CHAPTER 5

PRELIMINARY DESIGN OF PUMPING STATIONS

CHAPTER 5 PRELIMINARY DESIGN OF PUMPING STATIONS

5.1 SEWERAGE DISTRICT III

A pumping station is proposed on the left bank of Gomti River at the tail end of Mohan Meakin nala in District III. UPJN proposed this pumping station to convey the sewage from part of District III to existing TGPS. However, this proposal has been modified during the F/S, which is explained in the later part of this section.

5.1.1 Review / Collection of Existing Documents

MWH reviewed the proposal of new pumping station on the left bank of Gomti River at the tail end of Mohan Meakin nala in District III. This PS is already sanctioned by UPJN under GoAP - Phase II.

5.1.2 Need for the Scheme

Three nalas viz. Maheshganj nala, Roop pur Khadra nala and Mohan Meakin nala will be tapped and diverted to Mohan Meakin PS. The pumping station at this location is sanctioned for the requisite area under GoAP. The sanctioned project proposes to convey the flow from Mohan Meakin PS to TGPS through the existing TGTS. However, the existing TGTS does not have sufficient capacity to accommodate the entire flow of the three nalas.

5.1.3 Master Plan Provisions

The Master Plan prepared by JICA study team has been reviewed to assess the feasibility of having a pumping station at the tail end of Mohan Meakin PS. Under the Master Plan, this pumping station is provided to convey the sewage to the existing TGPS though a rising main (600mm dia, 4km). The location of the proposed pumping station has been kept at the same place as proposed by UPJN earlier.

This pumping station will cater to the following design flow –

Table 5.1 Design Flow of Mohan Meakin Rising Main

Sr.	Pumping Station	Average Flow, mld	
		2015	2030
1	Mohan Meakin PS	19	28

The rising main at the sanctioned pumping station has following provisions:

Sr.	Item	Provision
1	Rising main	One 1,300 m long and 700 mm dia rising main

5.1.4 Survey Works Executed

A reconnaissance survey was conducted by MWH team with the JICA Study Team and UPJN officials to understand the site conditions, which was followed by a detailed site survey.

(1) Topographical Survey

Topographical survey was conducted from proposed site of Mohan Meakin PS to existing TGPS. Levels were taken at 50 m interval and plane table survey was conducted to draw the road features along the entire route.

(2) Trunk Sewer Investigation on TGTS

Manhole survey was carried out to assess the hydraulic capacity of existing TGTS.

5.1.5 Design Engineering Works

After review of the survey results, the scheme proposed in the M/P has been revised to the extent as below:

- A new sewer to relieve the flow in the existing TGTS will be laid from near Mankameshwar temple upto TGPS.
- Pumping station at Mohan Meakin, which is already sanctioned, will convey the sewage from Mohan Meakin to the starting point of the proposed TGTS (New) at Mankameshwar Temple road.
- The rising main proposed in the Master Plan is modified. It will convey the sewage from Mohan Meakin PS to the proposed TGTS (new) at its starting point i.e. at Mankameshwar Temple road junction.
- The TGTS (new) will also receive the pumped discharge from Daliganj No. 1 and Daliganj No. 2 pumping station

This section covers the revised rising main only. The TGTS (new) has been described in Chapter 4.

(1) Design Flow

The rising main is designed for the same capacities as mentioned in Section 5.1.3.

(2) Details of Rising Main

A new 700 mm dia rising main, from Mohan Meakin PS to Mankameshwar temple road, is proposed. The length of this rising main is 1300 m.

The plan and profile of this rising main are presented in drawing LKO-PP-TGRM-1 & 2.

5.1.6 Capital Cost of Rising Main

The rates for labour and material are taken from UPJN. These rates are based on the published rates for the year 2000 and admissible premium has been accounted for while working out the present rates for the year 2004.

Rate for pipes and appurtenances are taken from the prevailing market rates based on the quotation from the recognised manufacturers.

Table 5.2 Capital Cost of Rising Main

Sr.	Item	Cost (Rs.)
1	700 mm dia CI B class pipe	13,126,000
2	Appurtenances	300,000
3	Excavation	223,000
4	Miscellaneous (crossing / encasement)	60,000
	Total	13,709,000

5.1.7 Maintenance Cost of Rising Main

Table 5.3 Maintenance Cost of Rising Main

Sr.	Item	Cost (Rs.) per annum
1	Maintenance cost of rising main @ 0.25 %	34,000

5.2 SEWERAGE DISTRICT IV

5.2.1 Review / Collection of Existing Documents

MWH reviewed the proposal of new pumping stations viz. Martinpurwa pumping station and terminal sewage pumping station (TSPS) at Mastemau, in District IV under the Master Plan prepared by JICA Study Team.

5.2.2 Need for the Scheme

As discussed in earlier section, a relief sewer is proposed in Cis-Gomti area in order to share the excess load on existing CGTS and also to cater to the additional sewage generated in District IV. A pumping station is proposed at Martinpurwa, within the premises of LaMarteniere school, which will receive the sewage from this relief sewer and convey the same to the proposed Sultanpur road trunk sewer near Dilkusha Crossing.

Further, a pumping station is proposed at Mastemau STP site to maintain the hydraulics of the treatment plant. This pumping station will receive sewage from proposed Sultanpur road trunk sewer and convey the same to the inlet of STP at the required elevation, which will ensure that the treated effluent can be discharged under gravity.

5.2.3 Master Plan Provisions

The Master Plan has been reviewed to assess the feasibility of having a pumping station at Martinpurwa. This pumping station is provided to receive the sewage from Cis-Gomti relief sewer and sanctioned GH canal pumping station, which will be further conveyed to Mastemau STP. However, during phase I, sewage from GH canal pumping station will be conveyed to Kakraha STP.

Further, a new STP is proposed at Mastemau to take care of the sewage generated in District IV and adjacent future sewerage areas. It is required to lift the entire flow of sewage to the required elevation in order to maintain the hydraulics of the treatment plant.

5.2.4 Survey Works Executed

UPJN had identified the site, for Martinpurwa PS, on the adjacent area that is available within the existing flood pumping station site. A reconnaissance survey was conducted by MWH team with the JICA Study Team and UPJN officials to understand the site conditions, which was followed by a detailed site survey.

Also a similar reconnaissance survey was conducted for TSPS at Mastemau and a suitable site for the pumping station was identified.

(1) Topographical Survey

Topographical survey was conducted at both the sites for proposed pumping stations, along with the contour survey. Spot levels were taken by a grid of 15 m x 15 m to plot a contour of 1 m interval.

(2) Geo Technical Survey

Martinpurwa Pumping Station

A 20 m borehole was taken at the proposed MPS at Martinpurwa, soil samples were collected at every meter for the first three meters and at changes of soil stratum but not exceeding 1.5 m interval. A standard penetration test (SPT) was also conducted to determine the N-value of the existing soil stratum at this site.

The details of the borehole are presented in the following table.

Table 5.4 Borehole at Martinpurwa PS Site

Ground level (RL)	Depth of borehole	Ground water table below GL
109.370 m	20.0 m	2.80 m

As per the topographical survey report the GL at the pumping station site varies from 109.00 m to 110.50 m. The finished ground level (FGL) for the pumping station is taken at 111.550 m. This site is protected from high floods due to existing bund.

The ground water table is considered at 109.55 m for structural design. The gross safe bearing capacity of soil is considered as 13 tonnes/sqm for structural design. As per the geo technical survey report, raft type foundation is provided, for the pumping station.

TSPS at Mastemau

Five numbers of boreholes of 20 m depth were taken at Mastemau STP site and the results of the soil analysis from two of these boreholes were used for design of TSPS at Mastemau.

The details of the borehole are presented in the following table.

Table 5.5 Borehole at Mastemau STP Site

Ground level (RL)	Depth of borehole	Ground water table below GL
111.865 m	20.0 m	0.60 m
112.525 m	20.0 m	0.70 m

As per the topographical survey report the GL at the pumping station site varies from 111.16 m to 112.95 m. The finished ground level (FGL) for the pumping station is taken at 113.25 m. A retaining wall is proposed along Gomti River for flood protection.

The ground water table is considered at 113.00 m for structural design. The gross safe bearing capacity of soil is considered as 15 tonnes/sqm for structural design. As per the geo technical survey report, raft type foundation is provided, for the pumping station.

5.2.5 Design Engineering Works

MPS is designed for the following capacity:

a) Civil structure is designed for year 2030
b) Rising main is designed for year 2015 based on most economical option

c) All mechanical and electrical equipment is designed for year 2015
d) Provision of extra space for pumps after year 2015 shall be made in the civil structure

Detailed designs of pumping stations were carried out to calculate the most techno- economical diameter in combination to various options of pumping. Based on the discussions in Chapter 3, horizontal type centrifugal pumps have been provided in this pumping station as the required capacity of individual pumps works out to more than 150 HP.

Various components of pumping station include:

a) Screen channel
b) Wet well and dry well
c) MEP room
d) DG room and control room
e) Transformer yard and
f) A rising main

Design Flow

The projected sewage flow to be received at pumping station, as discussed in Chapter 4, is presented in the following table.

Table 5.6 Design Flow of Sewage Pumping Station

Sr.	Pumping Station	Average Flow, mld	
		2015	2030
1	Martinpurwa PS	80	250
	Peak factor as per the CPHEEO Manual	2.25	2.0
2	TSPS at Mastemau	100	305
	Peak factor as per the CPHEEO Manual	2.25	2.0

5.2.6 Unit sizes for MPS at Martinpurwa

(1) Pumping Station

MPS at Martinpurwa is designed for a capacity of 250 mld for the year 2030, which includes sewage from CGPS, GH Canal MPS, Relief Trunk Sewer and LaMarteniere Nala, however mechanical/ electrical equipment will be provided for 2015.

Table 5.7 Provisions at Martinpurwa PS

Sr.	Item	Provision
1	Pumps for year 2015	9 nos. – 31.25 mld capacity and 23.75 m head (215 HP each) where 6 nos. are working and 3 nos. are stand by pumps
	Pumps for year 2030	In addition to the above, 15 nos. – 31.25 mld capacity and 23.75 m head (215 HP each) making it to 24 nos. of pumps where 16 nos. are working and 8 nos. are stand by pumps
2	Rising main	One 900 m long and 1200 mm dia rising main in pre stressed concrete
3	Coarse screen channel – 40 mm clear spacing	1 no. – 10.0 m x 8.0 m
4	Medium screen channel – 20 mm clear spacing	8 nos. – 8.75 m x 2.0 m
5	Wet well	2 nos. – 37.0 m x 12.0 m providing a detention time of 5 mins.
6	Dry well	1 no. – 22.0 m x 16.0 m

A layout drawing is presented in LKO-PS-MP-1. General arrangement of the pumping station is presented in drawing LKO-PS-MP-2.

(2) Allied Buildings

In addition to the above, following buildings are provided for provision of electrical panels and generating sets. Also, an open yard is provided for installation of transformer. The sizes are presented in the following table.

Table 5.8 Allied Buildings at Martinpurwa PS

Sr.	Item	Size
1	MEP building	20 m x 10 m
2	DG room & control room	14 m x 16 m
3	Transformer yard	14 m x 12 m

5.2.7 Capital Cost of MPS at Martinpurwa

The rates for labour and material are taken from UPJN. These rates are based on the published rates for the year 2000 and admissible premium has been accounted for while working out the present rates for the year 2004.

Rate for various equipment, pipes and appurtenances are taken from the prevailing market rates based on the quotation from the recognised manufacturers.

(1) Civil Cost

Table 5.9 Civil Cost for Martinpurwa PS

Sr.	Item	Cost (Rs.)
1	Inlet chamber, screen channels, dry well and wet well	115,999,000
2	MEP building	1,200,000
3	DG room / control room	1,344,000
4	Transformer yard	168,000
5	Staff quarter	1,231,000
	Total	119,942,000

(2) Mechanical Cost

Table 5.10 Mechanical Cost for Martinpurwa PS

Sr.	Item	Cost (Rs.)
1	Coarse screen	600,000
2	Sluice gates	160,000
3	Screen channel gates	1,200,000
4	Mechanical screens	4,800,000
5	Manual screens	300,000
6	EOT for pumps	250,000
7	EOT for screens	200,000
8	Pumps	13,927,000
9	Piping and valves	3,000,000
10	Conveyor belt	300,000
11	Dewatering pumps	120,000
12	Exhaust fans	288,000
	Total	25,145,000

(3) Electrical and Instrumentation cost

Table 5.11 Electrical & Instrumentation Cost for Martinpurwa PS

Sr.	Item	Cost (Rs.)
1	Provision for grid power supply from the adjacent 33 kV switch yard at point of supply in MPS	4,500,000
2	Power supply equipment and stand-by power equipment	26,467,000
3	Cables	2,699,000
4	Earthing and safety equipment	420,000
5	Lighting	169,000
6	Instrumentation	1,388,000
7	Miscellaneous	349,000
	Total	35,992,000

(4) Rising Main

Table 5.12 Rising Main Cost for Martinpurwa PS

Sr.	Item	Cost (Rs.)
1	PSC pipe	7,047,000
2	Appurtenances	300,000
3	Excavation	376,000
4	Miscellaneous (crossing / encasement)	100,000
5	Railway crossing by trenchless technology	12,075,000
	Total	19,898,000

5.2.8 Abstract of Costs for MPS at Martinpurwa

Table 5.13 Abstract of Costs for Martinpurwa PS

Sr.	Item	Cost (Rs.)
1	Civil cost	119,942,000
2	Mechanical cost	25,145,000
3	Electrical & instrumentation cost	35,992,000
4	Rising main cost	19,898,000
	Total capital cost	200,977,000

5.2.9 Operation & Maintenance Cost of MPS at Martinpurwa

Table 5.14 O & M Cost for Martinpurwa PS

Sr.	Item	Cost (Rs.)
1	Manpower cost	911,000
2	Power cost (20 hrs @ Rs. 3.25/kWh)	11,416,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	6,635,000
4	Maintenance of civil works @ 1.5 %	1,799,000
5	Maintenance of M&E works @ 3 %	1,834,000
6	Maintenance of rising main @ 0.25 %	50,000
	Total annual O & M cost	22,553,000

Power cost depends on peak flow

5.2.10 Land Cost for MPS at Martinpurwa

Table 5.15 Land Cost for MPS at Martinpurwa

Sr.	Item	Cost (Rs.)
1	Land cost for 8,500 sqm @ Rs. 4,000/- per sqm	34,000,000
	Total land cost	34,000,000

5.2.11 Unit sizes for TSPS at Mastemau

(1) Pumping Station

Table 5.16 Provisions at Mastemau TSPS

Sr.	Item	Provision
1	Pumps for year 2015	12 nos. – 30.50 mld capacity and 20.0 m head (180 HP each) where 8 nos. are working and 4 nos. are stand by pumps
	Pumps for year 2030	In addition to the above, 18 nos. – 30.50 mld capacity and 20.0 m head (180 HP each) making it to 30 nos. of pumps where 20 nos. are working and 10 nos. are stand by pumps
2	Rising main	One 100 m long of 1400 mm dia rising main in PSC
3	Coarse screen channel – 40 mm clear spacing	1 no. – 10.0 m x 10.0 m
4	Medium screen channel – 20 mm clear spacing	8 nos. – 12.0 m x 2.45 m
5	Wet well	5 nos. – 47.0 m x 11.5 m providing a detention time of 5 mins.
6	Dry well	1 no. – 53.0 m x 16.0 m

A layout drawing is presented in LKO-PS-MM-1. General arrangement of the pumping station is presented in drawing LKO-PS-MM-2.

(2) Allied Buildings

In addition to the above, following buildings are provided for provision of electrical panels and generating sets. Also, an open yard is provided for transformer. The sizes are presented in the following table.

Table 5.17 Allied Buildings at Mastemau TSPS

Sr.	Item	Size
1	MEP building	20 m x 10 m
2	DG room & control room	12 m x 10 m
3	Transformer yard	14 m x 12 m

5.2.12 Capital Cost of TSPS at Mastemau

The rates for labour and material are taken from UPJN. These rates are based on the published rates for the year 2000 and admissible premium has been accounted for while working out the present rates for the year 2004.

Rate for various equipment, pipes and appurtenances are taken from the prevailing market rates based on the quotation from the recognised manufacturers.

(1) Civil Cost

Table 5.18 Civil cost for Mastemau TSPS

Sr.	Item	Cost (Rs.)
1	Intel, screen channels, dry well and wet well	135,917,000
2	MEP building	1,200,000
3	DG room / control room	720,000
4	Transformer yard	168,000
5	Staff quarter	1,231,000
	Total	139,236,000

(2) Mechanical Cost

Table 5.19 Mechanical Cost for Mastemau TSPS

Sr.	Item	Cost (Rs.)
1	Coarse screen	640,000
2	Sluice gates	160,000
3	Screen channel gates	1,200,000
4	Mechanical screens	5,400,000
5	Manual screens	300,000
6	EOT for pumps	250,000
7	EOT for screens	200,000
8	Pumps	14,670,000
9	Piping and valves	2,000,000
10	Conveyor belt	300,000
11	Dewatering pumps	120,000
12	Exhaust fans	360,000
	Total	25,600,000

(3) Electrical and Instrumentation cost

Table 5.20 Electrical & Instrumentation Cost for Mastemau TSPS

Sr.	Item	Cost (Rs.)
1	33 kV Switch yard at point of supply*	157,500,000
2	Power supply equipment and stand by power equipment	41,497,000
3	Cables	4,473,000
4	Earthing and safety equipment	471,000
5	Lighting	352,000
6	Instrumentation	1,727,000
7	Miscellaneous	451,000
	Total	206,471,000

** includes provision for both TSPS as well as STP*

(4) Rising Main

Table 5.21 Rising Main Cost for Mastemau TSPS

Sr.	Item	Cost (Rs.)
1	PSC pipe	783,000
2	Appurtenances	300,000
3	Excavation	42,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	1,225,000

5.2.13 Abstract of Cost for TSPS at Mastemau

Table 5.22 Abstract of Costs for Mastemau TSPS

Sr.	Item	Cost (Rs.)
1	Civil cost	139,236,000
2	Mechanical cost	25,600,000
3	Electrical & instrumentation cost	206,471,000
4	Rising main cost	1,225,000
	Total capital cost	372,532,000

5.2.14 Operation & Maintenance Cost for TSPS at Mastemau

Table 5.23 O & M cost for Mastemau TSPS

Sr.	Item	Cost (Rs.)
1	Manpower cost	198,000
2	Power cost (20 hrs @ Rs. 3.25/kWh)	12,743,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	7,406,000
4	Maintenance of civil works @ 1.5 %	2,089,000
5	Maintenance of M&E works @ 3 %	6,962,000
6	Maintenance of rising main @ 0.25 %	3,000
	Total annual O & M cost	29,401,000

Power cost depends on peak flow

5.2.15 Land Cost for TSPS at Mastemau

The cost of land required for provision of TSPS at Mastemau STP is included in the total land cost for Mastemau STP presented under Chapter 6 of this report.

5.3 ABSTRACT OF CAPITAL COSTS FOR NEW PUMPING STATIONS AND RISING MAINS

Table 5.24 Abstract of Capital Costs for New Pumping Stations and Rising Mains

Sr.	Item	Cost (Rs.)
1	Rising main for Mohan Meakin PS	13,709,000
2	MPS at Martinpurwa	200,977,000
3	TSPS at Mastemau	372,532,000
	Total capital cost	587,218,000000

CHAPTER 6

PRELIMINARY DESIGN
OF
NEW SEWAGE TREATMENT PLANT

CHAPTER 6 PRELIMINARY DESIGN OF NEW SEWAGE TREATMENT PLANT

6.1 REVIEW / COLLECTION OF EXISTING DOCUMENTS

MWH reviewed the proposal of a new STP at Mastemau under the Master Plan prepared by JICA Study Team.

6.2 NEED FOR THE SCHEME

This is one of the key components taken up under priority projects. The sewage from district – IV of Cis-Gomti area will be diverted through the proposed relief trunk sewer to proposed pumping station at Martinpurwa. This sewage will be lifted along Sultanpur road trunk sewer, through a rising main, to the proposed STP at Mastemau.

This STP will treat the sewage to the desired standards and the treated effluent shall be discharged into Gomti River adjacent to the site. This treated effluent can also be used for irrigation purposes in the adjacent farms. This will also reduce, to a minor extent, further exploitation of the ground water in the vicinity.

6.3 MASTER PLAN PROVISIONS

Master Plan has proposed a STP that will cater to the entire flow generated in district – IV. The capacity of this plant has been planned as 100 mld in year 2015 and 305 mld in year 2030.

Master Plan recommends UASB with post treatment by aerated lagoon as the preferred treatment process based on detailed comparison of various treatment processes. Chlorination is required to meet the treated effluent standards published by NRCD.

6.4 SURVEY WORKS EXECUTED

UPJN had initially identified a 110 hectares site for construction of STP, towards south-east of Lucknow city in Mastemau village on Sultanpur road.

MWH carried out a reconnaissance survey of the identified site with UPJN officials and JICA Study Team. During the visit it was realized that the proposed land is close to the inhabitants of the Mastemau village and does not provide adequate buffer for the inhabitants of the village. It was suggested, by JICA Study Team, to identify an alternate safe site for this STP.

In order to identify an alternate site, discussions were held with the revenue officials of Mastemau village and also with the officials of adjoining village of Bakkas. Based on the discussions and a detailed survey, including discussion with the locals, suitable land for this STP was identified. The new identified STP site spreads across the villages Mastemau and its adjoining village Bakkas.

The revenue maps of these villages were collected and a composite map was prepared. This composite map was used to identify the exact plots. The plot boundary of the proposed STP site was marked by MWH team with the composite revenue map. The composite revenue map, with the proposed STP boundary was forwarded to the UPJN for further processing.

The proposed STP is also close to the planned extension of Gomti nagar, thus a discussion was held with the Lucknow Development Authority officials to incorporate the same in their landuse plan.

(1) Topographical Survey

Topographical and contour survey was conducted at the identified site. Spot levels were taken by a grid of 30 m x 30 m to plot a contour of 1 m interval.

(2) Geo Technical Survey

Five boreholes, each of 20 m depth, were taken to assess the soil profile at the proposed site. The results of this report are used while finalizing the design of STP units.

The details of the borehole are presented in the Table 6.1.

Table 6.1 Details of Boreholes at STP site

Ground Level (RL)	Depth of Bore Hole	Ground Water Table below GL
111.160 m	20.0 m	2.50 m.
112.950 m	20.0 m	0.45 m
111.865 m	20.0 m	0.60 m
112.525 m	20.0 m	0.70 m
111.420 m	20.0 m	1.05 m

As per the topographical survey report the GL at the pumping station site varies from 111.16 m to 112.95 m. The finished ground level (FGL) for the pumping station is taken at 113.25 m. A retaining wall is proposed along Gomti River for flood protection.

The ground water table is considered at 113.00 m for structural design. The gross safe bearing capacity of soil is considered as 15 tonnes/sqm for structural design. As per the geo technical survey report, raft type foundation is provided, for the pumping station.

6.5 DESIGN ENGINEERING WORKS

6.5.1 Design Flow

Table 6.2 Design flow at Mastemau STP

Sr.	Parameter	2015	2030
1	Average flow (mld)	100	305
	Average flow (m^3/hr)	4,167	12,708
2	Peak factor (as per CPHEEO manual)	2.0	2.0
3	Peak flow (m^3/hr)	8,333	25,416

6.5.2 Raw sewage Characteristics

Raw sewage characteristics differ from one situation to another depending on the level of sanitation, water usage, return factor, type of collection system, retention time in conveying system and infiltration. UPJN and JICA Study Team have collected a limited number of grab samples for a limited period of time (about 4 weeks). The BOD concentration in various nalas varied from 75 to 154 mg/l.

The catchment area of Cis Gomti relief sewer which will bring sewage to the proposed STP at Mastemau is densely populated and has over 60% sewer coverage area. The relief sewer will intercept sewage flowing through the existing sewerage system in this area along with China bazar nala sewer, Pata nala sewer, Wazirganj nala sewer, and Katchehary road sewer apart from the nala tapings. The sewage, which is flowing through these sewers, is expected to be having higher concentration than that

flowing through the nalas presently. The water supply rate considered in the Master Plan at user end is also on much higher side hence actual characteristics of the sewage are expected to be medium to strong strength.

Based on these facts the wastewater characteristics adopted for design of the proposed STP at Mastemau are presented in the Table 6.3.

Table 6.3 Raw Sewage Characteristics

Sr.	Parameter	Average Value
1.	Minimum temperature, ^{o}C	20
2.	pH	6.0 - 8.5
3.	Biochemical oxygen demand (BOD_5), mg/l	250
4.	Total suspended solids, mg/l	500
5.	Faecal coliform count, MPN/100ml	2×10^7

6.5.3 Discharge Standards

NRCD has conveyed the recommendations of the expert committee through their DO Letter No. A-33013/1/99-NRCD dated 5th October 1999, suggesting that the desired level for faecal coliform in treated water should not exceed 1,000 MPN per 100 ml sample irrespective of its mode of disposal in river or its use for irrigation to grow either restricted or unrestricted crops. It is also mentioned in NRCD guidelines that BOD and TSS concentration shall be less than 30 mg/l and 50 mg/l respectively.

The STP has been therefore designed so as to achieve treated wastewater of equal or better quality as mention in the Table 6.4 hereunder.

Table 6.4 Treated Wastewater Quality

Sr.	Parameter	Value (Irrigation Field/River)
1.	pH	5.5 – 9.0
2.	Biochemical oxygen demand, mg/l	$\leq$ 30
2.	Total suspended solids, mg/l	$\leq$ 50
3.	Faecal coliform count, MPN/100ml	Desired $\leq$1,000 Permissible $\leq$10,000

6.5.4 Treatment Scheme

In phase –I, the capacity of STP at Mastemau is 100 mld. As discussed in the earlier section, a terminal sewage pumping station (TSPS) is proposed at the STP site, which will lift sewage to the required elevation through a rising main. Horizontal type centrifugal pumps are provided in TSPS for pumping of sewage to the inlet chamber of STP for further treatment. A detailed schematic flow diagram for the proposed STP is presented in drawing no. LKO-LAY-STP-1.

