewer (2,200 to 3,200mm) in Rusafa District	96,000	0	0	96,000
Trunk sewer (1,600 to 3,600mm) in Karkh District	86,000	0	0	86,000
Total of (2)	182,000	0	0	**182,000**
(3) Pumping Stations				
Karkh District (Required p.s. average capacity, m^3/d))	39,000	3,000	3,900	45,900
Rusafa District (Required p.s.average capacity, m^3/d))	96,000	4,500	5,800	106,300
Total of (3)	135,000	7,500	9,700	**152,200**
(4) Wastewater Treatment Plants				
Karkh District (Required average daily capacity,m^3/d)	19,100	96,000	96,000	211,100
Rusafa District (Required average daily capacity,m^3/d)	0	191,000	96,000	287,000
Total of (4)	19,100	287,000	192,000	**498,100**
(5) O/M Equipment	0	5,800	5,800	**11,600**
Total of 1,2,3,4,5	**336,100**	**459,900**	**367,100**	**1,163,100**

6.4 PROCUREMENT/CONSTRUCTION INDUSTRY

Contracts are to be awarded through international competitive bidding for construction/ rehabilitation of wastewater collection, pumping stations, and wastewater treatment and disposal facilities, including mechanical and electrical contracts for plant and equipment, whilst the construction of property connections may be planned under several smaller contracts for local contractors.

Considerable attention is to be paid to the prospects for utilizing the capacity of Baghdad's suppliers and contractors in the proposed program. It is believed that the local construction industry will play a major role in the project.

Local contractors have long experience in constructing the large-scale sewerage systems, including WWTP, pumping station, pipe jacking and shield tunneling constructions, and have capabilities to manage all the selected sewerage works in the project; except for certain types of shield tunneling, and portions of the control, electric and mechanical equipment for pumping stations and WWTP, which may be imported.

7. OPERATION AND MAINTENANCE

7.1 GENERAL

It is conspicuously lacking at the present time of operational and maintenance staff and experience for wastewater systems in BSA. The engineering design for the program is therefore to focus on the provision of modern, simple, reliable system components requiring minimal operational and maintenance experience. Nevertheless, extensive staff training courses will need to be implemented to ensure that the project facilities are correctly operated and maintained.

O&M of the wastewater system means making sure that the system is kept in good operating condition. It requires that the facilities be adequately maintained, so that the system can efficiently accomplish its intended function of collecting and conveying wastewater to the treatment plant in a sanitary manner.

Maintenance can be categorized into preventive and corrective maintenance. Preventive maintenance involves inspection of the collection system and analysis of existing data to identify trouble areas. This can provide guidance in developing the type, degree, and frequency of preventive maintenance required.

Corrective maintenance refers more to emergency maintenance. This can be an actual collapse of an existing sewer; stoppage due to roots, grease, or other foreign materials; or excessive inflow or infiltration. These conditions require immediate action to correct the problem. The objectives are to improve service, reduce emergency occurrences, and to minimize the cost of the preventive maintenance program.

7.2 SEWER OPERATION AND MAINTENANCE

A year-round pipeline maintenance program should be developed. The emphasis is on preventive maintenance. Under the program, sewers, including manholes, pumping plants, and special structures, are to be regularly inspected. Known trouble locations are to be checked at more frequent in pipeline maintenance crews, operating City-wide, clean and maintain large sewer lines, chemically treat sewers for root control, and perform insect and rodent abatement work.

As a reference, Table-7.1 shows tentatively estimated number of the minimum personnel required for the sewerage operation and maintenance in a municipal level (11 districts).

Table –7.1 Personnel for Sewer Operation and Maintenance (Reference)

Jobs	No. of staff	Assigned locations	Day shifts	Day/night shifts
1. General Services				
A. Superintendent or Engineer	1	Administrative building	1	-
B. Office Manager	1		1	-
C. General Book Keeping	1		1	-
D. Permits and Records	1		1	-
E. Information and Trouble Calls	1		1	-
F. Drivers	1		1	-
Subtotal of Item 1	6		6	
2. Sewer Cleaning				
A. General Foreman	1	Stock yards	1	-
B. Sewer Cleaning Staff	4	2 parties	4	-
C. Equipment Operators	2		2	-
D. Mechanic I (senior)	1		1	-
E. Mobile Equipment Operator	1		1	-
Subtotal of Item 2	9		9	-
3. Pumping Station Operation				
A. Supervisor	1	Pumping station	1	-
B. Mechanic I (senior)	1		1	-
C. Mechanic II	3		-	3(*)
D. Auxiliary Staff (mechanical)	1		1	-
E. Electrician I (senior)	1		1	-
F. Electrician II	3		-	3(*)
G. Instrumentation Technician	1		1	-
Subtotal of Item 3	11		5	6
4. Repair Section		Administrative building/		
A. Supervisor	1	Stock yards	1	-
B. Repair crew (concrete works)	1		1	-
C. Turner	1		1	-
D. Equipment Operator	2		2	-
E. Auxiliary staff	1		1	-
F. Driver	1		1	-
Subtotal of Item 4	7		7	-
5. Emergency				
A. Supervisor	1		1	-
B. Staff (sewer rods, etc.)	3		-	3(*)

C. Auxiliary staff	1		1	-
Subtotal of Item 5	5		2	3
Total	38		26	12

(*) Note: *For this task, 4 persons (including senior staff) working in day and night shifts are required. Three persons will work during a typical 24-hour day. The additional one will serve as replacement so that the other three may rest one day a week.*

7.3 WWTP Operation and Maintenance

In the WWTP management organization, one "Administrative Assistant" may be included, with the purpose of alleviating the administrative tasks upon the Section Chiefs. During the operation shifts, it will be necessary that the chief of each shift should be an engineer, in order to improve supervision capacity and plant operation control.

In the Maintenance Section, an engineer as Supervisor is included in order to assure an adequate supervision of the job performed. Similarly, it is considered that the instrumentation area must be in charge of an electrical engineer. It is also considered that an Electrician is required for each shift.

Once the final design is accomplished, complementary timing and methods studies will be performed in order to determine the exact number of personnel required in each position. As a reference the following table shows the personnel required for a typical activated sludge treatment plant (at around 200,000m^3/day capacity activated sludge treatment plant).

Table-7.2 WWTP O&M Staff (*for reference*)

Jobs	No. of staff	Assigned locations	Day shifts	Day/night shifts
1. General Services				
A. Cleaning Staff	1	Administrative building	1	-
B. Gardener	1		1	-
C. Guardsmen	3		-	3
D. Time Controller	1		1	-
E. Auditing	1		1	-
Subtotal of Item 1	7		4	3
2. Operation Section				
A. Chief	1		1	-
B. Operator (engineer)	2		-	2
C. Equipment Operator	2	Central control	-	2
"	2	Prelim./prim. facilities	-	2
"	2	Secondary facilities	-	2
"	2	Anaerobic digesters	-	2
D. Auxiliary staff	1	Primary/secondary	1	-
"	1	Sludge handling	1	-