STP at Mastemau will consist of the following units:

1) Inlet chamber
2) Screen channel
3) Grit chamber
4) Division box
5) Distribution box

6) UASB reactor
7) Aerated lagoon
8) Chlorination system
9) Sludge pumping station
10) Filtrate pumping station
11) Sludge drying beds
12) Gas holder
13) Gas utilisation system
14) Allied buildings
15) Irrigation canal

The rising main from TSPS will deliver the sewage at the elevated inlet chamber of STP, further passing through the screen channel and to the grit chambers. In screen channel, floating matters are trapped and removed whereas grit is separated in grit chamber. After screening and grit removal, sewage flows into the UASB reactors for biological treatment. The treated wastewater from UASB reactors is taken to facultative type of aerated lagoons for further treatment and finally, taken for chlorination for further reduction of faecal coliform content in wastewater. Treated water is disposed off into Gomti River or alternatively taken for irrigation to villages Mastemau, Bakkas and Chilaula.

The sludge form UASB reactor is taken to sludge drying beds for dewatering before its disposal or its use as manure. The biogas generated in the UASB reactor is stored in the gasholder. This biogas is utilised for generation of electricity using a pure gas engine.

6.5.5 Unit Description

(1) Inlet Chamber

An inlet chamber is provided ahead of screen channel to receive the sewage from the TSPS via rising main.

(2) Screen Channel

Screening is an essential step in sewage treatment to remove large size floating materials like rags, wooden pieces, plastics, tobacco pouches, etc. which, otherwise would damage pumps and interfere with the operation of various treatment units. Screen channel is provided with bars placed across the channel to trap the floating material. The spacing of bars is kept depending on the degree of treatment required.

Mechanical screens are provided with four units working and two manual screen unit as standby unit. The screening process is undertaken by screen consisting of 50 mm x 10 mm thick flats with 6 mm clear openings to trap the floating materials.

The mechanically operated screens will be equipped with a mechanism, which will automatically rake at a pre-set timer control. The screened material will be collected in a hopper located above the water level such that it can be easily collected in a collection cart.

Each of the standby screen channels will have manually cleaned bar screens with bar clearance of 12 mm. A removable square mesh of 25 mm x 25 mm is provided after 12 mm opening screen to trap any floating matters that has escaped. Aluminium gates are provided, with RCC platforms and access staircase, for controlling the flow. Hand railing is provided on all platforms.

(3) Grit Chamber

The screened sewage flows through a grit removal system consisting of mechanical grit removal

mechanism in two grit chambers. Grit in sewage consists of coarse particles of sand, ash and clinkers, eggshells and many inert materials, which are inorganic in nature. Grit is non-putrescible and possesses a higher hydraulic subsidence value than organic solids. Hence, it is possible to separate the gritty material from organic solids by differential sedimentation in a grit channel.

Grit removal is necessary to protect the moving mechanical equipment and pumps from abrasion and abnormal wear and tear. It is separated in a grit chamber with designed detention period. A completely automatic grit washing and removal mechanism is provided for removal of grit. Also, a stand-by grit channel, having 50 percent capacity, is provided keeping in view the maintenance of mechanical grit removal.

(4) Upflow Anaerobic Sludge Blanket (UASB) Reactor

After screening and grit removal, wastewater flows into UASB reactors for biological treatment. A series of reactors are provided with a distribution system to ensure equal distribution of wastewater throughout all the reactors.

The development of the UASB reactor dates back to early 1970's. Pre sedimentation, anaerobic wastewater treatment and final sedimentation including sludge stabilization are essentially combined in one reactor making it most attractive high-rate wastewater treatment option. It produces high value by-products viz.:

- Treated wastewater usable for agricultural and gardening purpose or for pisci-culture after a simple post treatment
- Methane enriched biogas having high calorific value is converted into a usable energy resource like heat energy, electricity etc., and
- Mineralised excess sludge produced in UASB reactor for its usage as manure for agricultural purpose.

The UASB process initially was developed for the anaerobic treatment of industrial wastewater with a moderate to high COD and BOD concentrations. The basic idea is that flocculent or granular sludge developed in the reactor depending on the wastewater characteristics and operational parameters will tend to settle under gravity when applying moderate upward velocities in the reactor. In this way no separate sedimentation basis is necessary. Anaerobic bacteria are developed in the reactor and are kept in the biological reaction compartment for sufficient time. Organic compounds present in the wastewater are absorbed or adsorbed on the sludge particles in the reaction zone during its passage through the sludge bed. There after, organic compounds get anaerobically biodegraded converting it into methane-enriched biogas and a small part into the new bacterial mass. Biogas consists of methane CH_4, carbon dioxide CO_2, hydrogen gas H_2, hydrogen sulphide H_2S and traces of ammonia NH_3 and nitrogen N_2. This biogas can be used as energy source, and is collected in gas collectors for this purpose.

A gas, liquid and solids separator (GLSS) is provided below the gas collectors in order to provide an opportunity to the sludge particles to which biogas bubbles are attached to lose biogas and settle back into the reaction compartment. In between two gas collectors a settling zone is provided where virtually, no gas bubbles are present in the liquid. The sludge particles carried along with the wastewater flow are settled in the settling zone and slide down into the biological reactor in the upward direction. In order to ensure sufficient contact between the incoming wastewater and the anaerobic bacterial mass present in the reactor, the wastewater is fed uniformly all over the bottom of the reactor. Further mixing in the reaction zone is achieved by the production of the biogas travelling in the upward direction, settling velocity of the sludge particles and the density currents in the sludge mass.

Proper care is taken while designing the UASB reactor to absorb estimated shock loads in terms of

hydraulic and organic contents in the wastewater. The reactor is rectangular in size and modular approach is used for design.

(5) Aerated Lagoon (AL)

Design of a proper post-treatment system is important for the success of any project involving anaerobic treatment. Post-treatment required is given in various forms to meet effluent discharge standards. The wastewater from UASB reactors will require further polishing in order to meet the inland water discharge standards of BOD, suspended solids and faecal coliform.

Facultative type aerated lagoons are provided to achieve the desired quality of wastewater. This lagoon is provided in two zones viz. aeration zone and quiescent zone. A hydraulic retention time (HRT) of half a day is provided in aeration zone where oxygen is added for biodegradation of organic matter and oxidation of sulphides. In quiescent zone, an HRT of one a day is provided for settlement of suspended solids.

(6) Chlorination System

A chlorination system is provided to meet the faecal coliform standards. The chlorination system, mainly, includes three units viz. chlorine house, chlorine mixing tank and chlorine contact tank.

(7) Chlorine House

Chlorine house will have vacuum type gaseous chlorinator with all accessories and required number of chlorine toners.

(8) Chlorine Mix Tank

Chlorine mix tank is provided with slow speed mechanical mixer to mix the chlorine solution with treated effluent from AL. From chlorine mix tank water will flow to chlorine contact tank.

(9) Chlorine Contact Tank

Disinfection of wastewater takes place in the chlorine contact tank by way of adequate contact time, of 30 minutes, with chlorine. Baffle walls are provided to ensure proper contact.

6.5.6 Sludge Dewatering System

Sludge Dewatering System consists of the following:

- Sludge Pumping Station
- Sludge Drying Beds

A sludge pumping station is provided for the transfer of sludge, from UASB reactors to sludge drying beds, for dewatering. The capacity of sludge sump is adequate to hold the volume of sludge wasted from two reactors in a day. The pumps in sludge pumping station are provided with 100 percent standby capacity in case of failure or maintenance of operating pumps.

A 250 micron thick low density poly ethylene (LDPE) sheet is spread over the floor of the sludge drying beds to prevent the seepage of the filtrate into the ground as ground water table is found at higher level in this area. A 150 mm thick layer of gravel having a size of 30 - 50 mm is spread over the brick lining, which is followed by a 150 mm thick layer of gravel having a size of 12 - 30 mm. On top of this layer of gravel, a 225 mm thick layer of sand having 0.30 - 0.75 mm size is laid. When wet sludge is spread on the top of bed major portion of liquid drains off in few hours after which drying of

sludge commences by evaporation. The dried sludge is transported in trucks for disposal to sanitary landfills for use as manure on agricultural land.

This filtrate is collected in a sump though open jointed GSW pipe of 200 mm diameter. The filtrate is taken back to the inlet chamber with pumps of adequate capacity.

6.5.7 Sludge Utilisation

The various alternatives available for the disposal of sludge are:

(1) Land Filling

Sludge can be finally disposed off for the purpose of landfill, which is the most common method of solid waste disposal in India. Sludge disposal in this manner requires additional yearly operation & maintenance cost in terms of staff & vehicle for loading, unloading, transportation & disposal of sludge.

(2) Sludge as a Manure

Sludge produced from the UASB reactor is digested sludge and rich in nutrients (N, P, K), which are beneficial for plant growth. Digested sludge from STP is now acceptable to local farmers to be used as manure in the field. By selling sludge at a nominal rate, department can generate yearly revenue which will help in the operation & maintenance of the plant.

Keeping in view of the above two available options, use of sludge as manure is found most techno-economical alternative.

6.5.8 Biogas Handling System

(1) Gasholder

Floating type gasholders are provided in a concrete tank with a holding capacity of six hours of biogas production. Each gasholder is provided with inlet, gas outlet, water drain, pressure and vacuum relief valves arrangement.

(2) Gas Flaring System

A gas flaring system is provided consisting of the following components:

- Pressure regulator and water seal
- Flame check
- Pilot gas flame and valve along with the electronic lighter
- Gas flare at 6m height from ground level, and
- Moisture trap

6.5.9 Biogas Utilisation

Biogas generated in the UASB reactor is stored in the gasholder. This biogas is utilised for generation of electricity using a pure gas engine. Biogas blowers are also provided to boost the pressure of biogas to 0.4 to 0.6 kg/cm^2 before it is fed to the engines. Provisions for pressure measurement, gas flow measurement, hydrogen sulphide scrubbers and biogas blowers are provided on the biogas utilisation system before it is fed to biogas engines.

The various alternatives available for the disposal of biogas generated in the plant are:

(1) Flaring

Biogas generated from the UASB reactor can be directly flared to the sky in a controlled manner.

(2) As Cooking Gas

Bio- gas can be utilized as a cooking gas in the individual households. Due to psychological reasons, biogas generated from sewage is not acceptable to consumer in India and, moreover, a complete infrastructure is required for distribution and supply of large volumes of biogas.

(3) Fuel for Power Generation

Biogas can be used as a fuel for electricity generation, which can be utilised in the plant itself. Use of bio gas for power generation fulfills the power requirement of plant partially depending upon the quantity of bio gas generated which reduces the external power requirement and makes the system self sustainable. Keeping in view of the various options available, utilisation of biogas for power generation seems most suitable alternative and hence adopted in the present scheme.

6.6 DESIGN CRITERIA

The design parameters for STP at Mastemau are adopted from Manual on Sewerage and Sewage Treatment of CPHEEO and the latest NRCD guidelines. The parameters adopted for design are presented in following table.

Table 6.5 Design Parameters for STP at Mastemau

Sr.	Parameter	Value	Unit
Average flow		1.157	cum/sec
Peak factor		2.0	
Peak flow		2.315	cum/sec
Sewage Treatment Plant:			
1.	Inlet Chamber		
	Hydraulic retention time (minimum)	30	sec
2.	Fine Screen Channel		
	Clear opening through screen	6	mm
	Minimum approach velocity at average flow	0.3	m/sec
	Minimum velocity through screen at peak flow	0.6	m/sec
	Maximum velocity through screen at peak flow	1.2	m/sec
3.	Grit Chamber		
	Particle size	0.15	mm
	Specific gravity of grit at 20^{o} C	2.65	
	Efficiency	75	%
4.	UASB Reactor		
	Solids retention time, SRT	38	days
	Sludge bed concentration	65.0	kg TSS/cum
	Maximum sludge bed height	90.0	% of Ht to gas collector
	Average upflow velocity	0.5	m/hr
	Maximum upflow velocity	1.0	m/hr
	Average aperture velocity	2.5	m/hr
	Maximum aperture velocity	5.0	m/hr
	Angle of gas collector	50.0	degree
	Settling zone surface percentage	> 75.0	% of total surface area
	Settling zone detention time (minimum)	1	hr
	Feed inlet point distance (maximum)	2.0	m
	Overlap	0.15	m
5.	Aerated lagoon		
	Aeration zone		
	Detention time	0.5	day
	Depth	3.0	m
	Quiescent zone		
	Detention time	1.0	day
	Depth	1.5	m
	Sludge depth	0.3	m
6.	Chlorine Mix Tank		
	Detention time	2	min
7.	Chlorine Contact Tank		
	Detention time	30	min
8.	Gasholder		
	Detention time	6.0	hr
	Pressure	0.03	kg/sq.cm

6.7 UNIT SIZES

6.7.1 Civil Works

The treatment scheme adopted for STP at Mastemau consists of the following units. A detailed process design is carried out and the required sizes are presented in the Table 6.6. Detailed specifications are presented in Appendix A6.1.

Table 6.6 List of STP Units

Sr.	Units	No.	Size (meter)
1	Inlet chamber	1	1.8 x 7.8 x 5.0 liquid depth (LD) + 0.5 freeboard (FB)
2	Screen channel	4+2	5.0 x 1.8 x 1.0 LD + 0.5 FB
3	Grit chamber	2	11.6 x 11.6 x 0.7 LD + 0.6 FB
4	Division box - 1	1	5.6 x 5.4
5	Division box - 2	4	5.4 x 3.1
6	Distribution box	16	2.3 x 2.25
7	UASB reactor	8	32.0 x 32.0 x 5.3 LD + 0.5 FB
8	Aerated lagoon Aeration zone Quiescent zone	 2 2	 64.6 x 129.0 x 3.0 LD + 0.5 FB 258.4 x 129.0 x 1.5 LD + 0.3 sludge depth + 0.5 FB
9	Chlorine mixing tank	1	7.5 x 7.5 x 2.5 LD + 0.5 FB
10	Chlorine contact tank	1	40.8 x 20.4 x 2.5 LD + 0.5 FB
11	Sludge drying beds	38	28.3 x 16.7
12	Sludge pumping station	2	2.5 x 4.0
13	Filtrate pumping station	1	2.5 x 4.0
14	Gas holder	2	12.4 dia x 4.7 TD (total depth)
15	MEP room	1	10.0 x 12.0
16	Generator room	1	8.0 x 10.0
17	Transformer yard	1	10.0 x 12.0
18	Administration block cum lab	1	12.0 x 20.0

A general layout showing the proposed STP at Mastemau based on the UASB process followed by aerated lagoon with chlorination system is presented in drawing no. LKO-LAY-STP-2. The hydraulic flow diagram for this treatment plant is presented in drawing no. LKO-LAY-STP-3.

6.7.2 Mechanical Works

A list of mechanical equipment provided at STP is presented in Table 6.7. Detailed specifications are presented in Appendix A6.1.

Table 6.7 List of Mechanical Works

Sr.	Units	No.	Rating
1	Mechanical screen – 6 mm clear opening	4	5.0 HP
2	Conveyor belt – 0.75 m wide neoprene rubber	1	5.0 HP
3	Grit removal mechanism – scarper arrangement and grit washing arrangement	2	5.0 HP
4	Aerators – fixed type helical gear	6	30.0 HP
5	Sludge pumps – 50 cum/hr @ 15 m head	2	20.0 HP
6	Filtrate pumps – 40 cum/hr @ 15 m head	4	15.0 HP
7	Gas holder accessories including safety arrangement	1	-
8	Gas flaring system of 250 cum/hr	1	-
9	Chlorinators – gaseous type capable to provide 5 mg/l dose including safety arrangement	1	5.0 HP
10	Gates – aluminium gates installed at screen channel, grit chamber and at bypass arrangement	8	-
11	Electrically operated trolley and chain pulley	3	5.0 HP
12	Pure gas engines including all accessories	2	400 kVA

6.7.3 Electrical & Instrumentation Works

Following components are considered for electrical and instrumentation works for Mastemau STP. Detailed specifications are presented in Appendix A6.1.

Table 6.8 List of Electrical & Instrumentation Works

Sr.	Units	No.
1	33kV overhead transmission line	0.5 km
2	48V DC sealed maintenance free battery & battery charger	1
3	33kV vacuum circuit breaker panel	1
4	Gas engine synchronization and AMF panel	1
5	33/0.433kV of Dyn11 - vector group, oil natural air natural (ONAN) cooled transformer with off circuit tap changer	2
6	Main electrical panel	1
7	Screen and grit removal mechanism panel	1
8	Aerator and chlorine house panel	1
9	Sludge pump panel	1
10	Filtrate pump panel	2
11	Main lighting panel	1
12	Sub lighting panels	6
13	160kVAr (kilo volt ampere reactive) capacitor control panel with APFC (automatic power factor correction) relay	1
14	33kV & 1.1kV cables, cable terminations & cable carrier system	Lot
15	Indoor and outdoor lighting	Lot
16	Earthing and safety equipment	Lot
17	Instrumentation system	Lot

6.8 CAPITAL COST

The rates for labour and material are taken from UPJN. These rates are based on the published rates for the year 2000 and admissible premium has been accounted for while working out the present rates for the year 2004.

Rate for various equipment, pipes and appurtenances are taken from the prevailing market rates based on the quotation from the recognised manufacturers.

6.8.1 Civil Cost

Table 6.9 Cost of Civil Works

Sr.	Units	Civil Cost (Rs.)
1	Inlet chamber	579,000
2	Screen channel	405,000
3	Grit chamber	1,749,000
4	Division box - 1	760,000
5	Division box - 2	1,425,000
6	Distribution box	1,901,000
7	UASB reactor	190,054,000
8	Aerated lagoon Aeration zone Quiescent zone	 7,083,000 16,667,000
9	Chlorine mixing tank	464,000
10	Chlorine contact tank	5,625,000
11	Sludge drying beds	15,238,000
12	Sludge pumping station	900,000
13	Filtrate pumping station	315,000
14	Gas holder	4,237,000
15	MEP room	660,000
16	Generator room	400,000
17	Administrative building cum laboratory	1,080,000
18	Transformer yard	180,000
19	Interconnecting piping, roads and pathways	6,725,000
20	Interconnecting channels	4,160,000
21	Treated effluent channel (length of 300 m)	2,400,000
22	Chlorine room	360,000
	Total	263,367,000

6.8.2 Mechanical Cost

Table 6.10 Cost of Mechanical Works

Sr.	Units	Mechanical Cost (Rs.)
1	Mechanical screen	5,672,000
2	Conveyor belt	400,000
3	Grit removal mechanism	3,000,000
4	Aerators	2,100,000
5	Sludge pumps	300,000
6	Filtrate pumps	400,000
7	Gas holder accessories	350,000
8	Gas flaring system	320,000
9	Chlorinators	2,000,000
10	Gates	800,000
11	EOT and chain pulley	750,000
12	Pure gas engine	38,000,000
	Total	54,092,000

6.8.3 Electrical & Instrumentation Cost

Table 6.11 Cost of Electrical & Instrumentation Works

Sr.	Units	Electrical & Instrumentation Cost (Rs.)
1	Panels	9,190,000
2	Cables	3,942,000
3	Lighting	614,000
4	Earthing and safety equipment	628,000
5	Instrumentation	765,000
6	Miscellaneous	244,000
	Total	15,383,000

6.8.4 Utilities

The utility items required for operation of STP and its costs are presented in the following table.

Table 6.12 Cost of Utility Items

Sr.	Units	Utility Cost (Rs.)
1	Furniture	500,000
2	Laboratory equipment	1,200,000
3	Tube well and water supply system	600,000
4	Site drainage	1,000,000
5	Security room	50,000
6	Staff quarter	4,363,000
7	Green belt	150,000
8	Wheel barrow and trolley mounted pump	300,000
9	Fire fighting arrangement	80,000
10	Bypass arrangement	12,000,000
11	Outfall structure	300,000
12	Boundary wall	34,890,000
13	Vehicle	600,000
14	Site development	1,200,000
15	Irrigation channel (length of 5000 m)	62,500,000
16	Miscellaneous	500,000
	Total	120,233,000

6.8.5 Total Capital Cost

Table 6.13 Total Capital Cost

Sr.	Particulars	Costs (Rs.)
1	Civil	263,368,000
2	Mechanical	54,092,000
3	Electrical and instrumentation	15,382,000
	Sub total	332,843,000
4	Utilities	120,232,000
	Total	785,917,000

6.8.6 Land Cost

A total of 70 hectares of land is required for construction of STP at Mastemau. This land provision includes the requirement for both phases i.e. 100 mld in phase-I and 305 mld in phase-II. Also, provision has been made for the construction of pumping station (TSPS at Mastemau) within this plot.

Table 6.14 Land Cost

Sr.	Particulars	Costs (Rs.)
1	Land cost for 70 ha @ Rs. 2,476,000	173,320,000
	Total	173,320,000

6.9 OPERARATION & MANINTENANCE

6.9.1 General

The detailed operation and maintenance manual of the STP will be submitted at the time of start-up and monitoring phase of the plant. Operation and maintenance of the STP is very much required for sustainability of the STP and to achieve discharge standards. The operational aspects include regular checking of the units (which include the electrical and mechanical equipment), to identify any non-functionality of the units and to evolve the strategic measures to be taken, so as to run the plant.

All the activities of the STP are scheduled and coordinated by the plant manager. The plant manager will also be responsible for taking steps like shutting down the plant or bypassing the wastewater in case of emergencies, after having proper deliberations with the management and the operational staff.

6.9.2 Screens

Table 6.15 Operation and Maintenance - Screen

Sr.	Equipment	Operational	Maintenance
1	Mechanical screens	• Hourly Incoming amount of the screenings should be clearly recorded in the data sheet. The type of the screenings should also be recorded in the data sheet • A timer should control the mechanism for removal of the screenings • Frequent checks of the mechanical raking mechanism are required for every 2 to 3 hours	• Regular checks should be done for proper working of the rake mechanism • The screens should be painted for every 3 to 4 months
2	Manual screens	• Hourly incoming amount of the screenings are to be clearly recorded in the data sheet, which should also give details of the type of the screenings screened • The screens should be cleaned after every one hours, so that there will not be any clogging at the screens, and thus leading to the over flow of the wastewater • The labourer cleaning the screens should wear safety equipment such as gloves and shoes	• The screens should be cleaned every hour. • The screens should be painted for every 3 months

A coarse mesh screen is placed after the fine screen. The main function of the mesh screen is to remove the plastic materials and other small items, which pass through the bar screens. The operational staff should clean the wire mesh for every hour in order to avoid choking of the mesh. The staff should wear gloves and boots when they are in operation of cleaning the screens.

6.9.3 Grit Chamber

The grit chamber consists of circular tank, which consists of moving scrapper mechanism. An airlift pipe is provided in the grit chamber with a bypass line. The following are the operational and maintenance aspects of the grit chamber.

Table 6.16 Operation and Maintenance – Grit Chamber

Operational	Maintenance
• The time and amount of grit cleaned from each channel should be recorded in a daily record sheet.	• All the gates/valves should be cleaned periodically • The grit channel should be cleaned properly.

6.9.4 UASB Reactor

During the operation of the treatment plant, sludge samples from the reactor shall be taken, once in a week, for analysis. The operational parameters such as hydraulic retention time can be adjusted depending upon the sample results. The following illustrates the maintenance aspects of the UASB reactor:

- All the FRP piping and PVC piping should be checked for gas leakage and should be repaired immediately
- The levels of the inlet gutters of every reactor should be frequently checked
- The floating layer, whenever it forms, should be removed from the gas collectors
- The railing and other metallic works such as valves should be painted
- For every 4 to 5 years, the grit accumulated inside the reactor should be removed and the inside concrete surface should be given a new coat of epoxy paint.
- The sludge pits should be properly maintained

(1) Feed Inlet Boxes

The main problem with the feed inlet box is that the inlet pipes get frequently choked up. In case of choking, water hosepipe should be introduced so as to build up the pressure. If it so happens, that the choking of pipe cannot be removed by means of water hosepipe, a flexible rod should be used to clean up the feed inlet pipe.

(2) Effluent Gutters

The following are the operational and maintenance aspects of the Effluent gutters

Table 6.17 Operation and Maintenance – Effluent Gutters

Operational	Maintenance
• Care should be taken when fixing up the weir plates to the effluent gutters. The weirs should be horizontal and all gutters of a reactor should be at one level • Minimal slope should be provided to the effluent gutters towards the effluent channel • Frequent sludge removal should be done from the effluent gutters • The sludge should be transported to the dumping site by means of electrically operated trolley.	• Levelling and alignment of the weirs and the gutters should be checked properly twice in a year. • The notches should be cleaned frequently • In case of sludge accumulation in the effluent gutter, it shall be cleaned with a brush or with a water jet • Baffle plates and their fixing fixtures shall be checked for any kind of damage or corrosion every year and shall be repaired / replaced, if necessary

6.9.5 Sludge Discharge System

- Check the discharge of sludge discharge valves
- Check the operation of valves at sludge sampling points and replace the non-functioning valves
- Spindles of valves shall be greased regularly. Glands and packing of the valves shall be checked every three months and replaced, if necessary

6.9.6 Sludge Drying Beds

Sludge characteristics should be known at the time of the start up of the plant, as it determines the average sludge drying time. The sludge applied in shallow depths dewaters at a much rapid rate, but

more frequent discharge from the beds is required. So the optimum sludge height should be evaluated depending upon the sludge characteristics. The following table shows the operational and maintenance aspect of the sludge drying beds.

Table 6.18 Operation and Maintenance – Drying Beds

Operational	Maintenance
• The sludge should be applied after the dewatered sludge cakes are removed • The sludge drying beds should be free from vegetation before the application of the sludge • The sludge cakes should be removed at regular interval of time, which depends upon the sludge characteristics • The position of the splash gates and trays should be checked before applying the sludge on the bed	• Drain pipes should be checked frequently so that no clogging takes place • The sludge piping should be washed, after application of the sludge • All the metallic elements such as chequered plates etc. should be painted once in a year

6.9.7 Biogas Collection & Flaring System

System includes FRP piping for the conveyance of gas, gasholder system for the storage of gas and gas flaring unit for controlled flaring of gas into atmosphere as and when required. All the piping and valves shall be periodically checked against leakage. If any leakage is found, the same shall be repaired by isolating the line with the help of valves. Gas dome of gasholder shall be epoxy painted and shall be provided with break glass seal and emergency alarm for vacuum/ excess gas condition. Gas flaring system shall be operated & maintained as per manufacturer guideline.