E. Technician (laboratory)	2	Laboratory	2	-
F. Secretary	1		1	-
G. Driver	1		1	-
Subtotal of Item 2	17		7	10
3. Maintenance Section				
A. Chief	1		1	-
B. Supervisor	1		1	-
C. Mechanic I (senior)	1	Prelim./prim./secondary	1	-
D. Mechanic I (“)	1	Digesters/dewatering	1	-
E. Mechanic II	1	Pumps, conveyors, valves	1	-
F. Turner	1	All equipment	1	-
G. Auxiliary shop staff	1		1	-
H. Maintenance	1	Lubrication/painting, etc.	1	-
I. Auxiliary staff (mechanical)	1	Blowers, compressors	1	-
“	1	Clarifiers, screens	1	-
“	1	Digesters, dewatering	1	-
“	1	Pumps, valves	1	-
J. Instrumentation Chief	1		1	-
K. Instrumentation Technician	1		1	-
L. Electrician I (senior)	2		-	2
“	1	Motor maintenance	1	-
“	1	Electric substation	1	-
“	1	Preventive control	1	-
M. Auxiliary staff (electrical)	1	Electric substations	1	-
N. General concrete works	1	Repairing of structures	1	-
O. Auxiliary concrete works	1	“	1	-
P. Stock clerk I	1		1	-
Q. Stock clerk II	1		1	-
R. Secretary	1		1	-
T. Driver	1		1	-
Subtotal of Item 3	26		24	2
4. Laboratory Section				
A. Chief	1		1	-
B. Chemist	1		1	-
C. Microbiologist	1		1	-
D. Sampling auxiliary staff	1		1	-
Subtotal of Item 4	4		4	-
5. Administration				
A. Chief	1		1	-
B. Administration assistant	1		1	-
C. Secretary	1		1	-
E. Driver	1		1	-
Subtotal of Item 5	4		4	-
Total	58		43	15

(*) Note: For this task, 4 persons (including senior staff) working in day and night shifts are required. Three per-

sons will work during a typical 24-hour day. The additional one will serve as replacement so that the other three may rest one day a week.

8. STAFF TRAINING

8.1 GENERAL

It is important when starting to build up a workforce for the O&M organization of the collection and WWTP systems that the operators, electricians, mechanics and laboratory chemists are trained through regular planned meetings to understand the overall process of the collection and treatment of wastewater.

There will also be a need to conduct planned training courses, both locally and overseas, for the operations and maintenance staff. This training would be carried out with the assistance of management and finance experts and technical specialists to include the following topics:

- The establishment and running of training programs for staff (including managers, engineers, technicians, operators, chemists and accountants);
- The operation and maintenance of mechanical and electrical equipment;
- Current practices in safety and hygiene; and
- Current practices and techniques for monitoring, sampling, diagnosis and testing.

It is envisaged that training courses be scheduled to suit the necessary training for different levels of management. This could entail the following for operation and management personnel:

- Senior Staff (Chief Operations Manager and Senior Supervisors) - short duration (up to 3week) overseas courses on general O&M management, programming and training requirements;
- Technical Staff (Operations, Technical Support and Scientific Supervisors) - several short courses (of up to 3-week duration) carried out over an extended period (3 to 6 months) in both local and overseas, on more specific technical requirements for the sewerage system and wastewater treatment plant, safety and hygiene practices and techniques for monitoring, testing and sampling; and
- Day Staff (Operators and day-labor staff) - regular courses in Iraq by the Technical Staff based upon their training courses with overseas experts and specialists.

A range of excellent training courses and programs are now offered by various wastewater authorities in various countries, which could be undertaken by 2 or 3 specialists for durations of up to 1 month.

A suggested program for staff training is as follows:

- Overseas study/inspection tours during 2006 by appointed senior staff and technical staff (One tour, each comprising 2 persons for up to 1 month);

- Visits to Iraq during 2006 by overseas specialists (two visits, each comprising 1 or 2 specialists for up to 3 weeks); and

- Local (or in third country) training during 2006 of technical and day staff, including purchase of training equipment.

8.2 SUPERVISORS

Supervisors who are responsible for controlling the day-to-day work activities of the sewerage and wastewater treatment work force should be given training in the planning, organizing and control of work activities associated with their responsibility.

8.3 SCIENTIFIC STAFF

Qualified chemists with a minimum understanding of sewerage and wastewater treatment processes should be provided with knowledge of obtaining representative samples of wastewater and sludge and also to the mechanics, optimization and control of wastewater treatment together with the problems associated with the various processes.

8.4 OPERATORS

In order to be able to delegate responsibility to the lowest possible level there is a need to train operational personnel so as to shorten the line of communication and so attempt to optimize man management. For example where a fitter would be needed to stuff glands on a pump an operator could be trained to carry out this type of function.

Also where an electrician would change fuses in connection with electrical equipment this action could, through training, be carried out by an operator. Such training increases the flexibility of the workforce and therefore provides greater scope for management.

A technical introduction should also be given to operators on the basics of sewerage and wastewater treatment. The purpose would be to give a broad understanding of the sources and nature of wastewater and the treatment processes used to prevent water pollution. Subsequently this introduction could be further developed by knowledge of the fundamental mechanisms involved in the treatment of wastewater.

8.5 TRAINING EQUIPMENT

In addition to the O&M equipment described in the previous sections, it is likely that equipment will also need to be purchased to facilitate training programs for staff in Iraq, and in particular for safety-related courses. The equipment could be purchased directly by the wastewater authority or could be provided by specialists as part of the training program:

- VTR, playback screen and videotapes;
- DVD, player;
- Projectors with PCs; and
- Relevant publications on health and safety in design, constriction and operations with regard to wastewater management and environmental protection.

9. FINANCIAL IMPLICATION

It was difficult to obtain the detailed recent information indicating the budgetary and financial situations of BSA. The sewerage revenues are collected by the surcharge to water supply tariffs, but BSA has no control on their revenues. In exchange, BSA receives monthly allowances from the office of finance, free equipment from the OFFP.

The Baghdad's Sewerage Authority's income and expenditure for the year 2004 (From January1 to December 31) are ID 16,130,000.0 and ID 1,244,964,121, respectively, the break down of which is summarized in Table 9.1.

Table 9.1 Baghdad's Sewerage Sector Expenses (ID)

Item		Expenditures (ID)	Remarks
1	Worker fees	31,397,500	
2	Rental of equipment, machine & transportation	28,270,000	
3	Temporary employees' fee	36,747,056	
4	Materials and others	4,213,175	
5	Protection & eradication fees	11,775,450	
6	Stationary & literatures	15,766,550	
7	Buildings maintenance & repairing collapse	849,162,430	
8	Transportation maintenance	1,468,450	

9 Furniture	11,445,250	
10 Maintenance of machine & equipment	3,697,500	
11 Clothes	505,000	
12 Loans for activity purposes	250,515,760	
Total	1,244,964,121	

Source:BM, March 2005

10. SOUNDNESS OF THE PROGRAM

The proposed sewerage system improvement project comprises the sewerage facilities that require the most urgent improvement. Although at this stage of the study no detailed analysis on the economic soundness is undertaken, when measured by any of the generally-accepted methods of appraisal, total benefits of the program will be significant in terms of economic, socio-economic, and technical issues.

The program is sound and needed for immediate protection and improvement of the quality of public waterways and the health of communities. The program would be logically related to the Baghdad's potential growth and development.

11. ENVIRONMENTAL IMPACTS

The sewerage improvement project may have both positive and negative impacts. The preliminary evaluation of impacts due to the sewerage improvement program is briefly explained:

Public Health: The most obvious environmental impact of the project will be the water pollution alleviation in public water courses and resultant improvement of the public health of residents through the increased service standards for sewerage system.

Improvements of sewer reticulation throughout the BM area will eliminate stagnant and foul water, reduce disease hazards, and improve aesthetic throughout the area.

Construction Activities: Excavations for sewer lines may cause soil erosion, but such erosion will be limited by minimizing excavation during rainy season and by requiring reasonable soil conservation measures by the contractors.

Further, construction activities may cause some limited but unavoidable noise, vibrations and dust by heavy vehicles and construction equipment, and cause traffic congestions. Proper planning and efficient construction scheduling will minimize such inconvenience to residents and commerce.

Karkh WWTP may also cause such impacts as odor, noise, and vibrations during construction and operation stages: However, the plant site is isolated more than 500m from the nearest residential areas, thus the adverse impacts will be minimal.

Land acquisition**:** In most sections, sewers will be laid mainly in state rights-of-way. Access to these rights-of-way would not be problematic. Some unused areas may be acquired for small facilities such as pumping stations.