6.9.8 Chlorination System

Chlorination equipment shall be properly housed and items like cylinders, valves, gaskets etc. shall be kept in spare. Valves and piping shall be regularly checked for leaks. Leaks shall be attended to as per the instruction in the manufacturer's catalogues. Chlorine cylinders shall be kept on scales and the weight read each day as a check for the amount of chlorine used. Gas mask must be used while attending to chlorine leaks. Operation record shall show the volume of sewage chlorinated, rate of application of chlorine, residual chlorine in the plant effluent and the amount of chlorine consumed per day.

6.9.9 Sludge Pumps

Water level in the sludge sump shall not be lower than the minimum designed level. Also the water level in the sump shall not reach beyond maximum designed level. Floats and sequence switches controlling the pumping cycle shall be examined at the beginning of each shift. All bearings, water seal, motors, guide rail and electrical wire & control equipment shall be inspected periodically. The manufacturer's manual for operation and lubrication shall be strictly followed. The time interval between start & stop of any pump shall not be less than 5 minutes. All pumps including standby pumps shall be operated in rotation so that the wear and tear is distributed evenly.

6.9.10 Manpower Requirement

The manpower requirement for operation and maintenance for Mastemau STP is presented in the Table 6.19. The plant manager, a person at a level of Executive Engineer, will head the team. He will be assisted by Assistant Engineers, Junior Engineers and other supporting staff.

The organisational set up can be divided into three categories, mainly:

- Management level
- Operational level
- Supporting staff

The plant manager, plant engineer and process engineer come under the management level, which manages the treatment plant. The plant manager is responsible for smooth functioning of the plant. He is the bridge in between the administration and the treatment plant staff. He co-ordinates all the activities of the treatment plant. He is also responsible for training of the new personnel. The plant engineer and process engineer will support the plant manager in all the activities and instructs the operational staff in operation and maintenance of the plant. They act as a link in between the plant manager and the operational staff.

The process engineer will look after the sample collection, analysis - reporting part where as the plant engineer will instruct the operators in maintenance of the electrical and mechanical equipment. The group of chemist, plant supervisors, electrician and a fitter will support the process and plant engineers. Supporting staff comprising of sweepers, casual labourers, watchmen and gardener are proposed to work under the operational staff, to do the labour intensive works.

Table 6.19 Proposed Manpower Requirement at STP

Sr.	Function	Level	Time to be spent	Number of Personnel
1	Plant manager	Executive engineer	6 days/week	1
2	Assistant manager	Assistant engineer (E&M)	6 days/week	1
3	Assistant manager	Assistant engineer (Civil)	6 days/week	1
4	Junior manager	Junior engineer (E&M)	6 days/week	6
5	Junior manager	Junior engineer (Civil)	6 days/week	2
6	Fitter (mechanical)	1st class	6 days/week	2
7	Electrician	1st class	6 days/week	3
8	Fitter (mechanical)	2nd class	6 days/week	1
9	Electrician	2nd class	6 days/week	2
10	Gardener	_	6 days/week	2
11	Driver	_	6 days/week	1
12	Cleaner	_	6 days/week	1
13	Jr. accountant	_	6 days/week	1
14	Chemist	M.Sc. (Chemistry	6 days/week	1
15	Assistant chemist	B.Sc. (Chemistry)	6 days/week	1
16	Lab assistant	_	6 days/week	1
17	Lab attendant	_	6 days/week	2
18	Sweeper	_	6 days/week	2
19	Welder	ITI	6 days/week	1
20	Operator	ITI	6 days/week	19
21	Labourer	-	6 days/week	73
22	Senior assistant (Upper divisional clerk)	_	6 days/week	2
23	Junior assistant (Lower divisional clerk)	_	6 days/week	3
24	Peon	_	6 days/week	3
25	Stenographer	_	6 days/week	1

6.9.11 Operation and Maintenance Cost Estimates

(1) Operation Cost

Power Cost

Table 6.20 Cost of Power

Sr.	Equipment	No.	Rating (HP)	Working hours	Power consumption (kWh)
1	Mechanical screen	4	5.0	24	358.1
2	Conveyor belt	1	5.0	24	89.6
3	Grit removal mechanism	2	5.0	24	179.1
4	Aerators	6	30.0	24	3222.8
5	Sludge pumps	2	20.0	6	179.1
6	Filtrate pumps	4	15.0	2	89.6
7	Chlorinators	1	5.0	24	89.6
8	EOT, chain pulley	3	5.0	2	22.4
9	Lighting	1	5.0	8	29.9
	Total power consumption per day (kWh)				4,261
	Total cost for power per day @ 3.25 Rs./kWh				13,848.25
	Total cost for power per year				5,054,611

Manpower Cost

Table 6.21 Cost of Manpower

Sr.	Particulars	Amount (Rs.)
1	Manpower cost per month	634,300
2	Manpower cost per year	7,611,600

Chemical Cost

Table 6.22 Cost of Chemical

Sr.	Chemical	Dose (mg/l)	Quantity (kg/day)	Rate (Rs./kg)	Amount per day (Rs.)	Amount per year (Rs.)
1	Chlorine	5	500	8.00	4,000	1,460,000

Table 6.23 Total Operation Cost

Sr.	Particulars	Costs per year (Rs.)
1	Power	5,055,000
2	Manpower	6,534,000
3	Chemical	1,460,000
	Total	13,049,000

Maintenance Cost

Table 6.24 Maintenance Cost

Sr.	Particulars	Costs per year (Rs.)
1	Civil @ 1.5% per year	3,951,000
2	Mechanical, electrical and instrumentation @ 3% per year	2,084,000
	Total	6,035,000

Total Operation & Maintenance Cost

Table 6.25 Total O & M Cost

Sr.	Particulars	Costs per annum (Rs.)
1	Operation & Maintenance Cost	19,084,000

6.10 RESOURCE RECOVERY

Resource recovery from the valuable by products of the sewage treatment plant is considered in the form of manure on irrigation fields from the excess sludge produced in STP and the production of electric power from the methane enriched biogas.

The biogas generated in the UASB reactors will be utilized for the operation of STP and operation of a set of pumping stations installed at terminal pumping station. Pure gas engines are provided as alternate power source that will convert the biogas generated in the reactors into electricity.

The sludge generated in STP is rich in N:P:K value and can be utilized for irrigation as manure/soil conditioning.

Table 6.26 Resource Recovery

Sr.	Particulars	Quantity	Amount (Rs./year)
1	Excess sludge produced @ 300 Rs. per truck load (5 tonnes on each truck) considering 270 days per year	241.5 tonnes/day	3,912,000
2	Electricity generated from 2876 cum/day biogas production	3206.74 kWh/day	3,804,000
	Total resource recovery		7,716,000000

Note: the possible revenue from the supply of treated water to farmers in the nearby fields is not considered while estimating the resource recovery.

CHAPTER 7

INSPECTION, CLEANING AND REHABILITATION OF CGTS

CHAPTER 7 INSPECTION, CLEANING AND REHABILITATION OF CGTS

Sewer systems are an important part of infrastructure and play an essential part of maintaining public health. Yet they are largely out of sight and in the past this has often been a cause of neglect, leading to sewer flooding, pollution, collapse and blockage. A sewer normally fails to receive attention till it starts giving serious trouble.

As stated earlier, the sewerage system for Lucknow city was commissioned in 1960's. Considering the importance of existing old trunk sewer as a part of overall sewerage system of Lucknow, JICA Study Team considered the inspection, cleaning and rehabilitation of Cis-Gomti Trunk Sewer (CGTS) under priority project category. Preliminary investigation on trunk sewer was carried out through manhole survey, under feasibility study to propose a structured inspection, cleaning and rehabilitation plan.

7.1 BASICS OF SEWER REHABILITATION PLAN

Indian cities show a certain trend of development characterized by rapid unplanned growth of cities and its population puts considerable strain on the civic infrastructure. The infrastructure is put to such a strain that it becomes impossible to adopt conventional but relatively cheaper methods for restoration of underground infrastructure like sewers and water mains. This leads to delay in taking up actual rehabilitation work further deteriorating the system.

Lucknow is not an exception to such scenario. By virtue of its geographic situation on the banks of Gomti River the city's sewerage system discharging into Gomti River needs urgent attention for ensuring-

a) adequacy of sewerage system to meet the population growth,
b) ensure that the environment is not adversely affected due to deficiencies in wastewater system at all levels- collection, conveyance, treatment and disposal
c) source of potable water for cities, located at the downstream of the river, is not adversely polluted because of deficient sewerage.
d) Need to meet the growth of the city- demographic growth as well as geographical growth

This section provides an insight for the feasibility of rehabilitating and replacing of the existing CGTS.

7.2 REHABILITATION OF EXISTING SEWERAGE SYSTEM

CGTS, which is the backbone of city's present sewerage system, was laid in 1960's and requires immediate attention. Rehabilitation as a process has to be planned and executed based on established guidelines so as to achieve end results which are consistent with good practices and ensure long lifecycle for the system. For this reason defacto standard of WRc shall be adopted to formulate strategies and implementation plans as well as methods.

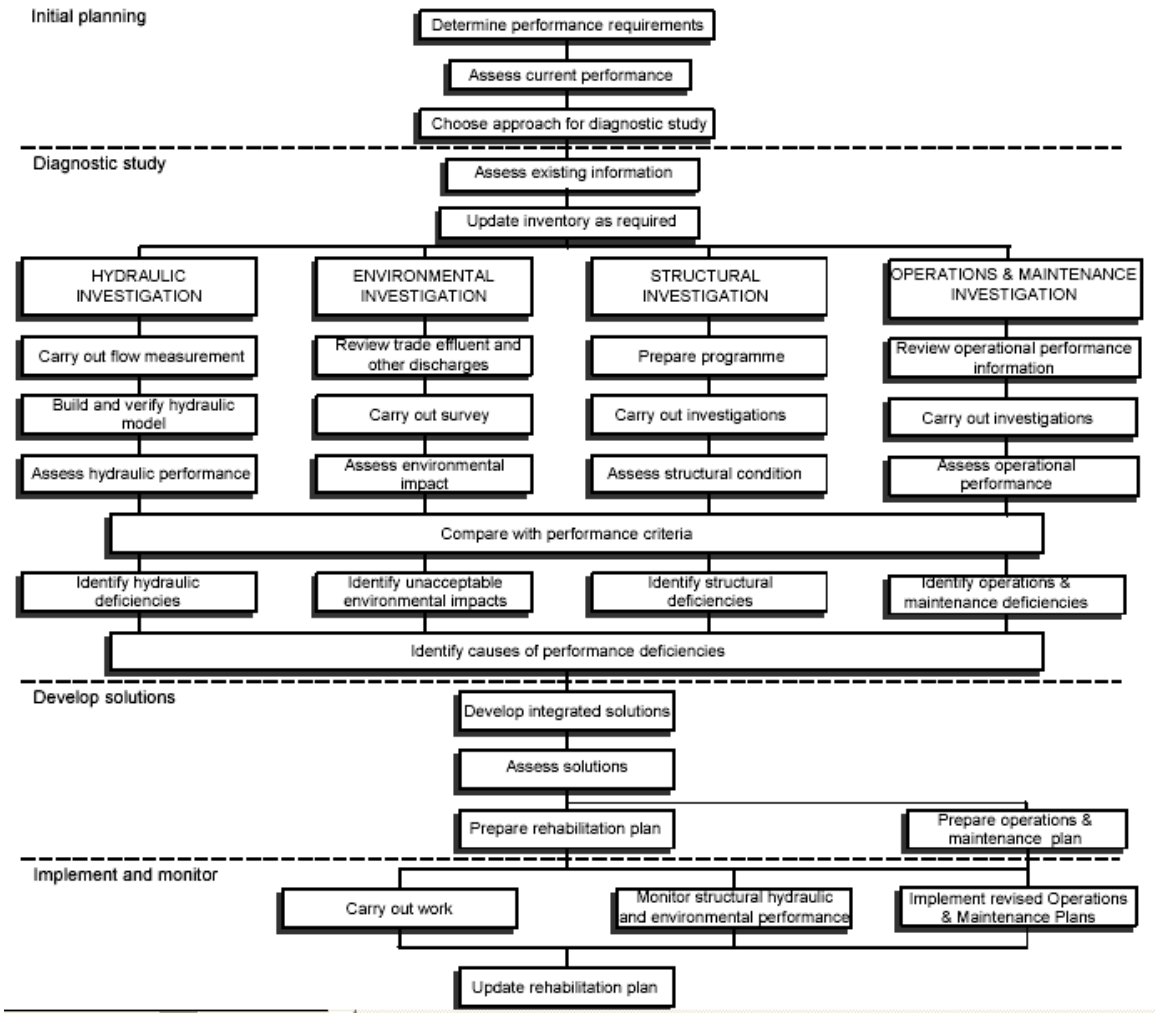
Advantages of WRc standards are-

1. Scientific approach to analysis of existing system
2. Use of proven techniques for condition assessment and system evaluation
3. Prioritising the implementation plan
4. Selection of appropriate method of trenchless technology.
5. Selection of a system to give durable end result having maximum lifecycle span.
6. Cost effectiveness
7. Effective planning of available funds

7.2.1 General Methodology

The recommendations for trenchless rehabilitation shall closely follow the WRc recommendations. The steps involved can be enlisted as under-

a. Initial planning:
   This is an initial investigation to establish extent and types of problems in the sewerage system and to plan the approach for diagnostic study, which is the next step in the procedure.
b. The diagnostic study shall comprise of various phases like
   a. Phase I: Information
   b. Phase II: Investigations
      i. Hydraulic
      ii. Environmental
      iii. Structural
      iv. Operations and management
   c. Phase III: Develop solutions
c. Implementation:
   This is the final stage which involves actual implementation with appropriate methods identified consistent with a well defined O & M plan/ strategy.



Implementation of each phase as given in WRc is reproduced in Figure 7.1

Figure 7.1 Stages in Sewer Rehabilitation

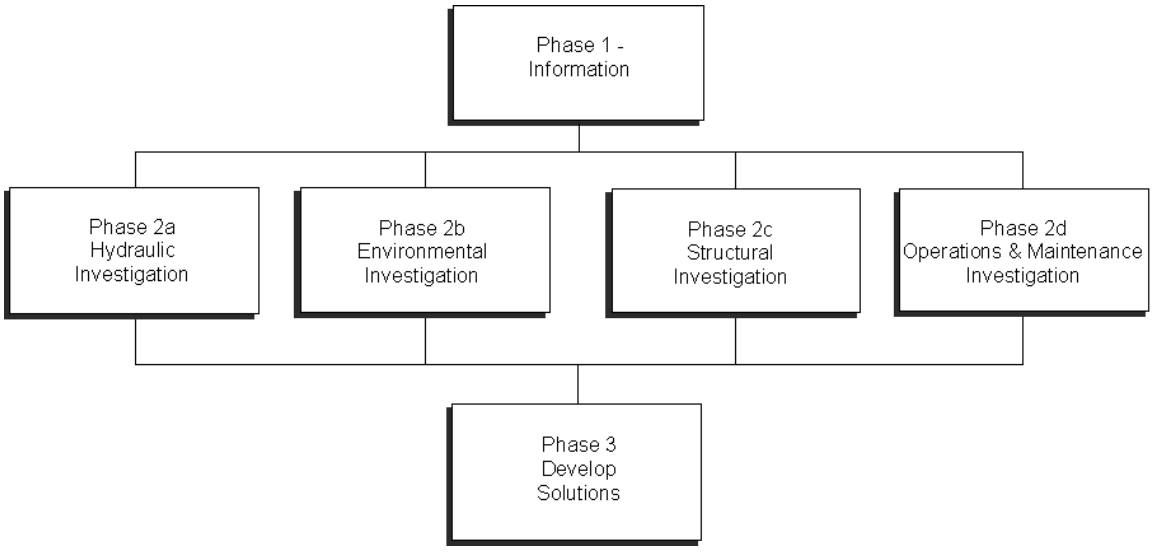
General reconnaissance of the system shows general observations as enlisted below-

1. No information is available in degree of silting in the sewers in a properly quantified manner
   It is learnt from enquiries that for initial 400m approx. the CGTS is fully silted while the degree of silting in downstream reaches it varies from three fourths to half.
2. No information is available about usual diurnal flow variations
3. No information is available about ground water fluctuations
4. Siltation with crown failures are commonly seen as major defects
   a. Some incidents of crown collapse are experienced during last two- three years.
5. No data on possible alignment shift between individual joints is available with the client
6. No data is available on settlement of individual pipes
7. Information on solidified deposits or root intrusions is not available
8. Systematic cleaning of the system in a planned manner is not carried out.
9. The slopes of the pipelines are reported to be in general satisfactory by the client. However since this affects the hydraulics of the system, it has to be re-ascertained for sample reaches in a scientific manner.
10. It is understood that a CCTV inspection has been carried out which is available on VHS tapes. However, these details could not be referred to due to the poor state of these tapes.
11. During inspection and rehabilitation work, the flows will have to be diverted through open drains, which lead to Gomti River. Though this is not advisable, possible means to overcome the issue of flow diversions shall have to be explored.
12. Augmentation of carrying capacity of existing sewers including CGTS is not required. However, as per initial estimates, the system has a capacity of 900 lps but flows of the order of 1042 lps are likely to occur during peak hours thereby overloading the system for some time during augmentation.

These basic observations on the system form the basis for formulation of rehabilitation strategy for the existing CGTS.

7.2.2 Recommended approach

Systematic approach as enlisted earlier shall have to be adopted.



(1) Stage 1: Initial planning

As complete survey of sewerage system will be an herculean task and may not be feasible considering the site conditions, available time, resources etc. Hence a scientifically selected sample must be selected for detailed conditions assessment for initial planning which shall help the client in formulating further strategy.

Based on the trunk sewer investigation conducted during F/S, it is recommended to carry out desilting followed by CCTV survey and other investigations throughout the stretch of CGTS.

(2) Stage 2: Diagnostic study

This stage is spread over sub tasks as mentioned and these need expert attention at every level for enabling proper strategy formulation.

Information : This component is dedicated to collection of information from all possible sources. Information is key to successful planning and implementation in trenchless technology. Though preliminary information collection has been completed, it will be essential to collect further information through various investigation components as contemplated in second sub task.

i) Hydraulic Investigation: This will be used to gauge the hydraulic performance of the existing system to form the basis for diagnostic purpose. The study could involve use of flow meters at strategic positions and then monitoring them over a period to cover a fair range of fluctuations in diurnal and seasonal variations. However, due to limitations on time (as may be stipulated by the client) full seasonal variation may not be possible to be recorded. The actual readings must be correlated with the design values from the available drawings and other records about the system. This stage is essentially meant to give in depth idea about
    1. Adequacy of existing system with respect to the original designs and projected flows over design period
    2. Need for augmentation of the capacity keeping in tune with the future requirements
    3. Likely impact on overall system due to additional components getting appended to existing system
    4. Likely impact of various systems of rehabilitation which may affect the hydraulic parameters like cross section area, roughness coefficients, and to some extent modifications in gradients of the system
ii) Environmental Investigation: This shall take care of various factors affecting the environment as a consequence of the rehabilitation plans. Complete system study with due regards to environment protection act and rules framed thereunder shall have to be taken up so as to ensure consistency with legislative requirements.
iii) Structural Investigation: These key components can be termed as the single most significant step in the entire systematic approach to trenchless rehabilitation. Some important steps involved are:

a. Condition Assessment using

CCTV inspection

In CCTV survey, a waterproof camera having capability to zoom, pan and tilt is introduced in the sewer. The camera features powerful xenon bulb, which provides illumination of the sewer in front of the camera. The camera

has ultra wide angle lens which gives 360 degree fisheye view of the sewer. The cameras differ in capabilities and features but the features mentioned here are bare minimum to give in depth idea of the condition of the sewer. The camera is connected to a LCV mounted monitor from where the operator can monitor its movements and guide the camera. Camera traverse is tracked in terms of chainage so that the defects detected can be recorded and logged properly. Zoom feature allows inspection of cracks or other defects closely. Cameras which can be inserted in pipelines as small as 100mm diameter up to 3000mm are available. However, it is specifically useful for non-man entry sewers where physical photography or videography is not possible.

One essential requisite for CCTV inspection is desilting of the barrel of sewer that the camera can move inside it.

In case of Lucknow, we recommend thorough desilting using combined suction and jetting equipment so that the camera can be introduced inside and the video recorded properly. The output per day can very but on an average it can be taken as at least 300m per day of operations.

The upstream stretches of CGTS must use CCTV inspection due to the size (750mm), which is a non man entry size.

Manual inspection of the system

Large diameter sewers can be inspected by sending trained personnel inside the sewer after thorough desilting and following all safety precaution for working inside sewers. In case of man entry inspections safety measures are the essential part and should not be compromised even to a minor degree. The person can video-graph the stretch traversed and while recording the video he can have voice narrations describing the conditions inside the sewer. At the same time, he can record still images of various conditions observed inside the sewer. One advantage of this type of direct inspection is ability to physically see the defects and take measurements of cracks, missing bricks or any other features. However, with improvements in electronic technologies, CCTV cameras are improving which has led to further developments like Sewer Evaluation Techniques (SET) with fuzzy logic and digital camera imaging. This provides ability to grade the sewers more rationally and at a faster speed.

b. Classification of defects and grading.

Based on the data collected from the condition assessment surveys using CCTV inspection as well as manual video graphs and photographs, the sewers can be classified into various grades representing their present structural stage. As per WRc manual the sewers are graded into five grades in which grade-I represents satisfactory condition while grade V-means already collapsed or collapsed imminent at any time. This scientific grading allows the planner to priorities sewer rehabilitation programme thereby allowing optimum use of the finances.

It is observed that the CGTS indicates varying degree of structural conditions from the primary assessment and the grades are most likely to be between grade III and V, which means they need immediate attention for rehabilitation.

A preliminary assessment for the CGTS is shown in Table 7.1.

Table 7.1 Preliminary Assessment of CGTS

From Downstream Manhole	To Upstream Manhole	Diameter (mm)	Length (m)	Preliminary remarks on condition/ accessibility	Recommendation
1	10	750	523	Non man entry size, silting level very high at upstream ends	Desilting shall be done to provide access for the camera to carry out CCTV survey
10	14	1050	346.5	Man entry size, silting level very high at upstream ends	Physical inspection by man entry and logging of defects. Complete desilting needed. More access points and ventilation facilities required
14	17	1400	378		
17	22	1500	769.5		
22	26	1650	922.5		
26	30	1800	1,158.5		
30	32	1950	266.5		
32	41	2100	2,540.5		
		Total	6,905		

It must be remembered that this grading is completely preliminary in nature as CCTV or manual inspection are yet to be carried out. The information provided in the table above is obtained from preliminary inspection. Detailed survey and study is required for more conclusive results.

The defect identified from condition assessment survey shall be plotted against the L- section giving a visual perspective about the present status to the planner.

iv) Develop solutions:

The steps involved formulating various options for rehabilitation replacement or repairs depending upon the conditions as evaluated under stage-II above. The points to be considered while developing the solutions are

i. Hydraulic factors:

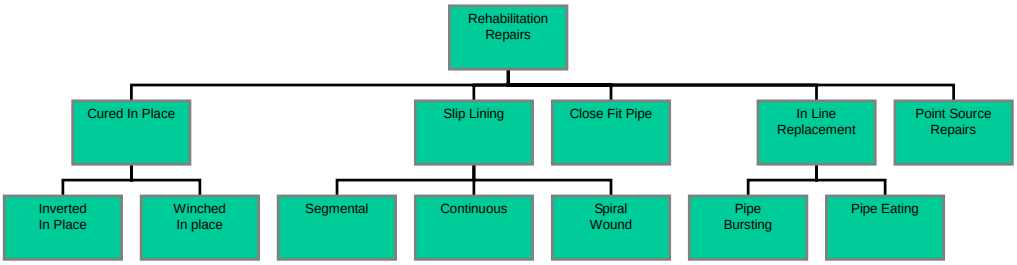
This shall indicate if the existing sewer has adequate hydraulic capacity to meet the future requirement at the end of the structural life of the rehabilitated system. If the sewer is found to be inadequate attempts to augment the capacity must be searched. The hydraulic factors would also include physical aspects such as slope, diameter, roughness, conditions of joints, etc. All these factors collectively affect the hydraulic performance and must be taken into account while developing the solutions.

If only hydraulic performance improvement is required then Type III lining would suffice. However, it will also be governed by other features like physical condition of joints. If major replacement is observed mere Type III lining would not be appropriate as it would require proper realigning and improvement of grade and alignment.

Attention must be paid towards the requirement of cross section. In general, lining reduces the cross section area, which influences the flow capacity of the system. It is common for the clients to cap the reduction in cross section area to about 10% of existing one. Though in some cases the reduction in cross section area allow may be as low as 4 to 5%. However, to achieve this, the liner system gets adversely influence. For example, if stand

alone system is required, it may not be possible to achieve the limit for the reduction in cross section area unless the existing pipe reamed to certain depth using appropriate technology. But this adds to the over all cost of the trenchless rehabilitation technology. The client must pay the proper attention to the reduction in cross section area and capacity requirement and structural requirement.

7.2.3 Options for Rehabilitation Technology:



The options for rehabilitation can be classified in to following categories

a. Rehabilitation: Involves structural and hydraulic improvement, existing section retained
b. Replacement: Total replacement of existing pipeline
c. Repairs: Mainly localized in nature and minor in nature, does not necessarily involve structural requirements.

Various methods in above categories are described below

a. Rehabilitation: It mainly comprises of providing structural lining inside the existing pipeline as per design requirements. The liners may be stand alone (Type 2) or composite i.e. Type 1 or Type 3, which is a non structural liner.

    a. Type 1 design philosophy: It relies on a strong and perfect bond between the parent pipe wall, liner and the grout injected between annular space between liner and the pipe wall. This requires that the existing pipe is in a position to withstand certain structural load. Normally it is suitable for condition grades up to 3. However with some precautions it can be used for grade 4 as well. It is completely unsuitable for grade 5 sewers.
    b. Type II design philosophy: The philosophy of this type is to install a liner that utilises the existing sewer & ground support where possible to produce a cost effective renovation. No bond is required between lining and the grout or existing sewer.
    Where the condition of existing sewer is intact (Gr.3 or 2) the lining is to be designed to resist ground water pressure only as the existing sewer will continue to support ground and traffic loads.
    Where the condition of existing sewer is deteriorated fully or partially (Gr.5 or 4) the lining will have to be designed to take ground and traffic loads in addition to ground water pressure also. Such liner is generally called ‘stand alone liners’.

(1) Methods of Rehabilitation

The various methods of rehabilitation are:

- Slip lining with continuous or discrete pipe lengths
- Lining with cured in place pipes (CIPP)

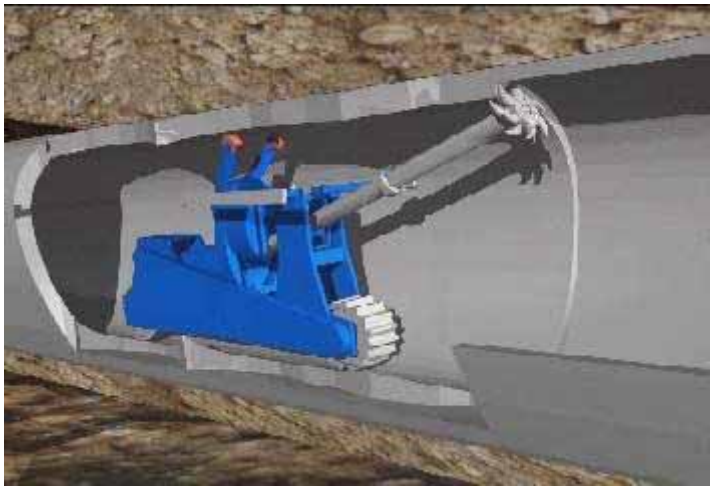
- Lining with closed-fit pipes
- Lining with spirally wound pipes
- Man entry lining with pipe segments
- Man entry in situ coating
- Non man entry in-situ coating

Many of these techniques have been used in India and have been successful. It is therefore recommended that the methods are selected using their soundness in filed, ease of adaptation in India, possibility of maximizing local resources/ inputs and cost effectiveness.

In this context, the methods worth considering for Lucknow are described below-

Slip lining with continuous or discrete pipe length

This method has been successfully used in Mumbai for rehabilitation of approximately 8 kms of sewers.



This involves enlarging the existing cross section by reaming scientifically evaluated thickness of existing shell of the pipe up to a certain depth and then putting GRP liners and then grouting the annular space so as to provide a composite section. The reaming is a specialized technique, which has been developed as proprietary method by various specialists.

With this method circular as well as oval shaped sewers can be rehabilitated. This is a man entry method suitable for large size sewers.

In addition to this GRP liners can be provided inside existing sewers without reaming, if the criterion for reduction in CSA allows for it.

Lining with Cured In Place lining (CIPP)

In this method a resin impregnated felt tube is inserted in to existing sewer by means of hydrostatic pressure through inversion or winched in place method. The water is heated after the tube is in place and the heat cures the resin forming a tube inside the existing pipe.

The method can take care of slight misalignments in the joints and can be done even if there is some water in the pipeline.

However, since the process depends on chemical properties of the resin and its pot life or shelf life which is affected by the hot and humid climate of India. The mixing and impregnation of resin is done in a specially set up unit for this purpose and resin impregnated tubes need to be kept in temperature controlled or refrigerated conditions. Further this method shall require huge quantities of water especially for large sewers and energy to heat cure the resin properly.

Lining with spiral wound lining

In this method a strip having structural profile generally of PVC is wound inside the existing pipeline to form a tube of spirals. If standalone section is desired, steel stiffeners may also be provided in the

strip.

These are most significant methods in Indian context, but some more variants may also be existing.

Selection of system of rehabilitation:

It is influenced by following factors:

i. Analysis of cause of defects
ii. Structural requirements
iii. Hydraulic considerations
Flow capacity
Flow velocity
iv. Foundation condition
v. Ground water table
vi Accessibility of the site
vii Traffic aspects along the road
viii. Availability of technical know-how
ix. Cost aspects

Liners can be of cementatious nature or polymeric in nature with polymeric liners being preferred due to their inherent capability to resist corrosive action.

In case of Lucknow city, based on preliminary investigations, it appears that slip lining with GRP stand alone sections would be the most appropriate techniques for majority of the sewer network. For CGTS, GRP stand alone liners or CIPP seems appropriate. However, final recommendation shall be governed by thorough condition assessment survey.

7.3 MANHOLE REHABILITATION

Manholes are rehabilitated to correct structural deficiencies, to address maintenance concerns, and to eliminate extraneous flows. Manhole rehabilitation may also minimize or prevent corrosion of the internal surface caused by sulphuric acid formed when hydrogen sulphide gas is released from the sewerage into the sewer environment.

Many methods to rehabilitate manhole are currently available. New products and application technologies are continually being developed. The evaluation of each method should consider:

a) Type of problem
b) Physical characteristics of the structure such as the construction material
c) Physical condition and age
d) Location of the manhole with respect to traffic and accessibility
e) Risk of damage or injury associated with the current condition of the structure
f) Cost/value in terms of rehabilitation performance

The rehabilitation of manholes can be divided into the following methods.

a. Chemical grouting
b. Coating systems
c. Structural linings
d. Corrosion protection
e. Manhole components

Table 7.2 Sewer Manhole Rehabilitation Options

Sr.	Rehabilitation Options	Principal Advantages	Principal Disadvantages
1	Rehabilitation of manhole structure by plugging, patching, and coating and sealant (Both non-cementitious & cementitious, with or without plastic lining)	Improve structural condition, eliminate leakage and provide corrosion protection. Little disruption	Will not rehabilitate badly deteriorated or structurally unsound manholes
2	Repair or rebuilding of manhole chimney and cone section when excavation is required	Rehabilitate badly deteriorated or structurally unsound chimney and cone section	Excavation required
3	Step removal and / or replacement	Improve access and safety and eliminate leakage	Installation difficulty
4	Replacement of manhole frame and cover	Improve service life and alignment, adjust grade, and eliminate leakage	Excavation required
5	Structural relining	Renew structural integrity	Reduction of dimension, cost
6	Seal or replace cover, or install insert	Eliminates inflow and stop rattle	Raises cover slightly
7	Chemical grouting of manhole structure	Eliminates infiltration and fills voids in surrounding soil	Does not improve or rehabilitate interior or manhole
8	Total replacement	New manhole	Cost

7.4 FLOW DIVERSION

It is necessary to bypass flow around the sewer that is to be taken up for rehabilitation work. Trunk relief sewer presently under execution will play an important part in the rehabilitation of old trunk sewer by diverting majority flow. Further segmental flow diversion can be achieved by providing portable pumps and temporary on ground rising main from upstream manhole of the sewer section under rehabilitation to the downstream manhole. Another important aspect of rehabilitation programme is traffic diversion planning during rehabilitation.

It must be borne in mind that flow diversion is the crucial process and may decide factor about success of a particular method of rehabilitation rather than the method itself.

7.5 COST ESTIMATES

Budgetary cost estimation of sewer inspection, cleaning and rehabilitation plan for CGTS is been calculated based on certain assumptions and feedback from ongoing/ completed similar type of projects under Delhi Jal Board and Municipal Corporation of Greater Mumbai. The same is presented in Table 7.3

Table 7.3 Technology wise Cost Estimate for Rehabilitation of CGTS

From Downstream (Manhole Number)	To Upstream (Manhole Number)	Diameter (mm)	Length (m)	Percentage of length considered for rehabilitation	Recommended method for rehabilitation
1	10	750	523.0	100	CIPP
10	14	1050	346.5	100	GRP liners with or without reaming
14	17	1400	378.0	30	
17	22	1500	769.5	30	
22	26	1650	922.5	30	
26	30	1800	1,158.5	30	
30	32	1950	266.5	30	
32	41	2100	2,540.5	70	
		Total	6,905		

Rate for Desilting (Rs./m)	Amount for Desilting (Rs.)	Rate for Condition Assessment (Rs./m)	Amount for Condition Assessment (Rs.)	Actual length for Rehabilitation	Rate for Rehabilitation (Rs./meter)	Amount for Rehabilitation (Rs.)
3,000	1,569,000	413	216,000	523.0	52,000	27,196,000
6,000	2,079,000	413	143,000	346.5	57,500	19,924,000
8,200	3,100,000	413	156,000	113.4	72,000	8,165,000
8,500	6,541,000	413	318,000	230.9	75,000	17,318,000
9,400	8,672,000	413	381,000	276.8	81,700	22,615,000
10,750	12,454,000	413	478,000	347.6	96,550	33,561,000
12,000	3,198,000	413	110,000	80.0	104,000	8,320,000
13,500	34,297,000	413	1,049,000	1,778.4	118,000	209,851,000
Total	71,910,000		2,851,000	3,696.6		346,950,000

Table 7.4 Total cost Estimate for Rehabilitation of CGTS

Sr.	Component	Amount (Rs.)
1	Amount for desilting	71,910,000
2	Amount for condition assessment	2,851,000
3	Amount for rehabilitation	346,950,000
	Grand total cost	421,711,000

CHAPTER 8

PRELIMINARY DESIGN
OF
AUGMENTATION / REHABILITATION
OF
OLD SEWAGE PUMPING STATIONS

CHAPTER 8 PRELIMINARY DESIGN OF AUGMENTATION / REHABILITATION OF OLD SEWAGE PUMPING STATIONS

8.1 CIS GOMTI PUMPING STATION (CGPS)

Master Plan, prepared by JICA Study Team, proposes to utilize the existing sewerage facilities e.g. existing sewers and pumping stations. These existing facilities are more than 30 years old and, therefore, require rehabilitation / upgradation. Existing CGPS, which was provided to receive sewage from Cis-Gomti area, requires major rehabilitation.

The existing pumping station was designed to cater to the sewage generated in District IV in Cis-Gomti area and it was commissioned in the year 1970.

8.1.1 Results of Inspection, Equipment (Inventory) Survey

Presently, it receives discharge from Cis-Gomti trunk sewer and Wazirhasan road sewer (through auxiliary PS). The sewage is conveyed to Gomti River through a 1200 mm dia CI rising main. The installed pumping capacity was 3000 lps, which has reduced substantially due to excessive wear and tear over a period of 30 years.

The impellers of these pumps are badly damaged requiring maintenance on regular basis. UPJN had got the discharge of one the pumps measured by Forbes Marshall in Year 2003. The actual discharge reported was 150 lps at 12.0 m head as against 600 lps at 19.81 m head. Following observations were made during the visit to the pumping station.

- The mechanical screen is out of order and only a manual screen was working
- Gates installed at the inlet sump are worn out
- There is no arrangement for removal of screened material from screen chamber area resulting in huge accumulation of material around this area
- HT panel has been damaged due to leakage of rainwater through the cracked roof of pumping house and therefore its working has become erratic
- The capacitor panel to improve the power factor of pumping station does not work and needs complete replacement
- Earthing system is inadequate and requires improvements
- Alternative power supply (DG generator) is not available
- Cable and its supports need to be improved
- There is no spare feeder in LT panel
- Indication lamps on panels are either missing or not working
- There is not a single instrument to measure level, flow, pressure, temperature, etc. for proper operation
- No telecommunication facility is available
- Wide cracks are developed in the civil structure, which divides the structure in three different parts
- Also, civil structure of transformer room, HT panel room and store room has several cracks and requires urgent attention
- Boundary wall towards the main road is non-existent resulting in encroachment along the road

8.1.2 Survey Works Executed

A reconnaissance survey was conducted by MWH team with the JICA Study Team and UPJN officials to assess the existing facilities, which were later followed by on site discussions with E&M experts from UPJN and MWH. A detailed site survey was conducted to obtain the required levels and site

layout.

(1) Topographical Survey

Topographical survey was conducted at the pumping station site, along with the contour survey. Spot levels have been taken by a grid of 15 m x 15 m to plot a contour of 1 m interval. All the existing facilities have been marked on the contour plan.

A layout plan of the existing pumping station and site plan are presented in drawing LKO-PS-TG-2.

8.1.3 Need to Replace Existing Equipment

As discussed earlier, all the existing mechanical and electrical equipment were installed in 1970 and have worn out.

It is felt that there is an immediate need to rehabilitate this pumping station to achieve the overall objective of reducing the pollution level in Gomti River.

8.1.4 Need for Additional Capacity: Pump and Sump

Under GoAP - phase II, CGPS is sanctioned for an ultimate average discharge of 172 mld. However, the CGTS does not have sufficient hydraulic capacity and a new relief sewer is proposed in District IV to reduce the inflow to CGTS and hence, the required capacity at CGPS will be less than the sanctioned capacity.

In addition to the poor present capacity of the system a considerable quantity of sewage overflows directly through three barrels of river before being intercepted by CGPS.

8.1.5 Proposed Rehabilitation Programme

Considering the requirement of reduced capacity and poor state of existing facility, it is proposed to dismantle the dry well and wet well completely and replace the same with new structures. However, the other existing allied buildings can be used in the future.

All the existing pumps shall be replaced with new pumps of required capacity. Also, all the existing electrical facilities require replacement. In addition, provision is made for instrumentation devices for optimum utilisation of pumping station.

In phase I, CGPS will convey its flow to the STP at Kakraha, which is already sanctioned under GoAP (Phase II), via a 900 mm dia rising main. However, in phase II, the entire discharge from CGPS will be diverted through the proposed Cis-Gomti relief sewer to the proposed STP at Mastemau.

8.1.6 Design Engineering Works

Pumping station is designed for the following capacity:

a) Civil structure shall be designed for year 2030
b) Rising main shall be designed for year 2015 based on most economical option
c) All mechanical and electrical equipment shall be designed for year 2015
d) Provision of extra space for pumps after year 2015 shall be made in the civil structure

Detailed designs of pumping stations were carried out to calculate the most techno- economical diameter in combination to various options of pumping. Based on the discussions in Chapter 3, horizontal type centrifugal pumps are provided in this pumping station as the required capacity of

individual pumps works out to more than 150 HP.

Various components of pumping station include:

a) Screen channel
b) Wet well and dry well
c) A rising main
d) Extension of Wazirhasan road sewer to proposed the inlet chamber

(1) Design Flow

The projected sewage flow, as discussed in Chapter 4, is presented in the following table.

Table 8.1 Design Flow of Sewage Pumping Station

Sr.	Pumping Station	Sewage Flow, mld	
		2015	2030
1	Cis-Gomti pumping station	50	55

8.1.7 Unit Sizes for CGPS

Submersible type centrifugal pumps are provided at this pumping station. Accordingly, a sump and a valve chamber are provided.

(1) Pumping Station

Table 8.2 Provision at CGPS

Sr.	Item	Provision
1	Pumps for year 2015	9 nos. – 18.75 mld capacity at 24.0 m head (120 HP each) where 6 nos. are working and 3 nos. are stand by pumps at peak load
	Pumps for year 2030	Replace all above pumps with, 9 nos. – 20.625 mld capacity at 24.0 m head (120 HP each) where 6 nos. are working and 3 nos. are stand by pump at peak load
2	Rising main	One 900 m long and 1000 mm dia rising main in pre-stressed concrete
3	Coarse screen channel – 40 mm clear spacing	1 no. – 4.15 m x 1.75 m
4	Medium screen channel – 20 mm clear spacing	2 nos. – 8.47 m x 1.75 m
5	Wet well	1 no. – 27.0 m x 6.0 m providing a detention time of 3.75 mins
6	Valve chamber	1 no. – 27.0 m x 5.0 m

A layout drawing is presented in LKO-PS-CG-1. General arrangement of the pumping station is presented in drawing LKO- PS- CG-2.

(2) Allied Buildings

In addition to the above, following buildings are provided for provision of electrical panels and generating sets. Also, an open yard is provided for transformer. The sizes are presented in the following table.

Table 8.3 Allied Buildings at CGPS

Sr.	Item	Size
1	MEP building	10 m x 8 m
2	DG room & control room	12 m x 10.0 m
3	Transformer yard	10 m x 8 m

8.1.8 Capital Cost of CGPS

(1) Civil Cost

Table 8.4 Civil Cost for CGPS

Sr.	Item	Cost (Rs.)
1	Extension of Wazirhasan road sewer	755,000
2	Intel, screen channels, dry well and wet well	8,454,000
3	MEP building	480,000
4	DG room / control room	720,000
5	Transformer yard	80,000
6	Staff quarter	1,231,000
7	Boundary wall	786,000
	Total	12,506,000000

(2) Mechanical Cost

Table 8.5 Mechanical Cost for CGPS

Sr.	Item	Cost (Rs.)
1	Coarse screen	200,000
2	Screen channel gates	260,000
3	Mechanical screens	850,000
4	Manual screens	60,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps	23,109,000
8	Piping and valves	2,500,000
9	Conveyor belt	450,000
	Total	27,879,000

(3) Electrical and Instrumentation cost

Table 8.6 Electrical & Instrumentation Cost for CGPS

Sr.	Item	Cost (Rs.)
1	Power line strengthening charges	5,370,000
2	Power supply equipment (including DG sets)	15,778,000
3	Cables	2,165,000
4	Earthing and safety equipment	292,000
5	Lighting	118,000
6	Instrumentation	971,000
7	Miscellaneous	132,000
	Total	24,826,000

(4) Rising Main

Table 8.7 Cost of Rising Main for CGPS

Sr.	Item	Cost (Rs.)
1	PSC pipe	4,182,000
2	Appurtenances	300,000
3	Excavation	270,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	4,852,000

8.1.9 Abstract of Costs for CGPS

Table 8.8 Abstract of Cost for CGPS

Sr.	Item	Cost (Rs.)
1	Civil cost	12,506,000
2	Mechanical cost	27,879,000
3	Electrical & instrumentation cost	24,826,000
4	Rising main cost	4,852,000
5	Dismantling existing facilities	1,600,000
	Total capital cost	71,663,00033,000

8.1.10 Operation & Maintenance Cost of CGPS

Table 8.9 O&M Cost for CGPS

Sr.	Item	Cost (Rs.)
1	Manpower cost	515,000
2	Power cost (20 hrs @ Rs. 3.25/kWh)	5,881,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	3,703,000
4	Maintenance of civil works @ 1.5 %	176,000
5	Maintenance of M&E works @ 3 %	1,581,000
6	Maintenance of rising main @ 0.25 %	12,000
	Total annual O & M cost	11,868,000

Power cost depends on peak flow

8.2 TRANS GOMTI PUMPING STATION (TGPS)

Master Plan prepared by JICA Study Team, proposes to utilize the existing sewerage facilities e.g. existing sewers and pumping stations. These existing facilities are more than 30 years old and, therefore, require rehabilitation / upgradation. Existing TGPS, which was provided to receive sewage from Trans-Gomti area, is taken up for rehabilitation.

As per the Master Plan, TGPS will receive sewage from the TGTS, Daliganj PS No.1 and Mohan Meakin PS.

8.2.1 Results of Inspection, Equipment (Inventory) Survey

The existing pumping station was commissioned in the year 1970. It was designed to cater to the sewage generated in District III in Trans-Gomti area.

Following observation were made during the survey of TGPS

- The appearance of the civil structure is poor
- There is no mechanized screen
- Pumps are not in operation due to excessive wear and tear
- There is no spare feeder in LT Panel
- There is no capacitor panel provided at the pumping station
- Earthing system is improper and requires urgent attention and improvements
- Alternate power supply (DG Generator) is not available
- There is no provision of instruments to measure level, flow, pressure, temperature, etc. for proper operation
- Indication lamps on panels are either missing or not working
- Skilled operation and maintenance staff is unavailable
- There is no telecommunication facility provided

8.2.2 Existing Capacity and Condition

The installed pumping capacity was 360 lps. This pumping station was out of order for more than four years and, presently, the entire flow received at the wet well is diverted to Gomti River.

The existing civil structure is in a dilapidated state with various cracks all over the structure. The gates

installed at the inlet sump have worn out due to non-operation. All the pumps have operated way beyond their life of fifteen years. Also, all the electrical installations have worn out as these were installed at the same time as the existing pumps.

There is a 900 mm dia CI rising main, which was used for conveyance of sewage to Gomti River.

8.2.3 Survey Works Executed

A reconnaissance survey was conducted by MWH team with the UPJN officials to assess the existing facilities, which later followed by a detailed site survey.

(1) Topographical Survey

Topographical survey was conducted at the pumping station site, along with the contour survey. Spot levels have been taken by a grid of 15 m x 15 m to plot a contour of 1 m interval. All the existing facilities have been marked on the contour plan.

A layout plan of the existing pumping station and site plan are presented in drawing LKO-PS-TG-2.

8.2.4 Need to Replace Existing Equipment

As discussed earlier, all the existing mechanical and electrical equipment were installed in 1970 and have worn out. Only one pump is in operation, which runs substantially below its rated capacity resulting in diversion of all the sewage to Gomti River and thus polluting it.

It is felt that there is an immediate need for complete renovation of this pumping station to achieve the over all objective of reducing the pollution level in Gomti River.

8.2.5 Need for Additional Capacity: Pump and Sump

TGPS is to receive sewage from the Trans-Gomti trunk sewer (new), which includes the flow from Daliganj PS No. 2. Also, UPJN has a proposal of connecting additional nalas viz. Kedarnath nala, Nishatganj nala and TGPS nala to the existing pumping station.

However, the hydraulic gradient of new nala sewer does not permit it to be connected to the existing sump at TGPS as the invert level of these nalas is below the invert level of the existing sump. Also, additional capacity is required at the sump to accommodate the additional flow from the above said nalas.

8.2.6 Proposed Rehabilitation Programme

Considering the requirement of additional capacity and poor state of existing facility, it is proposed to dismantle the entire structure and construct a completely new pumping station at the same location. Due to restriction of space, the present sump will also need to be dismantled and a new sump of larger capacity and required depth is proposed.

All the existing pumps shall be replaced with new pumps of required capacity. Also, all the existing electrical facilities require replacement. In addition, provision is made for instrumentation devices for optimum utilisation of pumping station.

From TGPS, sewage is conveyed to the sanctioned Kukrail pumping station via a rising main of 900 mm dia. This rising main was sanctioned by NRCD under GoAP, phase-II.

8.2.7 Design Engineering Works

Pumping station is designed for the following capacity:

a) Civil structure shall be designed for year 2030
b) All mechanical and electrical equipment shall be designed for year 2015
c) Provision of extra space for pumps after year 2015 shall be made in the civil structure

Detailed designs of pumping stations were carried out to calculate the most techno- economical diameter in combination to various options of pumping. Based on the discussions in Chapter 3, submersible type centrifugal pumps have been provided in this pumping station as the required capacity of individual pumps works out to more than 150 HP.

Various components of pumping station include:

a) Screen channel
b) Wet well and dry well
c) MEP and DG room
d) Transformer yard and
e) A Rising main

(1) Design Flow

The projected sewage flow, as discussed in Chapter 4, is presented in the following table.

Table 8.10 Design Flow of Sewage Pumping Station

Sr.	Pumping Station	Sewage Flow, mld	
		2015	2030
1	Trans-Gomti Pumping Station	60	80

8.2.8 Unit Sizes for TGPS

Submersible type centrifugal pumps are provided at this pumping station. Accordingly, a sump and a valve chamber are provided.

(1) Pumping Station

Table 8.11 Provision at TGPS

Sr.	Item	Provision
1	Pumps for year 2015	6 nos. – 33.75 mld capacity at 18.0 m head (150 HP each) where 4 nos. are working and 2 nos. are stand by pumps at peak flow
	Pumps for year 2030	Replace all above pumps with, 6 nos. – 45 mld capacity at 16.7 m head (170 HP each) where 4 nos. are working and 2 nos. are stand by pumps at peak flow
2	Rising main	A 900 mm dia PSC rising main is already sanctioned under GoAP (Phase II), in addition another rising main of 900 mm dia is provided to handle flow for the year 2015. Both these rising mains will be replaced by a 2000 mm dia rising main to cater to the flow for year 2030.
3	Coarse screen channel – 40 mm clear spacing	1 no. – 4.15 m x 2.5 m
4	Medium screen channel – 20 mm clear spacing	2 nos. – 8.47 m x 2.5 m
5	Wet well	1 no. – 18.0.0 m x 13.0 m providing a detention time of 3.75 mins
6	Valve chamber	1 no. – 18.0 m x 7.0 m

A layout drawing is presented in LKO-PS-TG-1. General arrangement of the pumping station is presented in drawing LKO-PS-TG-2.

(2) Allied Buildings

In addition to the above, following buildings are provided for provision of electrical panels and generating sets. Also, an open yard is provided for transformer. The sizes are presented in the following table.