Sufficiently wide land was already acquired for the expansion of Karkh WWTP, and no further land is required. WWTPs in both Sewer Districts are mostly located in sparsely-developed areas, so no significant interference with any utility is expected. There will be no resettlement of residents for the project.

Spills of wastewater: This impact may be caused by failures in the wastewater collection/ transfer system, or WWTPs. Despite sound engineering designs, it may still happen if proper maintenance and repairs are lacking, or an alternative and backup source of power is inadequate.

Proximity to present/future urban areas: Proximity to urban areas requires extra pressures for minimizing hazards and nuisance to the neighborhood. Such measures will consist of provision of larger buffer zones and more extensive security fencing, more vigorous noise and aerosol abatement and more elaborate contingency plans for accidental wastewater overflows or spills.

The proposed strategy has distinct advantages in that urbanization is not expected in the foreseeable future around the WWTPs. No impact of this type is expected.

Wastes: At present the capacity of solid waste disposal site in Baghdad is considered enough for disposing additional dewatered sewage sludge from the WWTPs. However, high concentrations of the organic substances (i.e. BOD_5, COD, NH_4-N, etc.) in the leachate from the solid waste disposal site may exceed the standard of wastewater discharged into municipal sewage system substantially. In addition, the number of the Coliform group may be relatively high. All of these may contribute a negative impact on the groundwater.

Odor: The deposition of solid and generation of sulfide because of high temperature of the region will be the major cause of odor. This problem may be solved by applying a design velocity at average flow not less than 75 cm/sec for cement-bonded pipes, and where needed, air injection into the sewers.

The pumping stations may also cause some odor, but could be either reduced or eliminated by careful design of the structure to enclose the source of Doura and appropriate maintenance.

The activated sludge process applied to the WWTP generally cause lower odor level than other processes when properly operated. Data from the activated sludge process WWTP under the similar conditions reveal that the concentrations of H_2S, NH_3 and odor level on the WWTP boundary-lines are generally lower than accepted standards. It may be reasonably assumed that the odor levels at adjacent areas to the WWTP site would normally be within acceptable levels, considering the facts that the nearest human settlement is located at almost 500 m from WWTP.

Conclusion: Certain items in the preliminary evaluation need to be further clarified from engineering viewpoints, and further studies will be made on the extent of impacts, mitigation and remedial measures, including the impacts possibly caused by the construction, operation and maintenance works of the sewerage facilities in the forthcoming M/P and F/S. Nevertheless, it is concluded at this stage that the overall expected environmental impacts of the project on the Baghdad are significant and positive.

12. IMPLICATION FOR FURTHER ACTIONS AND STUDIES

The immediate improvement program for sewerage system, several special actions and investigations are necessary to provide a sound basis for detailed planning and system design. In order to execute the program for the wastewater system discussed in this report, it will be necessary to have an expertly managed system of authority, responsibility and control over all aspects of the program.

It is pointed out that such basic data and information are not available for sewerage system improvement, as urban developmental plans, population distributions, long-term wastewater quality and quantity records, design bases for sewerage system, present conditions of existing sewerage system, etc. which are essential to develop a strategy plan for the Baghdad sewerage system.

For these reasons, Master Plan (M/P) and Feasibility Study (F/S) on the integrated Baghdad sewerage system are to be developed, in parallel with an Immediate Sewerage Improvement Program. Thorough studies and investigations are to be initiated immediately to provide the data necessary to guide future decisions on the integrated sewerage system improvement and management.