Table 8.12 Allied Buildings at TGPS

Sr.	Item	Size
1	MEP building	10 m x 8 m
2	DG room & control room	12 m x 10 m
3	Transformer yard	10 m x 8 m

8.2.9 Capital Cost of TGPS

(1) Civil Cost

Table 8.13 Civil Cost for TGPS

Sr.	Item	Cost (Rs.)
1	Intel, screen channels, dry well and wet well	14,072,000
2	MEP building	480,000
3	DG room / control room	720,000
4	Transformer yard	80,000
5	Staff quarter	1,231,000
	Total	16,583,000

(2) Mechanical Cost

Table 8.14 Mechanical Cost for TGPS

Sr.	Item	Cost (Rs.)
1	Coarse screen	200,000
2	Screen channel gates	600,000
3	Mechanical screens	1,200,000
4	Manual screens	60,000
5	EOT for pumps	250,000
6	EOT for screens	200,000
7	Pumps - 150 HP	14,645,000
8	Piping and valves	2,200,000
9	Conveyor belt	500,000
	Total	19,855,000000

(3) Electrical and Instrumentation Cost

Table 8.15 Electrical & Instrumentation Cost for TGPS

Sr.	Item	Cost (Rs.)
1	Power transmission line	7,590,000
2	Power supply equipment (including DG set)	11,758,000
3	Cables	2,672,000
4	Earthing and safety equipment	231,000
5	Lighting	166,000
6	Instrumentation	970,000
7	Miscellaneous	108,000
	Total	23,495,0005,000

(4) Rising Main

Table 8.16 Cost of Rising Main for TGPS

Sr.	Item	Cost (Rs.)
1	PSC pipe	8,358,000
2	Appurtenances	300,000
3	Excavation	784,000
4	Miscellaneous (crossing / encasement)	100,000
	Total	9,542,000

8.2.10 Abstract of Costs for TGPS

Table 8.17 Abstract of Costs for TGPS

Sr.	Item	Cost (Rs.)
1	Civil cost	16,584,000
2	Mechanical cost	19,855,000
3	Electrical & instrumentation cost	23,495,000
4	Rising main	9,542,000
5	Dismantling existing facilities	900,000
	Total capital cost	70,376,000000

8.2.11 Operation & Maintenance Cost of TGPS

Table 8.18 O&M Cost for TGPS

Sr.	Item	Cost (Rs.)
1	Manpower cost	515,000
2	Power cost (20 hrs @ Rs. 3.25/kWh)	4,901,000
3	Diesel cost (4 hrs @ Rs. 34/liter)	3,086,000
4	Maintenance of civil works @ 1.5 %	249,000
5	Maintenance of M&E works @ 3 %	1,301,000
6	Maintenance of rising main @ 0.25 %	24,000
	Total annual O & M cost	10,076,000000

Power cost depends on peak flow

8.3 ABSTRACT OF COSTS FOR REHABILITATION / RENOVATION OF OLD PUMPING STATIONS

Table 8.19 Abstract of Costs for Rehabilitation / Renovation of Old Pumping Stations

Sr.	Item	Cost (Rs.)
1	CGPS	71,633,000
2	TGPS	70,375,000
	Total capital cost	142,008,000000

CHAPTER 9

ENVIRONMENTAL IMPACT ASSESSMENT

CHAPTER 9 ENVIRONMENTAL IMPACT ASSESSMENT

9.1 INTRODUCTION

9.1.1 Justification of the Project

Lucknow city's population is projected to double from 2.5 million in 2003 to 5.4 million by 2030. At present the total domestic wastewater load is about 365 mld vs. an installed treatment capacity of 42 mld. The amount of wastewater collected and diverted to treatment represents just over 10% of the total amount generated. Remaining wastewater is discharged to Gomti river through open drains. The two largest drains are GH canal and Kukrail nala.

Water supply and sanitation services are inadequate for the present population of Lucknow city. The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads.

In the absence of sewerage master plan urban development continues without adequate infrastructure for public health and sanitation. New sources of pollution crop up as the population grows and new areas develop. To address the growing demands of sanitation and to prevent further pollution of the river, it is important to implement a sewerage Master Plan in the city.

9.1.2 Project Description

As an initial part of the project, JICA Study Team started their study in February 2003 to prepare a Master Plan for water quality management for Ganga river basin for a design target year of 2030. Based on the finding of initial study, Lucknow was identified as one of the target cities for which Sewerage Master Plan was prepared. Another important focus of the JICA Study Team was to identify priority projects to undertake the Feasibility Study. The methodology of the study has been to determine the least cost approach in meeting Lucknow city's sewerage and pollution control needs. This involves the consideration of existing infrastructure and proposals by UPJN for GoAP-II, alternative service coverage, alternative technologies, and alternative wastewater treatment and disposal methods.

With this concept JICA Study Team identified the priority projects that should be implemented as soon as possible to reduce the pollution in Gomti river and appointed MWH for carrying out the F/S of the same. The description of the various components of the F/S is given below.

Component	Description
Sewer (New)	Proposed rising main from Mohan Meakin PS to Mankameshwar temple road and a gravity sewer from Mankameshwar temple road to TGPS Proposed Cis-Gomti relief sewer from Medical university crossing to Martinpurwa PS Proposed rising main from Martinpurwa PS to Dilkusha crossing Proposed Sultanpur road sewer from Dilkusha crossing to Mastemau STP
Sewer (Old)	Replacement of Trans-Gomti trunk sewer Partial rehabilitation of Cis-Gomti trunk sewer
Pumping Station (New)	Proposed Martinpurwa PS
Pumping Station (Old)	Renovation of Trans-Gomti pumping station (TGPS) Rehabilitation of Cis-Gomti pumping station (CGPS)
STP (New)	Proposed Mastemau STP

9.1.3 Objective and Need for the Environmental Impact Assessment (EIA) Study

The purpose of the EIA study is to ensure that development options under consideration are environmentally sound and sustainable and that the environmental consequences of the project are recognized early and taken into account in the project design.

The Ministry of Environment and Forests does not make it mandatory to prepare an EIA for sewerage projects. The sewerage projects are not listed in Schedule I projects under the EIA Notification that makes it mandatory for them to get an environmental clearance. As such, these projects do not require an environmental clearance from the Ministry. The report however follows the guidelines laid out by the Ministry for industrial projects. It also takes into account the JBIC guidelines for preparation of an EIA.

The major objective of this study was to establish present environmental conditions along the project corridor through available data/information supported by field studies, wherever necessary, to predict the impacts on relevant environmental attributes due to the construction and operation of the proposed sewage facilities, to suggest appropriate & adequate mitigation measures to minimise/reduce adverse impacts and to prepare an environmental impact assessment (EIA) report including environmental management plan (EMP) for timely implementation and scheduling of the mitigation measures. The EIA has been carried out on the proposed priority projects in Lucknow.

9.1.4 EIA Methodology

An EIA study basically includes establishment of the present environmental scenario, study of the specific activities related to the project and evaluation of the probable environmental impacts, thus, leading to the recommendations of necessary environmental control measures.

An EIA study, thus, necessarily includes collecting detailed data and information on the existing environmental set up for establishing "Baseline Environmental Scenario" and study of related data on the proposed activities, i.e., "Project Description" or project data due to construction and operation of the project. The project details are correlated with the data and the environmental impacts associated with construction and operations are predicted with the help of effective and appropriate impact prediction tools and procedures under "Assessment of Environmental Impacts". To mitigate the adverse impacts on the environment, the necessary environmental control, protective and mitigation measures are finally recommended as "EMP".

The major environmental disciplines in this EIA study include water, wastewater, and sludge quality, land use and socio-economics. The EIA study has been conducted emphasizing the impact of the different components of the existing sanitation system as well as impact of the proposed sewage treatment plant (STP). The main components of the project on which EIA study has been conducted are construction of relief trunk sewer and Martinpurwa pumping station and proposed Mastemau STP. The entire EIA study has been carried out within existing policy, legal and administrative framework considering the applicable environmental legislation, regulations and guidelines.

Secondary data was collected with respect to physical, biological and socio-economic environment of the study area and other relevant information about the project. Primary field data was generated in the study area on soil, surface water and groundwater.

In brief, the scope of the EIA study includes:

- To collect relevant primary and secondary data pertaining to the city and the existing and proposed facilities in reference to priority projects.
- To identify the major impacts such as land acquisition, disposal site, change in landscape, land-use and vegetation, ground water contamination from seepage of the STP, pollution and

hydrological change in receiving bodies of treated water, sludge production and disposal or reuse, odour production, health hazard of plant operator, etc. of the proposed large sewage treatment plant (STP), pumping stations and gravity sewers.

- To carry out the mitigation measures for the risk in construction and operation of the STP due to accident, power cut, etc. and to formulate the necessary mitigation and monitoring plan to reduce the impact of the proposed pumping stations and STP.

The methodology adopted is presented in Figure 9.1.

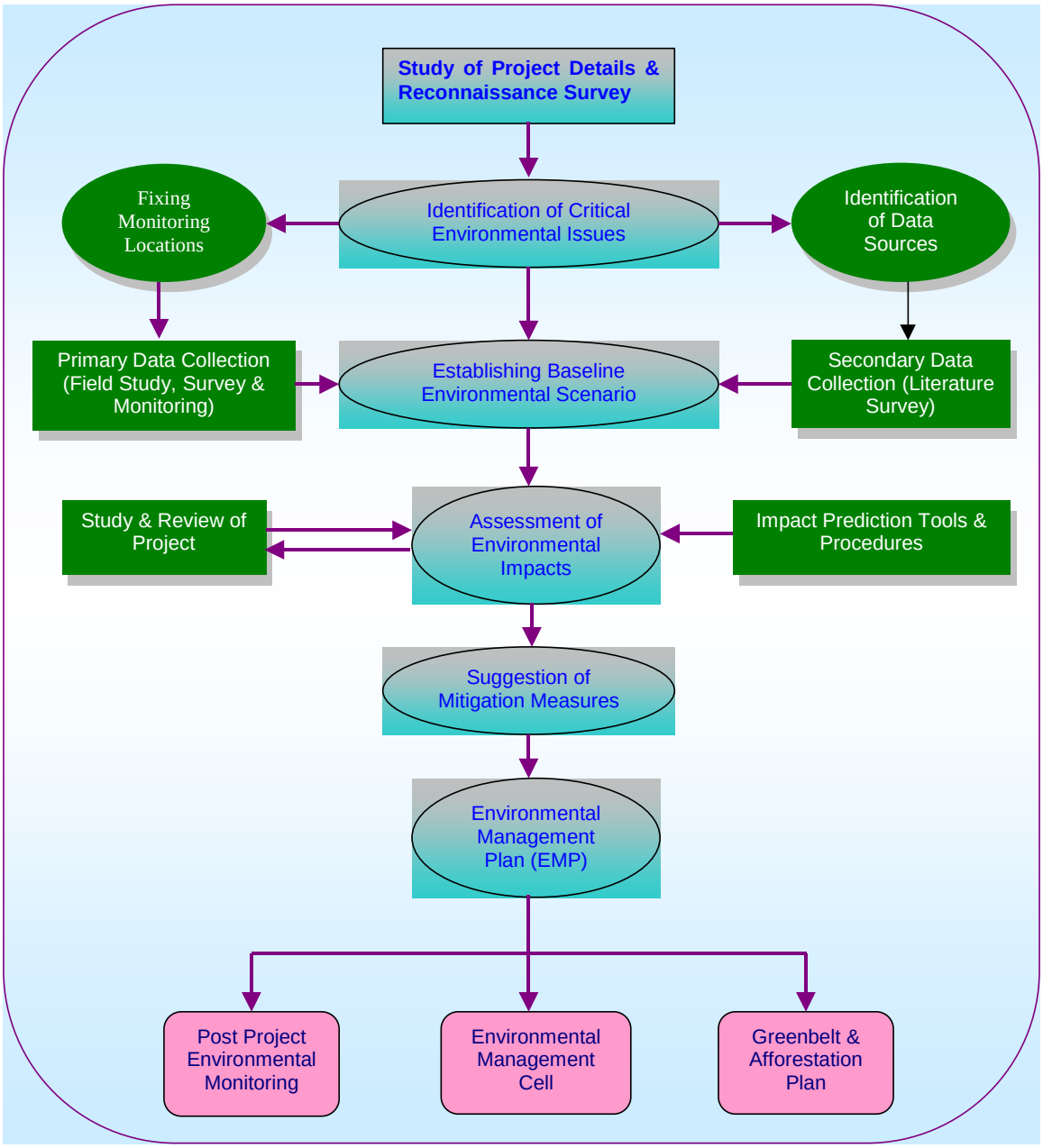


Figure 9.1 Schematic Diagram for Approach and Methodology of EIA

9.2 POLICY, ADMINISTRATIVE AND LEGAL FRAMEWORK

This section takes an account of all the relevant policies and the legal framework with regards to sewerage projects. The administrative framework existing in the country is also documented.

9.2.1 Policy

The National Water Policy of India adopted in September 1987 states that:

1. Water resources development projects should as far as possible be planned and developed as multipurpose projects. Provision for drinking water should be a primary consideration. The other uses being in priority order the following: irrigation, hydropower, navigation, pisciculture and industrial and other uses, unless otherwise dictated by area-specific requirements;
2. The integrated and coordinated development of surface and ground water and their conjunctive use should be envisaged at the project planning phase and should form an essential part of the project. There should be a close integration of water and land use policies.
3. There should be an integrated and multi-disciplinary approach to the planning formulation, clearance and implementation of projects, including catchment management, environmental and ecological aspects, the rehabilitation of affected people and command area development.

The Water (Prevention and Control of Pollution) Act and the Environment Protection Act promulgated in 1974 and 1986, respectively deal with the prevention and control of water pollution. The latter is considered as an umbrella act covering all aspects of the environment, under which the central government can take appropriate measures for:

- Protecting and improving the quality of the environment, and
- Preventing, controlling and abating environmental pollution.

The Pollution Control Boards (PCB) were established under this act both at the Central Government and also at the State Government levels for each state.

9.2.2 Administrative Framework

(1) Ministry of Environment and Forests (MoEF)

MoEF is the nodal agency, in the administrative structure of central government, for planning, promotion, co-ordination and overseeing the various environmental protection and forest conservation programmes. The Ministry is responsible for effective implementation of environmental legislation through its various divisions at Central Government level and also through Central Pollution Control Board, State Departments of Environment and Forests, State Pollution Control Boards and Pollution Control Committees in the Union Territories, which serve as implementing agencies of the Ministry. Besides several legislative measures taken by the ministry to protect the wholesomeness of the environment, a National Conservation Strategy and a policy statement on Environment and Development, 1992, National Forest Policy, 1988 and statement on abatement of pollution, 1992 have also been evolved to tackle the environmental protection issues effectively.

The principal activities undertaken by MoEF consist of conservation & survey of flora, fauna, forests and wildlife, prevention and control of pollution, afforestation & regeneration of degraded areas and protection of environment, in the framework of legislations.

The main tools employed for achieving the above objectives include surveys, impact assessment, control of pollution, regeneration programmes, support to organisations, research and development, collection and dissemination of environmental information and creation of environmental awareness

among target groups and stake holders at all levels of the country's population. Realizing the need for authoritative statistical data on environment, the work relating to collection, collation and analysis of environmental data and its depiction has been constantly taken-up through various projects.

The main functions of the ministry are:

- Environmental policy planning
- Effective implementation of legislation
- Monitoring and control of pollution
- Eco-development
- Environmental clearances for industrial and development projects
- Environmental research
- Promotion of environmental education, training and awareness
- Coordination with concerned agencies at the national and international levels
- Forest conservation development and wildlife protection
- Biosphere reserve programmes

(2) National River Conservation Authority (NRCA)

The NRCA was established in 1985 under the chairmanship of the Prime Minister as "The Central Ganga Authority", and laid down the policies for works to be taken up under the Ganga Action Plan. In July 1995, the Central Ganga Authority has been redesignated as the National River Conservation Authority (NRCA). It is the highest authority for policy framing for implementing the river action plans.

National River Conservation Directorate (NRCD), within the MoEF has been entrusted with the implementation of the National River Conservation Plan (NRCP) and National Lake Conservation Plan (NLCP). The NRCD coordinates the implementation of the schemes under the river and lake action plans. The main objective is to improve the water quality of the major rivers and lakes that are the major fresh water sources in the country, through the implementation of pollution abatement schemes.

Activities taken under NRCP

The activities under NRCP include the following:

- Interception and diversion works to capture the raw sewage flowing into the river through open drains and divert them for treatment
- Sewage treatment plants for treating the diverted sewage
- Low cost sanitation works to prevent open defecation on riverbanks
- Electric crematoria and improved wood crematoria to conserve the use of wood and help in ensuring proper cremation of bodies brought to the burning ghats
- River front development works such as improvement of bathing ghats, etc
- Public awareness and public participation
- HRD, capacity building, training and research in the areas of river conservation
- Other minor miscellaneous works

The major action plans that are carried out by the NRCD are:

- Ganga Action Plan – Phase I & II
- Yamuna Action Plan– Phase I & II
- Gomti Action Plan – Phase I & II
- Damodar Action Plan

- Sutlej Action Plan
- Khan River
- Sabarmati River
- 7 additional towns of Tamil Nadu
- 1 additional town of Maharashtra
- 1 additional town of Goa

Central Pollution Control Board

The Central Pollution Control Board (CPCB), a statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974. Further, CPCB was entrusted with the powers and functions under the Air (Prevention and Control of Pollution) Act, 1981.

It provides technical services to the MoEF under the provisions of the Environment (Protection) Act, 1986. The principal functions of the CPCB are as given below:

1. Advise the central government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air and water.
2. Plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water and air pollution;
3. Co-ordinate the activities of the State Pollution Control Boards (SPCB) and resolve disputes among them;
4. Provide technical assistance and guidance to the SPCB, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
5. Plan and organise training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
6. Organise through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;
7. Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement;
8. Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts;
9. Disseminate information in respect of matters relating to water and air pollution and their prevention and control;
10. Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air; and
11. Perform such other function as may be prescribed by the Government of India.

State Pollution Control Board

The functions of the SPCB under the Air and Water Act are:

1. To plan a comprehensive programme for the prevention, control or abatement of air pollution, or streams and wells in the state.
2. To advise the State Government on any matter concerning the prevention, control or abatement of air and water pollution;
3. To collect and disseminate information relating to air and water pollution;
4. To collaborate with the central board in organizing the training of persons engaged or to be engaged in programmes relating to prevention, control or abatement of air and water pollution and to organise mass-education programme relating thereto;
5. To inspect, at all reasonable times, any control equipment, industrial plant or manufacturing process and to give, by order, such directions to such persons as it may consider necessary to take steps for the prevention, control or abatement of air pollution;

6. To inspect air pollution control areas at regular intervals to assess the quality of air and take steps for the prevention, control of air pollution in such areas;
7. To inspect sewage or trade effluents, treatment plants and the system for the disposal of sewage or trade effluents or in connection with the grant of any consent,
8. To lay down or modify annual effluent standards for the sewage and trade effluents and for the quality of receiving waters resulting due to discharge of effluents.
9. To advise the State Government with respect to the suitability of any premises for an industry which is likely to cause air pollution.
10. To evolve economical and reliable methods of treatment of sewage and trade effluents, with regard to conditions of soil, climate, water resources and flow characteristics of water in streams and wells of different regions.
11. To evolve methods of utilisation of sewage and suitable trade effluents in agriculture.
12. To evolve efficient methods of disposal of sewage and trade effluents on land.
13. To advise the State Government with respect to the location of any industry the carrying on of which is likely to pollute a stream or well.

Uttar Pradesh Jal Nigam (UPJN)

UPJN is a Corporation of the State Government of UP. It was created in 1975 under the provisions of UP Water Supply and Sewerage Act, 1975 by converting the State Local Self Government Engineering Department into UP Jal Nigam. The UPJN is entrusted with the job of development of water supply and sewerage sector in the State. It has also been designated as the implementing agency for the NRCP and NLCP in the State of UP.

The Gomti Pollution Control Unit (GoPCU) of UPJN was basically formed to undertake the construction, execution of the assets that were created under the Gomti Action Plan (GoAP). Under GoAP-I, different pumping stations and one sewage treatment plant were built to take care of the sewage and effluent flowing into the Gomti River. Since then, it has been a primary body also responsible for the operation and maintenance of these assets. As per the policy of the Central Government, the operation and maintenance of these assets is supposed to be transferred to the local bodies. However, they have not yet been transferred except the Gaughat I/D works at Lucknow.

Lucknow Jal Sansthan (LJS)

LJS was established in the year 1975 under UP Water Supply and Sewerage Act 1975 as a local authority for water supply and sewerage services in the city. After creation of Jal Sansthan, the water supply and sewerage works were taken out from the activities of the Nagar Nigam and entrusted to the Jal Sansthan. Mayor of the city is the Chairman of Jal Sansthan.

Under the UP Water Supply and Sewerage Act, 1975 following are the functions of the Jal Sansthan:

i) To plan, promote and execute schemes of and operate an efficient system of water supply;
ii) Where feasible, to plan, promote and execute schemes of, and operate, sewerage, sewage treatment and disposal and treatment of trade effluents;
iii) To manage all its affairs so as to provide the people of the area within its jurisdiction with wholesome water and where feasible, efficient sewerage service;
iv) To take such other measures, as may be necessary, to ensure water supply in times of any emergency;
v) Such other functions as may be entrusted to it by the State Government by notification in the gazette.

Lucknow Nagar Nigam (LNN)

The administrative wing of LNN is headed by the Municipal Commissioner, who is supported by two Additional Commissioners. The LNN has the following sections/wings looking after each specific

area:

- Administrative service
- Engineering service
- Health service
- Account service
- Ministerial service
- Audit service
- Garden/parks
- Education

On a broader level, the LNN handles the responsibilities like health and sanitation, primary education, solid waste management, plantation, slaughterhouses, cleaning of roads, etc.
With special reference to the underground drainage system, LNN is involved in:

- Cleaning of surface drains and desilting of deep drains
- Construction and maintenance of surface drains, deep drains along the road and lanes within municipal maintenance

LNN currently is not engaged in any of the sewerage related infrastructure execution, operation and maintenance in the city. However, with the orders from the Government regarding the merger of Jal Sansthan with Nagar Nigam, in future there might be a possibility that the O&M of sewerage infrastructure may come under the purview of Nagar Nigam and Jal Sansthan jointly.

9.2.3 Legal Framework

The various rules and regulations are summarized in the Table 9.1.

Table 9.1 Summary of the Relevant Indian Rules

Environment Legislation	Salient Features
Forest (Conservation) Act, 1980 – as amended in 1988	The Central Government enacted The Forest (Conservation) Act in 1980 to stop large scale diversion of forest land for non-forest use. As amended in 1988, the Act requires the approval of the Central Government before a State "de-reserves" a reserved forest, uses forest land for non-forest purposes, assigns forest land to a private person or corporation, or clears forests land for the purpose of reforestation. Such diversion is generally allowed on the advice of an Advisory Committee constituted under the Act. In case of such diversion of forest land, compensatory afforestation has been made mandatory
Wildlife Protection Act	An act to provide for the protection of wild animals, birds and plants and for matters connected therewith. The provisions under this act are: ▪ Section 9 of the Act says that no person shall hunt any wild animal specified in Schedule I ▪ The act prohibits picking, uprooting, damaging, destroying, acquiring any specified plant from any forest land ▪ It bans the use of injurious substances, chemicals, explosives that may cause injury or endanger any wildlife in a sanctuary ▪ No alteration of the boundaries of a National Park shall be made except on a resolution passed by the Legislature of State ▪ Destruction or damaging of any wildlife property in National Park is prohibited.
Water (Prevention and Control Pollution) Act, 1974 - as amended in 1978 &1988	The Act vests regulatory authority on the State Pollution Control Boards and empowers them to establish and enforce effluent standards for industries and local authorities discharging effluents. Following are the important provisions under this Act which are to be compiled with: ▪ Provide the State Pollution Control Board (SPCB) any information which is sought for preventing or controlling pollution of water regarding the construction, installations, operation or the treatment and disposal system of an industrial establishment ▪ Not to discharge, knowingly of any effluent into the stream sewers or on land of quality which is not conforming to the standards prescribed by the SPCB ▪ Furnish information to the SPCB and other designated agencies of any accident or unforeseen event, in which effluents not conforming to the prescribed standards are being discharged or likely to be discharged in to a stream or sewer or on land ▪ Comply with the directions issued in writing by the SPCB , within the specified time. ▪ Comply with the condition as prescribed in the "Consent to Establish" or "Consent to Operate" for discharge of effluent in to stream or sewers or on land. Responsibilities ▪ Obtain "Consent to Establish", prior to taking any steps to establish any industry or any treatment and disposal system which is likely to discharge effluents. ▪ Obtain "Consent to Operate", prior to commencing operation of any industry or any treatment and disposal system which is likely to discharge effluents.

Environment Legislation	Salient Features
	▪ Apply for renewal of the "Consent to Operate: before the expiry of validity period along with the prescribed fee.
Water (Prevention and Control of Pollution) Cess Act, 1977 including Rules	An act to provide for the levy and collection of a cess on water consumed by persons carrying on certain industries and by local authorities to augment resources for the Pollution Control Boards. As per the provision of Section 3, all specified industries under the Water (Prevention and Control of Pollution) Cess Act, 1977 are liable to pay cess in the prescribed rate made under the statute. It is provided under Section 5 that every specified industry or local authority is liable to furnish cess to respective authorities. Also suitable meters shall be installed by all specified industries and local authorities for the purpose of measuring the quantity of water consumption. To encourage capital investment in pollution control, the Act gives a polluter 70 per cent rebate of the applicable cess upon installing an effluent treatment plant
Air (Prevention and Control of Pollution) Act, 1981 - as amended in 1987	An act providing for prevention, control and abatement of air pollution. • Section 21 of the Air Act specifies that no person shall without the consent of the State Board establish or operate any industrial plant in any air pollution control area. • It is also provided in the statute that industrial units cannot discharge any pollutants into the air in excess of the standards prescribed by the State Board. The States are required to prescribe such "Emission Standards" for industry and automobiles after consulting the Central Board and noting its Ambient Air Quality Standards. ▪ Furnish information to the SPCB and other designated agencies of any accident or unforeseen event, in which emissions of air pollutants occurred in excess of the prescribed standards or are likely to occur. ▪ Comply with the directions issued in writing by the SPCB , within the specified time. ▪ Comply with the condition as prescribed in the "Consent to Establish" or "Consent to Operate" for emissions Responsibilities ▪ Obtain "Consent to Establish", prior to establishing any industrial plant in an air pollution control area, which is likely to emit air pollutants. ▪ Obtain "Consent to Operate", prior to commencing operation of any industrial plant which is likely to emit air pollutants in an air pollution control area,. ▪ Apply for renewal of the "Consent to Operate: before the expiry of validity period along with the prescribed fee.
The Environment (Protection) Act, 1986	The Environment (Protection) Act was conceived as an "umbrella legislation" seeking to supplement the existing laws on the control of pollution (the Water Act and the Air Act) by enacting a general legislation for environment protection and to fill the gaps in regulation of major environmental hazards. • Section 3(1) of the Act empowers the Centre to " take all such measures as it deems necessary or expedient for the purpose of protecting and improving the quality of the environment and preventing, controlling and abating environmental pollution". • It also authorizes the government to make rules on any aspect related to environment protection. • No industries can discharge any solid, liquid or gaseous substances beyond the permissible limit as laid down by the Central Government on its behalf

Environment Legislation	Salient Features
	• Comply with the directions issued in writing by the Central Government within a specified time as mentioned in the order • Furnish information to the prescribed agencies of any accident or unforeseen event, in which environmental pollutants occurred in excess of the prescribed standards are being discharged, or are likely to be discharged in the environment. Responsibilities • Obtain prior "Environmental Clearance" from MoEF in case of a new project or for modernisation/expansion of the existing project and in respect of projects falling under EIA notification
Environment (Siting for Industrial Projects) Rules, 1999	*The Environmental Guidelines for Siting of Industries has been formulated for specific areas to be avoided for siting of industries. These rules are meant for protection of the sensitive areas such as national parks, sanctuaries, wetlands and archaeological monuments.*
Environment Impact Assessment Notification (amended upto June 2002)	Through this Notification, the MoEF made Environment Impact Assessment (EIA) statutory for 31 different activities. • Any person who desires to undertake any new project/ expansion or modernisation of any existing industry listed in Schedule I of the notification shall submit an application to the MoEF for environmental clearance. (Note: This Schedule I does not include sewerage projects). • The reports submitted with the application is reviewed by the Impact Assessment Agency which further prepares a list of recommendations based on the technical assessment of documents and data. • The assessment shall be complete within a period of 90 days on receipt of the application. The clearance granted is valid for a period of 5 years. Further whoever applies for environmental clearance shall submit to the SPCB/PCC's 20 copies of the relevant documents as mentioned in Schedule IV of the notification for conducting public hearing. • The SPCB/PCC's shall publish a notice for public hearing in at least 2 widely circulated newspapers in the region of the project; one in English and the other in vernacular language. SPCB is responsible for mentioning the date, time and venue of the public hearing. • All affected persons can participate in the public hearing.
The Hazardous Wastes (Management and Handling) Rules, 1989	These rules aim at providing control for the generation, collection, treatment, transport, import, storage and disposal of hazardous wastes. These Rules provide for effective inventorisation and controlled handling and disposal of hazardous waste. • Occupiers responsibility to ensure proper handling and disposal of hazardous waste either by themselves or through the operator of hazardous waste management facility • Restriction on handling of hazardous wastes without prior authorization • Packaging, labelling and transportation of hazardous waste to be done in the specified manner • Occupier generating hazardous wastes, or operator handling facility to submit annual returns in the prescribed format • Occupier or operator handling facilities to report to SPCB in prescribed forms, in case of accident at the hazardous waste handing site or during transportation
The Municipal Solid Wastes	• Every municipal authority will be responsible for the implementation of the provisions under these rules.

Environment Legislation	Salient Features
(Management and Handling) Rules, 2000	• The municipal authority shall make an application in Form-I for grant of authorization for setting up waste processing and disposal facility from State Board • The municipal authority shall comply with the implementation schedule under Schedule I • The municipal authority shall furnish its annual report in Form II on or before 30th June every year • Any municipal solid waste shall be managed in accordance to the procedure laid down in Schedule II • The waste processing and disposal facilities to be set up by Municipal authority shall meet the specifications and standards specified in Schedule II and IV
Bio- Medical Waste (Management and Handling) Rules, 1998	• The occupier of an institution generating bio-medical waste shall take all steps to ensure that such waste is handled without any adverse effect to human health and environment • Bio-medical waste shall be treated and disposed of in accordance with Schedule I and in compliance with the standards prescribed in Schedule V. • The occupier should set up requisite bio-medical waste treatment facilities in accordance with the time frame in Schedule VI. • Bio-medical waste shall be segregated into containers/bags at the point of generation as per Schedule II prior to its storage, transportation, treatment and disposal. • If a container is transported from the premises of the generation point to any waste treatment facility, it will also carry information as in Schedule IV apart from that prescribed in Schedule III. • Bio-medical waste shall be transported in vehicles as authorized for the purpose by the competent authority. • No untreated bio-medical waste shall be kept stored beyond 48 hours. • Occupier/operator shall submit an annual report to the prescribed authority (SPCB) in Form II by 31st January every year for the preceding year.
The Land Acquisition Act, 1894	The Act seeks to set out the circumstances and the purposes for which private land can be acquired by the Central/State Government. The procedure under the Act is briefly listed below. Stage I ▪ Publication of a preliminary notification by the Government that land in a particular locality is needed or may be needed for a public purpose or for a company ▪ Entry of authorised officers on such land for the purpose of survey and ascertaining whether it is suitable for the purpose in view ▪ Filing of objections to the acquisition by parsons interested and enquiry by Collector

Environment Legislation	Salient Features
	Stage II ▪ Declaration of intended acquisition by Government ▪ Publication of declaration as required by the Act ▪ Collector to take order from the Government for acquisition and land to be marked out, measured and planned Stage III ▪ Public notice and individual notices to persons interested to file their claims for compensation ▪ Enquiry into claims by Collector ▪ Award of Collector ▪ Reference to court Stage IV ▪ Taking of possession of the land by the Collector ▪ Payment of compensation

9.2.4 Emission Standards for Water, Air, Noise and Effluent

(1) River Water Quality Standards

Until recently the only criteria available for classification of water bodies was as per the 'Designated best use' (DBU) prescribed by bureau of Indian standards (BIS) and CPCB way back in 1981. According to this concept, out of various purposes for which the water body is used, the one which requires highest quality of water is taken as the benchmark and classified as 'Designated best use'. According to this criteria water bodies are divided in five categories viz.:

Class A: Drinking water source without conventional treatment, but with chlorination
Class B: Outdoor bathing
Class C : Drinking water source with conventional treatment
Class D : Propagation of wildlife and fisheries
Class E : Irrigation, industrial cooling and controlled waste disposal

This criterion lays down reference values for among others pH, dissolved oxygen (DO), biological oxygen demand, coliform, etc. For instance, specified limits for DO, BOD and coliform for class A are 6 ppm, 2 ppm and 50/100 ml, respectively. For lower category such as class D, specified values for these indicators are 4 ppm, 6 ppm and 5000/100 ml, respectively.

Recently, CPCB has revised the primary quality for class B regarding coliform number as; faecal coliform: <500 MPN/100ml (desirable), <2,500 MPN/100ml (maximum permissible).

As of now this criteria is followed by various agencies responsible for management and control of water quality in the country including the two ongoing programmes viz. NRCP and NLCP.

CPCB has proposed a new criterion for classification of water bodies. The new approach is based on the premise of maintaining and restoring 'wholesomeness' of water for the health of ecosystem and environment in general; and protecting the designated organised uses of water by human beings and involving community for water quality management.

The new classification system proposes three categories or tiers of indicators of water quality depending on the ease or complexity involved in their determination with regard to knowledge, skills, and equipment. Secondly, it classifies water bodies into three broad categories viz.:

Class A : Excellent (long term goal)
Class B : Desirable level of wholesomeness (medium term goal)
Class C : Minimum acceptable level (short term goal)

Table 9.2 Key Indicators of Inland Surface Water Quality under the Revised Criteria Proposed by CPCB

Indicator	Unit	A-Excellent	B-Desirable	C-Acceptable
DO	(% saturation)	90-110	80-120	60-140
BOD	(mg/l)	<2	<5	<8
Faecal Coliform	MPN/100 ml	<20	<200	<2000

(2) Effluent Standard

Effluent discharge standards are specified with reference to the type of industry, process or operations and in relation to the receiving environment or water body such as inland surface water, sewers, land or sea.

Table 9.3 Standards for Different Receiving Water Bodies

Indicator	Inland surface water	Public sewers	Land for irrigation	Marine outfall
Suspended solids	100	600	200	100
Oil and grease	10	20	10	20
BOD_5	30	350	100	100

Note: *All values are in mg/l and are the maximum permissible levels.*
Source: *Pollution control acts, rules and notifications issued hereunder, CPCB, September, 2001.*

The general BOD limit specified for discharge of wastewater from typical industrial sources or domestic wastewater is same at 100 mg/l. However, the rules specify that the discharge limits can be made further stringent if the concerned pollution control authority finds it appropriate depending on the condition of the receiving environment and severity of the discharges from various sources.

NRCD has specified guidelines for discharge of domestic effluents in the river, which is given in Table 9.4.

Table 9.4 Standards for Treated Wastewater Quality

Sr.	Parameter	Value (Irrigation Field/River)
1.	pH	5.5 – 9.0
2.	Biochemical Oxygen Demand, mg/l	$\leq$ 30
3.	Total Suspended Solids, mg/l	$\leq$ 50
4.	Faecal Coliform Count, MPN/100ml	$\leq$1000

NRCD has conveyed the recommendations of the Expert Committee through its letter no DO. No. A-33013/1/99-NRCD dated 5th October 1999, suggesting that the maximum permissible value for Faecal Coliform in treated water should not exceed 10,000 MPN per 100 ml sample irrespective of its mode of disposal in river or its use for irrigation to grow either restricted or unrestricted crops. However, the STP is designed to meet the discharge guideline of NRCD for <1000 MPN/100 ml sample. NRCD guidelines also suggest BOD and TSS concentration to be less than 30 mg/l and 50 mg/l, respectively.

(3) Standards for Irrigation

In order to protect various water bodies, standards for treated industrial waste / treated domestic waste have been prescribed by the CPCB. These standards are different for different types of receiving bodies. Treated effluent / treated sewage to be discharged into any of the following shall meet the relevant standards as prescribed by CPCB:

i) into inland surface waters,
ii) into municipal sewers,
iii) on land for irrigation,
iv) into marine coastal waters.

If treated sewage is to be used for irrigation, upper limits for important parameters will be:

Table 9.5 Treated Water Quality for Irrigation

Parameter	Unit	Limits
BOD_5	mg/l	100
Suspended Solids	mg/l	200
Dissolved Solids	mg/l	2100
pH		5.5-9.0
Oil & Grease	mg/l	10
Arsenic	mg/l	0.2
Boron	mg/l	2.0
Cyanide	mg/l	0.2
Chloride	mg/l	600
Sulphate	mg/l	1000

Source: CPCB, Stds for discharge of Ind./Dom. Wastewater

(4) Ambient Air Quality Standards

The CPCB has notified the national ambient air quality standards (NAAQS) in schedule VII of these rules, which are reproduced in Table 9.6

Table 9.6 National Ambient Air Quality Standards

Pollutant	Time weighted	Concentration in ambient air ($\mu g/m^3$)			Method of measurement
	Average	Industrial	Residential	Sensitive	
SO_2	Annual*	80	60	15	1. Improved West & Gaeke method
	24 hrs**	120	80	30	2. Ultra violet fluorescence
NO_x	Annual	80	60	15	1. Jacob & Hochheiser modified (Na-Arsenite) method
	24 hrs	120	80	30	2. Gas phase chemi-luminescence
SPM	Annual	360	140	70	Average flow rate not less than
	24 hrs	500	200	100	1.1 m^3/minute
RPM	Annual	120	60	50	
	24 hrs	150	100	75	
Pb	Annual	1.00	0.75	0.50	AAS method after sampling using
	24 hrs	1.50	1.00	0.75	EPM 2000 or equivalent paper
CO$	8 hrs	5	2	1	Non dispersive infrared spectroscopy
	1 hour	10	4	2	

Note:
* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24 hourly at uniform intervals.
** 24 hourly /8 hourly values to be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.
$ Values in mg/m^3

9.2.5 Ambient Noise Standards

The standards for ambient air quality in respect of noise are given in schedule III under the rules and are reproduced in Table 9.7

Table 9.7 Ambient Air Quality in Respect of Noise

Area code	Category of area	Limits in dB (A) Leq	
		Day time	Night time
A	Industrial	75	70
B	Commercial	65	55
C	Residential	55	45
D	Silence zone	50	40

Note 1: Day time is reckoned in between 6 am to 10 pm
Note 2: Night time is reckoned in between 10 pm to 6 am
Note 3: Silence zone is defined as areas upto 100 metres around such premises as hospitals, educational institutions and courts. The silence zones are to be declared by the Competent Authority. Use of vehicular horns, loudspeakers and bursting of crackers shall be banned in these zones.
Note 4: Mixed categories of areas should be declared as one of the four above mentioned categories by the Competent Authority and the corresponding standards shall apply.

9.2.6 JBIC's Environmental Guidelines

A fundamental principle of JBIC, as a government financial institution, is to confirm that the executor of a project proposed for JBIC financing takes into account appropriate environmental considerations. If, during the course of establishing the project meets acceptable environmental considerations, and JBIC finds that environmental considerations for the project are not appropriately addressed and the project carries significant risk of negative environmental impact, JBIC will require the project executor, to improve the project's environmental consideration.

Screening differentiates JBIC-financing projects on the basis of grouping them into three categories, A, B, and C, in accordance with the extent of the environmental impact(s) and/or JBIC's involvement in the project. Category A and B projects are deemed to have a significant likelihood of affecting the environment, as suggested by JBIC's experience. Sewerage projects fall under Category B projects.

(1) Standards to Confirm Appropriate Environmental Considerations

Natural Environment

JBIC confirms, in principle, that the project will comply with the laws and regulations and environmental standards pertaining to natural environments in the country where the project is located. In the event that environmental standards in the country where the project is located diverge significantly from Japanese or international standards (standards, etc. such as those provided in other environmental guidelines of World Bank and other standards of which appropriateness are recognized internationally), or that local environmental regulations are yet to be established in some areas, Japanese or international standards are taken into account to confirm that appropriate environmental considerations are made.

Social Environment (particularly Involuntary Resettlement)

In addition to considerations for natural environments, appropriate considerations, including adequate explanation, must be given to the social environment, particularly when local and neighbouring populations will be subject to involuntary resettlement, with a view to obtaining their consent. In the event that any problem arises, JBIC will confirm the appropriateness of environmental considerations by referring to internationally recognized principles and procedures.

9.3 BASELINE ENVIRONMENTAL STATUS

9.3.1 Physical Environment

(1) Topography

The city is situated in the Gangetic plain on the bank of Gomti River. The topography of the city is slightly undulating. In general, city slopes towards east with lateral slope towards the river Gomti which flows through the heart of the city from west to east. The area along the river on Cis-Gomti side is comparatively less in area and is congested than that on the Trans-Gomti side.

The district forms the part of Ganga basin with flat alluvial terrain. General elevation varies from 103 to 130 mts above mean sea level.

(2) Geology

The nature of this Gangetic alluvium does not show anything interesting except sand and sandy silt with occasional beds of clay and kankar (grit particles).

The entire district is covered with thick pile of quaternary sediments uncomfortably overlaying the basement of Bundelkhand granitoides and sedimentary rocks of Vindhyan supergroup. The borehole data of CGWB established the presence of bedrock at depth of 298m and 445m in the southern and western part, respectively. Terrace alluvium occurs as lenticular patches on either side of the Gomti River and Sai river. It consists of light khaki to brownish yellow. These are further classified into silt clay facies and sandy facies.

Geomorphologically, the district has been classified into three units viz .Varanasi plain, older flood plain and active flood plain. Varanasi plain covers major part of district. It is the oldest geomorphic unit lying between elevation of 106m and 130m above mean sea level. Old flood plain is represented by two levels of terraces viz. erosional terrace and depositional terrace. Both the terraces are developed on either side of Gomti River.

(3) Hydrological features

The district lies in the Gomti River and Sai sub basins of Ganga basin. The surface water resources of district are mainly dependant upon river Gomti, Sai and their tributaries. Network of Sharda canal system and its distributaries also partly serve as the surface water potential. The sub surface water resources of district are restricted to ground water potential. The northern and central part of district indicate fairly thick and regionally extensive confined /unconfined aquifer down to 300m providing large yield prospects above 150m^3/hr. The remaining part of district shows fairly thick and regionally extensive confined/unconfined aquifers down to 150m depth. The yield prospects are moderate and are of order of 50-150 m^3/hr.

(4) Soil Quality

The area falls in lower Gangetic plain. The soil is sedimentary in nature and contains transported alluvial sediments spread from the Shivalik Himalayas. The deposits dominantly belong to the pleistocene period quaternary era. The alluvium thickness ranges between 300 to 400 m. The dominant rocks are sandstone, shale, limestone, etc. The quality of subsurface soil is given in Table 9.8.

Table 9.8 Soil Characteristics in Lucknow

Sl. No	Depth cms	Colour	Nature	Type	pH	Remark
1	0-7	Brownish grey to dark yellow	Sticky and slightly plastic	Loamy	7.7	Medium roots may be encountered
2	7-40	Yellowish brown to dark brown	Sticky	Loamy sand	7.8	Gradual smooth soil is found with increase in depth
3	40-79	Brownish yellow	Sticky	Loamy with coarse sand	7.7	Structureless having common fine roots, fine to medium inter sectional spores
4	79-180	Light yellowish brown to dark yellowish brown	Non sticky non plastic	Fine sand	7.8	Single grain loose sand having fine and medium roots

Source: Environmental Status Report for Lucknow, 2002, CPCB

The results of primary survey for various soil parameters are summarized separately in Appendix A9.1.

(5) Seismicity

Seismically the district has not experienced any tremors of much significance in the past. The entire district has been placed in zone of moderate intensity earthquake (Zone III).

(6) Climate and Meteorology

The climate of the city is sub tropical. The average maximum and minimum temperature of the year are 32.2^{o}C and 16.7^{o}C, respectively. The city gets an annual average rainfall of the order of 1,016 mm out of which about 90% of the rainfall occurs during the monsoon months from June to September. The average relative humidity varies from 29% in April to 95% in August.

(7) Wind Speed and Direction

The characteristics of winds, i.e., direction, intensity and duration are shown in Table 9.9. The detailed observations from the data are given below.

Winter Season (From November to February)

During this period the winds from south west, west and north-west are very common. For most of the days the velocity of the winds are between 1.1 to 6.4 kmph and increase gradually from November to February. High velocity winds are rare during this period. Calm wind conditions are more prevalent in November and less in February.

Summer Season (from March to June)

During the months of March and April, the predominant wind directions are from west and north-west. Mean wind velocities are generally found between 8 to 10.9 kmph. High velocity winds associated with dust storms can be noticed during this period. In summers the wind directions are found to be unpredictable and generally change towards all the directions, however comparatively for shorter time towards SE direction.

Monsoon period (from July to October)

During the months of July and August the winds from east and south east predominate while during the months of September and October, the wind directions are unpredictable. The velocity of winds during July and August is in the range of 8.0 to 8.4 kmph, which decreases gradually to 2.1 kmph. For 75% of the time, the wind velocity is in the range of 1-19 kmph.

The average climatological data for the years 1952 to 1980 is summarised in Table 9.9.

Table 9.9 Climatological Data on Rainfall – Lucknow (1952 – 1980)

Month	Rainfall (mm)						Mean wind speed kmph
	Monthly Total	No. of Rainy Days	Total in Wettest Month with year	Total in Driest month with year	Heaviest Fall in 24 Hours	Date and Year	
January	21.9	1.6	73.7 1954	0.0	65.0	02 1980	6.1
February	11.2	1.1	61.3 1970	0.0	30.2	18 1978	7.5
March	7.7	0.7	39.2 1971	0.0	39.2	05 1965	8.6
April	4.9	0.5	26.2 1965	0.0	19.6	01 1965	9.9
May	16.5	1.0	72.5 1964	0.0	57.0	28 1959	10.8
June	107.4	4.2	412.0 1975	0.0	162.4	26 1971	11.7
July	294.3	11.6	761.7 1960	2.5 1952	272.4	09 1960	10.6
August	313.9	13.1	654.2 1967	44.7 1979	171.0	08 1967	9.1
September	180.6	7.4	570.4 1970	15.0 1979	155.8	20 1980	8.0
October	45.2	2.0	287.5 1960	0.0	191.4	03 1958	5.3
November	3.8	0.3	42.1 1979	0.0	25.3	30 1979	4.0
December	7.3	0.7	79.5 1967	0.0	24.9	24 1950	4.8
Annual Total or Mean	1031.7	44.2	2143.0 in 1980	161.1 in 1952	272.4 on July 09 1960		8.0
Number of years	30	30	31	31	31	-	20

Source: Environmental Status Report for Lucknow, CPCB, 2002

(8) Surface water

Gomti river, a significant tributary of Ganga, originates from a natural impounding reservoir near a village Chanderpur in district Pilibhit in the State of Uttar Pradesh and merges with Ganga river near Audiar in district Ghazipur after it takes a course of 715 kms through 15 districts of the State. The river contributes about 15% flow to Ganga and has an average dry weather flow of about 1,500 million litres per day (mld) which can go upto as high as 55,000 mld in monsoons and as low as 500 mld in summer. The river has an effective catchment area of 25,735 sq. kms.

In addition to the Gomti river, there is another river, Saryan that joins Gomti at Bhatpur Ghat in

district of Sitapur. This river is a seasonal river originating within the district of Sitapur. In dry weather, it primarily carries the spent water and wastes from the inhabitants and industries in the district of Sitapur.

There are many surface water drains that discharges into the Gomti River over most of the city. There are also a number of depressions in the city which contain water. The nalas / drains originally appear to have carried very low flows during dry weather, but with increased discharged on sewage and sullage and increase in population and inhabitation, all the nala presently carry substantial flows and pollution load all year round.

(9) Gomti River and its Pollution

Gomti river is the most important tributary of river Ganga. The main causes of pollution of river Gomti are

- Discharge of the cities' untreated sewage into the river through different drains and nala
- Discharge of industrial wastewater

It has been estimated that 364 mld of untreated sewage is discharged into the river in Lucknow, Sultanpur and Jaunpur.

Uttar Pradesh Pollution Control Board (UPPCB) carries out the regular monitoring of Gomti river water from Sitapur to Ghazipur at six different places. The salient features of the monitoring are as follows:

- It has been noted that the river quality of Gomti at upstream of Sitapur has improved marginally in 2004 as compared to the year 2001. The water quality at this point is suitable for drinking after purification.
- At Manjighat in Lucknow, it has been also observed that the water quality has improved since 2001 and the water is suitable for drinking after necessary purification.
- At Lucknow Gaughat water work intake, the DO has increased and the total coliforms have reduced in 2004 as compared to 2001. Since the water quality has improved at this point, it has been considered suitable for drinking after necessary treatment and purification.
- At Gomti river Mohan Meakins downstream, there has been no improvement in the quality of water since 2001. This water is therefore not suitable for drinking but can be used for propagation of wildlife and fisheries.
- At upstream of Nishatganj bridge, it has been observed that there has been an increase in the DO content and reduction in total coliforms in 2003 as compared to year 2000. However, this water has been classified under Class D suitable for propagation of fisheries.
- At Gomti barrage upstream, quality of the water has improved marginally in 2004 as compared to 2001. This water is classified under Class E, which is used for irrigation.
- At Gomti River downstream in Jaunpur and before its confluence with Ganga, at Rajwari, the water has been found suitable for propagation of fisheries.

The river water characteristics monitored by UPPCB from 2001 to 2004 are presented in Table 9.10

Table 9.10 River Water Quality

Sr. No.	Place of Monitoring	Year 2001			Year 2002			Year 2003			Year 2004		
		DO mg/l	BOD mg/l	Total Coliforms MPN/100 ml	DO mg/l	BOD mg/l	Total Coliforms MPN/100 ml	DO mg/l	BOD mg/l	Total Coliforms MPN/100 ml	DO mg/l	BOD mg/l	Total Coliforms MPN/100 ml
1	Gomti River Sitapur u/s	8.3	1.6	1,650	8.3	1.7	878	8.2	1.6	882	6.1	1.4	796
2	Manjighat	7.2	1.8	1,666	8.1	1.8	988	7.5	2.0	1,186	8.7	1.8	1,240
3	Gaughat Water Intake	6.7	2.5	5,680	7.7	2.4	2,478	7.1	2.7	3,280	8.1	2.4	2,680
4	Mohan Meakins d/s	5.4	5.6	84,000	5.7	5.5	60,777	6.0	5.0	45,416	6.4	5.9	43,600
5	Nishantganj Bridge	4.3	6.6	106,166	4.7	6.5	81,666	5.3	5.9	87,777	5.3	6.7	56,000
6	Barrage u/s	3.4	7.8	162,323	3.6	7.2	10,666	4.6	6.5	104,444	4.4	7.1	74,000
7	Pipraghat	3.6	7.6	76,666	4.1	7.2	111,389	4.0	7.0	127,222	2.8	7.6	68,000
8	Gomti d/s Jaunpur	7.8	2.9	51,333	8.2	2.8	44,156	8.1	3.9	31,333	8.1	3.2	25,400
9	At Rajwari	7.7	2.9	31,555	7.8	2.4	26,781	8.5	2.9	248,333	8.6	2.3	21,400

Source: Uttar Pradesh Pollution Control Board

(10) Characteristics of Nala and Wastewater

In order to have an estimate of the pollution load generated and discharged, the CPCB Study Team took up a comprehensive monitoring of all the incoming drains to the river during the years 1996 and 2000. The results of the survey are summarized below:

1. During 1996, the BOD of city sewage varied between 54 to 303 mg/l in various drains excluding the industrial drain, while during the monitoring conducted in the year 2000, the range of BOD in city sewage was observed as 42 to 180 mg/l excluding Jiamau and LaMarteniere drains.
2. The suspended solid concentration in 1996 was found to be between 125 to 852 mg/l which is seen reducing in 2000 in the range of 55 to 449 mg/l
3. The sodium absorption ratio (SAR) of the sewage as measured during 1996 confirmed that it might be used for irrigation. The BOD of the combined effluent marginally exceeded the land disposal limit.

CPCB also conducted a survey of the drains to detect the presence of heavy metals. The results of the survey are given in Tables 9.11 and 9.12.

Table 9.11 Presence of Heavy Metals in Drains of Cis Gomti Area (December, 2000)

Name of Drain	Cadmium mg/l	Chromium mg/l	Copper mg/l	Iron mg/l	Nickel mg/l	Lead mg/l	Zinc mg/l
Standard for Discharge	*2.0*	*2.0*	*3.0*	*3.0*	*3.0*	*0.1*	*5.0*
Nagaria Drain	NT	0.14	0.17	27.00*	0.13	0.13*	0.51
Gaughat Drain	No discharge was found						
Sarkata Drain	0.16	0.21	0.23	5.18*	0.09	NT	2.68
Pata Drain	0.36	0.04	0.28	11.64*	0.15	NT	2.29
Drain u/s NER	No discharge was found						
Drain d/s NER	NT	0.12	0.14	3.90*	NT	NT	1.25
Wazirganj Drain	NT	0.11	0.21	15.74*	0.05	NT	0.80
Ghasiyari Mandi Drain	NT	0.13	0.28	12.11*	0.06	0.01	0.94
China Bazaar Drain	NT	0.11	0.14	4.57*	0.05	NT	1.00
Laplace Drain	NT	0.22	0.15	4.07*	NT	0.03	1.16
CGPS	0.27	1.36	0.42	31.02*	0.11	NT	2.19
Jopling Road Drain	NT	0.55	0.81	49.68*	0.18	0.21*	2.18
GH Canal Drain	NT	0.29	0.41	27.50*	0.29	0.13*	1.76
Jiamau Drain	NT	0.2	0.08	14.30*	0.04	NT	0.79
La Marteniere Drain	NT	0.01	0.04	2.74	NT	NT	0.32

Source: Environmental Status Report for Lucknow, CPCB 2002.