13. CONCLUSIONS AND RECOMMENDATIONS

The success of the improvement of sewerage system and environmental conditions in BM requires the implementation of a range of actions, including:

(1) Establish a program implementation section in BSA, to take responsibility for the management, implementation and operation of the program;

(2) Establish comprehensive sewerage system Master Plan (M/S) and Feasibility Study (F/S),

in parallel with the Immediate Program (First Stage) for Sewerage Improvement, to develop a comprehensive strategy plan covering the entire BM districts;

(3) Rehabilitate the damaged sewers estimated to be about 40 percent of the existing sewers;

(4) Procure necessary operation and maintenance equipment for sewer pipe inspections and cleaning;

(5) Start surveys on such existing facilities as sewer pipelines, drainages, pumping stations, WWTPs to identify the present situations soon after the program formulation;

(6) Rehabilitate existing pumping stations in particular four pumping stations (P2, N2, PN, D1, and construct D-II pumping station in Karkh District, with necessary trunk sewers;

(7) Construct additional streams of primary treatment facilities in Karkh WWTP to increase the present capacity of 205,000 to 410,000m^3/day to treat all wastewater flows currently being diverted to the River ahead of the WWTP;

(8) Rehabilitate stormwater runoff intake facilities to the combined sewers to relief the low-lying areas from frequent inundation; and

(9) Train selected personnel for project management, operation and maintenance of wastewater facilities, testing and monitoring.

Annex

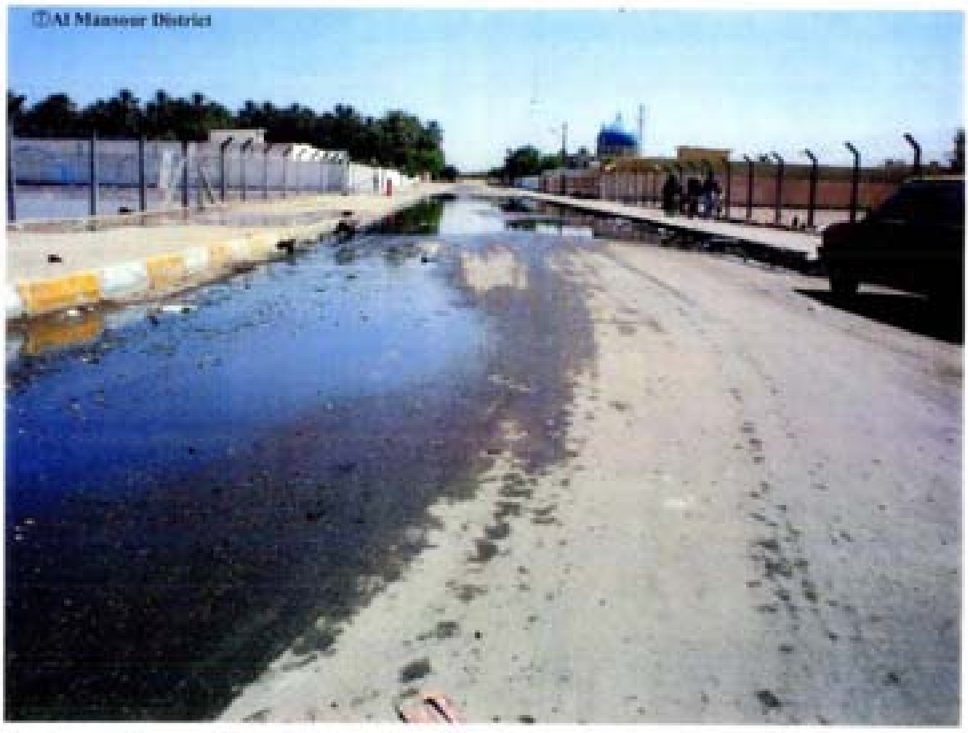
I. Baghdad City Land-use/Trunk Sewer Layout Plan (GIS Base Maps, 4-sheet)

II. Photos of Street Inundations in Karkh District (6-sheets)

III. Photos of Karkh Wastewater Treatment Plant (1-sheet)

Al Jihad District

Al Huria District



Al Mansour District

Al Bavaia District

Al Hamra District

Al Hamra District

Al Hamra District

Al Hamra District

Al Hamra District

Al Hamra District

Al Hamra District

Al Huria District


Detritus Tank


Receiving Chamber


Grit Removal Channel


Grease Removal Tank


Overflow Channel


Laboratory