Note : *marked values are exceeding the norms prescribed for discharge into inland water body

Table 9.12 Presence of Heavy Metals in Drains of Trans Gomti Area – Lucknow (December 2000)

Name of Drain	Cadmium mg/l	Chromium mg/l	Copper mg/l	Iron mg/l	Nickel mg/l	Lead mg/l	Zinc mg/l
Standard for Discharge	*2.0*	*2.0*	*3.0*	*3.0*	*3.0*	*0.1*	*5.0*
Maheshganj Drain	NT	0.18	0.08	3.64*	NT	0.02	0.67
Rooppur Khadra Drain	NT	0.23	0.27	24.40*	0.15	0.20*	1.09
Mohan Meakins Drain	NT	0.25	1.05	34.50*	0.10	0.31*	1.64
Daliganj Drain 1	NT	0.15	0.27	23.30*	0.14	0.43*	1.08
Daliganj Drain 2	NT	0.13	0.20	15.20*	0.03	NT	0.88
Arts College Drain	NT	0.11	0.20	17.50*	NT	0.53*	0.81
Hanuman Setu Drain	NT	21.27*	0.15	144.60*	0.63	0.15*	0.62
TGPS	NT	0.55	0.62	109.00*	0.17	0.32*	3.14
Kedarnath Drain	NT	78.30*	0.39	357.20*	1.62	0.36*	0.87
Nishatganj Drain	NT	0.20	0.14	22.70*	0.12	0.62*	0.63
Baba Ka Purwa Drain	NT	0.19	0.25	19.10*	0.07	0.13*	1.42
Kukrail Drain	NT	0.17	0.19	33.10*	0.14	1.79*	1.06

Source: Environmental Status Report for Lucknow, CPCB 2002.

Note : *marked values are exceeding the norms prescribed for discharge into inland

Following observations can be made from the survey:

1. The presence of heavy metals like iron, lead and chromium are much on the higher side in the drains of the Trans-Gomti side as compared to Cis-Gomti drains. Since most of the metal processing industries are located on this side of the river, there is a possibility that metals in dissolved form are discharged into the drains along with their effluents.
2. The iron concentrations exceed the limits in all the drains, except one in LaMarteniere drain. The concentrations range from 3.64 mg/l to 357.2 mg/l.
3. The lead concentrations exceed the prescribed standards in 13 out of 25 drains monitored by CPCB. It was found to be the highest in Kukrail drain.
4. Concentrations of chromium are found to be very high, especially in Kedarnath drain and Hanuman setu drains.
5. The most polluted drains as per the survey conducted in 2000 are Kedarnath drain, Hanuman Setu, TGPS and CGPS outfall and Kukrail drains.
6. The concentrations of cadmium, copper and zinc are within the permissible limits in all the samples.

(11) Groundwater

UP Jal Nigam has installed hand pumps at various locations. In addition local people have also installed hand pumps in their colonies. In order to understand the groundwater quality, a zone based survey was carried out in 1996 and 2000 by CPCB. The results of the survey are given in Table 9.13. CPCB report has made certain observations from the survey carried out:

1. As water is drawn out from greater depth, the quality of water is confirming to the norms laid down for the coliform standards.
2. Fluoride concentrations were found below 1.0 mg/l in 6 out of the 20 samples in 1996 and 10 out of 17 samples in 2000. It is therefore not suitable for drinking particularly for children for whom fluoride concentration of 1.0 mg/l is recommended.
3. During 1996, it was found that concentration of chromium at all the locations meets the prescribed standards but during the later monitoring, the same was exceeding at 6 locations.
4. Both during 1996 and 2000 surveys, it was found that the iron content exceeded the desirable limits at all the locations. CPCB report recommends detailed investigations to find out the same.
5. Copper and zinc concentration were meeting the desirable limits in both the surveys.
6. Lead and cadmium concentrations were not traceable in both the sample surveys.

The results of primary survey for various groundwater parameters are summarized in Table 9.13.

(12) Ambient Air Quality

Uttar Pradesh Pollution Control Board carries out ambient air monitoring throughout the year at selected locations in the city. The results of the survey from 1999 to 2003 are given in Table 9.14.

It is seen from the table that SPM values exceed the prescribed limits at all the monitored locations. This can be attributed to increase in vehicular and industrial emissions.

(13) Ambient Noise

UPPCB carries out ambient noise monitoring at selected 28 locations throughout the city categorized into residential, commercial, industrial and silence zones. The results are summarised in Table 9.15.

The noise levels in residential, commercial and silence zones were found to be higher than the prescribed limits. In all the areas under industrial zones, the noise levels were higher than the limits.

Table 9.13 Quality of Ground Water in Lucknow

Sl. No	Location	pH	Cond. µmhos/cm	TDS mg/l	Chlorides mg/l	Alkalinity mg/l	Total Hard mg/l	Ca++ mg/l	Fluorides as F mg/l	Sulphate as SO_4^- mg/l	Nitrate mg/l	Nitrites mg/l	Ammonical Nitrogen mg/l	COD mg/l	Coliform MP/100 ml
1	Alam Bagh (M-2)	7.4	1410	750	76	480	452	150	NT	63	19.0	0.022	0.57	12.0	<2
2	Rajaji Puram (M-2)	7.8	840	452	51	260	288	110	0.72	16	4.0	0.240	0.33	5.1	<2
3	Chowk (M-1)	7.7	610	348	21	230	229	42	0.70	55	2.6	0.014	0.13	NT	<2
4	Hardoi Road (M-2)	7.6	630	356	8	330	234	44	0.40	NT	NT	0.005	0.21	NT	<2
5	Purania, Sitapur Rd M-1	7.4	1160	650	55	410	363	187	0.60	193	NT	0.034	1.00	13.7	<2
6	Tadi Khana, Sitapur Road M-2	7.5	680	388	33	250	240	42	0.16	NT	NT	0.001	0.57	12.0	<2
7	Kalyanpur M-2	7.5	640	360	3	310	216	42	1.10	NT	NT	NT	0.20	3.4	<2
8	Indira Nagar M-2	7.7	680	390	17	250	265	26	1.20	14	5.1	0.010	0.16	20.5	<2
9	Hazratganj M-2	7.4	1000	622	67	290	326	27	1.23	15	13.0	0.101	0.49	20.5	<2
10	Daliganj M-2	7.8	1330	818	59	360	177	28	1.12	71	23.5	0.330	0.28	20.5	<2
11	Kaisar Bagh M-2	7.4	1880	1508	168	250	646	73	0.83	146	73.3	0.260	0.92	13.7	<2
12	Gomti Nagar M-2	7.8	460	360	24	180	166	33	0.82	170	2.0	0.010	0.17	18.8	<2
13	Dilkusha Garden M-2	7.7	720	398	4.4	340	292	39	0.81	3	NT	0.001	0.34	32.5	<2
14	Charbagh M-1	7.5	1140	664	77	340	392	60	0.52	NT	16.0	0.105	0.54	3.4	<2
15	Aishbagh M-2	7.7	660	412	27	250	248	41	1.52	73	4.7	0.208	0.28	NT	<2
16	Krishna Nagar M-2	7.6	760	480	10	360	296	15	1.13	34	NT	0.002	0.28	8.6	<2
17	Sarojini nagar M-1	7.5	620	374	7	300	233	24	1.28	NT	NT	0.004	0.18	6.8	<2

Table 9.14 Ambient Air Quality Results for Lucknow

Location	Category	Year 1999			Year 2000			Year 2001		
		SPM	SO_2	NO_x	SPM	SO_2	NO_x	SPM	SO_2	NO_x
Hazratganj	Commercial	370	24	28	321	28	30	3222	28	30
Mahanagar	Residential	328	25	27	354	29	30	358	28	30
Talkatora	Industrial	529	31	34	500	31	33	478	32	34

Location	Category	Year 2002			Year 2003			January to June 2004			
		SPM	SO_2	NO_x	SPM	SO_2	NO_x	SPM	RPM	SO_2	NO_x
Hazratganj	Commercial	347	23	29	337.29	17.53	27.07	340.58	158.01	16.97	29.64
Mahanagar	Residential	367	23	28	339.66	17.71	27.27	337.19	154.65	15.49	29.84
Talkatora	Industrial	467	27	31	432.03	20.17	28.89	413.37	180.39	18.16	31.91

Source: Uttar Pradesh Pollution Control Board
Note: All units in $\mu g/m^3$

Table 9.15 Ambient Noise Levels in Lucknow

Date	Location	Class/Area	Day Time	Noise levels dB(A)	Night Time	Noise levels dB(A)
	Gomti nagar near Jaipuria School		8.30	63.15	22.10	54.50
	Near Mahanagar Telephone Exchange		9.15	68.20	22.45	56.42
19.4.04	Indira Nagar near Amrapali	Residence	10.0	70.07	23.30	58.95
	Near Cantonment crossroad		11.0	69.71	00.20	55.67
	Ashiayana Colony (in colony)		11.45	70.72	1.00	56.35
	Chandar Nagar near Ladies Hospital		12.25	71.65	2.00	57.21
	Moti Nagar crossroads		10.30	70.16	22.00	60.52
	Khadra crossroads		11.35	71.85	23.00	61.64
	CDRI Colony		12.00	69.35	23.30	57.63
20.4.04	Vikas Nagar (Near Ramram Bank)	Residence	12.45	72.04	24.00	58.52
	Park Road (Near Vidhayak Nivas)		13.30	71.08	1.00	67.79
	Nirala Nagar (Near Post office)		14.20	72.55	1.45	59.55
				55.0		25.00
	Charbagh (near employment office)		10.30	82.64	22.05	73.52
	Nishat Ganj (near Karamat Market)		1.20	81.71	23.00	72.64
23.4.04	Alambagh crossroads	Commercial	12.25	83.65	24.00	70.85
	Nakkhas (near police booth)		13.00	82.05	01.00	69.72
	Hazratganj crossroads		14.00	81.75	1.45	68.75
	Rakabganj (near bridge)		15.00	81.67	2.35	69.63
	Munshipulia crossroad		10.00	78.61	22.10	67.65
	Laliganj (near bridge)		11.00	79.95	23.00	69.72
	Kaisarbagh crossroad		11.25	81.73	24.00	70.69
24.4.04	Naka (Near Thana)	Commercial	12.30	82.84	00.35	68.57
	Telibag (near bus stand)		14.00	81.92	02.00	67.84
	Aminabad (near Hanuman Temple)		15.45	80.75	02.00	65.62
				85.00		55.00
	Medical College (main gate)		15.10	67.77	22.00	56.06
	Command Hospital (main gate)		16.20	66.25	23.00	53.72
	Civil Hospital (main gate)		17.10	73.62	24.00	67.84
26.4.04	Avadh Hospital (main gate)	Prohibited	18.00	75.69	01.00	66.32
	High Court (main gate)		18.40	72.79	01.40	61.52
	Rani Laxmibai Hospital (main gate)		19.80	71.83	02.35	58.34
	Lucknow University (main gate)		20.15	72.67	03.30	59.68
				50.00		40.00
	Chinhut (near bus depot)		8.00	82.56	22.15	73.65
	Aishbagh (near waterworks)		9.20	81.69	23.35	72.52
27.4.04	Nadarganj (near bus depot)	Industrial	10.15	83.48	00.30	70.56
	Sarojani Nagar (Uptron turn)		11.00	82.84	01.15	68.52
	Amausi (near airport turn)		11.30	81.75	02.00	67.79
	Talkatora (near incardiorife)		12.30	82.85	03.00	68.54
				75.00		70.00

Source: Uttar Pradesh Pollution Control Board

(14) Waste Water Characteristics

Wastewater Characteristics at the Existing Sewage Treatment Plant
The influent and effluent samples are analysed regularly by the UP Jal Nigam to understand the performance of the plant. The latest wastewater samples were analysed in August 2004. The results are given in Table 9.16.

Table 9.16 Wastewater Quality of existing STP (42 mld at Daulatganj)

Sl. No.	Parameters	Inlet (mg/l)	Outlet (mg/l)
1	Suspended Solids	142.0	28.0
2	BOD	120.0	28.0
3	COD	274.4	66.64
4	Total Nitrogen	27.4	16.2
5	MPN/100 ml	6×10^9	700

The average results taken from May to August 2004 for the existing 42 mld STP at Daulatganj are summarized in Table 9.17.

Table 9.17 Effluent Results from 42 MLD STP

Sl. No	Month	Quantity of sewage (mld)	Influent			Effluent		
			TSS (mg/l)	BOD (mg/l)	MPN/ 100ml	TSS (mg/l)	BOD (mg/l)	MPN/ 100ml
1	May	41.83	202.58	141.45	11.0×10^6	22.21	20.19	809.68
2	June	43.84	208.80	129.17	1.4×10^6	23.33	19.03	796.97
3	July	44.45	192.26	113.71	2.1×10^6	22.58	17.68	790.32
4	August	40.63	200.65	108.06	1.2×10^6	23.45	16.77	764.74
5	September	40.57	217.92	119.53	0.9×10^6	23.42	20.71	750.00

(15) Existing Sludge Quality at Daulatganj STP

The analytical results of the sludge samples tested by the UP Jal Nigam in June 2004 are given below. However, the samples tested are only to assess the N:P:K ratio for its utilisation as manure in the agricultural fields. The results of the sludge analysis are given in Table 9.18.

Table 9.18 Sludge from 42 MLD STP

	N (% W/W)	P as P_2O_5 (% W/W)	K as K_2O (% W/W)
Sludge Cake	1.7	0.9	0.2

(16) Solid Waste Management

Lucknow city generates about 1,500 MT of waste per day. The transport system for solid waste caters approximately to 70% of the total waste generated in the city. There are two separate parts of the collection system: Primary collection by street sweepers and secondary collection by vehicles.

The waste that is thrown in nala eventually finds its way into the river or adds to the debris blocking the river. At the depots, waste is scavenged by the rag pickers and animals and most of the recyclable material and organic waste is extracted.

9.3.2 Biological Environment

Total land area in Lucknow district is estimated at 2,528 sq. km. Out of this area, 115 sq. km falls under dense forests, 14 sq. km under open forest. This accounts for 5.1% of the total land. 289 sq. kms of land is under scrubs. Afforestation for about 32,000 plants was completed in the district alongside roads and rails in 1990s. Small areas of shrub jungles may be seen in the areas of Mohanlalganj, Mohona and Malihabad.

The area along both the sides of Kukrail nala before its confluence with Gomti River forms a compact block of 2,403 ha known as Kukrail forest. Recently, the Uttar Pradesh government has declared it as reserved forest.

A crocodile sanctuary has been developed in Kukrail. This reptile park is one of the recreation places and one of the few very well organised crocodile sanctuaries in the country.

National Botanical Research Institute has prepared a catalogue of the flora of both wild and commonly cultivated species of Lucknow district, which has recorded 914 numbers of species. Accordingly, the commonly found species are shisam, mango, neem, jamun, babool. A number of orchard trees species having medicinal importance and insectivorous plants are also found in the city.

Plantation, by the roadside, found in abundance in Lucknow is listed in Table 9.19. Among them, moringnaceae, myrataceae and meliaceae families are very common. A large number of economically important plants have been introduced here.

Table 9.19 Plants Fund in Lucknow

Sl. No	Local Name	Botanical Name
1	Ber	Zizuphus jujuba
2	Imli	Tamarindus indica
3	Gulmohar	Delonix regia
4	Kaitha	Feronica limonia
5	Jamun	-
6	Amrud	-
7	Rose	Rosa indica
8	Neem	Azadirachta indica
9	Babul	Aceocia seorpoides

9.3.3 Socio-Cultural Environment

(1) Demography

The proposed 305 MLD (Year 2030) STP will be situated at the Mastemau. The socio economic profile of the adjoining villages, i.e., Ardhanamau, Mastemau and Bakaas are given below.

Since the proposed STP will be located at village Mastemau, it becomes necessary to understand the socioeconomic situation of the adjoining villages, i.e., Ardhanamau, Mastemau and Bakaas so that the positive or the negative impacts arising out of the project on the socio economic environment can be correctly analysed. Details on the demography of Lucknow district, schedule caste population, literacy rate, number of workers, demography of the nearby villages and the facilities available are given in Table 9.20. to 9.26.

Table 9.20 Demographic Details of Lucknow District

Name of Tehsil/ Town	Level	No. of households	Persons	Male	Female	Sex Ratio
Lucknow Rural	Tehsil	66,721	389,747	207,657	182,090	876.88
Lucknow Urban	Tehsil	406,059	2,262,369	1,198,468	1,063,901	887.72
Lucknow (Total)	Tehsil	472,780	2,652,116	1,406,125	1,245,991	886.12
Lucknow (MC)	Town	393,005	2,185,927	1,156,151	1,029,776	890.69
Lucknow (CB)	Town	10,452	59,582	33,315	26,267	788.44

Table 9.21 Population in Age Group of 0-6 years

Name of District	Level	Persons	Male	Female	Sex Ratio
Lucknow Rural	Tehsil	72,056	37,379	34,677	927.71
Lucknow Urban	Tehsil	283,033	148,451	134,582	906.58
Lucknow (Total)	Tehsil	355,089	185,830	169,259	910.83
Lucknow (MC)	Town	273,401	143,232	130,169	908.80
Lucknow (CB)	Town	6,941	3,755	3,186	848.47

Table 9.22 Schedule Caste and Schedule Tribe Population

Name of District	Level	Schedule Caste population				Schedule Tribe Population			
		Male	Female	Sex Ratio	Proportion % to total population	Male	Female	Sex Ratio	Proportion % to total population
Lucknow Rural	Tehsil	74435	66182	889.12	36.08	49	28	571.43	0.02
Lucknow Urban	Tehsil	123922	109449	883.21	10.32	1279	1132	885.07	0.11
Lucknow (Total)	Tehsil	198357	175631	885.43	14.10	1328	1160	873.49	0.09
Lucknow (MC)	Town	116972	103063	881.09	10.07	1233	1087	881.59	0.11
Lucknow (CB)	Town	5171	4853	938.50	16.82	46	45	978.26	0.15

Table 9.23 Literacy Rate

Name of District	Level	Persons	Male	Female
Lucknow Rural	Tehsil	55.80	66.86	43.04
Lucknow Urban	Tehsil	77.08	81.75	71.81
Lucknow (MC)	Town	77.11	81.72	71.91
Lucknow (CB)	Town	82.26	88.13	74.75

Table 9.24 Number of Workers

Name of District	Level	Persons	Male	Female
Lucknow Rural	Tehsil	122,917	99,671	23,246
Lucknow Urban	Tehsil	624,052	547,663	76,389
Lucknow (MC)	Town	598,579	525,338	73,241
Lucknow (CB)	Town	19,085	17,554	1,531

Table 9.25 Demographic Details of Villages

Village Name	No. of Households	Population	Males	Females
Mastemau	312	1,945	1,053	892
Bakaas & Chilol	1,060	6,482	3,447	3,075
Ardhanamau		233	126	107

Table 9.26 Facilities Available in Villages

Village Name	Schools	Medical Facilities	Water	Electricity	Roads
Mastemau	2 primary schools 1 junior high school	No	None	No transformer	3 km pakka road 5 kms kuccha road
Bakaas & Chilol	3 primary schools	1 PHC	85 wells, 75 borewells	3 transformers	1.5km pakka 2.5 km kuccha 0.5 km Sultanpur
Ardhanamau	1 primary school	No	NA	NA	3 kms

NA : Not Available

(2) Agriculture

The Lucknow district may be divided in 8 blocks in respect of agricultural land: Kakori, Sarojini Nagar, Chinhut, Bakshi ka Talab, Mau, Malihabad, Mohanlalganj and Gusaiganj. The major agricultural products are rice, wheat, maize, jowar, etc. These areas produce both the rabi and kharif crops. Besides the above mentioned grains, mustard and other vegetables are also grown here.

Maximum land is used for wheat and mustard cultivation during rabi season. Significant area is used for sugarcane cultivation too. The agricultural land use for kharif and rabi season are shown in Table 9.27.

Table 9.27 Land Availability for Rabi and Kharif Crops

Kharif Crop	Area under irrigation in ha	Rabi Crop	Area under irrigation in ha
Rice	54,000	Mustard	3,000
Maize	3,000	Wheat	82,000
Jowar	6,000		

Block-wise distribution of major crops cultivated around Lucknow city is given in Table 9.28.

Table 9.28 Major Crops in Lucknow

Sl. No.	Name of Block	Area in ha	Main Crops
1	Kakori	21,872	Maize, vegetables, rice, wheat
2	Sarojini Nagar	38,109	Non agricultural land
3	Chinhat	20,510	Maize, rice, wheat
4	Bakshi ka Talab	37,208	Maize, rice, wheat
5	Mau	24,989	Mostly non-agricultural land
6	Mallabad	20,752	Maize, rice, wheat
7	Mohanlalganj	33,608	Vegetables, maize, rice, wheat
8	Gusai Ganj	39,977	Vegetables, maize, rice, wheat

CPCB report states that fertilizers are used in cultivation, however low amounts of nitrogen in the soil demands large quantities of nitrogenous fertilizer

(3) Wastelands

The total area of wasteland in Lucknow is 27,534 ha. Most of the land lying waste in the district is salt affected occupying 81.73% of the total wasteland. The maximum salt affected land is in Mohanlalganj tehsil. The salt affected land is associated with waterlogged areas in most of the cases. In most of the salt affected areas, salt efflorescence has taken place and no vegetation grows on it while in other places small grass grows occasionally as these are not affected by salt efflorescence.

(4) Land Use

The initial master plan for Lucknow was prepared for the period 1970-1996. A modified action plan has been prepared and is effective from 2001.
The objectives of the modified master plan are:

- Assessment of execution of the proposals made in previous master plan
- Framing of suitable policies and measures for sustainable development of the city
- To ensure effective transportation system
- Provision of uniform distribution of facilities/ services for citizens
- To develop strong coordination among different land uses
- To frame policies for conservation and maintenance of historical buildings and monuments
- To develop and maintain a healthy environment in the city

The land-use break-up in the previous and the modified master plan is shown in Table 9.29.

Table 9.29 Land use Break up in Lucknow

S. No	Type of Activity	Land proposed in 1970 (ha)	% Area	Land proposed in modified plan (ha)	% Area
1	Residential	7105.7	48.73	15923.8	67.2
2	Commercial	377.4	2.58	936.2	3.9
3	Residential cum commercial	-	-	47.0	0.2
4	Govt. or semi govt offices	160.6	1.10	378.5	1.7
5	Industrial	1514.5	1.10	378.5	1.7
6	Recreational (parks, gardens etc)	1630.0	11.17	1868.5	7.9
7	Community Facilities	90.1.1	6.19	1537.0	6.5
8	Traffic and transportation	2891.4	19.84	2260.0	9.5
	Total	14580.7	100.0	23682.0	100

(5) Traffic

Traffic and transportation system in Lucknow is not sufficient to take the pressure of the increasing population. The city is connected with most of the important Indian places through express highways. The major roads passing through the city are NH 24 (to Sitapur, Bareilly, Delhi, etc), NH 28 (to Faizabad, Gorakhpur) and state highways to Sultanpur, Raebareilly and Hardoi.

The total length of road network in Lucknow city is 172.445 km. The roads in the older part of the city are narrow and encroachment by road side shops and vendors is common. The traffic characteristics of Lucknow are described in brief below:

1. Narrow roads, unplanned development, illegal encroachments and on road parking are a common sight in the older part of the city.
2. Steady increase in number of the vehicles causes congestion on roads.
3. Slow moving vehicles like bicycles, cycle rickshaws are in a high number in the city which affect the movement of the traffic during peak hours.
4. Public transport facilities are not adequate in Lucknow. Bus services are sparingly used inside the city and their use is limited to only longer routes covering city suburbs.
5. Availability of parking space is difficult during peak hours.
6. The two wheelers dominate the total number of vehicles accounting for almost 80.1% of the total vehicles.

(6) Public Health

Water borne diseases are common at places where contamination of drinking water supply takes place. This generally happens due to leakage in water supply and sewer pipes. At many places it has also been seen that the water pipelines are laid into the drains carrying wastewater. The most susceptible areas where infectious and water borne diseases are most commonly seen in southern part of the Lucknow city are:

1. Azad Nagar
2. Bada Barha
3. Chotta Barha
4. Near Chander Nagar vegetable market

5. Kuriana Sardari Kheda
6. Sudama puri Charbag
7. Kasaibada Mavaiyya
8. Bhola kheda
9. Prem Nagar
10. Nat Kheda Nai Basti

Efforts were made to collect data regarding the past history of water borne diseases in Lucknow and their occurrences. During discussions, the team tried to analyse if there was any direct co-relation between the diseases and the pollution of the river. The trend of the water borne diseases (commonly gastro) is shown in Table 9.30.

Table 9.30 Frequency of Water Borne Diseases

Description	2000	2001	2002	2003	2004
No. of cases of gastro	2112	677	656	984	1561
No. of deaths due to gastro	0	14	0	0	5
No. of jaundice cases	14	10	0	0	26
No. of deaths due to jaundice	0	0	0	0	0

Source: Chief Medical Officer

Various health disorders are also associated with supply of contaminated water and other sanitation facilities available in the city. The relationship between the project activities and facilities and the water borne diseases is given in Table 9.31

Table 9.31 Relationship between Diseases and Project Activities

Project Activities	Water borne diseases	Water related diseases	Soil pollution	Food contamination	Chemical toxicity
River water supply	+	-	-	-	-
Ground water supply	+	-	-	-	-
Water storage	+	-	-	-	-
Stand pipes	+	+	-	-	-
Sewage/ sanitation	+	+	+	-	-

Source: Chief Medical Officer

Malaria is prevalent in Lucknow from July to October, every year corresponding to rainy season and the subsequent period of water retention and stagnation.

Although malaria cases are seen on a rise in the last 4 years, there have been no major outbreaks of any water borne diseases or epidemics in the last 3-5 years. Cases of malaria registered with the Chief Medical Officer (CMO), Lucknow from 2000 – 2004 is given in Table 9.32.

Table 9.32 Trend Analysis of Malaria Cases

Species	2000	2001	2002	2003	2004
P. vivax	26	45	28	162	68
P. falciparum	2	0	1	13	0
Total	28	45	29	175	68

Source: Chief Medical Officer

(7) Places of Historical and Archaeological Importance

Lucknow has a rich cultural heritage being one of the important historical and commercial cities of north India. The city reminds of the rich culture. Lucknow had been a very important place during the period of Nawabs and a glimpse of city reflect the rich Moghul architecture. The famous Chhatar Manzil was constructed by the Nawab Naseruddin Haider, which currently houses the Central Drug Research Institute. Also, there are many places of historical and archaeological interest in the city. The places of interest are:

- The Residency
- The Alambag
- Dilkusha palace
- The Bara Imambara
- Hazrat ganj
- The Jama Masjid
- La Martiniere, and many more

9.3.4 Existing Situation of Sewerage Infrastructure in Lucknow

The existing sewerage system in Lucknow has not been designed to cater to the ever growing population and other needs of the city. The sewer lines are very old and outdated. The pumping stations do not function to their optimum capacity and therefore are unable to pump the required amount of sewage to the existing treatment plant at Daulatganj.

Lucknow City's population is projected to double from 2.5 million in 2003 to 5.4 million by 2030. At present the total domestic wastewater load is about 365 mld vs. an installed treatment capacity of 42 mld. The amount of wastewater collected and diverted to treatment represents just over 10% of the total amount generated. Remaining wastewater is discharged to Gomti River through open drains. At present there are 26 such drains that discharge the wastewater of Lucknow directly into the river thereby drastically deteriorating the quality of river.

The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads.

In the absence of a well-planned sewerage infrastructure, urban development continues without adequate infrastructure for public health and sanitation. New sources of pollution crop up as the population grows and as new areas develop:

- Existing sewer facilities are overloaded, effluent at treatment plants becomes a significant pollutant load
- The amount of wastewater in open drains increases thereby overflowing at existing diversion facilities
- New sources of pollution appear as natural drains serve as outlets for wastewater from new developments

Diversion facilities constructed under GoAP are not designed to operate during wet weather, therefore the use of open drains for wastewater disposal remains a significant source of pollution in river during wet weather.

Diversion of drains, as proposed under GoAP is an important initial step for improving water quality. However, the Government of India and NRCD have recognized that the benefits of GoAP will be short lived unless these activities are framed within a more holistic approach to the development of sewerage infrastructure in large urban centres. In the absence of a comprehensive plan, efforts at pollution control will always remain reactive, never quite catching up with the source of the problem.

In a large proportion of households' sullage water from kitchen, bathing and laundry is discharged into street side drains. This compounds the problem arising from inadequate surface water drainage. The reluctance to discharge sullage to the sewer is due to the frequency of and duration of sewer blockages.

Of the total volume of sewage generated within the city, only a small proportion enters the main sewerage system. A large fraction enters the surface water drainage system either directly or through spillage from damaged or blocked sewers. This pollutes the water environment and results in unsanitary living conditions particularly when it rains.

Damaged manholes, sewer defects particularly around the nala and connections of nala to the sewerage system have led to the increased risk of solid waste entering and blocking the system. There is currently no way of controlling the amount of storm water that enters the system at location where drains have been diverted. Storm water overloads the sewer system and causes overflows to the river.

In view of the current situation, urgent steps are required to be taken to stop the pollution in the river. Given the scenario, the sewerage system of the city should be improved to stop the flowing of sewage via drains into Gomti.

9.4 ANALYSIS OF ALTERNATIVES (INCLUDING WITHOUT PROJECT OPTION)

9.4.1 Project Benefits and Positive Impacts

Objective of implementation of the sewerage and pollution control projects is to ameliorate overall development and betterment of public health and hygiene coupled with upgradation of environmental management in the target project area through abatement of pollution; improvement of public health and aesthetics leading to improvement in quality of living and inducing economic growth. The project therefore, is associated with following benefits and positive impacts:

- The collection and treatment of untreated wastewater before entering Gomti r will improve water quality of the river and river environment.
- The project will improve river water quality of upstream of the city, where municipal water supply intake is located.
- Proper collection, treatment and disposal system of wastewater will reduce the risks of parasitic infections, incident of various diseases including malaria, typhoid etc.
- A proper wastewater handling and disposal arrangement will minimise the chances of contamination of ground and surface water.
- Such provisions assist to maintain ecological balance by reducing damages to flora and fauna.
- Controlled reuse of wastewater supplements agricultural activities and development and sustenance of environmental protection components like greenbelt development.
- Improvement in the existing sewerage system will help reduce the nuisance in streets and road blockages.
- Development of the project will encourage increased economic activities like commercial, industrial, etc. and will generate enhanced employment alternatives and economic growth for the city.
- Improvement in the existing sewerage facilities will help tourism and boost the economy of the area.
- Public health gains such as increased output through improved health resulting in higher economic activity and productivity.
- The construction activity can provide opportunities to the local population and residents of the neighbouring area to earn. They may come to provide labour or to service the construction camps.
- Nutrient rich treated water and dried sludge can be used for irrigation

9.4.2 With and Without Proposed Project

With and without project scenarios are compared at upstream of the city barrage and downstream of proposed STP effluent discharge point in the following table.

Table 9.33 Comparison of With and Without Project in Year 2015

	Without Project (incl. sanctioned project)	With Project
(1) Up stream of the barrage		
Estimated wastewater generated in 2015	247 mld	247 mld
Treatment capacity in 2015 *1	56 mld	56 mld
Diverted to other district	120.3 mld	191 mld
Untreated wastewater in 2015	70.7 mld	0 mld
Percentage of untreated wastewater in 2015	28.6 %	0 %
Estimated BOD discharge (untreated + treated)	22.89 ton-BOD/day	1.68 ton-BOD/day
BOD concentration at upstream (u/s) of city (Assumption)	2.5 mg/l	2.5 mg/l
BOD contribution to the River (if treated water is used for irrigation)	+19.4 mg/l (+18.0 mg/l)	+1.4 mg/l (+0.0 mg/l)
BOD concentration at downstream (d/s) of city (if treated water is used for irrigation)	21.9 mg/l (20.5 mg/l)	3.9 mg/l (2.5 mg/l)
(2) Down stream of proposed STP		
Estimated wastewater generated in 2015	224.9 mld	224.9 mld
Treatment capacity in 2015	345 mld (sanction)	445 mld
Untreated wastewater in 2015	0 mld	0 mld
Percentage of untreated wastewater in 2015	0 %	0 %
Estimated BOD discharge	33.24 ton-BOD/day	15.03 ton-BOD/day
BOD concentration at u/s of city	20.5 mg/l	2.5 mg/l or 3.9 mg/l
BOD contribution to the River (if treated water is used for irrigation)	+1.9 mg/l (+0.0 mg/l)	+7.6 mg/l *3 (+0.0 mg/l)
BOD concentration at d/s of city (if treated water is used for irrigation)	23.8 mg/l (+20.5 mg/l)	11.5 mg/l (2.5 mg/l or 3.9 mg/l)
Bathing environment	Raw wastewater is discharged in the Gomti, which is causing unhygienic condition for bathing	All raw wastewater is intercepted and treated before entering the Gomti. Bathing environment will be improved.
Protection of water source of drinking water	Discharge of raw wastewater will be increased, which affects the municipal water intake and decrease city water supply quality.	The raw wastewater discharged near the municipal intake will be intercepted and treated and thus the source will be protected.
Water quality of effluent of proposed STP	Chlorination is applied to existing STP.	Chlorination will be applied to proposed STP. Bacterial pollution will be reduced

Note: 1) The dry flow of the Gomti Rover is used for analysis.
2) BOD concentrations of untreated and treated wastewater of 300 mg/l and 30 mg/l are used for analysis.
3) As the wastewater generated upstream will be diverted to the proposed STP downstream, BOD contribution to the River is higher than the situation without project.
4) The sanctioned project include 345 mld STP construction at Kakraha downstream of the city and is assumed to be implemented.
*1: Additional 14 mld STP is planned by Development Authority.

9.4.3 Alternatives

Different treatment processes are available for biodegradation of organic material present in domestic wastewater. Individual treatment process has its own limitation and advantage in terms of land requirement, environmental impacts, power consumption and operation and maintenance.

Four treatment processes have been selected for detailed evaluation before finalising the suitable one that would be environmentally, technically and financially viable option. This has been summarised in Table 9.34.

Table 9.34 Analysis of Alternative Sewage Treatment Technologies (based on 100,000 m^3/d) at Proposed Mastemau Site

Parameters	Waste Stabilisation Pond	Activated Sludge Processes	UASB + AL+Chlorination	AL+ Maturation Ponds
Treated Water Quality	BOD: 30 mg/l TSS: 50mg/l Faecal Coliform: 1000 MPN/100ml			
Irrigation Reuse	Applicable as per Indian Standards	Applicable as per Indian Standards	Applicable as per Indian Standards	Applicable as per Indian Standards
Air Quality	Maximum odour	Moderate odour	Moderate odour	Medium odour
Possibility of ground water pollution	Maximum	Minimum	Marginal	Marginal
Maintenance	Minimal	Maximum	Moderate	Moderate
Power Requirement	525 KWh/day	20000 KWh/day	3700 KWh/day	18225 KWh/day
Land Area Required	101.21 Ha	20.24 Ha	20 Ha	55.87 Ha
Estimated Investment cost	Rs. 666 million	Rs. 452 million	Rs. 360 million	Rs. 415 million
O & M Cost	Rs. 6.1 million	Rs. 39.8 million	Rs. 8.5 million	Rs. 32.1 million
Capitalised Cost	Rs. 711 million	Rs. 696 million	Rs. 359 million	Rs. 660 million
Conclusion	Not recommended sufficient land is not available at Mastemau	Not recommended due to high O&M cost	Recommended	Not recommended due to high land requirements and higher capital cost

Regarding the above parameters, their related importance in the comparison of alternative sewage treatment processes has been decided in view of the following site constraints:

- Power Constraint: - Power outages frequently happen in Lucknow, thus a technology with a high dependency on power for effective and reliable treatment of wastewater should not be desirable.
- Land Constraint: - the city is densely populated and hence, offers few choices for locating the STP.

The site Mastemau is surrounded on the northern side by the Gomti river. On the west side it is bounded by the ring road that is being constructed. Other two sides it is bounded by several villages. Sufficient land is not available at this side for providing waste stabilisation ponds. Also there is potential for re-use of treated effluent for irrigation.

Hence, for this site UASB followed by AL and chlorination would be a better environmental solution.

9.5 PREDICTION OF IMPACTS: CONSTRUCTION PHASE

9.5.1 General

This section identifies environmental implications, both beneficial and adverse, of the proposed priority projects. Where possible, the magnitude of the impact is identified. However, it should be noted that at the feasibility stage of the project, an overall identification and assessment of the impacts is possible from the available information.

General discussions and site-specific impacts that are predicted to be generated by major components of the project are presented in this section.

The majority of the impacts identified are temporary and restricted to the construction phase. The actual benefit of the total “priority projects” cannot be estimated until commissioning has been completed.

The potential impacts will be seen during the construction phase where major disruption in the local areas is likely to take place. However, most of the impacts of this nature are temporary and cease once the construction activities are completed. It therefore becomes important to ensure that the construction activities are completed in the least possible time. A detailed analysis of such impacts arising on various environmental parameters is given in this chapter. These impacts comprise:

1. Soil quality impacts,
2. Air quality impacts,
3. Noise and vibration,
4. Water quality impacts,
5. Loss of ecological habitat,
6. Loss of agricultural land and trees,
7. Impacts on cultural assets,
8. Demolition of buildings/resettlement,
9. Severance /disruption,
10. Traffic impacts,
11. Visual impacts,
12. Waste disposal (solid and liquid),
13. Public health impacts,
14. Socio-economic impacts.

The construction activities will lead to localised increases in dust and suspended particulate matter in the ambient air. Noise impact on nearby communities will be significant. The sewer laying work

within the city is likely to disrupt vehicular traffic, pedestrian access and consequently commerce and business. Careful management can mitigate this impact, but some disruption is unavoidable.

9.5.2 Beneficial Impacts of the Project during the Construction Phase

Beneficial impacts of the project will not be realised during the construction phase, when most of the impacts are usually adverse, though of short duration and temporary. The tremendous beneficial impacts of the project will be observed only in the operation phase of the project.

The beneficial impact of the construction phase of the Project would be the potential for employment of local population during construction stage, and the associated increase in trade and business, which would have a positive impact on the economy and the population, as long as it lasts.

9.5.3 Sewerage and Pumping Station Impacts: Construction Phase

(1) General

Most of the proposed trunk sewers are being laid alongside the right of way of roads. However, within the city limits the sewer lines will cross some busy areas and therefore adequate attention should be paid to such areas. Outside the city limits the sewers will be laid in the undeveloped or under developed areas

(2) Soil Quality

During laying the sewers, top soil will be displaced and permanent loss of top soil may occur if it is not stored and replaced. The sewer lines under the priority projects will be laid within the city. Therefore, the economic benefits associated with topsoil will not be significant in this case. Once excavation is completed the soil quality can be restored. The impact thus will be of temporary duration. In certain areas where the sewer lines will cross agricultural patches of land and areas with plantation, special care should be taken to store the topsoil.

(3) Air Quality

- During the construction phase, air quality will be deteriorated by the increase in the suspended particulate matter in the atmosphere during excavation and removal of the excavated earth. It will also be deteriorated due to vehicular movements near the site of laying the sewers. The impact will remain adverse during construction stage. Increase in particulate matter during construction will cause inconvenience to the people staying and working nearby.
- Vehicular movement to transport sewer pipes and earth moving equipment will give rise to smoke, hydrocarbons, carbon monoxide and NO_x emissions.
- Fugitive emissions during load/ unloading of equipments, material transport is possible.

Though, the nature of the impacts is temporary and localized but it is important to formulate mitigation plan to reduce the impacts.

(4) Noise

At the construction site various machineries and equipments will be employed such as excavators, cranes, concrete mixer, pay loaders, etc which will generate high noise. Workers and labours in the vicinity of these machineries are likely to be affected with the noise generating activity.

Noise levels near the construction site will be in the range of 90-105 dB(A), when all the equipments work together. Hence workers near the machineries will be exposed to high noise levels. The impact will however be temporary in nature and suitable measures should be taken to minimise the impact.

(5) Receiving Water Quality

If excavated material is not properly stacked, it will find its way during monsoon run off into the ponds, lakes, nala and the rivers, thus increasing suspended solids in the receiving water body. However, if due care is taken then this will not cause any impact to the nearby water bodies.

(6) Ecology

Construction of the sewerage system will not have any impact on the ecological aspects of the area.

(7) Land use

Construction of the sewerage system will not make any impact on the land use pattern of the area, as most of the sewers will be laid on the right of way of the roads.

(8) Heritage and Historical Sites

There will not be any impact on cultural assets during the construction phase of the sewerage system. The proposed trunk sewer will not pass through any significant historic or archaeological sites as such no impacts are anticipated.

(9) Severance/Acquisition

The sewerage system will be installed part by part. Only part of an area will be disturbed at a time and that too for a temporary period, indicating that severance experienced by the people will be for a short time at each particular site.

The proposed Martin Purwa PS which will require 1.0 ha will be constructed besides the existing flood pumping station, which is situated on the collage ground. The land should be acquired from the collage, but no resettlement will happen.

At Ardhanamau near the Mastemau STP, the sewer line will pass through some private lands for which right of way have to be acquired through their lands. The list of landowners through which the sewer line will pass is given in Table 9.35.

Table 9.35 List of Landowners through which the Sewer Line Will Pass

Sr.	Gata No.	Area (acre)	Name of Landowners
1.	174	0.329	Shiv Govind, etc.
2.	175	0.088	Bhajan Lal, etc.
3.	176	0.234	N. Charan, Ram Chandra
4.	173	0.316	Sant. Ram Bilas, etc.
5.	207	0.177	Savitri
6.	208	0.101	Sath Narain
7.	209	0.341+0.304+1.265	Tanveer Aga, Sajivan lal
8.	210	0.326	Ceiling
9.	255	0.325	Chandra Shakhar, Hari Ram
10.	258	0.326	Fazil Aliumi Jangir
11.	260	0.291	Jagdev, etc.
12.	287	0.243	Deep Chand Puddi Lal
13.	291	0.283	N. Govind, etc.
14.	355	0.076	Krishna Pal, etc.
15.	327	0.395	Tej Shankar, Jai Shankar
16.	328	0.128	Jadish Prasad
17.	323	0.223	Laxmi Narain
18.	324	0.215	Garibelal
19.	355	0.297	Shiv Shankar, etc.
20.	356	0.154	Krishna Pal, etc.
21.	354	0.294	Smt. Minia Bhola
		0.294	Smt. Durga
22.	353	0.199	Prabhu Dayal, etc.
23.	352	0.273	Fazil Aliumi Jangir
24.	370	0.075	Non cultivated (banjar)
25.	366	0.835	Munni Lal
26.	365	0.809	Prabhu Dayal
27	369	0.967	Munni Lal
Total		10.183	

(10) Traffic

The traffic will have to be diverted during sewer laying, as much of the roads will be occupied for sewerage work. Traffic congestion will be experienced on the roads connected to the sewerage sites. Although the impacts will be limited for a temporary period, the severity of the impact would be high during the construction phase.

The proposed new relief sewer passes through following important places

Pata Nala Junction	:	Heavy Traffic
Rail Under Bridge	:	Narrow Road
Kaisarbagh Bus Station	:	Heavy Traffic
Lalbagh Junction	:	Heavy Traffic
Hazratganj Junction	:	Heavy Traffic
Park Road (near Civil Hospital)	:	Road cannot be fully closed due to Civil Hospital
GH Canal	:	Canal Crossing
Railway Crossing near Martinpurwa	:	Railway Crossing
Railway Crossing in Sultanpur Road	:	Railway Crossing

However, trenchless sewer technology will be used to minimise the impacts on traffic, air quality and day to day activities of the people.

(11) Visual Impacts

The visual impact during sewer laying will be unaesthetic because of dusty atmosphere, water spreading, muddy soil all around project site. Broken roads and pavements will add to the shabby look. The area will look crowded, however these impacts will be temporary.

(12) Public Health

During laying of sewer lines, there is a possibility that water used for construction will get accumulated in the nearby areas forming small stagnant pools. If left unattended, it can become a cause for breeding of mosquitoes. The suspended matter may affect those with respiratory tract problems and those suffering from asthma.

However, if due precautions are taken from the beginning, this will not lead to any adverse impacts and will be of a temporary nature.

(13) Socio-economic

The construction of sewer lines is likely to affect the economic activity of the hawkers and the small street side vendors and shops. This is because no people would like to visit the areas where construction would be taking place. Construction activities will also cause inconvenience and hindrance for the hawkers to make business. Areas mainly affected will be Lalbag crossing, Kaiserbag crossing for hawkers.

Although the sewerage activity is temporary, lasting for 2 - 3 months in each locality, moderate impacts on this aspect will be seen. The project may create temporary job opportunities for a few persons in the area as construction labourers, traders and contractors, etc. for that period, which will be a beneficial outcome.

9.5.4 Sewage Treatment Plant Impacts: (Construction Phase)

(1) General

The intensity of the impacts depends on the area to be covered by the treatment plant, which depends in turn on the process and the flow to be treated. Basically the proposed treatment processes will be UASB followed by AL and further followed by chlorination. The proposed treatment has been selected after analysing other treatment technologies which is given in Chapter 3.

The construction impacts are also related to the phasing of the works. In general the impacts will be more intense during the first phase of works because the land use of the site will change radically. A description of the impacts during construction stage is described below.

(2) Soil Quality

Total land requirement for the option selected for STP is 70 ha. Whatever the alternative, the topsoil of the area that will be covered by the treatment units will be definitely lost. The topsoil of the other parts of the STP site that will be temporarily disturbed or excavated during the construction phase, will have to be restored after construction.

(3) Air Quality

The air quality during the construction phase will be slightly deteriorated due to increased concentration of SPM in the air. However, the area selected for the treatment plant is purely agricultural with no settlements or human habitation. Hence, this impact will be insignificant in nature with respect to inconvenience caused to people.

(4) Noise

Noise levels at the STP is expected to increase up to 80 to 90 dB(A) during the construction phase. Since the area is agricultural with no habitation nearby, high levels of noise will not cause any discomfort. However, the workers and the labour employed during the construction might face inconvenience and suitable measures will have to be accordingly adopted.

Since nearest villages are at some distance of proposed STP site, the adverse impact will not be significant

(5) Receiving Water Body

Gajaria nala and Gomti river are very close to the proposed Mastemau STP site. If excavated material is not properly stacked, it will find its way, especially during monsoon into this natural drain, which shall lead to silting and weed growth.

(6) Ecology

At the proposed STP sites, the impact will be largely felt since agricultural land will be converted into non-agricultural land. The crops grown on this land are wheat, rice, mustard, all kinds of vegetables.

Animals like Nilgai and Barasingha are found to be common at the proposed site and their movement is likely to be affected during the construction phase.

(7) Cultural Assets

There will not be any impact on the cultural assets in the project area because there are no such assets near the proposed STP sites. In any case, construction activity will not last long (less than 3 years) and will not involve any blasting or other techniques, which might damage or weaken the nearby structures.

(8) Land Acquisition

It is estimated that 70 ha of land will be acquired for the construction of the proposed STP at Mastemau. The resettlement is avoided by selecting appropriate sites without displacement of villages, and 70 ha for the STP will be acquired in agricultural land. The STP site is located in Mastemau and Bakkas villages and the information of land owners has been collected during the field visit as shown in table below. The revenue map is also shown in Figure 9.2. The most commonly grown crops in the area are wheat, rice, mustard and vegetables. The average income reported ranges between Rs. 10,000 to 15,000 per acre per year.

Although this will be a permanent impact, compensation given will assure the financial security of the landowners.

STP	Land use	Name of village	No. of land owners affected
Mastemau STP (70 ha)	Agricultural land	Mastemau	79
		Bakkas	60

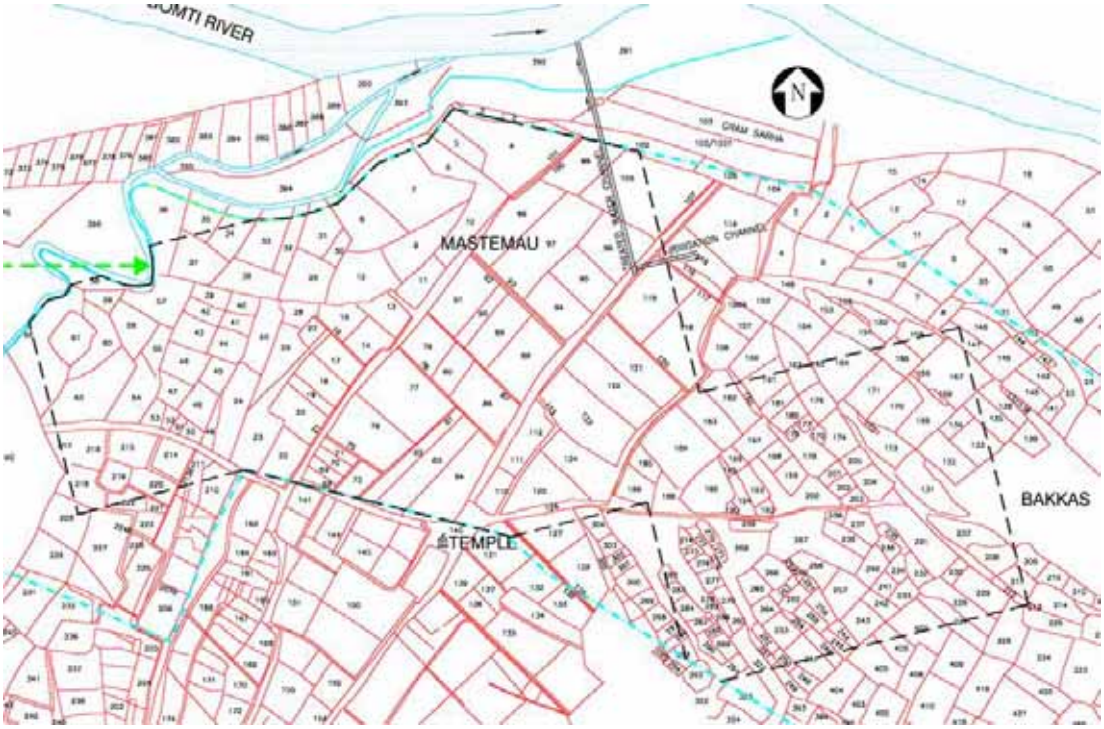


Figure 9.2 Revenue Map of Mastemau STP

(9) Traffic

Currently the traffic in Lucknow city is heavy and it is expected that the construction materials has to be transported through the city. This will lead to traffic congestion within the city limit.

(10) Visual Impacts

The visual impacts at the construction site of the treatment plant will be unaesthetic. The dumping of construction materials will not look any better. The dust at the site will be carried over to nearby areas in windy or stormy weather conditions. Broken pavements and opened roads would add up giving an unaesthetic look to the construction site. However, the impact will be temporary and localised.

(11) Spoil Disposal

The spoil will be generated during construction of the treatment plant by way of rejected plant materials, bushes during site clearing, excess earth, etc. The spoil will have to be disposed of in a proper manner at the pre-identified safe disposal sites. Suitable dumping sites will have to be identified near the proposed treatment plant location for any of the options. If not disposed in an environmentally compatible manner, it may create minor adverse impacts in the surrounding area.

(12) Public Health

Since there is no habitation near the STP site, adverse impacts to the people in terms of health is not anticipated. Workers are usually the immediately affected people if unsanitary practices adopted on the construction site are not adequate. High fever, diarrhoea, malaria and other epidemic diseases may occur frequently in the labour camp. The impact will thus be adverse but it will be avoidable by providing adequate sanitation facilities for the labour camps.

(13) Socio-Economic

In general the construction of the STP will have some positive impact on the economy due to increase